

THE TASMANIAN RIVER CATCHMENT
WATER QUALITY INITIATIVE

DEVELOPMENT AND VALIDATION OF A
PESTICIDE IMPACT RATING INDEX (PIRI)
FOR TASMANIA.

FORESTRY TASMANIA REPORT
TO
DEPARTMENT OF PRIMARY INDUSTRIES AND WATER
2008



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Cover: Collecting water samples in the field.

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Glossary of terms and acronyms

AWS	Automatic Water Sampler
BoM	Bureau of Meteorology
EMS	Environmental Management System
FT	Forestry Tasmania
PIRI	CSIRO's Pesticide Impact Rating Index assessment tool
RSS	Rising Stage Sampler
SDI	Soil Dryness Index
SFM	Sustainable Forest Management
UTAS	University of Tasmania

Keywords: pesticides, PIRI, water

Executive summary

Forestry Tasmania (FT) undertook to provide historical water monitoring data associated with routine pesticide application operations for validation and improvement of the CSIRO Pesticide Impact Rating Index (PIRI) model. FT also examined data held by other forestry companies to fill gaps in data, especially for pesticides not used by FT. FT and the forestry companies have over 10 years of water monitoring data, but the focus was concentrated on post 2000 samples.

The data supplied for validation of PIRI models were gathered according to strict rules of data quality. Any data that did not meet these rules were rejected. On two occasions an independent auditor scrutinised the data that had been gathered, the manner in which it had been gathered and the water monitoring protocols used by FT. Suggestions for improvement were implemented during the project.

FT requested that Soil Dryness Index (SDI) be tested for inclusion in a PIRI modified for Tasmania. SDI is a measure of the amount of rainfall required for soils to be saturated and hence increase risk of runoff. SDI is readily available from Bureau of Meteorology reports and can be easily applied.

PIRI outputs for risk assessments were validated against historical data sets, where soil properties, buffer widths and site conditions were known. Prototype versions of PIRI-Tas were also used in operational spray programs in 2007 and early 2008.

PIRI-Tas was able to predict with a reasonable level of confidence the situations where contamination of water could occur after a spray operation. It was found that vegetated buffers are effective in reducing risk of contamination. Where contamination does occur it was found that this is the result of direct over-spray of drainage lines or where no-spray buffers are not vegetated.

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1 Introduction

1.1. Background

The Tasmanian Water Quality Initiative provided \$1 million over two years to develop methods to manage and monitor water quality in Tasmanian waterways. In particular, the management of agricultural pesticides is of prime concern in relation to contamination of water used for drinking, and effects on the aquatic environment and downstream commercial activities.

An initial meeting was held at DPIW (then the Department of Primary Industries, Water and the Environment, DPIWE) at its facility in New Town near Hobart on 2 June 2005. Various proposals were discussed. It emerged that there were three main projects that could contribute to the initiative:

1. Use of a risk assessment tool such as a Pesticide Impact Rating Index (PIRI) to target monitoring programs undertaken by DPIWE. PIRI could determine which pesticides were of high risk from a toxicity and mobility perspective and therefore should be part of the monitoring program. Included would be a retrospective analysis of existing monitoring data. Led by DPIWE.
2. Further study on breakdown rates and toxicity of various agricultural pesticides in the Tasmanian environment to enable better parameterisation of the PIRI tool. Led by UTAS and SFM.
3. Development of a risk assessment tool for forestry (Forestry PIRI) using the excellent soil and environmental data sets developed by the forestry sector in combination with extensive water monitoring data and planning documents. This could be a precursor to development of PIRI for other sectors (e.g. agriculture, local government, utilities). Led by Forestry Tasmania.

This proposal addresses the third of these projects.

1.2. Objectives

- To develop PIRI for Tasmanian forests, by incorporating soil dryness index (SDI), vegetation cover, other relevant input data (soil and climate) and pesticide use for selected scenarios to represent the Tasmania forestry industry.
- To amalgamate and analyse existing data (collected by forestry companies) on pesticide contamination of surface water in Tasmanian forests following broadscale pesticide application. This will identify the frequency of direct contamination versus transport with soil and water, and which pesticides are at most risk of off-site transport, in which landscapes under which conditions.
- To use the data to validate PIRI-Tas for the relevant pesticides used in forestry.

There is a clear expectation from the community that pesticide pollution of water resources should not occur – in the interests of human and ecosystem health. Occasional instances of water contamination occur during broadacre application of pesticides in forests despite rigorous prescriptions and planning. The frequency of contamination could be further reduced with greater knowledge and risk assessment.

PIRI provides a decision support tool that will help land managers to identify which pesticides they can apply under certain circumstances to minimise risk to water resources. PIRI has predominantly been utilised in agricultural systems in the past. Forests differ from agricultural landscapes in their different nature of vegetation cover, retention of habitat strips, buffering of sensitive areas, roughness of terrain and low frequency of pesticide application. Tasmanian soil types, landscape, and climate differ from those seen in other landscapes, and these differences will affect the likelihood of pesticides leaving the site.

Forests provide a good starting point for this kind of study as the range of pesticides applied is small in comparison to agricultural systems. There are fewer forest owners, making data collection and implementation of new processes easier and increasing the possibility of modifying existing codes of practice. Community and political pressure has meant there are routine sampling programs in place for broadacre pesticide application in forests. As such, there is a large pool of historical forest water quality monitoring data available for validating the tool.

1.3. Expected outcomes

- Reduced risk of contamination of surface water resources from pesticides. Pesticide users will be in a better position to make decisions about application of pesticides on specific sites and at specific times to minimise the risk of water contamination. This aims to arrest the problem of contamination at the source, before it occurs.
- Better communication with the community through ability to demonstrate the use of state-of-the-art planning tools.
- Documentation of decision-making processes for pesticide application which would be suitable for EMS and Forest Certification requirements.
- Technology transfer of the state-of-the-art technology to Tasmania.

2 Description and analysis of contracted services

Table 2-1 Timetable for completion of project phases (as per Schedule 1 of Contract).

Activity	Date completed	Comment
Develop work plan for tailoring CSIRO's PIRI to Tasmanian conditions.	Nov 06	Despite some difficulties in drafting a business plan to DPIW requirements a final plan was accepted in November 2006.
Recruit Project Officer	Oct 06	Appointment made until June 30 2008
Identify and report to Crown on the availability of appropriate water monitoring data sets supported by actual or extrapolated environmental and planning records.	Jan 07	First set of data was provided to CSIRO on time after external audit was undertaken at request of DEH. FT has received a working spreadsheet version of PIRI to evaluate. This has been trialed using the historical data provided to CSIRO. Field evaluation will commence once operational autumn spraying programs commence.
Provide soil dryness index, Tasmanian soils database and climate surface model to CSIRO's PIRI authors.	Feb 07	SDI data acquired from BOM. Ongoing negotiations with BOM on acquisition of past and future SDI data. Project team decided on methodology for acquisition and use of SDI information, which FT has undertaken to pursue in the coming months.
Trial Forestry PIRI incorporating soil dryness index, Tasmanian soils database and climatic surface models.	Apr 07	The provision of a comprehensive soils database is not necessary to achieve the aims of the project as PIRI only requires texture, organic carbon % and erosion rate as an input. The climate database derived from BIOCLIM can be supplied as an MS Access look-up table.
Progress Report 1 submitted	Apr 07	Report submitted on time
Report on utility of PIRI in forestry operational programs.	June 07	PIRI was used in FT's autumn operations and comparison made to the monitoring results. The report was made available to the management committee within the planned timeframe.
Provision of historic water monitoring data from other forestry companies.	Sept 07	This data were collated from companies willing to participate in the program and provided to the CSIRO on time.
Trial version 2 of PIRI incorporating Spring 06 sorption, leaching, fractionation, half-life data and preliminary results on Autumn 07 adsorption and leaching studies.	Oct 07	
Report on development of PIRI trial version 2 and evaluation against all historic water monitoring data.	Jan 08	CSIRO provided the report utilising historical data obtained from FT and other forestry companies.
Progress report 2 to Management Committee	Nov 07	Completed on time.

3 Completion of contracted services

3.1. Examination of existing data

Examination of existing data held by Forestry Tasmania and (where possible) other Tasmanian forestry companies on pesticide contamination of water in Tasmanian forests following broadscale pesticide application, to identify which pesticides are most at risk of off-site transport and under which site characteristics and environmental conditions.

The first set of data was compiled as follows:

- All water samples taken to monitor pesticide applications, post 2000, that registered a positive reading were identified. Positive samples that were taken pre-spray (prior to the application of pesticides) were positive for a pesticide that was not applied in the spray operation being monitored or that were known to be the result of cross-contamination were not considered suitable for a validation set.
- The remaining positive samples formed the basis of data set 1 to be delivered to the CSIRO for PIRI-Tas validation. For each sample the location was identified and the site-specific information, including soil type, topography, slope and climate; and collected operational details, including pesticides applied, application rates, weather conditions and application method, were collated and compiled with the site details. Since all of the site information had already been collected any other pesticide applications at these locations were also utilised.

For each pesticide application, protocol requires three samples to be taken:

1. Pre-spray sample: taken 15–60 minutes prior to pesticide application. To establish whether any background contamination exists before spraying, from previous on-site operations or an upstream source.
2. Post-spray sample: taken 30–20 minutes after pesticide application. To determine whether over-spray of, or drift into, waterways has occurred during the operation.
3. Post-rain sample: taken after the first significant rainfall (*significant* being defined as rainfall that is likely to generate runoff from the site). To ascertain if coupe runoff is transporting applied pesticide into waterways.

For each pesticide application under scrutiny the results of the water samples taken, pesticide detection limits and the dates of sampling and delivery to the laboratory were also compiled as a part of the validation data set.

