AN INTEGRATED APPROACH TO MANAGING AND MITIGATING THE RISK OF AGRICULTURAL NONPOINT SOURCE PESTICIDE POLLUTION TO THE AQUATIC ENVIRONMENT

J.M. Dabrowski

Volume 2: Development of risk maps and a risk indicator for identifying hotspots and prioritising risks of pesticide use to aquatic ecosystem health

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EXECUTIVE SUMMARY

BACKGROUND

Agricultural nonpoint source pollution (NPS) plays a major role in the degradation of water quality, particularly regarding pesticides, nutrients and sediment. It has therefore become increasingly important to address the contributions of NPS pollution in management of water quality, an aspect that is seldom considered in South Africa. The Water Research Commission (WRC) has addressed this gap by funding a number of studies, which, amongst others, have generated a knowledge review of modelling agricultural NPS pollution at multiple scales and developed an integrated modelling approach to prediction of agricultural NPS pollution. As a follow on to the latter project, the WRC is currently funding a more detailed study on the fate and transport of nutrients in agricultural catchments.

With respect to pesticides, Burger and Nel (2008) produced a scoping study report on the impact of pesticides with endocrine disrupting properties on water resources of South Africa. This led to the solicitation of a directed project to perform a more detailed investigation of the contamination of water resources by agricultural chemicals and their impact on human health. This study produced national maps of the spatial distribution of estimated use of over 200 pesticides and is an essential input in identifying important sources of agricultural chemicals in the country.

Furthermore, the study confirmed the presence of numerous pesticides in surface waters in three case study catchments representing different crop types (i.e. maize, sugar cane and sub-tropical fruit). Given the widespread use of pesticides in large and small-scale farming, in combination with their potential toxic and endocrine disrupting effects on human and ecological health, it is important to develop, evaluate and test modelling and monitoring approaches that enable farmers and catchment managers to identify and reduce their impacts on the environment. These approaches need to consider the nature of NPS pollution and the variety of geographical, climatic and management practices that influence the transport of pesticides in the environment.

There are essentially three types of management options suitable for reducing the pollution of water pollution by agricultural pesticides:

1. Reduce the amount of pesticide applied through:
   a) Improving application efficiency; and
   b) Using non-chemical (Integrated Pest Management) control measures.

2. Substitute current use pesticides with less toxic, less persistent or less mobile pesticides.

3. Reduce the physical transport of applied pesticides from fields to aquatic systems.

AIMS & OBJECTIVES

Considering the increasing challenges related to water quality management in South Africa and acknowledging the role of NPS pesticide pollution in the deterioration of water quality, the aim of this project is to improve the management of NPS pesticide pollution in South Africa through investigating and developing monitoring, modelling and risk assessment approaches that:

1. Identify target areas (or hotspots) where agricultural NPS pollution of pesticides is of greatest concern;

2. Identify specific pesticides in hotspot areas which are likely to pose the greatest risk to freshwater resources;

3. Identify important transport routes of contamination and reliably predict pesticide concentrations derived from these transport routes;

4. Provide guidance on reducing impacts through:
    a) Improving application, or
    b) Selecting pesticides which pose less risk to the aquatic environment, or
    c) Reducing the transport of chemicals from source to the aquatic environment.

These aims were addressed through addressing the following project objectives:

1. Knowledge review of current management practices aimed at reducing pesticide impacts in the environment.

2. Identify priority areas for implementation of management practices through integrating recently developed pesticide use maps with geographical data to produce maps of aggregated risk to the environment.

3. Develop calibration guidelines for small-scale farmers designed to reduce pesticide application rates and associated environmental impacts.

4. Develop relative risk-based guidelines that enable farmers to identify the relative environmental risk of different pesticides registered for use on a crop.

5. Perform field and catchment scale modelling studies under different cropping systems to characterise pesticide contamination in associated water resources.

6. Perform field and catchment scale monitoring studies under different cropping systems to test novel monitoring techniques and validate the accuracy of model outputs in predicting pesticide transport.

This report documents the research conducted as part of Objectives 2 and 4. Research outputs associated with Objectives 1, 3, 5 and 6 have been described in Volume 1 of this report.

METHODOLOGY

Updated pesticide use maps

The development of pesticide risk maps for South Africa builds on the pesticide use maps produced in WRC Project No. K5/1956. Maps produced previously were based on 2009 data. Pesticide maps were therefore updated using more recent pesticide use data for South Africa (2014) which was purchased from GfK Kynetec, an international market research company. Data was provided as the aggregated total amount of active ingredient applied to all crops as well as the disaggregated application per crop.
The spatial distribution of pesticide use is dependent on the spatial distribution of the crops to which they are applied. As for the development of maps based on 2009 pesticide use data, the Census of Agriculture Provincial Statistics performed by Statistics South Africa in 2002 was used to estimate the spatial distribution of crop production in South Africa. Data from a more recent survey conducted in 2007 was scrutinised but was found to lack sufficient detail regarding the number of different crops included in the survey.

The 2002 census collected data on crop area (ha) and production (tonnes) for commercial crops at a magisterial district level, which was used to estimate the percentage agricultural area covered by a specific crop type within a magisterial district. It is important to note that the magisterial district boundaries in South Africa have changed since 2002. For the purposes of this project, the magisterial district boundaries as demarcated in 2002 were used for the spatial mapping of crop coverage and pesticide use. Pesticide use, land cover, and geographical data need to be represented in hydrologically distinct zones (e.g. catchments) in order to predict risk. Pesticide use quantified at a magisterial district scale was therefore normalised to a quaternary catchment scale resulting in maps displaying the estimated application rate (kg/ha) of each pesticide per quaternary catchment.

Pesticide risk maps

National-level risk mapping was undertaken to identify specific catchments within South Africa with the greatest potential for impacts on aquatic biodiversity from estimated agricultural use of pesticides. This a development on the maps of pesticide use produced in WRC Project No. K5/1956 in that the method aggregates the risk of all pesticides applied on all crops within a catchment to provide a more refined spatial overview of hotspot areas. This is an important step within the general approach adopted in the larger project framework, which is to identify priority areas where the implementation of management practices is most urgently required.

Pesticide use maps, length of river network, geographical variables (slope, soil and rainfall) and physicochemical (half-life and Koc) data were integrated in a geographical information system (GIS) to make first order predictions of pesticide concentrations in the river network of each quaternary catchment in South Africa. These concentrations were compared with ecotoxicological data (algae, insects and fish) for each pesticide to determine the number of toxic units of the pesticide present in the system (toxic unit is the ratio of pesticide concentration to the specific toxicity value for a given pesticide). This was done for every pesticide (for which use data was available) in every quaternary catchment.

The total risk per catchment was determined by summing the estimated toxic units for every pesticide applied in a catchment and is therefore representative of the aggregated risk posed by all pesticides applied in the catchment. This utility enables users to identify hotspot areas/catchments based on the ability of pesticides to move into water resources and/or potential risk to aquatic ecosystem. As pesticide use is directly related to crop type, it is possible to identify the contribution of different crops to the total aggregated risk. The selection of priority areas for management interventions can therefore be informed by the total toxic unit score for the catchment as well as important crops that contribute to the score. This information can be used in targeting monitoring and mitigation campaigns designed to protect the aquatic environment.

Pesticide Risk Indicator

Prioritisation of pesticide risks (i.e. for designing monitoring programmes) or the substitution of pesticides requires the need for a comparative assessment of different pesticides that can be potentially applied to a pest on a crop. This approach is relevant given that several pesticides may be registered for use against a specific pest on a specific crop, each of which will vary in terms of its application rate, mobility (i.e. physicochemical properties) and toxicity to non-target biota. Environmental pesticide risk indicators provide a relative indication of the impact of pesticides, with an emphasis on relatively few and simple data input parameters.

An output of WRC Project No. K5/1956 was the development of a prioritisation tool that allowed for the prioritisation of pesticides based on their quantity of use, environmental mobility and risk to human health. The tool was designed to identify priority pesticides at a very coarse, national level. The overall aim of this current project required a more refined catchment- or farm-level approach and is focussed on aquatic ecological health as opposed to human health.

The aim of the risk-based indicator developed in this project is to:

1. Assist in reducing the impacts of agricultural chemicals in water resources by allowing farmers and catchment managers to easily assess the risk of different pesticides to the environment and therefore choose pesticides that pose the least risk to the environment.

2. Assist catchment managers in prioritising high-risk pesticides within a catchment based on the crops produced in the catchment, with a view to informing monitoring programmes or management interventions.

The approach adopted in the development of the indicator involves the development of an Excel based software tool that provides an indication of the relative risk of pesticides applied to a crop. The tool enables the user to select a crop, for which a list of registered active ingredients is automatically generated. Based on the input of several easily obtainable input parameters, the tool provides a relative assessment of the risk of each pesticide to aquatic ecosystem health. This risk is estimated by calculating a Predicted Environmental Concentration (PEC) for each pesticide, which is compared to a toxicity concentration for each pesticide. The ratio of the PEC to the toxicity value, gives an indication of the risk of the pesticide and comparison of ratios for all pesticides provides a means to compare risks between pesticides.

The calculation of the PEC assumes contribution of pesticide loads derived from runoff and spray drift. The load of pesticide derived from each transport pathway is calculated by the spreadsheet, using simple, empirical formulae. These loads are expressed as a concentration through the input of basic stream dimension and flow parameters.

The spreadsheet relies on three databases, which have been developed as part of this project and include the following:

- A database of active ingredients registered for use on specific pests for specific crops;
- A pesticide physicochemical database;
- A pesticide toxicity database;
- A database of crop-specific pesticide application rates.

RESULTS & DISCUSSION

Updated pesticide use maps

The maps produced here rely on more recent pesticide use data and therefore represent an update of the maps produced in WRC Project No. K5/1956. Excel databases of estimated pesticide application (kg) and pesticide application rates (kg/ha) for more than 200 active ingredients for all quaternary catchments in South Africa have been produced. These databases have been incorporated into a GIS shapefile of quaternary catchments for South Africa from which maps illustrating the application of each pesticide in each quaternary catchment can be produced. The maps provide important information not only in terms of estimated application rates but also in terms of identifying where in the country specific pesticides are most likely being applied. As pesticide application has been quantified according to hydrologically distinct units, it is possible to apply catchment scale modelling approaches to estimate pesticide transport and associated risk per quaternary catchment.

As with the development of the first version of the maps, it is important to note the limitations associated with the assumptions used in the production of the maps. These include the following:

1. The magisterial district coverage is based on the 2002 Census of Agriculture Provincial Statistics and did not represent total coverage, as accurate statistics were dependent on farmers that responded to the census. Data was therefore normalised to reflect actual crop coverage as

reported by the FAO (i.e. the area of each crop type in a magisterial district was multiplied by the ratio of total national area reported by STATSSA to total national area reported by the FAO);

2. The methodology assumes that a specific pesticide was evenly distributed to a specific crop regardless of the magisterial district the crop was produced in. Pesticide use data as displayed in the maps may therefore not reflect the local variability of pesticide management practices found within a magisterial district;

3. Because the agricultural land cover does not discriminate between different crop types, pesticide use was aggregated up to a magisterial district level and assumed to be distributed across all agricultural land within a magisterial district. All agricultural land cover that fell within a magisterial district was therefore assigned a pesticide use category for the pesticide in question;

4. Crop production statistics may not have been available for all magisterial districts where a pesticide may have been applied to agricultural land, and therefore, are not displayed on the maps; and

5. Pesticide use estimates are based on market research data for the year 2014

Pesticide risk maps

Maps illustrating the relative risk of pesticide application per quaternary catchment to algae, invertebrates and fish were developed. In general, risks are highest for the following areas:

- Berg, Breede and Olifants primary catchments in the south-western Cape
- Along the lower reaches of the Orange River in the vicinity of Upington in the Lower Orange primary catchment
- Upper and Middle Vaal primary catchments
- The eastern sections of the Luvulvhu and Letaba and Inkomati primary catchments
- The Usuthu to Mhlatuze, Tugela and Mvoti to Umzimkulu primary catchments.
- Quaternary catchments located in the southern section of the Fish to Tsitsikamma primary catchment

The spatial extent of risks generally decreases in the order from algae to invertebrates to fish. This is a function of the high quantities of herbicides (and associated increased toxicity to algae) used on South African crops in comparison to fungicides and insecticides, which are generally less toxic towards algae. The maps provide an initial assessment in identifying priority areas where pesticide use may be impacting on aquatic ecosystem health. Databases produced as part of this deliverable can be used to identify further, which specific pesticides contribute most towards the Toxic Unit value for a quaternary catchment of interest. For example, pesticide application in quaternary catchments G10D, G21C and G21E (Berg River primary catchment) is highlighted as being very high risk towards fish. This is of concern given the high prevalence of endemic, endangered fish species that generally occur in the south-western Cape. Interrogation of the toxic unit database indicates that for quaternary catchment G10D (as an example), three pesticides (gamma-cyhalothrin, chlorpyrifos and esfenvalerate) clearly contribute significantly towards the total Toxic Unit score for the catchment (77.9% of the total).

Risk indicator

Two versions of the indicator have been developed. The Generic Risk Indicator can be used when the user has some knowledge of which crops are produced in a catchment but does not have any information of what specific pesticides are applied to the crop. The Specific Risk Indicator can be used when the user has some knowledge of which pesticides are applied to a particular crop in a catchment (including their application rate) or can also be used to assess the relative risk of several specific pesticides of interest.

The Data Input Tab for the Generic Indicator allows the user to add relevant geographical information required for the calculation of the PEC and the associated RQ. These input parameters are easy to obtain using readily available resources (e.g. Google Earth, Cape Farm Mapper, etc.) or GIS data. Based on the input of parameters in this tab, the PEC for all pesticides that are likely to be used on the crop is automatically calculated through reference to lookup pesticide use tables (as supplied by the GfK Kynetec database) included in the spreadsheet. The Generic Indicator therefore provides a list of pesticides (and associated risks) that are likely to be applied on a crop (as determined by market research).

As mentioned above the Specific Risk Indicator can be used when the user has some knowledge of which pesticides are applied to a particular crop in a catchment or can also be used to assess the relative risk of several specific pesticides of interest. In addition to the catchment data input that is required for the Generic Risk Indicator an additional input box is provided where specific pesticides can be selected (up to ten active ingredients can be selected) and the application rate can be included.

CONCLUSION

The combination of resources produced as part of this deliverable are clearly an effective means of:

1. Identifying and/or prioritising catchments where agricultural pesticide use may pose an unacceptable risk to aquatic biota.

2. Identifying specific pesticides that contribute the greatest potential risk to aquatic biota.

3. Designing appropriate monitoring and management programmes aimed at mitigating risks in the catchment area.

The outputs of the Generic Pesticide Risk Indicator are based on crop-specific application rates obtained from the pesticide use database as provided in the Appendix to this report. The utility of the outputs can be summarised as follows:

- Provides a best guess of which pesticides could be applied in a catchment area where no detailed pesticide application information is available;
- Provides an indication of the relative risks these pesticides may pose to algae, invertebrates and fish;
- The outputs differentiate risks associated with runoff and spray drift and therefore provide guidance on monitoring strategies as well as which management interventions are most likely needed to control the source of pesticides in the catchment (i.e. spray drift will require different management interventions in comparison to runoff).
- The outputs can identify which pesticides are likely to be used in high quantities and the risk associated with these pesticides and can therefore be used to identify target pesticides for further monitoring/screening/management;
- The indicator can be used to assess how changes in certain crop management inputs (i.e. increased buffer widths, vegetated buffer zones, etc.) can potentially affect the risk associated with the use of a pesticide; and
- The indicator can be applied in different sub-catchments or tributaries in order to identify specific hotspot areas within a larger catchment area.