A set of 11 criteria (Appendix A) was developed to assess the appropriateness of data for the purpose of validating PIRI-Tas. All data were subjected to evaluation against these criteria, and only data of suitable quality were provided to CSIRO.

At the request of the Consultative Committee an external audit of the data was undertaken. Professor Ian Rae (Rae 2007a) conducted the audit at FT in

Hobart. He was given full access to the data sets and any other required information with the co-operation and assistance of the Project Officer.

A second set of data was compiled using selection criteria established in the first audit. The sites selected were triggered by availability of information, whilst trying to cover a broad spectrum of site-specific variables including soil type and rainfall and also provide good coverage of different pesticides used. Professor Rae also audited this data set (Rae 2007b).

During the first half of 2007, meetings with forestry companies were held to introduce them to the project and determine their level of interest in participating. The Project Officer formed links within companies and worked with staff to obtain the necessary information for the validation process. The aim of obtaining such data was to widen the scope of pesticides reviewed, and to include different crop types such as radiata pine, which is only planted by FT to a small extent.

Data on soil, vegetation, weather, pesticide application and water-monitoring programs was collated and scrutinised. The audit reports on FT data, provided by Professor Rae, were used as a basis for determining validity of company data. Data not fitting the selection criteria for this validation set were rejected. Data from all participants was combined and delivered to CSIRO.

By the early stages of 2007 a prototype version of PIRI-Tas had been provided to the Project Officer. This tool was utilised to calculate risks for all of the autumn pesticide operations. The predicted risks were compared to actual water monitoring results. This was used as a trial to check PIRI-Tas progress as a risk management tool and to discern any outstanding issues with use and implementation of the tool. A report on these trials was provided to CSIRO (Trainer and Volker 2007).

3.2. Provision of soil dryness index

Provision of soil dryness index, Tasmanian soils database and climatic surface models for use in modification and local validation of CSIRO's Pesticide Impact Rating Index (PIRI).

The Bureau of Meteorology (BoM) uses recorded weather station data and topography to extrapolate rainfall and temperature onto a grid of approximately five kilometres. Soil dryness index (SDI) can be calculated using this site-specific rainfall and temperature data (Mount 1972). These data were used throughout the validation process to calculate the daily SDI and hence the runoff likely to be experienced at the sites from the time of pesticide application to the time of water sampling following rainfall.

In Tasmania, ESOCCLIM (Nix *et al.* unpublished data; Hutchinson 1991) has been used to model average monthly values of rainfall and maximum and minimum temperatures onto a 0.5 km grid. This information was then used to create average values on a 10 km grid, which is the background climate table

for the Site Selection tool in Farm Forestry Toolbox.¹ This information has been provided to DPIW and CSIRO.

At project meetings it was decided that a Tasmanian soils database may not be the most appropriate way of presenting soil information for the project. The soil-related information required for PIRI is topsoil texture, OC% and erosion rate. The Tasmanian forest soils database provides estimates of erosion rate and OC% for undisturbed forest situations. This is not relevant to plantation forest or agricultural situations where soils have been modified by clearing and cultivation. It was decided that a soil database was not the most appropriate way to deal with this data. Individual users are likely to have knowledge of their soil texture and other soil information can be derived for each site specifically; this was deemed to be a more accurate way of obtaining soil information.

There is a lack of soil erosion data; the rate can vary with soil type and land use. While there are some broadly defined average quantities for various land uses (DPIW 2008) these are neither temporally distributed nor site-specific. This is an area where more work could improve the input data quality and hence the output risks.

3.3. Identification of links

Identification of links between contamination/non-contamination of water samples and vegetation cover (height and density), landscape (soil, slopes, buffer strips), climatic conditions (rainfall events, soil dryness index) and methods of pesticide application (broadacre, point, aerial and ground based).

Some initial results can be found in Kookana (2007). The Project Officer undertook an investigation of landscape characteristics and on site where pesticide detections occurred. This report is attached (Appendix B).

3.4. Determination of usefulness of validated Forestry PIRI-Tas

Determination of usefulness of validated Forestry PIRI-Tas, which includes assisting DPIW with conducting field trials and assessing all environmental considerations.

FT was continually in receipt of the most recent version of PIRI-Tas during the project. The MS Excel version was used to assess PIRI-Tas' predictive capabilities during FT's 2007 autumn spray operations. This report is attached (Appendix C).

¹ Farm Forestry Toolbox is a package of computer programs for forest management, developed and distributed by Private Forests Tasmania.

With the release to the project team of the trial TclTk version of PIRI-Tas the Project Officer went through all of the workings of the program and provided feedback to CSIRO in the form of a report.

CSIRO has performed validation trials using data sets provided. Refer to the CSIRO report for more details.

DPIW has conducted similar water monitoring trials; during this time they have had full assistance as required. This includes analysing for the organic carbon content of their selected soils and providing sampling devices.

3.5. Provision of all data

Provision of all data and assistance with development of CSIRO PIRI assessment tool.

The required data sets were provided to CSIRO within the specified time frames, along with the provision of any assistance required in interpreting the data and any further information required.

The Project Officer attended two Project Committee meetings in Adelaide with DPIW, UTAS and CSIRO staff. At these meetings the practical aspects of the project have been discussed and plans revised to meet the aims of the project. The Project Officer also took these opportunities to work with CSIRO staff on use of PIRI-Tas and validation using the data sets supplied. This provided opportunities to examine the sensitivity of the various inputs provided, such as soil information and vegetation cover. An outcome has been to modify the required data to be used as input.

Throughout the project the Project Officer continually provided feedback on the PIRI-Tas tool, sometimes in the form of a report, often through email and phone communications with the CSIRO team as problems and issues arose.

3.6. Utilisation of PIRI-Tas in forest operations

Utilise PIRI-Tas in forestry operations and report on its functionality.

Throughout five FT Districts, PIRI-Tas was used during the autumn 2007 spray operations. In all Districts, field staff were briefed on PIRI-Tas' capabilities, required inputs and output information. During this process attention was given to any problems, practical issues and potential improvements that could be made in the program. PIRI-Tas' performance against monitoring data of these operations was observed with sensitive and unresponsive variables observed. A report detailing this process was made available to the Management Committee in June 2007 (Trainer and Volker 2007).

3.7. Intensive water quality monitoring

Intensive water quality monitoring on selected sites during Forestry Tasmania's spring spray program to gain better quality data for PIRI-Tas validation.

At the project committee meeting held at DPIW in July 2007 it was decided that the water monitoring data available from all forestry companies had the potential to be flawed. This was a result of practical limitations and a lack of information available to field staff while they undertook operations, especially knowledge about rainfall events which may lead to runoff. It was decided that some intensive water quality monitoring in plantations post pesticide application would contribute valuable information to the project.

Eight sites were selected across the State, on a variety of soil parent materials that were suitable for the trials. At each of the sites automatic water monitoring equipment, triggered by increased water flow, was installed and soil samples for OC% determination were collected. A detailed report on this work is included as Appendix C.

4 Discussion

The water sampling protocols adopted by FT are outlined in Elliott and Hodgson (2004). These are designed to determine if pesticides have entered water through either direct over-spray or as a result of pesticides contaminating runoff or leachate from the site. Other forestry companies in Tasmania also carry out water sampling associated with pesticide application operations as part of their environmental management systems.

Forestry sites differ from agricultural sites in a number of respects:

- Soil surface is generally rougher due to disturbance by heavy machinery, debris distributed across the sites, stumps left in-situ, occasional windrows or other piles of debris.
- Vegetated buffers are left near defined streams and drainage lines, even in situations where pasture is being converted to plantations.
- In many situations the riparian area near defined streams is left completely intact.
- Forestry sites are broadcast sprayed with herbicide once or twice in the first year, usually prior to establishment. Subsequent herbicide applications are generally targeted to spots around planted trees or strip applications along the planted row or between rows, depending on crop species, target weeds and herbicide used. These post-plant operations are generally restricted to the first or second year after establishment.

The individual area sprayed in forestry operations at any one time is usually in the order of tens of hectares. Due to terrain roughness, aerial application by helicopter is the preferred method for broadcast pesticide application in many cases. Strip or spot spraying is done by ground-based operations.

Despite the large amount of data held by FT and other forestry companies, there has never been an attempt to associate inherent site conditions with environmental risk of offsite movement. Part of the reason for this is that offsite movement is rare (Elliott and Hodgson 2004), partly due to the strict rules applied to pesticide application operations.

The PIRI program developed by CSIRO was seen as a useful tool to perform risk assessment prior to application of pesticides in forestry situations. It was developed for agricultural uses. The large amount of detailed data held by FT about site conditions and the associated water monitoring results was seen as useful to validation of PIRI-Tas for forestry use.

The use of SDI (Mount 1972) was also seen as a useful addition to PIRI-Tas. SDI is calculated on a daily basis by the Bureau of Meteorology and can be used to predict how much rainfall would be needed for soil to reach field capacity and hence be at risk of producing runoff. FT encouraged the incorporation of SDI into PIRI-Tas as a means of assessing risk associated with pesticide application operations.

The project has led to consideration of issues associated with the water monitoring protocols used by FT. At present, every pesticide operation is monitored regardless of risk. Until PIRI-Tas is used in operational programs there are no means of quantifying risk in this sense.

We found that the condition of no-spray buffers is important. Where buffers are vegetated, even where PIRI-Tas risk assessment is high, there was no contamination of water downstream of the spray site. The only detections of pesticide downstream of spray sites were in situations where the no-spray buffer was bare ground. This finding requires further investigation. Vegetated buffers serve two purposes: firstly, they are useful to capture any unintended drift or over-spray of pesticides; secondly, they can act as a filter for runoff, especially for sediment, which may settle out from runoff as it is slowed down through vegetation.

The effectiveness of the type of vegetation contained in buffers to filter water leaving a treated site should be investigated further.