The outputs of the Specific Pesticide Risk Indicator are based on user defined pesticides and associated application rates. The utility of the outputs can be summarised as follows:

- Provides a higher confidence estimate of relative risks based on more detailed knowledge of pesticide application programmes in the catchment;
- The outputs differentiate risks associated with runoff and spray drift and therefore provide guidance on monitoring strategies as well as which management interventions are most likely needed to control the source of pesticides in the catchment (i.e. spray drift will require different management interventions in comparison to runoff);
- The indicator can be applied in different sub-catchments or tributaries in order to identify specific hotspot areas within a larger catchment area;
- The indicator can be used to assess how changes in certain crop management inputs (i.e. increased buffer widths, vegetated buffer zones, etc.) can potentially affect the risk associated with the use of a pesticide; and
- The indicator can be used to compare specific pesticides of interest with a view to identifying lower risk pesticides (i.e. for application to crops) or higher risk pesticides that might need to be included in a monitoring programme.

TECHNOLOGY TRANSFER & INNOVATION

South Africa has a well-developed agricultural sector, which uses high quantities of numerous different pesticides on an annual basis. We have very little information on the impact that this pesticide use has on our very limited freshwater resources and no reliable resources are available for identifying risks of pesticides to water resources in South Africa. The outputs of the project have developed pesticide use and risk maps and a risk indicator and have tested software models aimed at prioritising risks of pesticides and predicting environmental concentrations in water resources. These resources significantly improve our ability to assess risks of pesticides to the aquatic ecosystem in South Africa. While similar products have been developed throughout the rest of the world, no such products have been developed for South Africa. The outputs of this project therefore help improve our understanding of the potential impacts of pesticides at multiple scales (i.e. field, catchment and national scale) and directly addresses the Department of Agriculture Draft Pesticide Management Policy (2006) in which the need to minimise hazards and risks to health and the environment was highlighted.

Risk maps

The following resources have been produced in the development of pesticide risk maps for South Africa:

File Name	Description
PestApp_RSA_2014.xlsx	Excel database of total pesticide application per crop for South Africa (data obtained from GfK Kynetec)
PestApp_MD_2014.xlsx	Excel database of pesticide application per magisterial district (kg and kg/ha)
PestApp_Quat_2014.xlsx	Excel database of pesticide application per quaternary catchment (kg and kg/ha)
PestTox.xlsx	Excel database of pesticide physicochemical (half-life, water solubility and *KOC*) and toxicity (EC50 for algae, *Daphnia magna* and fish) data used to predict runoff PECs and associated risk to aquatic biota
ToxicUnits.xlsx	Excel database of calculated toxic units per active ingredient per quaternary catchment for algae, invertebrates and fish

PestApp_MD_2014.shp	GIS shapefile containing data of pesticide application rates (kg/ha) per active ingredient applied in each magisterial district of South Africa
PestApp_Quat_2014.shp	GIS shapefile containing data of pesticide application rates (kg/ha) per active ingredient applied in each quaternary catchment of South Africa
Quat_TUs.shp	GIS shapefile containing data of the total toxic units (for algae, fish or invertebrates) for all pesticides applied in a quaternary catchment
Quat_AlgaeTUs.shp	GIS shapefile containing calculated toxic units (for algae) per active ingredient applied in each quaternary catchment of South Africa
Quat_InvertTUs.shp	GIS shapefile containing calculated toxic units (for invertebrates) per active ingredient applied in each quaternary catchment of South Africa
Quat_FishTUs.shp	GIS shapefile containing data of the toxic units (for fish) per active ingredient applied in each quaternary catchment of South Africa

Risk indicator

The following Excel-based pesticide risk indicators have been produced as part of this project:

File Name	**Description**
GenericRI.xlsx	Excel software tool designed to assess the relative risks of pesticides applied to different crop types in catchments without any detailed knowledge of pesticide application programmes.
SpecificRI.xlsx	Excel software tool designed to assess the relative risks of pesticides applied to different crop types in catchments with some knowledge of pesticides used and their application rates. The tool can also be used to compare the relative risks of pesticides of interest.

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Dr L. Nhamo	*Water Research Commission*
Prof R. Pieters	*North-West University*
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Mr D. J. Ollis	*Freshwater Research Centre*
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

ALC	Agricultural land cover
AVCASA	Organisation for Economic Co-operation and Development
B	Vegetative runoff buffer
D	Average distance between field and watercourse
DEM	Digital elevation model
EC50	Median effective concentration
FAO	Food and Agriculture Organization of the United Nations
GAI	Gram active ingredient
GIS	Geographical information system
LC50	Median lethal concentration
NPS	Nonpoint source
OECD	Organisation for Economic Co-operation and Development
PAR	Pesticide application rate
PEC	Predicted environmental concentration
PEL	Predicted environmental load
PI	Plan interception
PPDB	Pesticide properties database
PEC	Present environmental concentration
RAR	Recommended application rate
RD	Recommended dosage
RQ	Risk quotient
SV	Spray volume
TAC	Total area of fields in catchment
TAS	Total area of fields adjacent to stream
TP	Total perimeter of fields adjacent to stream
TSL	Total stream length
TU	Toxic units
STATSSA	Statistics South Africa

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CHAPTER 1: DEVELOPMENT OF PESTICIDE RISK MAPS FOR AQUATIC ECOSYSTEMS IN SOUTH AFRICA

By:
James M. Dabrowski (Freshwater Research Centre)

1.1 INTRODUCTION

Given the large spatial footprint associated with nonpoint source (NPS) pollution (many diffuse sources covering a large area) and the large number of active ingredients registered for use in South Africa (over 200) a key step in managing agricultural pesticides is to identify areas where the risks associated with pesticide use are likely to be high (hotspots) (Figure 1-1). While monitoring data is ideal for identifying such hotspot areas, this is generally lacking in South Africa. Hence, the use of surrogate indicators of contamination is important to identify areas where catchment specific monitoring and management programmes can be implemented. Such indicators need to provide some indication of potential risk of pesticide use to the aquatic environment.

According to the framework presented in Figure 1-1 this step can be regarded as a screening approach and makes use of a number of readily available spatial, toxicity and physicochemical databases to make a relative assessment of the potential risks posed by pesticides to aquatic ecosystems. Once target areas and priority pesticides have been identified, a more detailed assessment can be conducted with the ultimate aim being to minimise risks to the environment.

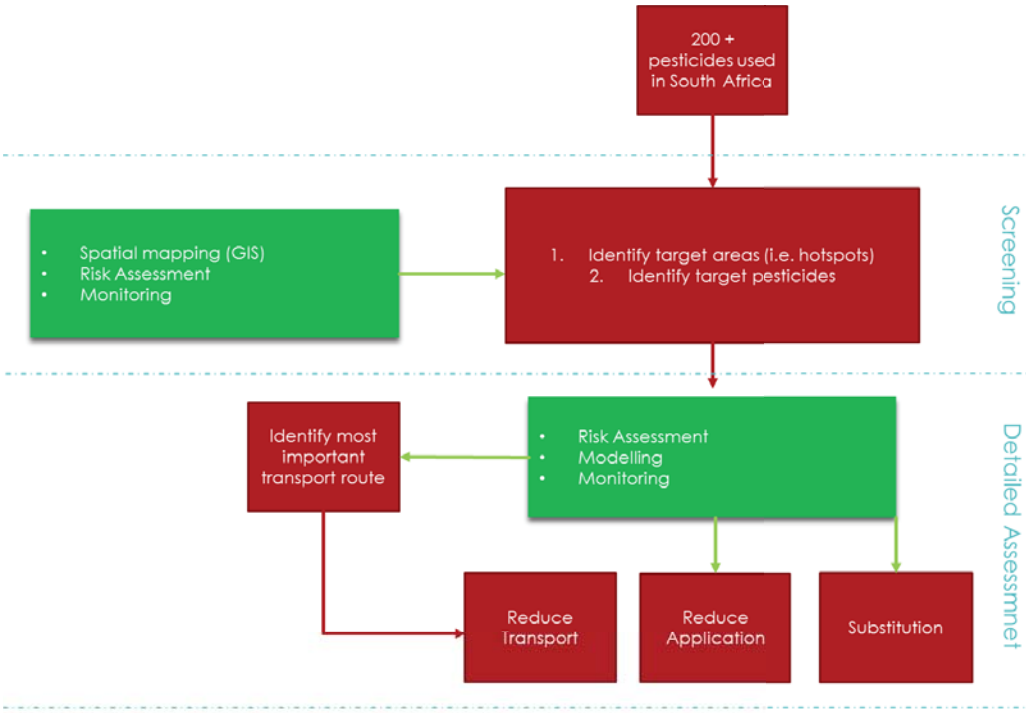

Figure 1-1: Nonpoint source pesticide assessment framework.

WRC Project K5/1956 produced maps providing estimates of application rates (kg.ha^{-1}) of over 200 different active ingredients registered for use in South Africa (Dabrowski, 2015). The designed maps are intended to provide a spatial overview of the relative application rates of specific active ingredients based on the distribution of crops throughout the country. From a practical perspective, these maps are useful for identifying hotspot areas if the risk associated with the use of a specific pesticide is already known. For example, there may be a need to manage atrazine levels in water resources due to a known human or ecological health risk associated with exposure to atrazine. In this instance, the maps could be used to identify areas where atrazine is applied in high quantities to prioritise further management interventions.

It is however important to note that, while an important contributing factor, quantity of use alone does not necessarily translate into risk. Risk occurs due to a combination of factors, including the quantity of use, the likelihood of transport from the point of use into a receiving water body and ultimately exposure to a concentration that may or may not exceed a specific toxicity threshold. Pesticide transport is influenced by several factors including climatic and geographic conditions and physicochemical properties of pesticides (which vary significantly from pesticide to another). Therefore, while quantity of use provides a good indication of where risk may occur, these other factors, when taken into consideration, provide a more refined estimate of the likelihood that a risk will in fact occur.

From the perspective of identifying high-risk areas, the pesticide use maps provide very important information not only in terms of estimated application rates, but also in terms of identifying where in the country specific pesticides are most likely being applied. Integrating this information together with spatial (e.g. soil type, slope, rainfall, etc.) and toxicity data using an environmental risk mapping technique can identify hotspot areas at a national scale.

Environmental risk mapping is a technique whereby a Geographic Information System (GIS) is used to superimpose sets of spatial information (i.e. those that influence transport) to combine variability in terms of pollution pressure and vulnerability (Brown *et al.* 2007). Information regarding the spatial distribution of risk to surface waters arising from pesticide use can be used to target monitoring campaigns, to identify priority areas for management interventions, and to investigate optimal mitigation strategies.

1.2 UPDATING PESTICIDE USE DATA (2014)

The development of pesticide risk maps for South Africa builds on the pesticide use maps produced in WRC Project No. K5/1956 (Dabrowski, 2015). Maps produced previously were based on 2009 data. Pesticide data was updated using more recent data (2014) using the methodology described in Dabrowski (2015). Pesticide use data for South Africa was purchased from GfK Kynetec (http://www.gfk.com/gfk-kynetec/), an international market research company. Data was provided as the aggregated total amount of active ingredient applied to all crops as well as the disaggregated application per crop.

In comparison to data for 2009, the 2014 database showed the following differences:

- Stone fruit were grouped as a single crop class (including apricots and plums)
- Sub-tropical fruit were grouped as a single class (including avocadoes, bananas, mangoes and papayas)
- Beans were grouped as a single crop class (including dry and green beans)

Additional crops for which data was obtained included the following:

- Lucerne
- Vegetables (grouped as a single crop class)

Table 1-1: Crops included in the 2014 GfK Database

Apples	Pears
Barley	Pineapples
Beans	Potatoes
Citrus	Sorghum
Cotton	Soya beans
Grapes-table	Stone fruit
Grapes-wine	Sub-tropical Fruit
Groundnuts	Sugar cane
Lucerne	Sunflower
Maize	Tomatoes
Peaches	Vegetables
	Wheat

Pesticide data for 2014 is included in the Appendix to this report.

1.2.1 Crop Distribution

The spatial distribution of pesticide use is dependent on the spatial distribution of the crops to which they are applied. As for the development of maps based on 2009 pesticide use data, the Census of Agriculture Provincial Statistics performed by Statistics South Africa in 2002 (STATSSA, 2002) was used to estimate the spatial distribution of crop production in South Africa. Data from a more recent survey conducted in 2007 was scrutinised but was found to lack sufficient detail regarding the number of different crops included in the survey.

The 2002 census collected data on crop area (ha) and production (tonnes) for commercial crops at a magisterial district level, which was used to estimate the percentage agricultural area covered by a specific crop type within a magisterial district. It is important to note that the magisterial district boundaries in South Africa have changed since 2002. For the purposes of this project, the magisterial district boundaries as demarcated in 2002 were used for the spatial mapping of crop coverage and pesticide use. Furthermore, the census provides data only for farmers that responded. The census therefore underestimates the total area and production of a crop at a magisterial district and national level, but does provide as accurate an estimate of the relative distribution of crop coverage and production as is possible at this level of spatial detail.

The census data was therefore normalised to consider this under-estimation, as well as to account for changes in area and production over time to provide an estimate of total crop coverage per magisterial district in 2014. The normalisation procedure compared total crop coverage estimated by the 2002 STATSSA census data (i.e. the sum of the area of each crop type for all nine provinces) with total crop area statistics collected by the United Nations Food and Agriculture Organisation (FAO) for the year 2014 (FAOSTAT, 2016). The crop normalisation quotient was expressed as the ratio of FAO to STATSSA crop coverage. The crop coverage reported by STATSSA for each magisterial district in South Africa was multiplied by the respective crop normalisation quotient to derive a normalised crop coverage for each crop type in each magisterial district. The normalised area of each crop in each magisterial district was expressed as a percentage of the national crop area for the crop.

Table 1-2: National crop area statistics reported by STATSSA and the FAO. The ratio of FAO to STATSSA statistics was used to normalise crop area data for each magisterial district in South Africa.

Crop	STATSSA Area	FAO Area	Normalisation
Apples	16 634	20 580	1.2
Barley	44 978	85 125	1.9
Beans	37 494	64 000	1.7
Citrus	66 394	77 615	1.2
Cotton	22 105	15 000	0.7
Grapes-table	18 737	27 516	1.5
Grapes-wine	65 592	96 323	1.5
Groundnuts	53 188	52 125	1.0
Lucerne	128 604	250 000	1.9
Maize	1 770 455	2 688 200	1.5
Peaches	11 197	9 361	0.8
Pears	9 694	12 014	1.2
Pineapples	6 352	7 250	1.1
Potatoes	41 652	63 907	1.5
Sorghum	56 488	70 000	1.2
Soya beans	58 258	502 900	8.6
Stone fruit	2 996	11 071	3.7
Sub-tropical Fruit	30 516	32 252	1.1
Sugar cane	224 167	272 590	1.2
Sunflower	298 683	598 950	2.0
Tomatoes	8 319	6 521	0.8
Vegetables	25 682	38 000	1.5
Wheat	590 902	476 570	0.8

Once crop coverage data had been normalised, the methodology described in detail in Dabrowski (2015) was used to quantify pesticide application (kg) and pesticide application rates ($kg.ha^{-1}$) on agricultural land in each magisterial district for the year 2014.

The amount of each pesticide applied to a crop was expressed as a percentage of the total national application. For example, approximately 34% of the total national of azinphos-methyl is applied to maize (Table 1-3). These percentages were used to estimate the percentage of the total amount of each pesticide applied to each crop in each magisterial district *(P%)*:

$$P\%_{x,y,z} = \frac{Area_{y,z}}{100} \times CApp_x$$

Where *Area* is the proportion of crop type *(y)* in a magisterial district *(z)* expressed as a percentage of the total national coverage of the crop and *CApp* is the proportion of the pesticide *(x)* applied to the crop, expressed as a percentage of the total application of the pesticide. This assumes that a specific pesticide was applied equally (or at an identical application rate) to a specific crop regardless of the magisterial district the crop was produced in.

Table 1-3: Example of a summary of the application of azinphos-methyl to crops produced in South Africa

Crop	Pesticide	Application (kg x 10^3)	Application (% of national use)
Citrus	Azinphos-methyl	1.8	4.1
Cotton	Azinphos-methyl	0.4	0.8
Apples	Azinphos-methyl	14.8	34.3
Peaches/nectarines	Azinphos-methyl	7.0	16.2
Pears	Azinphos-methyl	11.6	26.8
Stone Fruit	Azinphos-methyl	4.2	9.7
Potatoes	Azinphos-methyl	3.5	8.1
Citrus	Azinphos-methyl	1.8	4.1

The total estimated quantity (Pq, in kg) of each applied pesticide (x) to each crop type (y) in each magisterial district (z) was calculated as follows:

$$Pq_{x,y,z} = \frac{P\%_{x,y,z}}{100} \times TApp_x \;;$$

Where $TApp$ is the total quantity of pesticide x applied to all crops in the country. From this data, it was possible to estimate the total quantity ($Ptot$, in kg) of pesticide (x) applied within a magisterial district (z) regardless of crop type (y):

$$Ptot_{x,z} = \sum_{y=1}^{n} Pq_{x,y}$$

1.2.2 Defining pesticide use according to quaternary catchment

Pesticide use, land cover, and geographical data need to be represented in hydrologically distinct zones (e.g. catchments) in order to predict risk. Pesticide use quantified at a magisterial district scale therefore had to be normalised to a quaternary catchment scale.

GIS was used to execute the following steps:

1. The latest agricultural land cover data set was used to quantify the amount of agricultural land cover (ALC) per magisterial district.

2. The magisterial district was intersected with the quaternary catchment layer to produce a shapefile with polygons representative of each magisterial district and quaternary catchment combination.

3. The ALC within each combination of magisterial district and quaternary catchment polygon was quantified using zonal statistics.

Agricultural land cover (ALC) in each quaternary catchment (v) was expressed as a percentage of the total agricultural land cover contained within the corresponding magisterial district (z) (e.g. quaternary catchment v contains 5% of agricultural land cover contained within magisterial district z):

$$ALC\%_v = \frac{ALC_{v,z}}{ALC_z} \times 100 \;;$$

The quantity of each pesticide *(x)* applied in each combination of magisterial district (z) and quaternary catchment (v) combination was calculated by multiplying the percentage of agricultural land cover in the quaternary catchment ($ALC\%v$) by the total amount ($Ptot$) of pesticide (x) applied in the magisterial district (z):

$$P_{v,x,z} = \frac{ALC\%_v}{100} \times Ptot_{x,z}$$

From this data, it was possible to estimate the total quantity ($Ptot$, in kg) of pesticide *(x)* applied within a quaternary catchment *(v)* by summing the application in each magisterial district falling within the quaternary catchment:

$$Ptot_{x,v} = \sum_{z=1}^{n} P_{x,z}$$

1.2.3 2014 Pesticide Maps for South Africa

The maps produced here rely on more recent pesticide use data and therefore represent an update of the maps produced in WRC Project No. K5/1956. Excel databases of estimated pesticide application (kg) and pesticide application rates (kg/ha) for more than 200 active ingredients for all quaternary catchments in South Africa have been produced. These databases have been incorporated into a GIS shapefile of quaternary catchments for South Africa from which maps illustrating the application of each pesticide in each quaternary catchment can be produced (Figure 1-2). The maps provide important information not only in terms of estimated application rates but also in terms of identifying where in the country specific pesticides are most likely being applied. As pesticide application has been quantified according to hydrologically distinct units, it is possible to apply catchment scale modelling approaches to estimate pesticide transport and associated risk per quaternary catchment.

As with the development of the first version of the maps, it is important to note the limitations associated with the assumptions used in the production of the maps. These include the following:

1. The magisterial district coverage is based on the 2002 Census of Agriculture Provincial Statistics and did not represent all total coverage, as accurate statistics were dependent on farmers that responded to the census. Data was therefore normalised to reflect actual crop coverage as reported by the FAO (i.e. the area of each crop type in a magisterial district was multiplied by the ratio of total national area reported by STATSSA to total national area reported by the FAO);

2. The methodology assumes that a specific pesticide was evenly distributed to a specific crop regardless of the magisterial district the crop was produced in. Pesticide use data as displayed in the maps may therefore not reflect the local variability of pesticide management practices found within a magisterial district;

3. Because the agricultural land cover does not discriminate between different crop types, pesticide use was aggregated up to a magisterial district level and assumed to be distributed across all agricultural land within a magisterial district. All agricultural land cover that fell within a magisterial district was therefore assigned a pesticide use category for the pesticide in question;

4. Crop production statistics may not have been available for all magisterial districts where a pesticide may have been applied to agricultural land, and therefore, are not displayed on the maps; and

5. Pesticide use estimates are based on market research data for the year 2014.

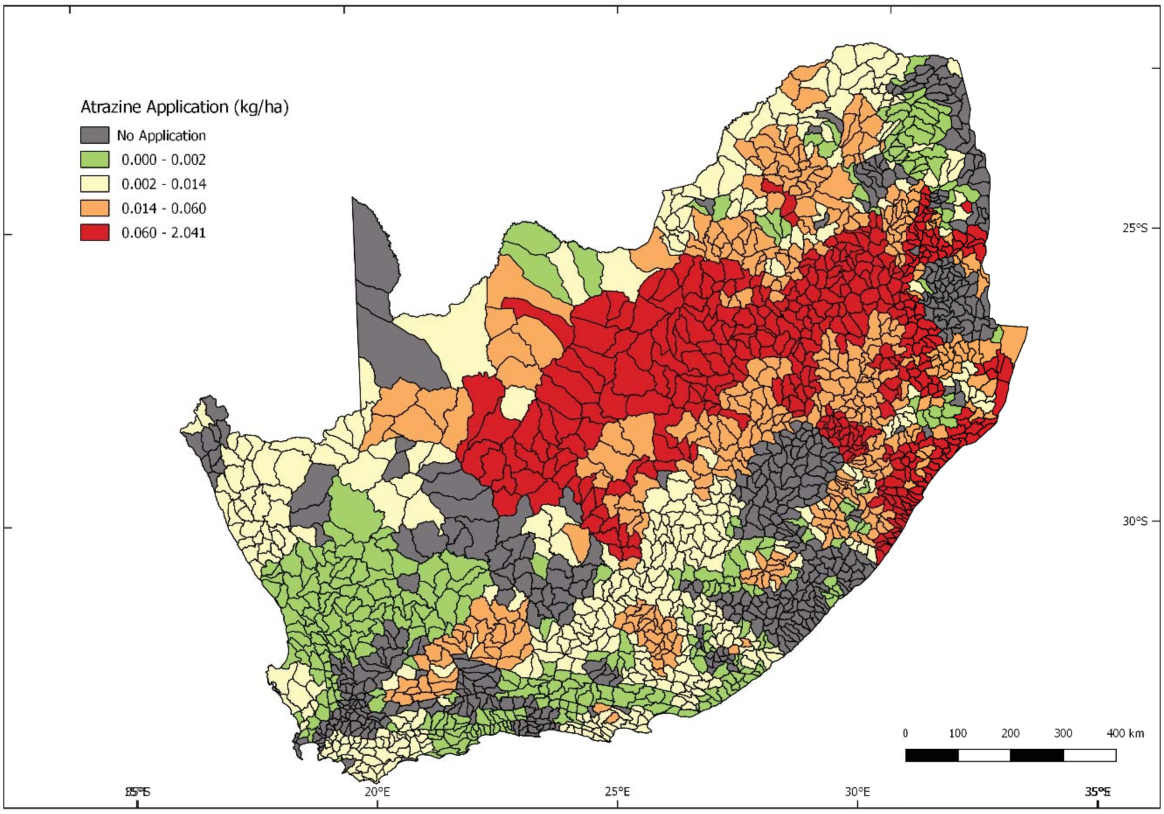

Figure 1-2: Example of map displaying estimated crop application rates of atrazine per quaternary catchment in South Africa.

1.3 PESTICIDE RISK MAPS

1.3.1 General approach

The development of pesticide risk maps for South Africa builds on the pesticide use maps produced in WRC Project No. K5/1956 (Dabrowski, 2015). National-level risk mapping was undertaken to identify specific catchments within South Africa with the greatest potential for impacts on aquatic biodiversity from normal agricultural use of pesticides. This a development on the maps of pesticide use produced in WRC Project No. K5/1956 in that the method aggregates the risk of all pesticides applied on all crops within a catchment to provide a more refined spatial overview of hotspot areas. This is an important step within the general approach adopted in the larger project framework, which is to initially identify priority areas where the implementation of management practices are most urgently required (Figure 1-1). Pesticide use as indicated by the pesticide use maps, length of river network, geographical variables (slope, soil and rainfall) and physicochemical (half-life and *KOC*) data will be integrated in a GIS to make first order predictions of pesticide concentrations in the river network of each quaternary catchment in South Africa. These concentrations will be compared with ecotoxicological data (algae, insects and fish) for each pesticide to determine the number of toxic units of the pesticide present in the system (toxic unit is the ratio of pesticide concentration to the specific toxicity value for a given pesticide). This will be done for every pesticide (for which use data is available) in every quaternary catchment. The total risk per catchment can be determined by summing the estimated toxic units for every pesticide applied in a catchment and is therefore representative of the aggregated risk posed by all pesticides applied in the catchment. This utility will enable users to identify hotspot areas/catchments based on the ability of pesticides to move into water resources and/or potential risk to aquatic ecosystem. As pesticide use is directly related to crop type, it will be possible to identify the contribution of different crops to the total aggregated risk. The selection of priority areas for management interventions can therefore be informed by the total toxic unit score for the catchment as well as important crops that contribute to the score. This information can be used in targeting monitoring and mitigation campaigns designed to protect the aquatic environment.

1.3.2 OECD runoff model

The Organisation for Economic Co-operation and Development (OECD) as part of their development of a pesticide risk indicator for both human health and the environment developed a simple model designed to estimate the percentage of an applied pesticide that leaves an agricultural field as runoff following a rainfall event (OECD, 1998).

1.3.2.1 Application in South Africa

The OECD model has been rigorously tested in the Lourens River catchment, Western Cape, South Africa. Dabrowski and Schulz (2003) used the model to estimate loadings and Predicted Environmental Concentrations (PECs) of azinphos-methyl in the main stem and tributaries of the Lourens River. PECs corresponded well with measured concentrations taken during monitored runoff events and demonstrates the potential of the model for use in risk assessment for registration purposes. An additional study conducted in the Lourens River catchment used the equation as an indicator to predict the relative mobility and occurrence of several pesticides in the river following runoff events (Dabrowski and Balderacchi, 2013). Samples were collected weekly at five sites from the beginning of the spraying season (October) until the beginning of the rainy season (April) and were semi-quantitatively analysed for relevant pesticides applied according to the local farmers spraying programme.

A comparison of indicator outputs to monitoring data showed that the OECD model could:

1. Differentiate between highly contaminated and less contaminated sites;
2. Accurately predict the relative exposure potential of specific pesticides across and within sites; and
3. Identify the most important route of transport for all pesticides at all sites.

In contrast to the Dabrowski and Schulz (2003) study, the aim of this study was not to estimate PECs but rather to provide a relative indication of exposure and associated risk. In this context, the model proved to be a reliable screening tool and could therefore be applicable in a lower tier assessment. Another study conducted in the Lourens River catchment examined the effect of erosion rills on the efficiency of vegetative buffer strips (Stehle *et al.*, 2016). The results showed that erosion rills are common in buffer strips adjacent to tributaries and represent concentrated entry pathways of pesticide runoff into the tributaries during rainfall events. Exposure modelling using the OECD runoff equation showed that measured pesticide surface water concentrations correlated significantly with runoff losses predicted by model scenarios in which buffer strip width was set to zero at sites with erosion rills. In contrast, no relationship between predicted runoff losses and in-stream pesticide concentrations were detected in the model scenario that neglected erosion rills and thus assumed efficient buffer strips.

Application of the OECD model in this context was able to show that erosion rills may substantially reduce buffer strip pesticide retention efficacies during runoff events. This suggests that the capability of buffer strips as a risk mitigation tool for runoff is largely over-estimated in current regulatory risk assessment procedures conducted for pesticide authorisation.

In summary, results from the above-mentioned studies indicate that the OECD model can be reliably used to estimate pesticide concentrations in runoff in South African conditions.

1.3.2.2 Application internationally

The Pesticide Impact Rating Index (PIRI) developed by CSIRO, Australia is an example of a risk indicator that is regularly applied in managing pesticides in agricultural catchments (Kookana *et al.* 2005). The index integrates built in toxicity and physicochemical data with user inputs of application data (i.e. application rate, frequency of application) and readily available geographical data (e.g. soil type, rainfall amount, slope, etc.) to provide a relative index of a mobility and risk for a number of pesticides. Runoff transport is estimated using the OECD runoff formula by Reus *et al.* (1999).

Figure 1-3 provides a visual representation of the relative mobility and risk of herbicides applied to sugarcane. By entering geographical data specific to several different catchments (e.g. soil type, slope, etc.) the relative risk of different pesticides applied across the different catchments can also be determined. In addition to the PIRI model, the Australian Pesticides and Veterinary Medicines Authority (APVMA) uses the OECD runoff model in the risk assessment process for the registration of pesticides in Australia (Lee-Steere, 2007).