We also found that there were no soil physical properties that could be used reliably as a predictor of risk. Therefore a tool such as PIRI-Tas, which combines chemical properties of pesticides, soil physical and chemical properties and soil saturation is more useful as a risk assessment tool.

The use of a risk assessment tool such as PIRI-Tas would facilitate a more effective approach to monitoring. Resources could be applied to areas where risk was assessed to be above a certain threshold. Alternatively, a risk threshold could be set so that application operations did not proceed until the measurement fell below that threshold. These thresholds are yet to be determined.

5 Recommendations

- PIRI-Tas should be used as a risk assessment tool in pesticide application operations and to prioritise post-spray sampling of water bodies.
- Periodic validation of PIRI-Tas against operational monitoring results should be carried out from time to time.
- The use of Rising Stage Samplers should be investigated further as a means of collecting water samples.
- The efficacy of buffer widths and vegetation which can act as a filter for runoff could be investigated further.

Appendix A – Criteria to be met for the inclusion of water sample data for Pesticide Impact Rating Index (PIRI) validation

Throughout this procedure a Quality Assurance/Quality Control procedure will be followed, with original records being obtained where possible and all documentation acquired to fulfil this criteria kept. Where all criteria are not met, the reason will be noted and the data labelled as having a lower quality.

1. The sample was taken at the appropriate time with regard to sample protocols.
2. Wind was less than 12 km/hr on the day of spraying.
3. Waterways and roads were buffered and not sprayed.
4. The pre-spray sample was not positive.
5. An appropriate site for collecting the water sample was chosen.
6. The sample was not taken on a class 1 stream.
7. Samplers had completed the FT water sampling course or equivalent in other organisations.
8. A field blank was used to verify that contamination had not occurred, and positive samples did not have a corresponding positive blank.
9. Samples, once collected, were treated appropriately by FT staff and delivered to lab within 4 days with a chain of custody maintained.
10. Samples were sent to a National Association of Testing Authorities (NATA) accredited laboratory for testing of the appropriate pesticides.
11. The relevant operation, landscape and climate data for the coupe is obtainable.

Appendix B – Assessing common features at water sampling sites with pesticide detections observed by Forestry Tasmania since Jan 2000

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Introduction

The aim of this report is to try to establish links common to sites where off-site movement of pesticides to surface water has occurred through the collation of site-specific, climatic and operational factors for sites where pesticide detection has occurred. This may provide a better understanding of sites that are at risk and help reduce the number of contaminations that occur on State forest.

Forestry Tasmania (FT) has been collecting water quality data associated with pesticide spray operations since 1993 (Elliott and Hodgson 2004). For every pesticide application FT protocol is to take three water samples:

1. Pre-spray sample: taken 15–60 minutes prior to pesticide application. To establish whether any background contamination exists before spraying, from previous on-site operations or an upstream source.
2. Post-spray sample: taken 30–120 minutes after pesticide application. To determine whether over-spray of, or drift into, waterways has occurred during the operation.
3. Post-rain sample: taken after the first significant rainfall (*significant* being defined as rainfall that is likely to generate runoff from the site). To ascertain if coupe runoff is transporting applied pesticide into waterways.

From the beginning of 2000 to the end of 2007 there have been approximately 1600 pesticide operations, with about 2800 individual pesticide applications. During this time 23 sites have had pesticide detection(s) as a part of the routine monitoring; details are shown in Table 1. This represents 0.8% frequency rate for detection from pesticide application operations over this time.

Table 1 Site, date, sample type and concentration of pesticide detections on State forest since 2000.

Coupe ID	Pesticide Detected	Was this pesticide applied?	Concentration (µg/L)	Date	Sample Type
13218	Metsulfuron-methyl	Yes	0.1	8/5/04	Post spray
30766	Terbacil	Yes	0.3	28/8/02	Post spray
15956	Metsulfuron-methyl	Yes	0.2	20/10/04	Post spray
21511	Sulfometuron-methyl	Yes	0.3	21/5/04	Post rain
13415	Hexazinone	No	0.12	2/5/03	Post spray
19918	Metsulfuron-methyl	Yes	0.1	23/5/03	Post spray
16236	Metsulfuron-methyl	Yes	0.1	16/10/03	Post spray
14191	Sulfometuron-methyl	Yes	0.4	8/9/03	Post spray
30202	Sulfometuron-methyl	Yes	0.2	6/8/02	Post rain
18357	Metsulfuron-methyl	Yes	0.5	9/8/03	Post rain
13855	Metsulfuron-methyl	Yes	0.2	24/4/03	Pre spray
13497	Clopyralid	Yes	0.3	29/9/05	Post rain
21134	Terbacil	Yes	Complex (Appendix 1)		
13055	Sulfometuron-methyl	Yes	0.1	5/8/03	Post rain
14320	Metsulfuron-methyl	Yes	0.2	10/9/02	Post rain
14020	Metsulfuron-methyl	Yes	1.0	16/4/03	Pre spray
21030	Metsulfuron-methyl	Yes	0.3	10/5/04	Post spray
	Sulfometuron-methyl	Yes	0.3	10/5/04	Post spray
14179	Metsulfuron-methyl	Yes	1.0	24/7/03	Post rain
			0.3	5/8/03	Follow up
			0.5	11/8/03	Follow up
15556	Metsulfuron-methyl	Yes	0.2	11/5/04	Post spray
	Sulfometuron-methyl	Yes	0.3	11/5/04	Post spray
17881	Metsulfuron-methyl	Yes	0.4	9/8/03	Post rain
19891	Sulfometuron-methyl	Yes	0.4	10/6/04	Post spray
19898	Metsulfuron-methyl	Yes	0.1	10/11/03	Post spray
21350	Sulfometuron-methyl	Yes	0.3	21/5/04	Post rain

Two of the detections in Table 1, 14020 and 13855, were from pre-spray samples, so the cause of pesticide presence was not the pesticide operation (which had not occurred yet). The cause of contamination of these samples is not known. The detections on sites 19898, 19891, 15556, 21030, 16236, 14191, 19918, 13218, 30766 and 15956 were all post-spray samples, which are taken on the same day directly after spraying has occurred, therefore the cause can be attributed to direct over-spray or drift. The detection on 13415 was for a pesticide that was not applied to the site hence no links can be made to the site. As the cause of detection for the aforementioned sites was not on-site pesticide movement, these instances cannot be used to find common links between the sites that may have contributed to the contamination, hence these sites will not be considered further in this report.

Site 21134 is an unusual case where an inappropriate sampling point was chosen (still-water on the coupe). Following application there was not significant rain to join this water to a flowing waterway. As a result detections were observed. While pesticide application protocols may not have been fully observed, the data generated at this site is not useful for this study and will not be discussed further.

The remaining sites, where pesticides have moved off-site into waterways following a rainfall event, will be considered in greater detail.

The Sites

13055

Parent Material: Silurian - Devonian Sandstone and Siltstone

Soil Type: Maweena (sandy clay loam topsoil)

Slope of Coupe (degrees): 5

Climate: Elevation 350 m, Rainfall 1350 mm

Vegetation Cover: Bare ground

Buffer Width: 40 m

Water Sample Location: Uncertain

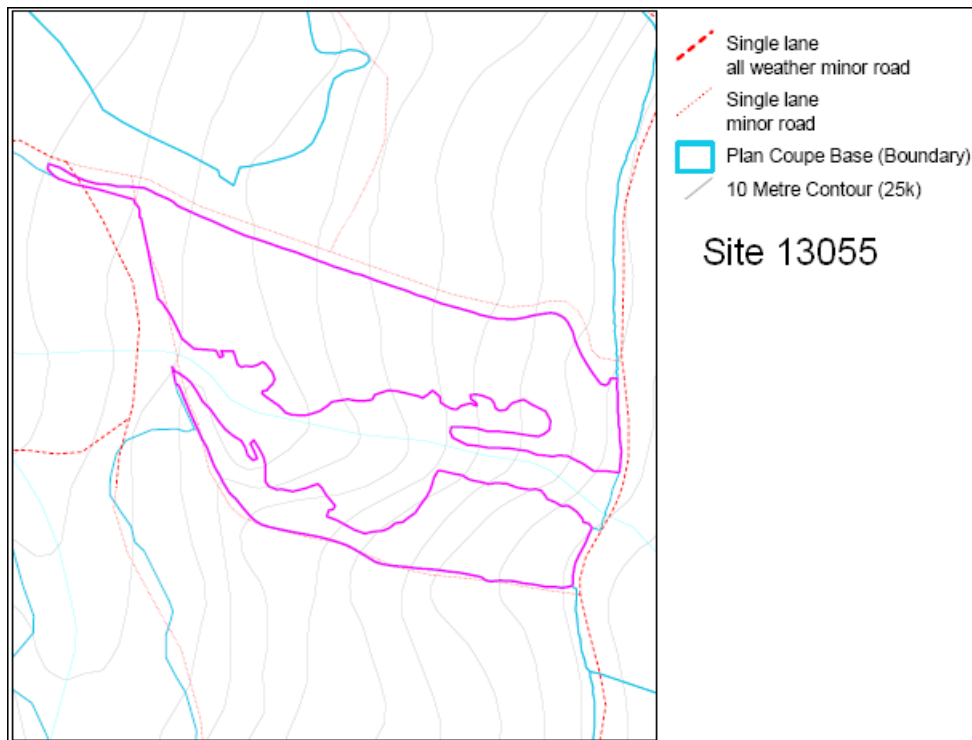


Figure 1 Map of site 13055 with topography, roads, waterways and coupe boundary.