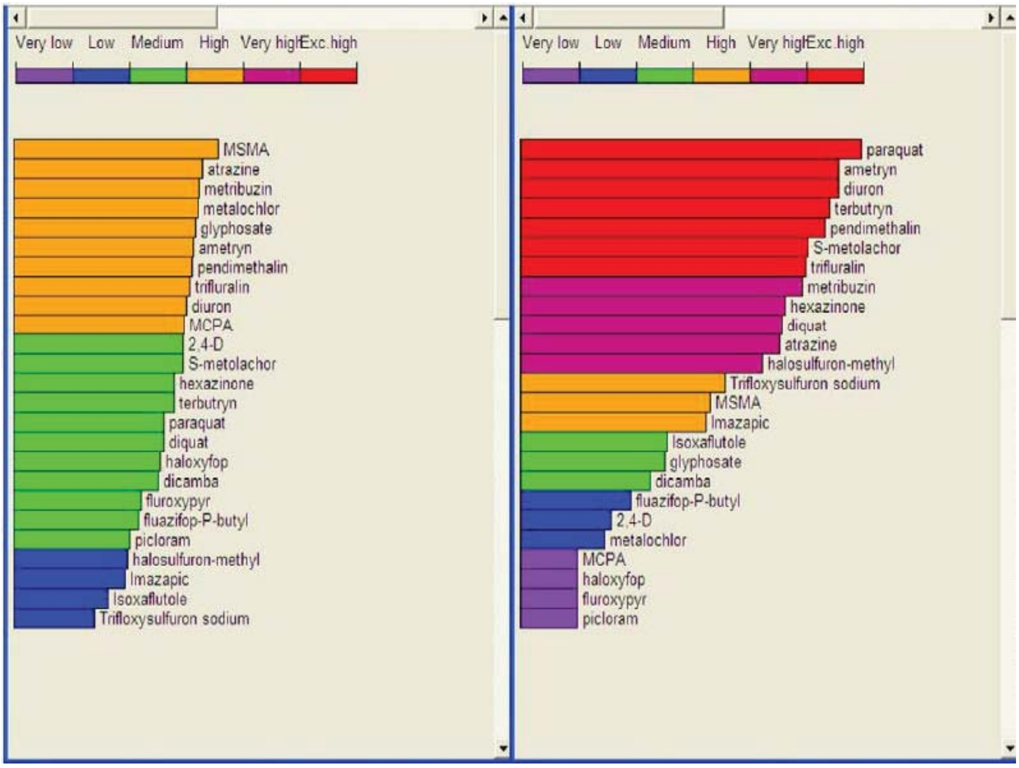

Figure 1-3: Example of output of the PIRI risk indicator showing a comparison of the relative mobility (left) and risk (right) of different pesticides applied to a crop (Kookana et al. 2005)..

1.3.3 Estimating pesticide loss

The equation essentially consists of empirical and physical components, including a hydrological model predicting runoff amounts, catchment related factors, which influence the extent of runoff, a first-order kinetic model describing the degradation of a pesticide and a term referring to the proportion of pesticide occurring in the water phase of runoff.

The equation is as follows:

$$L\%_{runoff} = \frac{Q}{P} \times f \times \exp\left(-3 \times \frac{ln2}{DT_{50\ soil}}\right) \times \frac{100}{(1 + Kd)}$$

Where
$L\%_{runoff}$ = percentage of application dose being available in runoff water as a dissolved substance;
Q = runoff amount (mm) calculated according to hydrological models (Lutz (1984) and Maniak (1992));
P = precipitation amount (mm);
DT_{50soil} = half-life of active ingredient in soil (d);
$f = f1 \times f2 \cdot x\ f3$, the correction factor reflecting the influence of slope ($f1 = 0.02153 \times slope + 0.001423 \times slope^2$), plant interception ($PI$), the percentage of applied pesticide intercepted by trees in the orchards ($f2 = 1 - PI/100$), and buffer width ($f3 = 0.83^{WBZ}$, and WBZ is the width of buffer zone [m]; if the buffer zone is not densely covered with plants, the width is set to zero);
t = time (d) between application and rainfall;
$Kd = (Koc \times \%OC)$, a factor reflecting the tendency of the pesticide to bind to organic carbon in the soil, where Koc is the sorption coefficient of the active ingredient to organic carbon (mL/g) and $OC\%$ is the organic carbon content of the soil.

Tables developed by Lutz (1984) and Maniak (1992) are used to obtain the Q value corresponding to rainfall events above 10 mm (Table 1-4). The methodology used to derive Q in this equation is relevant to German conditions. Other approaches could be used to estimate runoff amounts (e.g. the Soil Conservation Service Curve Number approach). While this is a relatively simple model, the Australian Pesticides and Veterinary Medicines Authority (APVMA) use this model for registration of pesticides in Australia (Lee-Steere, 2007).

Table 1-4: Runoff volumes (mm) for sandy and loamy soils according to the model of Lutz (1984) and Maniak (1992).

Rainfall (mm)	Sandy Soil	Loamy Soil
6	0.1	0.45
8	0.28	0.82
10	0.54	1.29
12	0.88	1.86
14	1.29	2.51
16	1.78	3.24
18	2.32	4.05
20	2.92	4.93
22	3.58	5.88
24	4.29	6.88
26	5.04	7.95
28	5.84	9.06
30	6.69	10.23
32	7.57	11.45
34	8.48	12.7
36	9.44	14
38	10.42	15.34
40	11.43	16.71
42	12.47	18.11
44	13.53	19.54
46	14.62	21.01
48	15.73	22.5
50	16.87	24.01

Rainfall (mm)	Sandy Soil	Loamy Soil
55	19.78	27.89
60	22.79	31.9
65	25.89	36.01
70	29.06	40.2
75	32.29	44.47
80	35.57	48.8
85	38.9	53.18
90	42.26	57.6
95	45.65	62.06

1.3.4 Model input data

1.3.4.1 GIS data

Sources of all relevant GIS data are included in Table 1-5. Agricultural land cover was extracted from the 2009 National Land Cover and was used to identify the location of agricultural crops per quaternary catchment. This layer was used to extract corresponding soil type (Figure 1-4), organic carbon content (Figure 1-5) and slope data (Figure 1-6) required for the runoff calculation. The OECD runoff equation determines the total amount of runoff (mm) following a rainfall event based on whether the soil type is a sand or loam soil. The WR90 soil coverage was therefore used to identify soils according to these two categories (Table 1-6, Figure 1-4).

Table 1-5: Source of GIS data used to extract geographical information required to predict.

GIS Layer	Source
Agricultural Land Cover	2013-14 South African National Land-cover dataset
Soil Type	Derived from WR90 Soil Map
Organic Carbon Content	ARC-ISWC
Slope	30 m SRTM Digital Elevation Model

Table 1-6: WR90 soil texture classes used to define loamy and sandy soils for the purposes of predicting runoff related pesticide input using the OECD model.

Soil Type	WR90 Soil Texture Class
Loamy Soils	Sandy Clay – Clay (SaCl – Cl)
	Sand Clay Loam (SaClLm)
	Sandy Loam – Sandy Clay Loam (SaLm – SaClLm)
	Sandy Loam (SaLm)
	Sandy Loam – Sandy Clay Loam (SaLm – SaClLm)
	Sand Clay (SaCl)
Sandy Soils	Sand – Sandy Loam (Sa – SaLm)
	Loamy Sand – Sandy Loam (LmSa – SaLm)
	Sand – Loamy Sand (Sa – LmSa)
	Sand (Sa)
	Loamy Sand (LmSa)

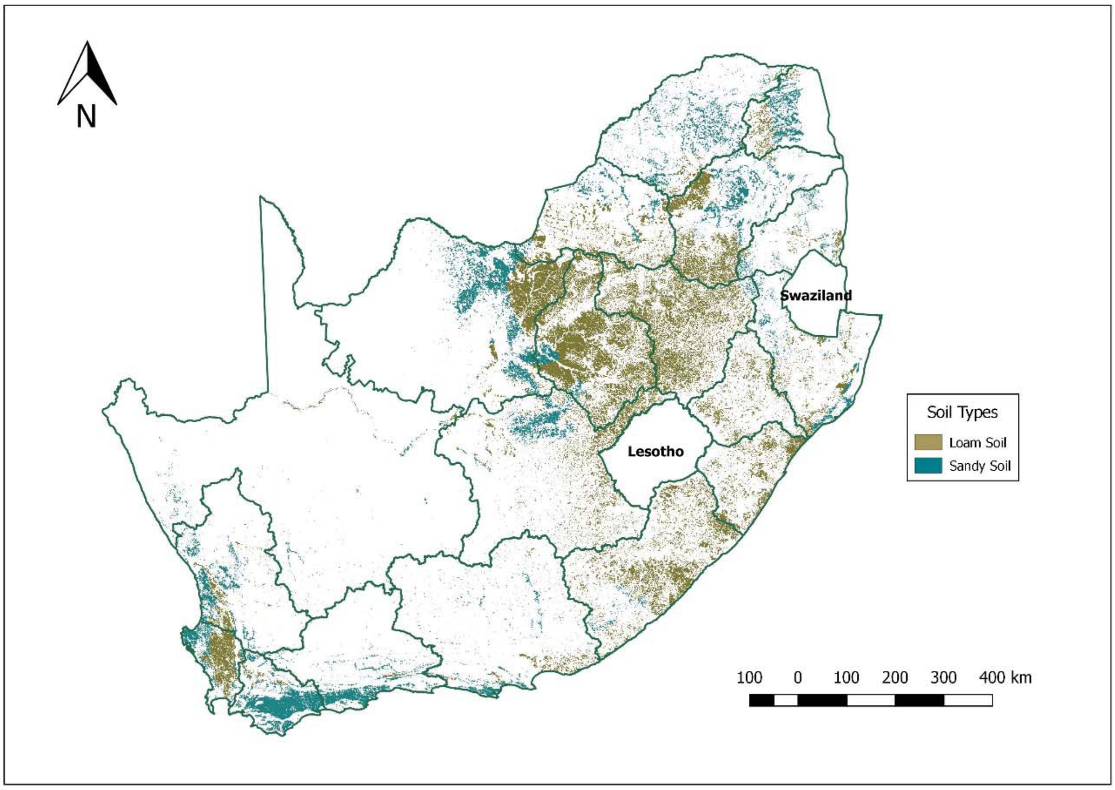

Figure 1-4: Map illustrating the soil categories derived for predicting runoff related pesticide losses in South Africa.

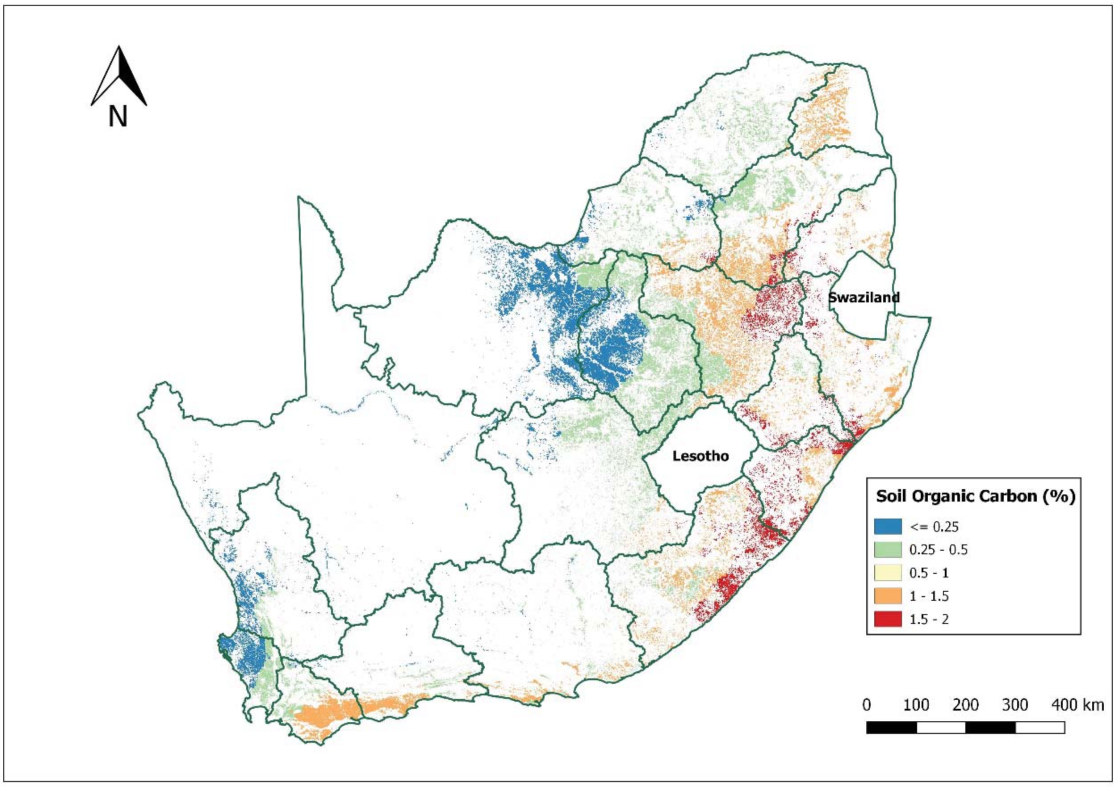

Figure 1-5: Map illustrating the organic carbon content (percentage) of soil covered by agricultural land use in South Africa.

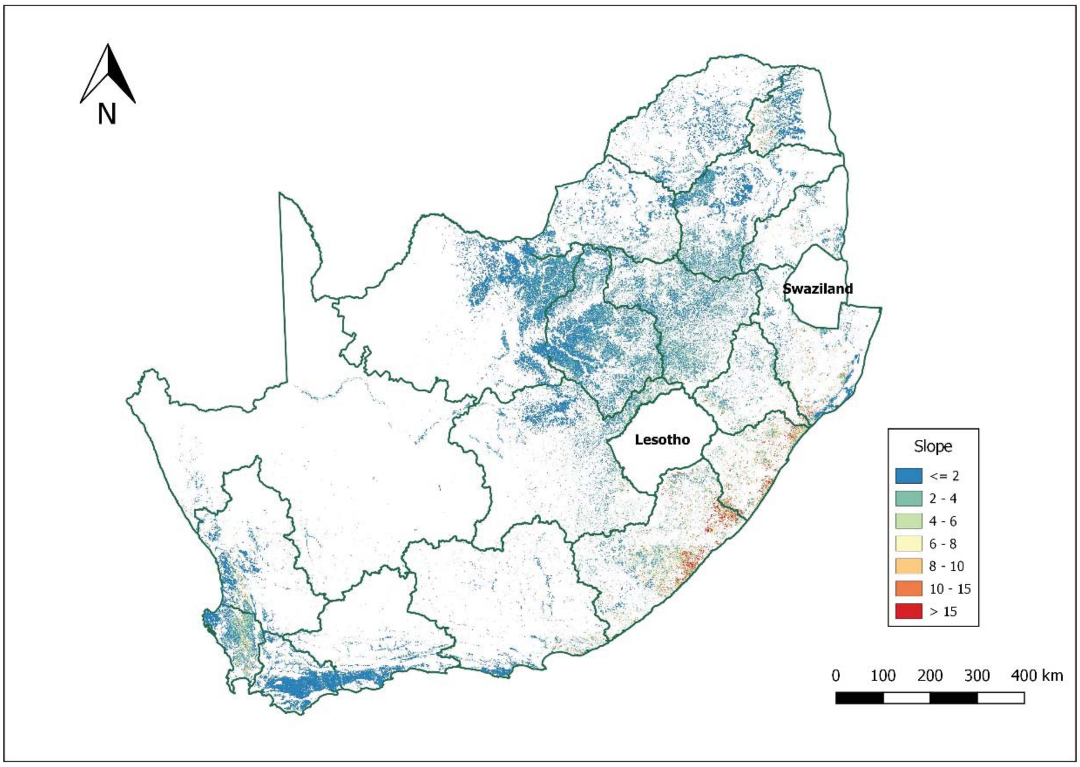

Figure 1-6: Map illustrating slope categories (percentage) of agricultural land in South Africa.

1.3.4.2 Pesticide physicochemical data

Physico-chemical data (half-life and *KOC*) for each pesticide was obtained from the Pesticide Properties Database (Lewis *et al.* 2016) and captured in an excel database. Toxicity data for algae, *Daphnia magna* and fish was also obtained.

1.3.5 GIS processing

All GIS processing was done using QGIS 2.18 according to the following steps:

1. An agricultural land cover raster was extracted from the national land cover data set.

2. The agricultural land cover raster was overlaid with the soil type raster to assign a soil type (e.g. loamy or sandy soil) to each agricultural land cover pixel (Figure 1-4).

3. The agricultural soil raster (Figure 1-4) was overlaid with the slope raster (Figure 1-6) to assign a slope percentage to each agricultural soil pixel. Zonal statistics was then used to calculate the average slope for each agricultural soil type in each quaternary catchment. This data was exported into an excel database.

4. The agricultural soil raster (Figure 1-4) was overlaid with the organic carbon raster (Figure 1-5) to assign an organic carbon content (percentage) to each agricultural soil pixel. Zonal statistics was then used to calculate the average organic carbon percentage for each agricultural soil type in each quaternary catchment. This data was exported into an excel database.

1.3.6 Predicted environmental load (PEL)

Pesticide application data per quaternary catchment (Section 1.2.2), physicochemical data (Section 1.3.4.2) and summarised geographical date per quaternary catchment (Section 1.3.5) were included in an excel database in which the runoff calculations were performed using the OECD formula (Section

Error! Reference source not found.). The formula was applied for each pesticide applied to agricultural land under each soil type (i.e. sand and/or loam) in each quaternary catchment. The final output was the percentage of applied pesticide being available in runoff water ($L\%_{runoff}$). The following assumptions were made for predicting pesticide runoff losses:

- Calculations assumed a 20 mm rainfall event
- Pesticide application had taken 3 days prior to the rainfall event
- Plant interception (PI) was assumed to be 80%.

The PEL refers to the total amount of each pesticide (x) washed off from agricultural crops located in each quaternary catchment (y) into adjacent water bodies:

$$PEL_{x,y} = \frac{L\%_{x,y}}{100} \times (PApp_{x,y} \times ALC_y)$$

Where $L\%$ = estimated percentage of applied pesticide lost because of runoff and was calculated according to the equation in Section 1.3.3; $PApp$ = the application rate of the pesticide (kg/ha) and ALC = the total agricultural land cover (ha). The calculation of $L\%$ used average slope and organic carbon content values for each soil type in each quaternary catchment as described in Section 1.3.5.

PEL calculations were performed separately for loam and sandy soils under agricultural land cover in each quaternary catchment. This is because estimated runoff volumes (Q) vary according to each soil type (see Section 1.3.3). PELs for each soil type were then combined (i.e. summed together) to give a final PEL per quaternary catchment.

1.3.7 Estimating predicted environmental concentrations (PECs)

PECs were calculated based on the PEL and estimated hydrological discharge volumes for each quaternary catchment. The following assumptions were made for estimating discharge volume:

- Runoff volumes were estimated according to the OECD model 20 mm rainfall event
- The rainfall event was assumed to last for 1 hour
- Discharge in surface waters of the quaternary catchment were assumed to be equal to the mean hourly runoff (calculated from the mean annual runoff (MAR) for the catchment).

The PEC for each pesticide (x) in each quaternary catchment (y) was calculated as follows:

$$PEC_{x,y} = \frac{(PEL_{x,y} \times 10^6)}{V_y}$$

Where 10^6 is a conversion factor to convert kg to mg and V is the total volume of water (in litres) in the quaternary catchment (y) in which the pesticide is dissolved.

The volume of water was assumed to be equal to the sum of the volume of water flowing in surface waters of the catchment (V_{stream}) and the volume of water derived from runoff (V_{runoff}) for a period of 1 hour:

$$V = V_{stream,y} + V_{runoff,y}$$

V_{stream} was derived from the estimated MAR (m^3) for each quaternary catchment:

$$V_{stream,y} = \frac{(MAR_y \times 10^3)}{365 \times 24 \times 60}$$

Where 10^3 is a conversion factor to convert m^3 to litres; MAR = the mean annual runoff (m^3) for the quaternary catchment.

The volume of water entering water bodies in the quaternary catchment because of the rainfall event (V_{runoff}) was calculated as follows:

$$Volume_{runoff,y} = \left(0.00493 \times \ ALC_{loam,y} \times 10^4 \times 10^3\right) + (0.00292 \ \times ALC_{sand,y} \times 10^4 \times 10^3)$$

Where 0.00493 is the runoff amount (m) on loamy soils and 0.00292 is the runoff amount (m) on sandy soils; ALC is the agricultural land cover (ha); 10^4 is a conversion factor to convert hectares to m^2 and 10^3 is a conversion factor the convert m^3 to litres.

1.3.8 Calculation of toxic units

Toxic units (TUs) were calculated for each pesticide (x) applied in each quaternary catchment (y). Toxic units were calculated for three taxonomic groups (z i.e. algae, invertebrates and fish) according to the following formula:

$$TU_{x,y,z} = \frac{PEC_{x,y}}{TOX_{x,z}}$$

Where TOX is the acute EC50 for algae and *D. magna* and the acute LC50 for fish (Lewis *et al.*, 2016). A single toxic unit value was calculated for each taxonomic group (z) per quaternary catchment (y) by summing the toxic units calculated for each pesticide (x) applied in the quaternary catchment:

$$TU_{y,z=} \sum_{x=1}^{n} TU_{x,y}$$

1.4 RESULTS

Maps illustrating the relative risk of pesticide application per quaternary catchment to algae, invertebrates and fish are presented in Figure 1-7, Figure 1-8 and Figure 1-9, respectively. In general, risks are highest for the following areas:

- Berg, Breede and Olifants primary catchments in the south-western Cape
- Along the lower reaches of the Orange River in the vicinity of Upington in the Lower Orange primary catchment
- Upper and Middle Vaal primary catchments
- The eastern sections of the Luvulvhu and Letaba and Inkomati primary catchments
- The Usuthu to Mhlatuze, Tugela and Mvoti to Umzimkulu primary catchments.
- Quaternary catchments located in the southern section of the Fish to Tsitsikamma primary catchment

Risks generally decrease in the order from algae to invertebrates to fish. This is a function of the high quantities of herbicides (and increased toxicity to algae) used on South African crops in comparison to fungicides and insecticides, which are generally less toxic towards algae. The maps as presented below provide an initial assessment in identifying priority areas where pesticide use may be impacting on aquatic ecosystem health. Databases produced as part of this deliverable can be used to identify further, which specific pesticides contribute most towards the Toxic Unit value for a quaternary catchment of interest. For example, pesticide application in quaternary catchments G10D, G21C and G21E (Berg River primary catchment) is highlighted as being very high risk towards fish (Figure 1-9). This is of concern given the high prevalence of endemic, endangered fish species that generally occur in the south-western Cape. Interrogation of the toxic unit database (ToxUnits.xlsl) indicates that for quaternary catchment G10D (as an example), three pesticides (gamma-cyhalothrin, chlorpyrifos and esfenvalerate) clearly contribute significantly towards the total Toxic Unit score for the catchment (77.9% of the total) (Table 1-7).

Table 1-7: The contribution of the top ten pesticides that contribute towards the total Toxic Unit score for the G10D quaternary catchment.

Active Ingredient	Toxic Units	Contribution to the total Toxic Unit score (%)
Gamma-cyhalothrin	0.537	39.2
Chlorpyrifos	0.306	22.3
Esfenvalerate	0.225	16.4
Cypermethrin	0.079	5.8
Thiram	0.048	3.5
Chlorfenapyr	0.032	2.3
Copper-sulphate	0.023	1.7
Methidathion	0.014	1.0
Azinphos-m	0.013	0.9
Copper-hydroxide	0.013	0.9

The combination of resources produced as part of this deliverable are clearly an effective means of:

1. Identifying and/or prioritising catchments where agricultural pesticide use may pose an unacceptable risk to aquatic biota.

2. Identifying specific pesticides that contribute the greatest potential risk to aquatic biota.

3. Designing appropriate monitoring and management programmes aimed at mitigating risks in the catchment area.

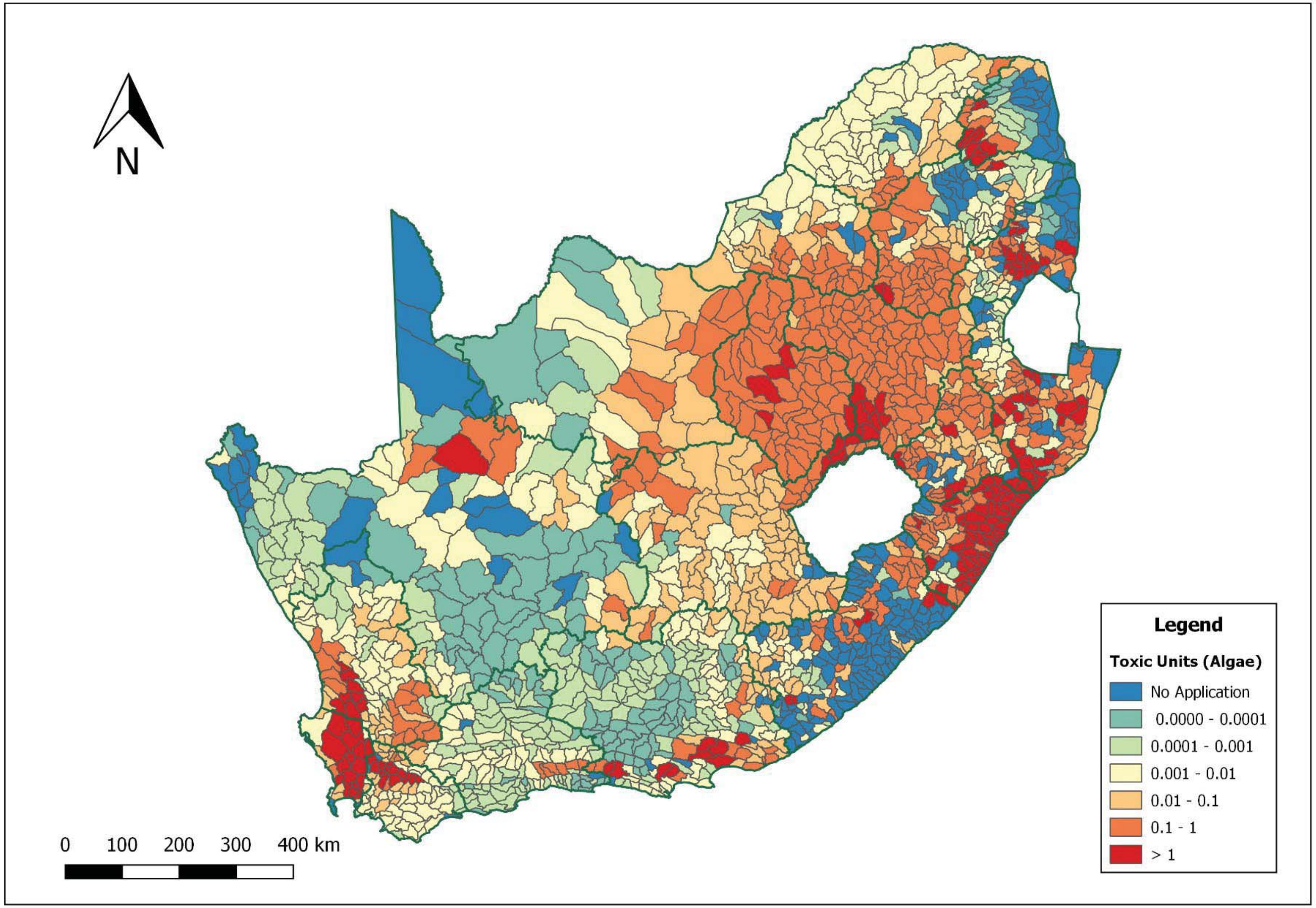

Figure 1-7: Maps showing the potential risk to algae following exposure to pesticides via runoff based on pesticide use data for the year 2014.

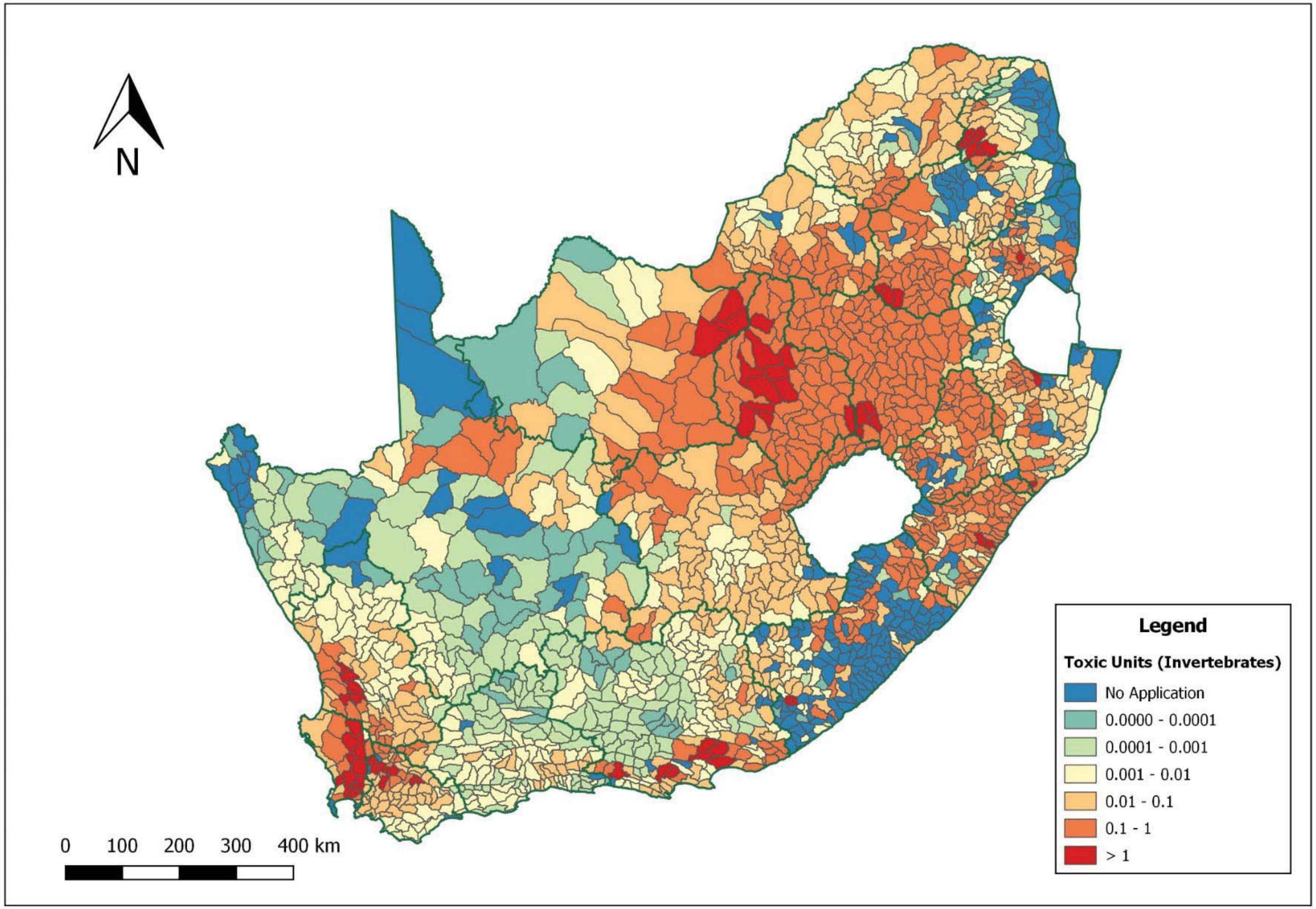

Figure 1-8: Maps showing the potential risk to Daphnia magna following exposure to pesticides via runoff based on pesticide use data for the year 2014.