13497

Parent Material: Tertiary Basalt

Soil Type: Yolla (clay topsoil)

Slope of Coupe (degrees): 10

Climate: Elevation 300 m, Rainfall 1600 mm

Vegetation Cover: Sparse to mid-dense pasture/herbfield

Buffer Width: 40 m

Water Sample Location: Suitable, capturing majority of the runoff

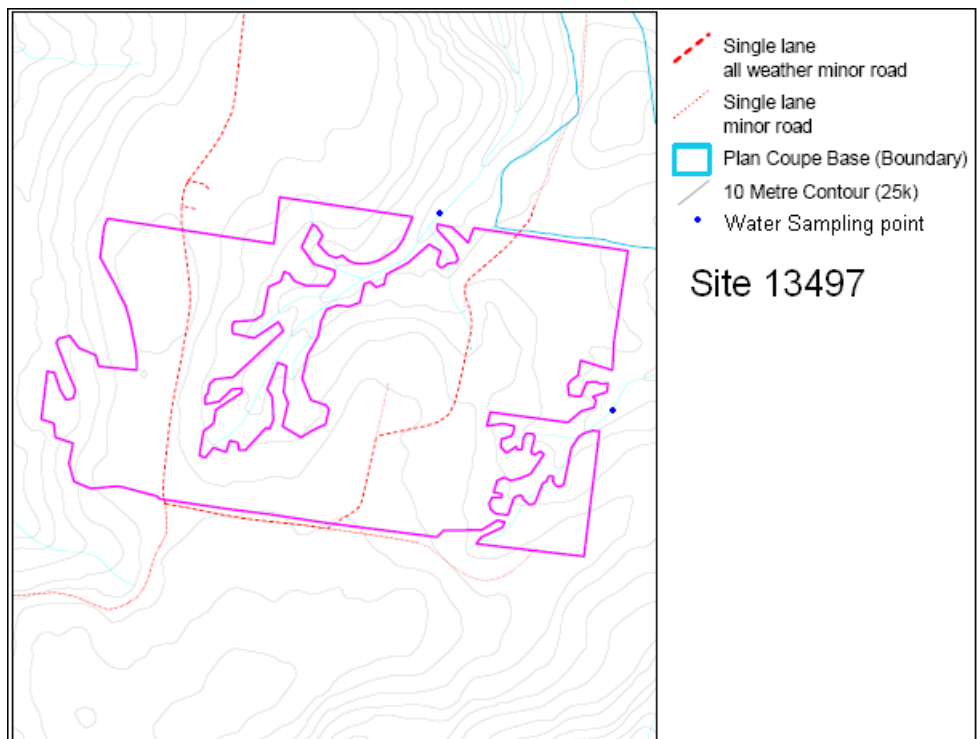


Figure 2 Map of site 13497 with topography, roads, waterways and coupe boundary.

14179

Parent Material: Jurassic Dolerite

Soil Type: 15.1 or 15.2 FSoT (Grant *et al.* 1995) (clay loam topsoil)

Slope of Coupe (degrees): 12

Climate: Elevation 500 m, Rainfall 1000 mm

Vegetation Cover: Sparse to mid-dense pasture/herbfield

Buffer Width: 40 m

Water Sample Location: Does not capture the entirety of the runoff

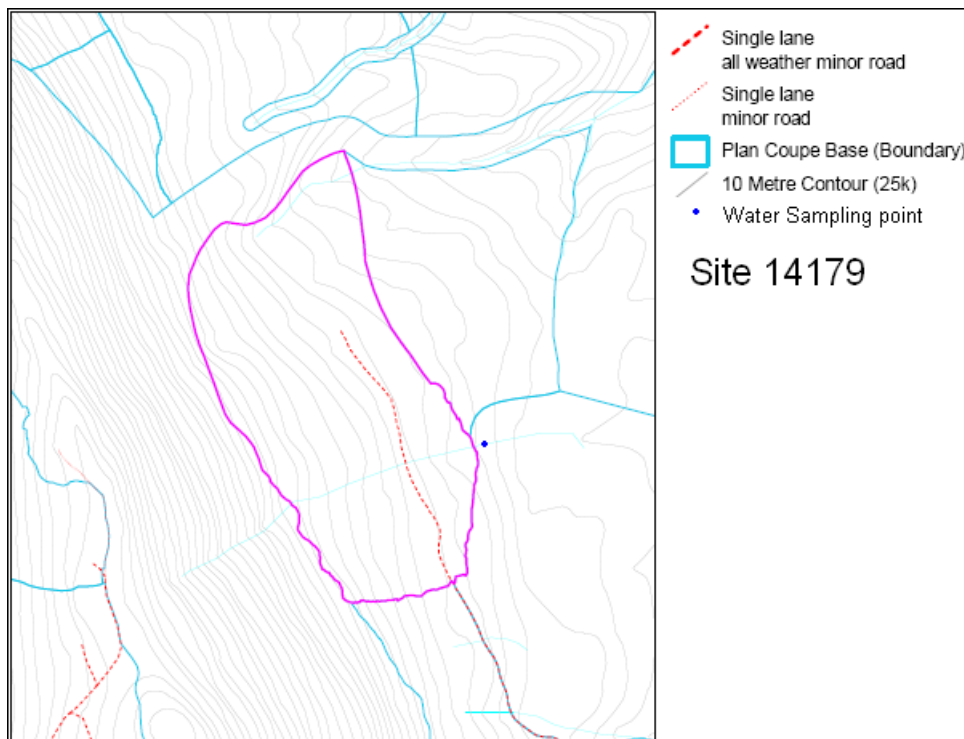


Figure 3 Map of site 14179 with topography, roads, waterways and coupe boundary.

14320

Parent Material: Jurassic Dolerite

Soil Type: 15.3 or 15.4 FSoT (Grant *et al.* 1995) (clay loam topsoil)

Slope of Coupe (degrees): 10

Climate: Elevation 100 m, Rainfall 1400 mm

Vegetation Cover: Sparse to mid-dense pasture/herbfield

Buffer Width: 40 m

Water Sample Location: Suitable, but does not capture all of the runoff

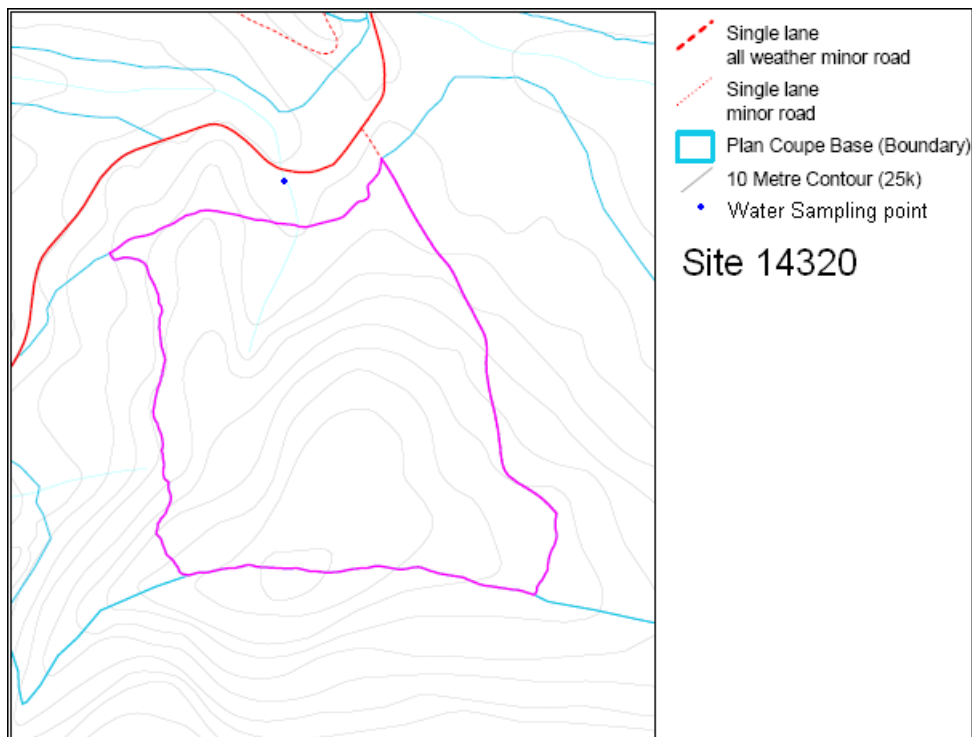


Figure 4 Map of site 14320 with topography, roads, waterways and coupe boundary.

17881

Parent Material: Jurassic Dolerite

Soil Type: 15.3 FSoT (Grant *et al.* 1995) (clay loam topsoil)

Slope of Coupe (degrees): 10

Climate: Elevation 150 m, Rainfall 1400 mm

Vegetation Cover: Bare ground

Buffer Width: 40 m

Water Sample Location: Suitable, but slightly far from coupe

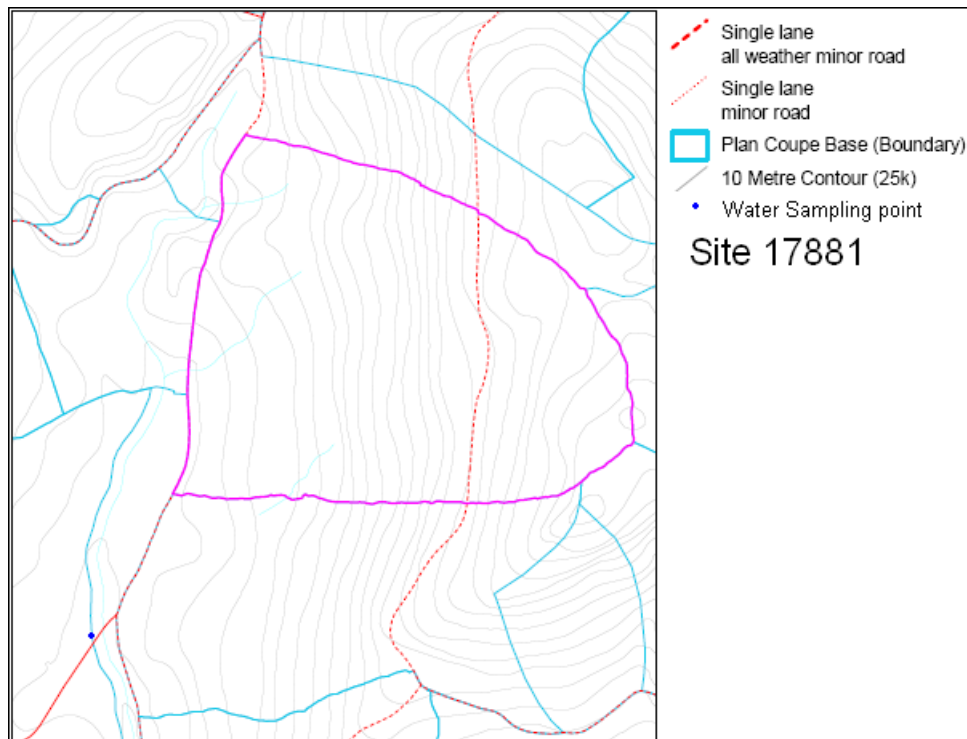


Figure 5 Map of site 17881 with topography, roads, waterways and coupe boundary.