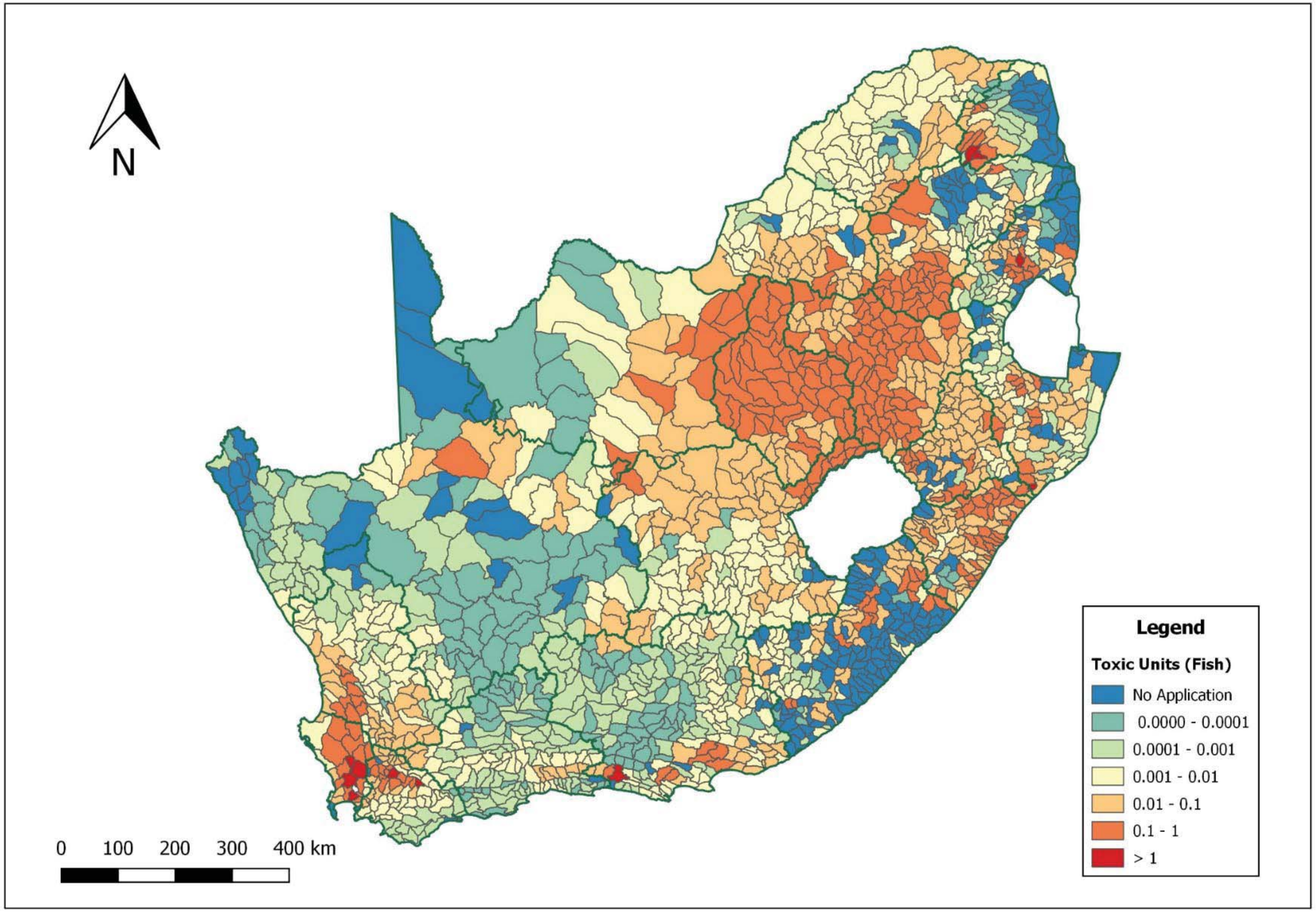

Figure 1-9: Maps showing the potential risk to fish following exposure to pesticides via runoff based on pesticide use data for the year 2014.

1.4.1 Data Products

Table 1-8 provides a summary of electronic outputs produced as part of the development of pesticide risk maps for South Africa.

Table 1-8: Summary of data products (Excel databases and GIS metadata) produced as part of the development of pesticide risk maps for South Africa.

File Name	Description
PestApp_RSA_2014.xlsx	Excel database of total pesticide application per crop for South Africa (data obtained from GfK Kynetec).
PestApp_MD_2014.xlsx	Excel database of pesticide application per magisterial district (kg and kg/ha).
PestApp_Quat_2014.xlsx	Excel database of pesticide application per quaternary catchment (kg and kg/ha).
PestTox.xlsx	Excel database of pesticide physicochemical (half-life, water solubility and KOC) and toxicity (EC50 for algae, *Daphnia magna* and fish) data used to predict runoff PECs and associated risk to aquatic biota.
ToxicUnits.xlsx	Excel database of calculated toxic units per active ingredient per quaternary catchment for algae, invertebrates and fish.
PestApp_MD_2014.shp	GIS shapefile containing data of pesticide application rates (kg/ha) per active ingredient applied in each magisterial district of South Africa.
PestApp_Quat_2014.shp	GIS shapefile containing data of pesticide application rates (kg/ha) per active ingredient applied in each quaternary catchment of South Africa.
Quat_TUs.shp	GIS shapefile containing data of the total toxic units (for algae, fish or invertebrates) for all pesticides applied in a quaternary catchment.
Quat_AlgaeTUs.shp	GIS shapefile containing calculated toxic units (for algae) per active ingredient applied in each quaternary catchment of South Africa.
Quat_InvertTUs.shp	GIS shapefile containing calculated toxic units (for invertebrates) per active ingredient applied in each quaternary catchment of South Africa.
Quat_FishTUs.shp	GIS shapefile containing data of the toxic units (for fish) per active ingredient applied in each quaternary catchment of South Africa.

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CHAPTER 2: DEVELOPMENT OF PESTICIDE RISK INDICATOR TO DETERMINE THE RELATIVE RISKS OF PESTICIDES APPLIED IN AGRICULTURAL CATCHMENTS

By

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2.1 INTRODUCTION

Nonpoint source agricultural pollution is generally considered one of the major threats to surface water quality in rural areas (Loague *et al.*, 1998). Nutrients, sediments and pesticides potentially enter aquatic environments via runoff, leaching and spray drift and pose a risk to the communities that inhabit them. Of all nonpoint source pollutants, pesticides are among the most crucial chemical stressors, simply because of their extremely high toxicity to many non-target aquatic organisms (e.g. algae, fish and macroinvertebrates).

Numerous studies have now documented the occurrence of pesticides in South African surface waters. The most extensive research has been performed in the Lourens River, in the Western Cape of South Africa. Studies have shown that current-use insecticides frequently enter the river via runoff and spray drift (Schulz, 2001a; Schulz, 2001b; Dabrowski and Schulz, 2003). Although contamination is transient, field, experimental microcosm (Schulz *et al.*, 2002) and in-situ bioassay studies (Schulz, 2003) have shown that measured pesticide levels pose significant risks to aquatic macroinvertebrate communities in the Lourens River.

Another study measured high levels of chlorpyrifos and endosulfan in several agricultural catchments throughout the Western Cape (London *et al.*, 2000). A more recent study, where monitoring was conducted quarterly in three different catchments (Letsitele, Komati and Vals River catchments in Limpopo, Mpumalanga and Free State, respectively), each representative of different crop types (sub-tropical fruit, sugar cane and citrus, maize), showed regular contamination by current-use pesticides in all three catchments (Dabrowski, 2015).

Despite these findings, the potential impact of pesticides in South African surface waters has been a low priority and is generally not considered in aspects of water resource management, especially concerning routine monitoring. Even in developed countries, despite strict regulatory procedures, pesticides are frequently detected in surface waters at concentrations that exceed environmentally acceptable levels (Stehle and Schulz, 2015). Although intensive monitoring can identify pesticide impacts, the cost of sampling and analysis makes this a highly costly exercise (particularly in the context of less developed countries such as South Africa). There is therefore a need to develop cost effective decision support methods of predicting the environmental risks of pesticide use at a field or catchment scale, which can be used to prioritise specific pesticides for monitoring purposes and identify spatial patterns of contamination.

At a farm management level, substitution of use of high-risk pesticides with those that pose lower risk is one of several operational Best Management Practices (BMPs) aimed at reducing pesticide risks to the environment. Risk is dependent not only on the toxicity of a pesticide, but also on the quantity of use, and the mobility of the pesticide in the environment. A highly toxic pesticide used in low quantities, with low mobility for example, could pose a lower risk to the environment than a less toxic pesticide used in higher quantities with higher mobility. Ultimately, the combination of the concentration of the pesticide in the water body and its toxicity threshold will determine the level of risk, which should be used as the basis upon which to make decisions on substituting one pesticide for another.

2.2 RISK INDICATORS

Prioritisation of pesticide risks (i.e. for designing monitoring programmes) or the substitution of pesticides requires the need for a comparative assessment of different pesticides that can be potentially applied to a pest on a crop. This approach is relevant given that several pesticides may be registered for use against a specific pest on a specific crop, each of which will vary in terms of its application rate, mobility (i.e. physicochemical properties) and toxicity to non-target biota. Environmental pesticide risk indicators provide a relative indication of the impact of pesticides (Levitan *et al.*, 1995), with an emphasis on relatively few and simple data input parameters (Kookana *et al.*, 2005). Risk indicators vary greatly in terms of their purpose and methodologies, and are often very broad in scope covering, for example, the impact on aquatic organisms, soil organisms, bees, occupational exposure and human health effects (Reus *et al.*, 2002). With respect to aquatic ecosystems, risk indicators are generally regarded as lower tier risk assessment tools that provide a relative assessment of the environmental impact of pesticides through integration of multiple catchment-scale factors that influence the fate, transport and toxicity of pesticides. These factors include site specific geographical conditions (e.g. soil type, soil organic matter content, water input, slope of land, soil loss, recharge rate, depth of water table etc), ecotoxicological (e.g. LC50 data or species sensitivity distributions) and environmental fate (e.g. half-life and *KOC* values) properties and pesticide use data (Sánchez-Bayo *et al.*, 2002; Sala and Vighi, 2008). Empirical pesticide transport equations integrate these factors and calculate pesticide loading and associated PECs via different routes of pesticide transport (i.e. spray drift and runoff). By comparing PECs to a toxicity endpoint for each pesticide (e.g. acute LC50 for aquatic biota), the relative risk of different pesticides can be made. The objective in such an approach is to make a relative estimate of the differences in risk associated with the use of the different pesticides. This can allow a farmer or catchment manager to identify which of several different pesticides pose the lowest risk to the environment. Similarly, water resource/catchment managers could use outputs to identify which high risk pesticides could be potentially used in a catchment based on the type of crops produced in the catchment.

2.3 AIMS & OBJECTIVES

An output of WRC Project No. K5/1956 was the development of a prioritisation tool that allowed for the prioritisation of pesticides based on their quantity of use, environmental mobility and risk to human health (Dabrowski et al, 2014). The tool was designed to identify priority pesticides at a very coarse, national level. The overall aim of this current project requires a more refined catchment- or farm-level approach and is focussed on aquatic ecological health as opposed to human health.

The aim of the risk-based indicator developed in this deliverable is to:

1. Assist in reducing the impacts of agricultural chemicals in water resources by allowing farmers and catchment managers to easily assess the risk of different pesticides to the environment and therefore choose pesticides that pose the least risk to the environment.

2. Assist catchment managers in prioritising high-risk pesticides within a catchment based on the crops produced in the catchment.

A key component of this deliverable was to develop a risk assessment methodology that compliments existing guidelines of pesticide application for different pests on different crops, as provided by Association of Veterinary and Crop Associations of South Africa (AVCASA) and CropLife South Africa. These pesticide application guidelines give recommended application rates for all pesticides (including insecticides, fungicides and herbicides) registered for use on a specific pest on a specific crop. For example, up to eight different pesticide are registered for use for control of false codling moth on peaches. These pesticides vary significantly in terms of their recommended application rate (Table 2-1), physicochemical properties and toxicity to aquatic biota (Table 2-2). Application rates are a key input to assessing the risk of a chemical to the environment. Using these application rates in combination with other parameters that influence exposure (i.e. physicochemical properties) and by using empirical pesticide transport equations, relative predictions of pesticide loading associated with use of the different pesticides will be made. Using a deterministic risk assessment approach, the relative risk of the different pesticides registered for use on a pest for a particular crop can be identified (i.e. identify which of the 8 insecticides registered for use on false codling moth pose the least risk to aquatic environment).

The output of this risk assessment is therefore an additional source of information to the guidelines provided by CropLife and AVCASA so that farmers can not only identify what pesticides are registered for use for a particular pest on a particular crop, but can then also identify which of these pesticides poses the lowest risk to the environment. Similarly, water resource/catchment managers could use the outputs to identify which high risk pesticides could be potentially used in a catchment based on the type of crops produced in the catchment.

Table 2-1: An example of pesticide application guidelines for controlling false codling moth on peaches.

Pesticide	**Formulation**		**Dosage**	**Application directions and *minimum time between last application and harvest or feeding (F)**
	Type and grams active ingredient		**Per 100 ℓ water or as indicated**	**Unless otherwise indicated dilution directions are for high volume application**
alpha-cypermethrin	EC	100 g.L^{-1}	HV 5 mL	Early cultivars: full cover spray at 14-day intervals beginning 6 weeks prior to harvest. Late cultivars: full cover spray at 14-day intervals beginning 8 weeks prior to harvest. In summer rainfall region application should commence not later than 3rd week of December
	SC	100 g.L^{-1}	HV 5 mL	
azinphos-methyl	SC	200 g.L^{-1}	HV 125 mL	Early cultivars: full cover spray 5 and 3 weeks prior to harvest Late cultivars: full cover spray 7, 5 and 3 weeks prior to harvest Do NOT apply to fruit destined for export. NOT for home .garden use
	SC	350 g.L^{-1}	HV 70 mL	
	WP	350 g.kg^{-1}	HV 70 g	
beta-cypermethrin	EC	100 g.L^{-1}	HV 6,5 mL	Early cultivars: full cover spray at 14-day intervals beginning 6 weeks prior to harvest Late cultivars: full cover spray at 14-day intervals beginning 8 weeks prior to harvest. In summer rainfall region application should commence not later than 3rd week of December
cypermethrin	EC	20 g.L^{-1}	10 mL/10 water	Home garden use
	EC	200 g.L^{-1}	HV 5 mL	Early cultivars: full cover spray at 14-day intervals beginning 6 weeks prior to harvest Late cultivars: full cover spray at 14-day intervals beginning 8 weeks prior to harvest. In summer rainfall region spray should commence not later than 3rd week of December
			1 mL/10 ℓ water	Home garden. Apply as a full cover spray at 75% petal fall. Repeat at 14 - 21 day intervals.
methomyl	SL	200 g.L^{-1}	HV 225 mL	Early cultivars: full cover spray 4 and 2½ weeks prior to harvest Late cultivars: full cover spray 6, 4 and 2½ weeks prior to harvest. NOT for home garden use
	SP	900 g.kg^{-1}	HV 50 g	
spinetoram	WG	250 g.kg^{-1}	20 g	Apply as a full cover spray in 1 - 3 applications
triflumuron	SC	480 g.L^{-1}	HV 10 mL	Chitin inhibitor. Apply 2 full cover sprays 6 and 3 weeks prior to expected harvest
zeta-cypermethrin	EW	100 g.L^{-1}	HV 5 mℓ	Early cultivars: full cover spray at 14-day intervals beginning 6 weeks prior to harvest Late cultivars: full cover spray at 14-day intervals beginning 8 weeks prior to harvest. In summer rainfall region spray should commence not later than 3rd week of December

Table 2-2: Physicochemical properties and toxicity endpoints for insecticides registered for control of false codling moth on peaches

Active Ingredient	Half-Life (days)	*KOC*	Algae - Acute EC50 ($mg.L^{-1}$)	Daphnia - Acute EC50 ($mg.L^{-1}$)	Fish - Acute LC50 ($mg.L^{-1}$)
alpha-cypermethrin	35	57889	0.1	0.0003	0.0028
azinphos-methyl	10	1000	7.15	0.0011	0.02
beta-cypermethrin	10		56.2	0.00026	0.03
cypermethrin	60	76344	0.1	0.00015	0.00069
methomyl	7	25.2	60	0.0076	0.63
spinetoram	No Data				
triflumuron	22	2757	0.025	0.0016	320
zeta-cypermethrin	21	121786	1	0.00014	0.00069

2.4 GENERAL APPROACH

The approach adopted in the development of the indicator involves the development of an Excel based software tool that provides an indication of the relative risk of pesticides registered for the treatment of a specific pest on a specific crop. The tool enables the user to select a combination of pest and crop, for which a list of registered active ingredients is automatically generated. Based on the input of several easily obtainable input parameters, the tool provides a relative assessment of the risk of each pesticide to aquatic ecosystem health. This risk is estimated by calculating a PEC for each pesticide, which is compared to a toxicity concentration for each pesticide. The ratio of the PEC to the toxicity value, gives an indication of the risk of the pesticide and comparison of ratios for all pesticides provides a means to compare risks between pesticides.

The calculation of the PEC assumes contribution of pesticide loads derived from runoff and spray drift. The load of pesticide derived from each transport pathway is calculated by the spreadsheet, using simple, empirical formulae. These loads are expressed as a concentration through the input of basic stream dimension and flow parameters.

The spreadsheet relies on three databases, which have been developed as part of this deliverable and include the following:

- A database of active ingredients registered for use on specific pests for specific crops;
- A pesticide physicochemical database;
- A pesticide toxicity database;
- A database of crop-specific pesticide application rates.

Data used to develop each of the above-mentioned databases is discussed in more detail in sections below.

2.5 CALCULATION OF PEC

2.5.1 OECD runoff model

The OECD model as described in Section **Error! Reference source not found.** was used to estimate the percentage of the applied pesticide that was lost in runoff.

2.5.1.1 Data Requirements

Physicochemical data

Physicochemical properties greatly influence the fate and transport of pesticides in terrestrial and aquatic environments. These properties vary significantly from one pesticide to another, leading to differences in the mobility and exposure potential of pesticides in aquatic environments. The most important physicochemical properties required by the OECD model and that determine the fate and movement of pesticides in the soil, are the sorption coefficient of the active ingredient to organic carbon (*KOC*) and half-life (DT_{50soil}) (Pionke and Chesters 1973; Gavrilescu 2005; Müller *et al.* 2007, Gassmann *et al.* 2015).

Environmental fate data should ideally be generated under conditions that would be expected to occur in the country/area where the pesticide is being registered. While this is often the case in countries from North America and the European Union, this is not necessarily so for other countries. For example, while this data is required for registration of pesticides in South Africa, the data is often generated in countries outside of South Africa. There is often a degree of reservation about using physicochemical data from more temperate climates as combinations of the chemical properties as well as site-specific environmental conditions (e.g. soil properties, temperature, etc.) also play a role in the fate and behaviour of pesticides (Daam and Van den Brink, 2010). These conditions vary greatly among different agro-ecological zones making the direct extrapolation of data between geographical regions very challenging (Ahmad and Kookana, 2007). However, Wauchope *et al.* (2002) found that while there is often variation in the Koc value of a specific pesticide (as an example), the values are adequate for discriminating between the relative mobility of a number of different pesticides. A study on the behaviour of three pesticides in South African soils reported similar *KOC* values to those reported in the international literature, while half-lives were generally longer in South African soils (Meinhardt, 2009). Other studies performed in South Africa have also shown good correspondence between Koc values and partitioning of pesticides between the sediment and water phase (Dabrowski *et al.*, 2002; Sereda and Meinhardt, 2005). These studies indicate that the international values provide a relatively good indication of pesticide behaviour in soils of South Africa and have been used successfully in predicting the relative mobility of pesticides under South African conditions (Dabrowski and Balderacchi, 2013).

Physicochemical data required for input into the OECD model was therefore obtained from the Pesticide Properties Database (PPDB, Lewis *et al.*, 2016). The PPDB is a comprehensive relational database of pesticide chemical identity, physicochemical, human health and ecotoxicological data. It has been developed by the Agriculture & Environment Research Unit (AERU) at the University of Hertfordshire for a variety of end users to support risk assessments and risk management. This data was captured in an Excel database from which the relevant data is retrieved for runoff calculations.

Pesticide Use Data

The quantity of pesticide applied is obviously an important factor in estimating losses into the environment. For the purposes of the indicator developed as part of this deliverable, two sources of pesticide use data were considered; estimated pesticide application rates based on market research and recommended pesticide application rates for products registered in South Africa.

Market Research Application Rates for Pesticides in South Africa

Pesticide use data for South Africa was purchased from GfK Kynetec (http://www.gfk.com/gfk-kynetec/), an international market research company. Data was provided as the aggregated total amount of active ingredient applied to all crops as well as the disaggregated application per crop. This data provides estimates on application rates (kg/ha) per active ingredient per crop. While this data is generated from market research, the US Geological Survey has sufficient confidence in the data provided by GfK Kynetec to use the data for estimating pesticide use in the USA as part of their National Water Quality Assessment Programme (Thelin and Stone, 2013).

Recommended Pesticide Application Rates for Pesticides Registered in South Africa

The risk indicator also allows for customised input of pesticide application data. This is particularly useful for farmers that have to deal with specific pests affecting their crop. Recommended rates of application for different pests on different crops can be obtained from guidebooks produced by AVCASA and CropLife. These books are published annually and list all pesticides registered for use on specific pests per crop. Application rates for each of the products can be estimated from the guidebooks according to specific formulae for insecticides, fungicides and herbicides, respectively.

The risk of pesticide products to aquatic biota are calculated based on the exposure to the active ingredient of the product. Pesticide products contain a certain concentration of the active ingredient, which is normally expressed as g.L-1, or $g.kg^{-1}$ of the pesticide product. For example, the product Dursban contains the active ingredient chlorpyrifos at a concentration of 480 $g.L^{-1}$. In order to derive a PEC for the active ingredient it is important to calculate the application rate of the active ingredient and not of the product.

For example, the product Goal that contains oxyfluorfen as the active ingredient is registered for use as a herbicide on onions. The recommended dosage is three $L.ha^{-1}$. The concentration of oxyfluorfen in Goal is however 240 $g.L^{-1}$. The application rate of the active ingredient is therefore calculated as follows:

$$3L.ha^{-1} \text{ x } 240\ g.L^{-1} = 720\ g.ha^{-1} = 0.72\ kg.ha^{-1}$$

Calculations for each of the active ingredient classes (fungicides, herbicides and insecticides) are explained in more detail in the sections below.

Herbicides

The recommended dosage for herbicides is provided as a unit of the volume or weight of the pesticide active ingredient applied per hectare (i.e. $L.ha^{-1}$ or $kg.ha^{-1}$). The recommended application rate of the active ingredient is therefore calculated as follows:

$$RAR = \frac{GAI}{1000} \times RD$$

Where *RAR* is the recommended application rate of the active ingredient ($kg.ha^{-1}$); *GAI* is the gram active ingredient per litre ($g.L^{-1}$) or per kg ($g.kg^{-1}$) of the applied product, and *RD* is the recommended dosage of the product ($L.ha^{-1}$ or $kg.ha^{-1}$).

Fungicides & Insecticides

Recommended dosage for fungicides and insecticides is typically provided as a unit of volume (ml) or weight (g) of the product mixed per 100 ℓ of water used to make up the total spray volume. The total spray volume per hectare is dependent on the method of application which can be a high volume (1000 $L.ha^{-1}$ or higher), low volume (200 – 250 $L.ha^{-1}$) or aerial application (30 $L.ha^{-1}$). The recommended application rate of the active ingredient is therefore calculated as follows:

$$AR = \frac{GAI}{1000} \times \left(RD \times \frac{SV}{100}\right)$$

Where *RAR* is the recommended application rate of the active ingredient ($kg.ha^{-1}$); *GAI* is the gram active ingredient per litre ($g.L^{-1}$) or per kg ($g.kg^{-1}$) of the applied product; *RD* is the recommended dosage per 100 ℓ of water (ml or g) and *SV* is the total volume of pesticide mixture applied per hectare ($\ell.ha^{-1}$)

Geographical Data

Geographical inputs required for the model are easily obtainable from either field-based observations or desktop mapping resources (Table 2-3).

Table 2-3: Source of GIS data used to extract geographical information required to predict

Data	Source	Reference
Slope	Topographical Maps	Chief Directorate: National Geo-Spatial Information (www.ngi.gov.za)
Soil Type	WR90 Soils Map	Water Resources of South Africa, 2012 (WR2012) http://waterresourceswr2012.co.za/resource-centre/
Soil OC%	Agricultural Research Council	Department of Agriculture Forestry and Fisheries (http://daffarcgis.nda.agric.za/portal/home/)
Vegetative Buffer Width	Field measurements Google Earth Imagery	
Plant Interception	See Appendix 1	Linders *et al.* (2000)

The OECD runoff equation determines the total amount of runoff (mm) following a rainfall event based on whether the soil type is a sand or loam soil. The WR90 soil coverage can be used to identify soils according to these two categories based on the aggregation of classes as listed in Table 2-4.

Table 2-4: WR90 soil texture classes used to define loamy and sandy soils for the purposes of predicting runoff related pesticide input using the OECD model.

Soil Type	WR90 Soil Texture Class
Loamy Soils	Sandy Clay – Clay (SaCl – Cl)
	Sand Clay Loam (SaClLm)
	Sandy Loam – Sandy Clay Loam (SaLm – SaClLm)
	Sandy Loam (SaLm)
	Sandy Loam – Sandy Clay Loam (SaLm – SaClLm)
	Sand Clay (SaCl)
Sandy Soils	Sand – Sandy Loam (Sa – SaLm)
	Loamy Sand – Sandy Loam (LmSa – SaLm)
	Sand – Loamy Sand (Sa – LmSa)
	Sand (Sa)
	Loamy Sand (LmSa)

2.5.2 Spray drift model

In Europe drift loadings are calculated based on drift values derived by the German BBA (Ganzelmeier *et al.*, 1995; Rautmann *et al.*, 1999), which divided crops into five groups (arable crops, fruit crops (orchards), grapevines, hops and vegetables/ornamentals/small fruit), with additional distinctions made between the early and late growth stages for fruit crops and grapevines and a crop height distinction for vegetables/ornamentals/small fruit. For each crop type and growth stage combination, experimental spray drift deposition data have been compiled as a function of distance from the edge of the treated field (Table 2-5). The 90th percentile drift values were calculated for each distance and used to generate a 90th percentile regression curve for each crop and growth stage combination. The figures in Table 2-5 are the percentage of an applied pesticide that is likely to move off target as spray drift. The application rate of the pesticide can be determined based on resources or methods described in 2.5.1.1.

Table 2-5: 90th percentile drift values based on crop type and distance from the point of application.

Distance (m)	Vine (early)	Vine (late)	Fruit (early)	Fruit (late)	Arable (early)	Arable (late)
1	23.2	20	46.2	26.7	4	5

Distance (m)	Vine (early)	Vine (late)	Fruit (early)	Fruit (late)	Arable (early)	Arable (late)
2	8	12	34.5	22.3	1.6	1.8
3	4.9	7.5	29.6	19.6	0.9	1.4
4	2.6	5.8	23.8	15.3	0.6	1
5	1.6	5.2	19.5	10.1	0.5	0.7
7.5	1	2.6	14.1	6.4	0.3	0.5
10	0.4	1.7	10.6	4.4	0.3	0.4
15	0.2	0.8	6.2	2.5	0.2	0.2
20	0.1	0.4	4.2	1.4	0.1	0.1
30	0.1	0.2	2	0.6	0.1	0.1
40	0.1	0.2*	0.4	0.6*	0.1*	0.1*
50	0.1	0.2*	0.2	0.6*	0.1*	0.1*

Drift values generated by the German BBA have been successfully validated in a number of studies conducted in the Lourens River catchment, South Africa. Deposition of azinphos-methyl and endosulfan was accurately predicted by the Ganzelmeier drift values at varying distances from the point of application (0, 5, 10 and 15 m) (Schulz *et al.*, 2001). In another study, drift deposition of azinphos-methyl in a stream adjacent to a pear orchard was accurately predicted by the Ganzelmeier drift values (Dabrowski *et al.*, 2005).

2.5.3 Toxicity data

Toxicity data required for assessing the relative risk of pesticides was obtained from the Pesticide Properties Database (PPDB, Lewis *et al.*, 2016). The PPDB is a comprehensive relational database of pesticide chemical identity, physicochemical, human health and ecotoxicological data. It has been developed by the Agriculture & Environment Research Unit (AERU) at the University of Hertfordshire for a variety of end users to support risk assessments and risk management. This data was captured in an Excel database from which the relevant data is retrieved for risk calculations.

2.5.4 Deterministic risk assessment

Deterministic methods are commonly used to assess risk the risk of pesticides to the aquatic environment. In this approach, a risk quotient (RQ) is calculated by dividing a point estimate of exposure (i.e. a single PEC value) by a point estimate of effects (i.e. relevant toxicity value). The calculation therefore integrates ecological effects (obtained during the exposure assessment) and exposure (pesticide use and fate and transport data) in quantifying risk. This ratio is a simple, screening-level estimate that identifies “risk” or “no risk” situations:

$$PEC/(Toxicity\ Value)<1 \rightarrow No\ Risk$$
$$PEC/(Toxicity\ Value)>1 \rightarrow Risk$$

The output is therefore a single point estimate of risk which could result in a simple “Yes” or “No” decision. A major disadvantage of this method is that a single exposure and effect endpoint is used to make a decision on the potential risk that could be expected to occur in a natural field situation. This incorporates a large amount of uncertainty into the risk assessment calculation, as there is inherently a large amount of variability in factors that influence both of these endpoints that may not be adequately considered in evaluating true risk. Single point estimates of exposure (i.e. PEC value) derived from environmental fate and transport models used in exposure assessment are particularly uncertain due to a number of reasons (Dubus *et al.*, 2003b):

- Spatial and temporal variability of environmental variables (e.g. physicochemical properties, soil properties and climatic and geographical factors) that influence model results;

- Uncertainty originating from difference in field sampling methods used to determine physical or chemical properties of pesticides;
- Uncertainty in spatially referenced data; and
- The choice of model used to predict environmental concentrations, with some studies indicating that the variability in model results due to model selection could be more significant than that due to input parameter variation.