18357

Parent Material: Jurassic Dolerite

Soil Type: 15.3 or 15.4 FSoT (Grant *et al.* 1995) (clay loam topsoil)

Slope of Coupe (degrees): 6

Climate: Elevation 300 m, Rainfall 1500 mm

Vegetation Cover: Bare ground

Buffer Width: Should be 40 m buffer for the class 4 stream, but the sprayed area map indicates that this buffer was not fully observed.

Water Sample Location: Closer to coupe could have been better, doesn't capture all runoff

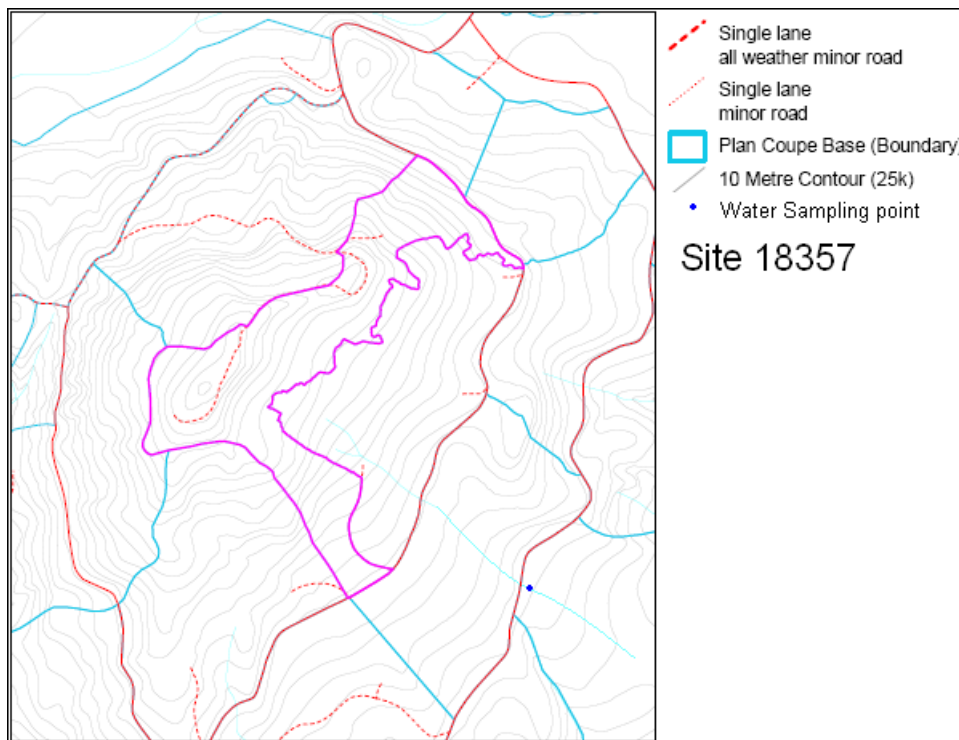


Figure 6 Map of site 18357 with topography, roads, waterways and coupe boundary.

21350

Parent Material: Silurian - Devonian Siltstone, Mudstone and slate

Soil Type: 9.1 FSoT (Grant *et al.* 1995) (clay loam topsoil)

Slope of Coupe (degrees): 15

Climate: Elevation 100 m, Rainfall 950 mm

Vegetation Cover: Bare ground

Buffer Width: 60 m

Water Sample Location: Suitable, capturing all runoff

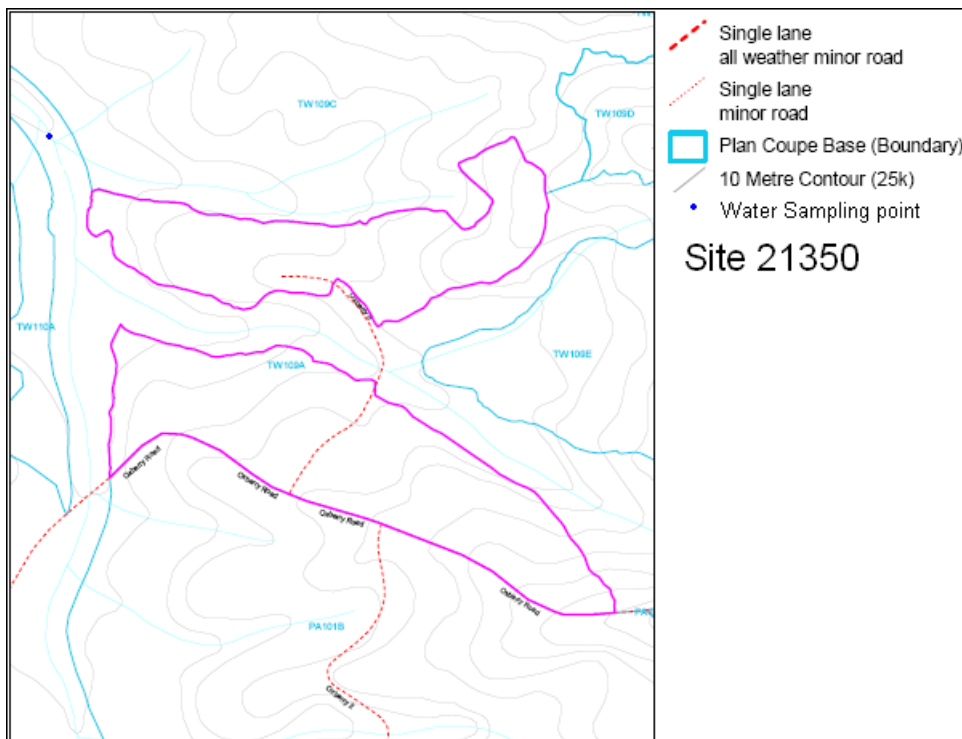


Figure 7 Map of site 21350 with topography, roads, waterways and coupe boundary.

21511

Parent Material: Mathinna beds (Silurian-Devonian sandstone, siltstone, mudstone and slate)

Soil Type: Knight (loamy topsoil)

Slope of Coupe (degrees): 10

Climate: Elevation 650 m, rainfall 1500 mm

Vegetation Cover: Sparse to mid-dense pasture/herbfield

Buffer Width: 40 m

Water Sample Location: Suitable

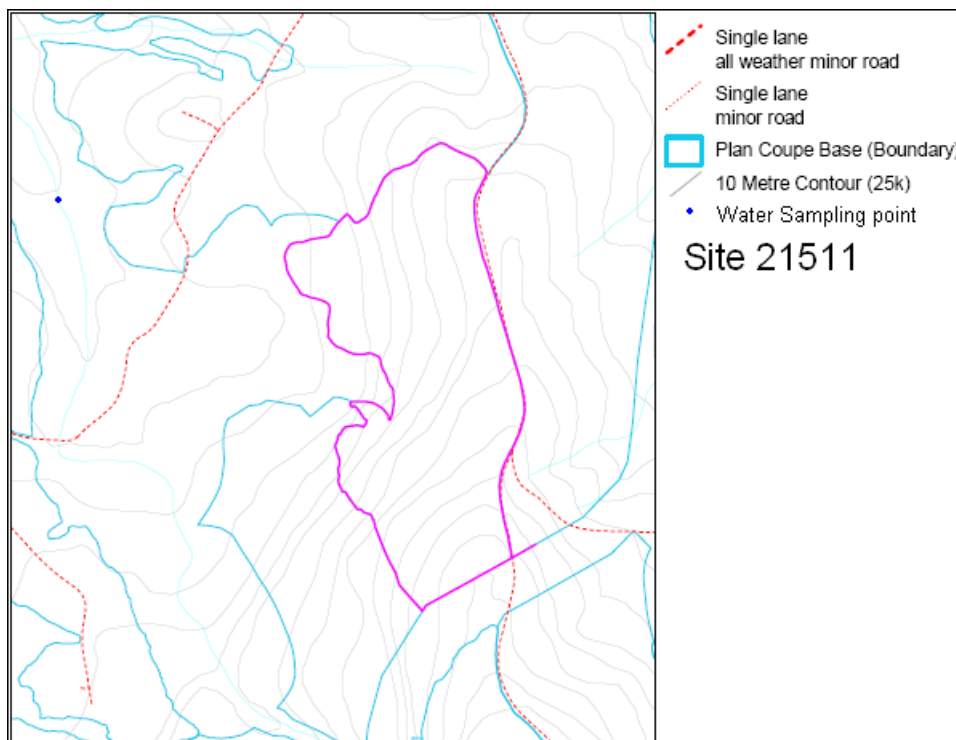


Figure 8 Map of site 21511 with topography, roads, waterways and coupe boundary.

30202

Parent Material: Devonian granite and derived tertiary deposits

Soil Type: a mix of 5 soil types that occur in a complex pattern and are varied in their nature (predominantly loamy topsoil)

Slope of Coupe (degrees): 12

Climate: Elevation 150 m, Rainfall 1100 mm

Vegetation Cover: Bare ground

Buffer Width: 60 m

Water Sample Location: Suitable

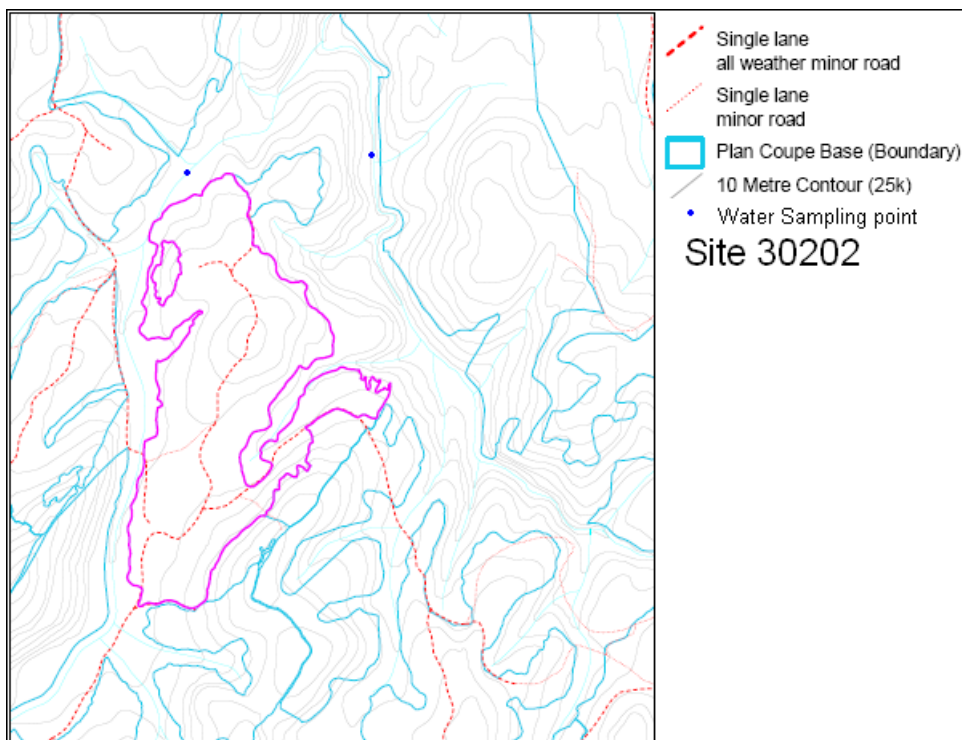


Figure 9 Map of site 30202 with topography, roads, waterways and coupe boundary.

Results and Discussion

The detections have occurred over a large variety of topsoil textures (sandy clay loam to clay), elevations (50m–650m), slopes (5–15 degrees) and climatic regimes (800–1800 mm/yr rainfall). There was no dominant characteristic in any of these attributes, as such no direct links between off-site movement of pesticides and these factors can be drawn.

The timing of pesticide application and sample collection, application method, SDI at spraying as well as volume of rain are shown in Table 2.

Table 2 Spray dates, sample dates, application method, SDI and rain volumes for time between sampling and spraying for coupes with post-rain detections.

Coupe	Application method	Spray date	Sample date	SDI	Rain volume between spraying and sampling (mm)	Days lapsed between spraying and detection
13055	Broadcast - aerial	1/8/03	5/8/03	34	9	4
13497	Broadcast - aerial	20/9/05	29/9/05	7	41	9
14179	Broadcast - aerial	4/7/03	24/7/03	34	74	20
14320	Broadcast - aerial	27/8/02	10/9/02	34	131	13
17881	Broadcast - aerial	2/8/03	9/8/03	19	28	7
18357	Broadcast - aerial	2/8/03	9/8/03	19	33	7
21350	Broadcast - aerial	7/5/04	21/5/04	79	34	14
21511	Broadcast - aerial	10/5/04	21/5/04	51	66	11
30202	Broadcast - aerial	30/7/02	6/8/02	43	8	7

It can be seen that the quantity of rain causing pesticide movement varied between 8 and 131 mm. This is a large range and shows that the quantity of rain is not the sole driver in the process. However, it can be seen that no large time periods have elapsed, the most being 20 days (14179) and the rest being 14 days or less. Rain is a variable that cannot be controlled, but the weather forecast must be taken into consideration when undertaking operations.

SDI at the time of spraying for these sites has varied between 7 and 79; it seems logical that if SDI was high (>100) that infiltration of rain would be higher, decreasing the runoff volume and likelihood for off-site movement of pesticides.

Buffer strips along defined waterways for each site were at least 40 m wide. All detection has occurred where the application method was aerial broadcast. It is difficult to allow for small drainage lines and depressions in aerial operations. These may concentrate runoff during heavy downpours, so in conditions of high SDI water may still flow through these areas and drain into waterways. Another explanation could be deposition of herbicides on or near minor roads and tracks where table drains or other drains may flow directly into waterways.

The most commonly detected pesticides were metsulfuron methyl (Brushoff®) and sulfometuron methyl (Oust®), the most commonly used pesticides other than glyphosate (Roundup®). The trend that commonly used pesticides are more commonly detected does not indicate that any particular pesticide is at risk of off-site movement.

It is also recognised that there may be other scenarios where off-site movement has occurred but not been observed because only a single grab sample has been taken, possibly at an inappropriate time. To amend this, improvements in sampling procedures and practices need to occur.

Conclusions

This report has examined the site-specific, operational and climatic factors associated with sites where pesticide detections in surface waterways post rain have occurred. The aim was to identify common factors present in these situations, and to ascertain if any factors have a higher risk of causing off-site pesticide contamination.

Among the site-specific factors – soil texture, elevation, annual rainfall and slope – there was a high variability; no specific factors were identified as being common to the observed detections.

All but one of the detections were within a fortnight of application; the one outside this two week period was at 20 days. This indicates that contamination is most likely to occur if there is significant rainfall in the first two weeks after spray application. Following this there is decreased chance of pesticide movement; however, this investigation is not enough to state that there is no risk after this time period. Applying pesticides when low rainfall is forecast will therefore help mitigate off-site pesticide transport.

All instances of detection are associated with aerial operations. There has been no reason determined as to why this occurs.

The SDI at the time of application was not higher than 79 in any of the cases observed here, indicating that when the soil is dry, off-site surface water contamination is less likely to occur – most likely the result of increased infiltration of rainfall, which in turn reduces the runoff experienced at the site.

Appendix 1 Water sampling results for Terbacil at site 21134 on the 4 sampling points, following pesticide application

Water Sample point	Post-Spray 06/09/01	Post-Rain 19/10/01	Follow up 27/11/01	Follow up 02/05/02
21134 – 1 (A drainage depression on the coupe containing still water not flowing into any waterways)	ND	38.6	9.8	NS
21134 - 2	ND	ND	0.3	ND
21134 - 3	0.9	3.1	ND	ND
21134 - 4	NS	NS	ND	NS
Field Blank	?	ND	ND	ND

ND = Not detected, NS = Not sampled

Appendix C – Assessing runoff water quality following pesticide applications for validation of the PIRI Risk Assessment Tool



Technical Report 02/2008

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February 2008

Introduction

At present Forestry Tasmania (FT) voluntarily participates in pesticide monitoring of waterways surrounding pesticide applications. This monitoring comprises a minimum of three grab samples:

1. Pre-spray sample: taken 15–60 minutes prior to pesticide application. To establish whether any background contamination exists before spraying, from previous on-site operations or an upstream source.
2. Post-spray sample: taken 30–120 minutes after pesticide application. To determine whether over-spray of, or drift into, waterways has occurred during the operation.
3. Post-rain sample: taken after the first significant rainfall (*significant* being defined as rainfall that is likely to generate runoff from the site). To ascertain if coupe runoff is transporting applied pesticide into waterways.

If pesticides are detected during this process further sampling is conducted until detections are no longer found.

The Pesticide Impact Rating Index (PIRI) is a risk assessment tool designed to assess the risk of contaminating surface water following a pesticide application via runoff generated from rainfall (Kookana *et al.* 2005).

Previously PIRI has mainly been utilised in broadscale agricultural situations where topography is fairly consistent, and has not been capable of taking antecedent soil moisture conditions into consideration. In Tasmania, topography and soil dryness can be highly variable and have a large influence on the generation and transport of rainfall runoff, making their inclusion in the PIRI tool valuable for use in Tasmania. *The Tasmanian River Catchment Water Quality Initiative*, funded by the Department of Environment, Water, Heritage, Water and the Arts, Australia, has the primary goal of validating PIRI for use in Tasmania.

For validating PIRI it is the third, or post-rain, sample that is relevant, as both PIRI and the post-rain sample aim to assess the influence of runoff on water quality. FT volunteered to participate in this project by collating and providing historical data sets with water monitoring results and the corresponding site-specific, climatic, environmental and operational information required for validating PIRI.

During the utilisation of this data it became clear that the interpretation and implementation of the sampling protocol after significant rainfall limited the accuracy of the data. Difficulty arises because there cannot be a defined quantity for significant rain. The generation of runoff is influenced by many factors, including soil dryness, soil type and rainfall intensity, not just the quantity of rain; therefore the sampling protocol has a fundamental flaw in this sense. Weather is not monitored at every coupe, hence knowing if enough or any rainfall has occurred poses a practical problem.

To try to provide higher quality data for the purpose of validating PIRI, intensive water sampling surrounding pesticide applications was conducted at selected sites on State forest.

Materials and methods

The sites

For this study eight sites across Tasmania were selected to undergo intensive water quality monitoring. Sites were selected that:

- did not have any current activity above them in their sub-catchment i.e. only undisturbed or mature native forest in areas that could produce runoff into the coupe
- had a high chance of rain in the weeks following pesticide application
- had a high gradient, making runoff more likely to occur and therefore possible to capture
- covered the most common parent materials present in plantations in State forest in Tasmania (Table 1).

Table 1 Parent materials and areas for selected sites.

Site ID	Parent material	Area
33781	Jurassic dolerite	South
34013	Sandstone / mudstone	South
33834	Jurassic dolerite	South
34216	Sandstone / Dolerite	West
29934	Permian Mudstone	West
22533	Silurian-Devonian sandstone and siltstone	North-east
32589	Silurian-Devonian sandstone and siltstone	North-east
33046	Devonian granite	North-east

Water sampling

Rising Stage Samplers (RSSs, Figures 1 and 2) and Automatic Water Samplers (AWSs) (GAMET Waste Watcher, Figure 3) provide an alternative to grab sampling. These sampling methods do not rely on human judgement to assess if *significant* rain has occurred but automatically sample when there is a rise in water level i.e. when runoff is generated following rainfall. The RSSs take a single sample when water levels rise above the level of the intake tube. RSSs were installed at all sites in each location where runoff from the coupe was expected to occur, with 2–6 per site.

GAMET AWSs are triggered, as water level rises, by a float switch and can take up to 12 temporally distributed samples. AWSs were installed at sites 33046 and 32589 in a waterway downstream where the majority of coupe runoff had converged and were set to take one sample per hour for the 12 hours following a rise in water level.



Figure 1 Photo of RSS in situ at site 34216.

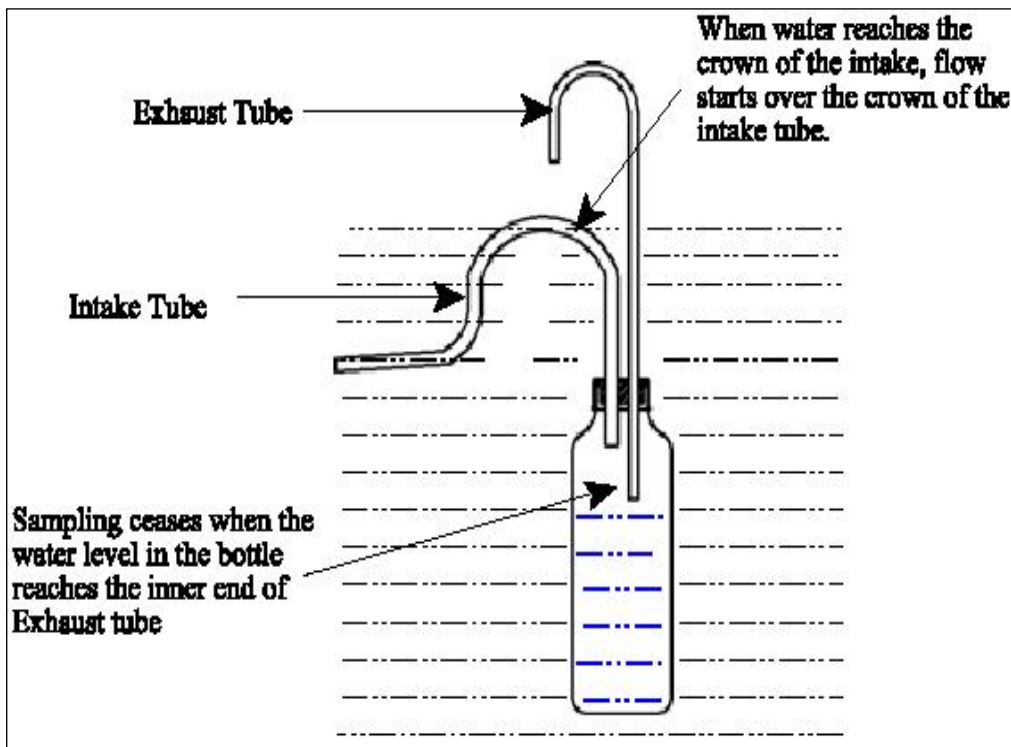


Figure 2 Schematic diagram of Rising Stage Sampler (RSS).



Figure 3 AWS in situ at site 32589.

Table 2 PIRI input parameters for each coupe.

Coupe	22533	29934	32589 - aerial	32589 - ground	33046	33781	33834	34013	34216
Soil texture	Clay loam	Clay loam / sandy clay	Clay loam / light clay	Clay loam / light clay	Sandy clay loam	Light clay	Clay loam / sandy clay	Sandy clay	Sandy clay
% OC	6.6	4.6	5.9	5.9	5.6	6.2	7.3	8.2	5.9
Slope (%)	48	34	40	20	38	29	17.5	29	34
Vegetation cover index (VCI)	2	1	2	3	1	1	1	1	1
Spray date	18/10/07	6/9/07	2/10/07	1/10/07	6/10/07	22/8/07	22/8/07	22/8/7	7/9/07
Sample date	31/10/07	24/9/07	5/10/07	5/10/07		4/9/07	4/9/07	4/10/07	25/9, 2/10/07
Pesticide 1	Glyph	Glyph	Glyph	Glyph	Glyph	Glyph	Glyph	Glyph	Glyph
Application rate (kg or L/ha)	2.7	3	2.7	2	2.7	2.7	2.7	2.7	3
Fraction active ingredient	0.54	0.54	0.54	0.68	0.54	0.54	0.54	0.54	0.54
Fraction compartment (%)	100	100	100	100	100	100	100	100	100
Pesticide 2	M-m		M-m	Terbacil	M-m	M-m	M-m	M-m	M-m
Application rate (kg or L/ha)	0.02		0.04	1.00	0.02	0.03	0.03	0.03	0.02
Fraction active ingredient	0.6		0.6	0.88	0.6	0.6	0.6	0.6	0.6
Fraction compartment (%)	100		100	100	100	100	100	100	100
Pesticide 3	Clop		Clop	Clop	Clop				
Application rate (kg or L/ha)	0.8		0.8	0.8	0.8				
Fraction active ingredient	0.75		0.75	0.75	0.75				
Fraction compartment (%)	100		100	100	100				

(Glyph = Glyphosate, M-m = Metsulfuron-methyl, Clop = Clopyralid)

PIRI risks

For each sampler the necessary information was entered into PIRI (Table 2) and the risk of pesticide mobility at that location generated (shown in Tables 3 to 10). By comparing water sample results with the corresponding PIRI risk at each location, PIRI's predictive ability can be assessed.

Results

PIRI risk calculation and water samples

Risks produced by PIRI on each coupe for each RSS, along with the corresponding water sample results where sufficient rainfall occurred, are shown for each coupe (Tables 3 to 10). The number of samplers per coupe was dependent on the number of waterways and drainage lines exiting the coupe. Where there was no sample, IR (Insufficient Rain) is shown.

Buffer width refers to the un-sprayed distance between the sprayed area and the waterway being sampled; hence it varied for each sampler. The vegetation status of the buffer was also included as part of the input.

22533

This coupe received some rain post spraying, but this was not enough to trigger sampling of all the RSSs. Only one of the samplers collected water (~250 mL); this was a drainage line without native forest as a buffer. The other samplers were on class 4 streams with vegetated buffers. The risk recorded is for 31/10/07, after four days of patchy rain which totalled 22 mm, triggering only one of the samplers.

Table 3 PIRI risk ratings for all applied pesticides at each sampling point for site 22533.

Sampler - Buffer width	Metsulfuron-methyl	Glyphosate	Clopyralid (C)	Water sample results (µg/L)
1 - 30m (v)	low	medium	medium	IR
2 - 40m (v)	low	low	medium	IR
3 - 10m (b)	medium	medium	high	C - 4.9
4 - 30m (v)	low	medium	medium	IR

v – buffer is vegetated, b – buffer is bare, C – Clopyralid, IR – insufficient rain

29934

Table 4 PIRI risk ratings for all applied pesticides at each sampling point for site 29934.

Sampler - Buffer width	Glyphosate	Water sample results (µg/L)
1 - 50m (b)	low	nil detect
2 - 10m (b)	medium	nil detect
3 - 25m (b)	medium	nil detect

v – buffer is vegetated, b – buffer is bare

32589

This coupe had rain (~15 mm) four days after spraying, enough to trigger the AWS to take seven samples, however none of the RSSs collected water. There was another rain event three weeks later of ~15 mm, but this did not trigger

either the RSSs or the AWS. The PIRI risks shown below refer to the earlier rain event and are for 5/10/07.

Table 5 PIRI risk ratings for all applied pesticides at each sampling point for site 32589.

Sampler - Buffer width	Metsulfuron-methyl	Glyphosate	Terbacil	Clopyralid	Water sample results (µg/L)
1 - 20m (b)	medium	medium	high	high	IR
2 - 40m (v)	low	low	medium	medium	IR
3 - 40m (b)	low	low	medium	medium	IR

v – buffer is vegetated, b – buffer is bare, IR – insufficient rain

AWS results for 32589

A rise in water level triggered the sampler; a sample was taken every hour for the next seven hours until the water level dropped back and sampling ceased. The PIRI risks recorded above for a 40 m vegetated buffer are appropriate and no pesticides were detected in any of the seven samples.

33046

Table 6 PIRI risk ratings for all applied pesticides at each sampling point for site 33046.

Sampler - Buffer width	Metsulfuron-methyl	Glyphosate	Clopyralid	Water sample results (µg/L)
1 - 40m (v)	low	low	medium	IR
2 - 200m (b)	low	low	low	IR
3 - 40m (v)	low	low	medium	IR

v – buffer is vegetated, b – buffer is bare

An automatic water sampler was installed at this site, however the rainfall that occurred post application did not cause a rise high enough to trigger sampling.

33781

Table 7 PIRI risk ratings for all applied pesticides at each sampling point for site 33781.

Sampler - Buffer width	Metsulfuron-methyl	Glyphosate	Water sample results (µg/L)
1 - 40m (b)	low	low	M - 0.8
2 - 80m (b)	low	low	nil detect
3 - 40m (b)	low	low	nil detect
4 - 5m (b)	high	high	M - 1.8
5 - 5m (b)	high	high	M - 1.4
6 - 120m (v)	low	low	nil detect

v – buffer is vegetated, b – buffer is bare, M – metsulfuron-methyl

33834

Table 8 PIRI risk ratings for all applied pesticides at each sampling point for site 33834.

Sampler - Buffer width	Metsulfuron-methyl	Glyphosate	Water sample results (µg/L)
1 - 50m (v)	low	low	nil detect
2 - 15m (b)	medium	medium	M - 0.7

v – buffer is vegetated, b- buffer is bare, M – metsulfuron-methyl

34013

This coupe, sprayed at the end of August, received ~33 mm over four days at the beginning of September with >15 mm on the first day but not enough runoff was generated until 1 month later for the RSSs to sample.

Table 9 PIRI risk ratings for all applied pesticides at each sampling point for site 34013.

Sampler - Buffer width	Metsulfuron-methyl	Glyphosate	Water sample results (µg/L)
1 - 40m (v)	low	low	nil detect
2 - 80m (b)	low	low	nil detect
3 - 40m (v)	low	low	nil detect
4 - 40m (v)	low	low	nil detect
5 - 40m (b)	low	low	nil detect

v – buffer is vegetated, b – buffer is bare

34216

This coupe received ~30 mm rain in 2½ weeks post application, which triggered some of the RSSs. Grab samples were taken at the locations that had not automatically sampled, and all results came back negative. Five days later there was a large quantity of rain (>30 mm) that continued for several days; all of the RSSs sampled and again returned negative results. The risks given below are for the second rain event in which all RSSs were triggered.

Table 10 PIRI risk ratings for all applied pesticides at each sampling point for site 34216.

Sampler - Buffer width	Metsulfuron-methyl	Glyphosate	Water sample results (µg/L)
1 - 25m (v)	medium	medium	nil detect
3 - 40m (v)	low	low	nil detect
4 - 10m (b)	high	high	nil detect
5 - 25m (v)	medium	low	nil detect

v – buffer is vegetated, b – buffer is bare

Routine sampling

Routine water sampling surrounding a pesticide operation was carried out as usual and the results and sample timing compared with those obtained from this

study. This has highlighted discrepancies between when runoff occurs and when water sampling is conducted (Table 11). The reasons for this are:

- *Significant* rainfall is site-specific (dependent factors including soil type and soil dryness) and therefore variable. The specific significant rainfall for each site is not known.
- Rainfall can vary greatly over short distances in the landscape. Without a weather station on each coupe (unfeasible), operational staff have no certainty about the volume of on-site rainfall, and whether runoff has occurred.

As can be seen in Table 10 the date of routine water monitoring does not always correlate to the date that the RSS sampled, i.e. when runoff was generated. On sites 33781 and 33834 runoff triggered RSSs 27 days before routine sampling occurred. In contrast at sites 22533, 32589 and 34013 the routine samples were between one and seven days prior to RSS sampling and hence before significant rainfall had occurred. These examples draw attention to whether post-rain samples are being taken at the appropriate time.

Table 11 Sites, the date of routine water sampling, and date the RSS sampled.

Site	Date of routine sampling	Date of RSS sampling	Difference (days)	Results from routine sampling
22533 (runoff only on one RSS site)	29/10/07 -1	30/10/07 nil detect		
29934	None – only Glyphosate applied	24/9/07		nil detect
32589 (AWS sampled, not RSS)	30/10/07 -7	7/10/07 nil detect		
33046	30/10/07	No runoff		nil detect
33781	1/10/07	4/9/07	27	nil detect
33834	1/10/07	4/9/07	27	nil detect
34013	1/10/07	4/10/07	-3	nil detect
34216	26/9/07	25/9/07	1	nil detect

Low, medium and high-risk predictions by PIRI and how the monitoring results corresponded to these risks are shown in Table 12. The majority of risks were low; this correlates well with the results, which were predominantly nil detections.

Table 12 Summary of PIRI risks and their corresponding monitoring results.

	PIRI risks		
	Low	Medium	High
Number of sites with nil detects	23	8	4
Number of sites with detects	1	1	3
Number of sites with no results due to lack of runoff	15	13	2
Total number of sites	39	22	9

39 low-risk sites were produced during these trials. 15 of the results were not obtained due to insufficient runoff being produced. Where runoff did occur there were 23 nil detections and one detection, which was for metsulfuron methyl. Where medium risks were predicted, eight were nil detections, one produced a detection for metsulfuron methyl, and for the high risks there were four nil detections and three detections, two for metsulfuron methyl and one for clopyralid. At the four high risk ratings sites where there was no detection, three were for glyphosate, which has a detection limit of 100 times that of the other pesticides monitored (Table 13).

Table 13 Pesticides monitored and their detection limits.

Pesticide	Detection Limit (µg/L)
Glyphosate	10
Metsulfuron-methyl	0.1
Sulfometuron-methyl	0.1
Clopyralid	0.1
Terbacil	0.1

At site 33781, two of the sample sites had high risks for metsulfuron methyl and glyphosate. In both samples metsulfuron methyl was found to be present, but not glyphosate. Given the limits of detection, even if glyphosate had been present at a similar concentration to the metsulfuron methyl, it would not have been detected. Further research would be required to determine if it is absent or passing by undetected due to technological limitations.

Discussion

Overall the agreement between PIRI-Tas predicted risks for runoff contamination and the results that were observed is reasonable. The detections mostly correlate to higher risk categories and the majority of nil detect samples correlate to sites assessed as low or medium risk for contamination of runoff.

It was observed during these trials that buffer width had a significant impact on the risk produced by PIRI. In this study all detections occurred where the buffer was bare ground. Currently PIRI does not have the capacity to differentiate between bare and vegetated buffer strips. Four high risks were produced where

no detection was recorded; three of these were for glyphosate and one for metsulfuron methyl. The metsulfuron methyl and one of the glyphosate scenarios had a vegetated buffer. This suggests that vegetated buffers are effective in filtering runoff. This is consistent with research showing that vegetated buffer strips can be more effective than bare buffer strips (Otto *et al.* 2008; Vianello *et al.* 2005). Incorporating this factor into PIRI may therefore enhance the output.

While the AWSs are expensive and time-consuming, making them impractical for use in regular operations, they can provide valuable information. AWSs were installed at sites 32589 and 33046. Unfortunately there was not enough rain on 33046 to obtain results within six weeks of application and no results were obtained. On 32589 only a small amount of runoff was generated, with a rise in water level lasting only seven hours, in which all of the samples taken showed no detections.

The RSSs are relatively cheap, expedient and easy to use. They are able to sample the first flush of runoff from the coupe. This study demonstrates that RSSs present a promising possibility for regular operational use. The main logistical issue for their use is that the sampling height is set when they are installed in a stream or drainage line, according to the water level at that time. Post pesticide application, the water level may drop before significant rain occurs and the sampler may not sample the first flush of runoff from the site, if at all. The solution to this problem is manual adjustment on a periodic basis after spraying if no rainfall has occurred; however, this is not always possible. So far the RSS has only been used at the edge of the coupe boundary. Trials using the RSS downstream at a point where all coupe runoff has converged, corresponding with current operational sampling protocols, would be required before implementation at an operational level.

This trial has also highlighted that more research is required to determine exactly when the post rain sample should be taken. If pesticides are being transported off-site what is the window of opportunity for detecting them? Is it in the order of hours or days following significant rain? If the window for detection of contamination in runoff is short then current operational water sampling practices, which are not consistent in the timing of collection after the first flush of runoff, may not be detecting any contamination, if it exists.

This study and many previous studies have shown that detections are well below the published health values for the pesticides applied. It has also demonstrated that the use of PIRI will assist in predicting the potential for contamination of runoff should sufficient rain produce such runoff after the spray event.

Conclusions

The results from these trials show a good consistency between PIRI predictions and the results from monitoring data, which is encouraging and an indication that previous validation data sets have helped to get PIRI closer to being ready for use in Tasmania. The majority of detections were preceded by high-risk predictions, and the majority of low risk predictions were followed by nil

detections. The largest discrepancy was high risks being produced for glyphosate with no detections of this pesticide in the results. Currently the detection limit for glyphosate is 10 µg/L; this is high relative to the detection limit for other pesticides, 100 times higher than that of metsulfuron methyl. At the present time there is no way of knowing if PIRI is producing over-conservative risks for glyphosate or whether its presence is going unnoticed, a result of technological limitations. It was noted that buffer width has a large impact on risk, but that currently bare and vegetated buffers are not differentiated within PIRI. Incorporating this factor may improve PIRI's predictive capacity.

It was seen that the routine sampling for post rain samples is not always carried out at the appropriate time. This is not due to intention or negligence, but because of practical obstacles in knowing when sufficient rainfall that generates run-off has occurred at a remote site. There is no practical solution to obtaining this knowledge without installation of remote weather stations with telemetry at each sampling site. Even in that case, the person collecting samples would need to be able to respond in a timely fashion to travel and collect the first flush of runoff from the site.

The RSSs used for sampling in these trials show promise for operational use, and in most cases are able to overcome the issue of appropriate sample timing. The RSS works best if the water level at the sampling point does not decrease between the time of setting the RSS and the first runoff event. Installing the RSS at a point downstream of the coupe where flow levels are more consistent may solve this problem.

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