From an effect perspective, different species exhibit differing sensitivity to chemical stressors. There is also intra-species variation depending on the life-stage of the test organism.

In summary, deterministic methods are relatively simple to execute and interpret and can be used to determine what is safe and is most likely protective of the environment. There is however a large amount of uncertainty associated with the method, it is not predictive and could also be too conservative (or over-protective) which could lead to certain beneficial products not being approved for use in agriculture.

2.6 METHODS

2.6.1 Estimating runoff loads

The percentage of applied pesticide lost as runoff ($L\%_{runoff}$) is estimated using the OECD model. The quantity of pesticide lost as runoff is calculated as follows:

$$Q_{runoff} = \left(\frac{L\%_{runoff}}{100}\right) \times \left(\frac{PAR}{10000}\right)$$

Where Q_{runoff} is the quantity of pesticide lost as runoff (kg.m^{-2}), $L\%_{runoff}$ is the percentage of applied pesticide lost as runoff (percentage) and *PAR* is the Pesticide Application Rate (kg.ha^{-1}).

2.6.2 Estimating spray drift loads

The percentage of applied pesticide lost as spray drift ($L\%_{spray}$) is estimated according to the distance between the crop and water body and the crop type using the Ganzelmeier *et al.* (1995) tables (Table 2-5). The quantity of pesticide lost as spray drift is calculated as follows:

$$Q_{spray} = \left(\frac{L\%_{spray}}{100}\right) \times \left(\frac{PAR}{10000}\right)$$

Where Q_{spray} is the quantity of pesticide lost as spray drift (kg.m^{-2}); $L\%_{spray}$ is the percentage of applied pesticide lost as runoff (percentage) and *PAR* is the Pesticide Application Rate (kg.ha^{-1}).

2.6.3 Estimating the predicted environmental concentration (PEC)

The Predicted Environmental Concentration (PEC) is calculated as follows:

$$PEC = \left(\frac{Q_{runoff} + Q_{spray}}{D}\right) \times 1000$$

Where *PEC* is in mg/L and *D* is the depth of the adjacent waterbody (m).

2.6.4 Estimating the risk

The risk of the pesticide applied to a specific drop is calculated as follows:

$$RQ = \frac{PEC}{TOX}$$

Where *RQ* is the Risk Quotient (dimensionless) *PEC* is the Predicted Environmental Concentration ($mg.L^{-1}$) and *TOX* is the acute toxicity endpoint ($mg.L^{-1}$). The *RQ* can be defined as the acute toxic effect ratio for active ingredients in a watercourse adjacent to fields that are treated according to the estimated application rate. Risk is calculated for algae, invertebrates and fish. Risk categories are expressed according to Table 2-6.

Table 2-6: Categories of risk of pesticide application to aquatic biota

Symbol	Risk Quotient	Description
	RQ > 1	High Risk
	1 > RQ > 0.1	Medium Risk
	0.1 > RQ	Low Risk

2.7 RISK INDICATOR SOFTWARE

2.7.1 Data input tab

Two versions of the indicator have been developed. The Generic Risk Indicator can be used when the user has some knowledge of which crops are produced in a catchment but does not have any information of what specific pesticides are applied to the crop. The Specific Risk Indicator can be used when the user has some knowledge of which pesticides are applied to a particular crop in a catchment (including their application rate) or can also be used to assess the relative risk of several specific pesticides of interest.

2.7.1.1 Generic risk indicator

The Data Input Tab allows the user to add relevant information required for the calculation of the PEC and the associated RQ (Figure 2-1). These input parameters are easy to obtain using readily available resources (e.g. Google Earth, Cape Farm Mapper, etc.) or GIS data, and have been discussed in more detail in the previous sections. Based on the input of parameters in this tab, the PEC for all pesticides that are likely to be used on the crop is automatically calculated through reference to lookup pesticide use tables (as supplied by the GfK Kynetec database) included in the spreadsheet. The Generic Indicator therefore provides a list of pesticides (and associated risks) that are likely to be applied on a crop (as determined by market research).

Field Data:	
Select Crop Type & Growth Stage:	Fruit Tree (late)
Select Crop:	Apples
Total Area of Fields in Catchment (TAC) - (ha):	500
Total Area of Fields Adjacent to Stream (TAS) - (m):	80
Total Stream Length (TSL) - (m):	90
Average Stream Depth - (m):	0.5
Total Perimeter of fields Adjacent to Stream (TP) - (m):	300
Average Slope of Field/s - (%):	2
Organic Carbon Content of Soil - (%):	0.5
Average Distance between Field & Watercourse (D) - (m):	30
Average Width of Vegetated Buffer Strip (B) - (m):	5
Rainfall - (mm):	30
Soil Type:	Sandy Soil

Figure 2-1: Example of Data Input Tab showing the information that needs to be entered in order to estimate the relative risk of pesticides applied to apples on aquatic biota.

The definitions for all parameters are included in the spreadsheet (which can be seen by hovering the mouse cursor over the blue coloured cell) and are described as follows:

Crop Type: Distinguishes between vines, fruit trees, and field crops and early and late growth stages, which can be selected from a drop-down list.

Crop: The specific crop type for which pesticide use data is available can be selected from a drop-down list.

Total Area of Fields in Catchment (TAC): The total area (ha) of the crop in the catchment.

Total Area of Fields Adjacent to Stream (TAS): Total area (ha) of the crop that lies within 50 m of a stream.

Total Stream Length (TSL): The total length of the stream network (m) that lies within 50 m of crop.

Average Stream Depth: The average depth of the stream network (m).

Total Perimeter of Fields Adjacent to Stream (TP): The total perimeter of the crop (m) that lies within 50 m of the stream.

Average Slope of Field: The average slope (percentage) of all fields in the catchment area.

Organic Carbon Content of Soil: The organic carbon content (percentage) of the soil in which the crop is cultivated

Average Distance Between Field and Watercourse (D): The distance (m) between the edge of the field adjacent to the stream and the edge of the stream closest to the field

Vegetative Runoff Buffer (B): The width of buffer (m) that is covered by vegetation that can potentially mitigate pesticide transport through slowing surface flow and providing an organic surface for adsorption. This width is distinct from the distance between the field and watercourse. For example, the distance between the field and the watercourse may be 20 m, however only 5 m of this width may be vegetated and act as a buffer to runoff.

Rainfall: The amount of rainfall. This can be the average rainfall per rainfall event or expressed as the average rainfall per rainfall event above 6 mm.

Soil Type: Distinguishes between sandy soils and loamy soils that can be selected from a drop-down list.

The risk indicator can be applied at the scale of a single field or at a larger scale that could include many fields along a river reach or catchment area. A diagram illustrating how the different input parameters can be calculated for scenarios including multiple fields is included in the 'Input Data' tab (Figure 2-2).

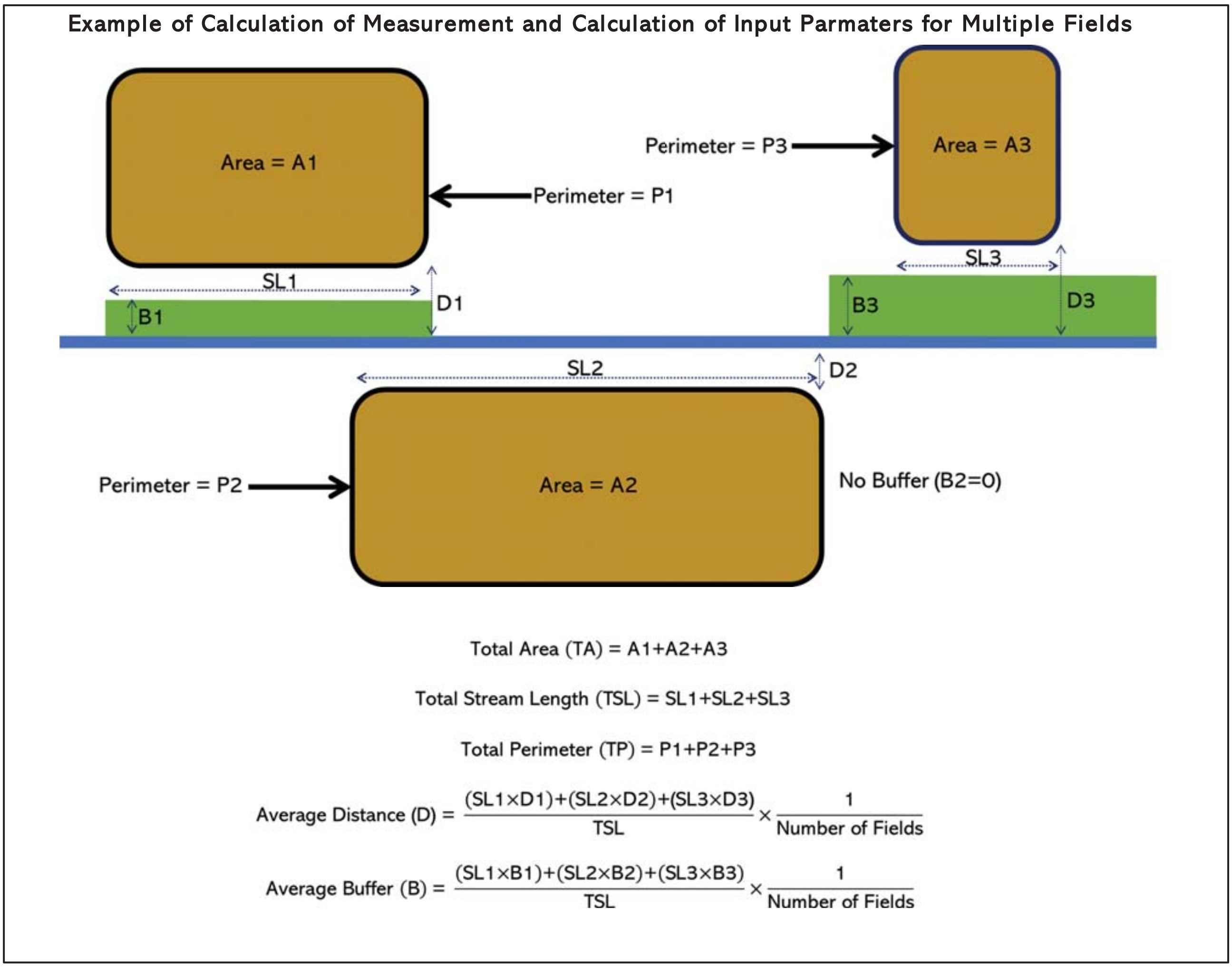

Figure 2-2: Diagram illustrating methods for calculating the data input parameters required for the Generic and Specific Risk Indicators.

The majority of inputs can be derived using relatively simple GIS mapping techniques including the following:

- Delineation of sub-catchments within a larger catchment area using a Digital Elevation Model (DEM) for the catchment area (Figure 2-3);
- Identification of crop types per sub-catchment area based on existing
- Total area crop in the catchment (Figure 2-3);
- Total area and perimeter of crop within 50 m of a watercourse (Figure 2-4)
- Total length of river within 50 m of the crop (Figure 2-5)
- The average distance between the crop and the watercourse (Figure 2-5 and Table 2-7)
- The slope of fields under a specific crop (Figure 2-6)
- The average slope of all fields under a specific crop (Table 2-7)

GIS analysis would need to be repeated for each crop type and sub-catchment of interest.

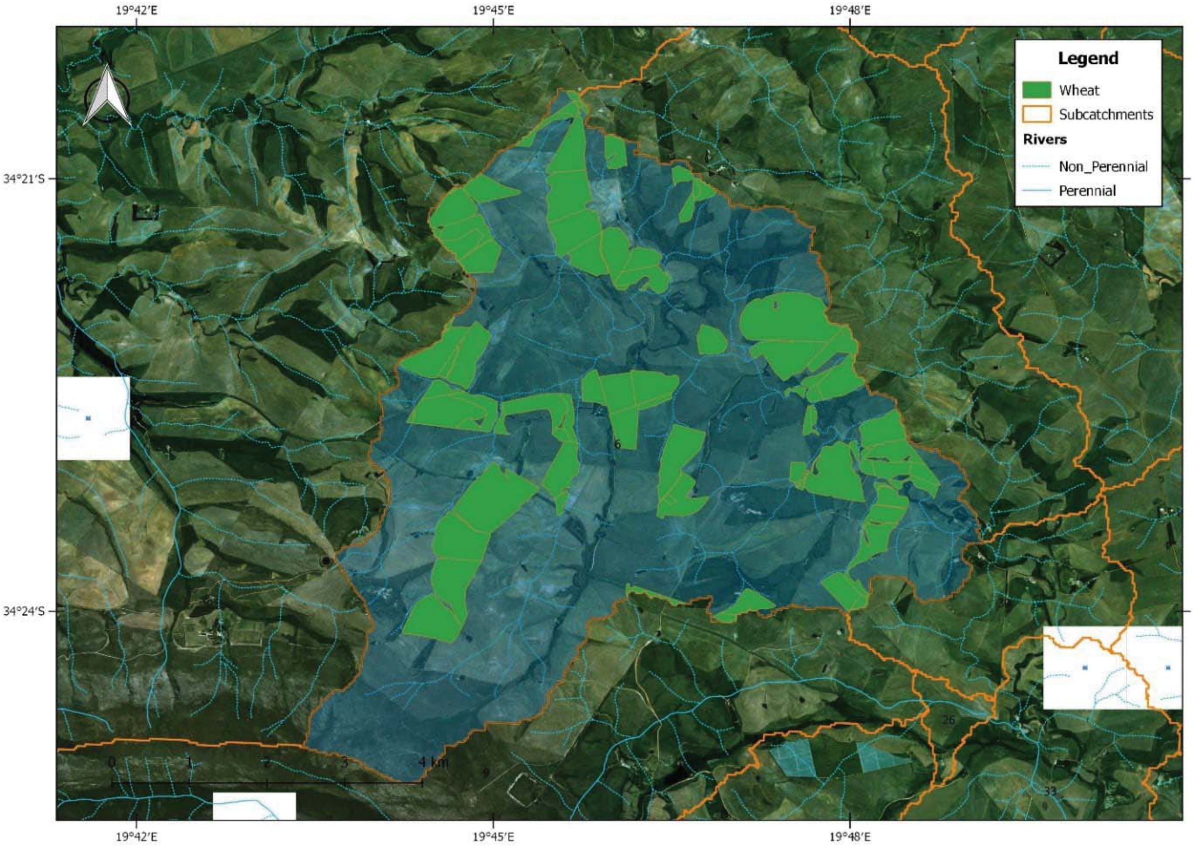

Figure 2-3: Example of a GIS map showing wheat grown in a sub-catchment of the Kars River, from which the TAC can easily be calculated.

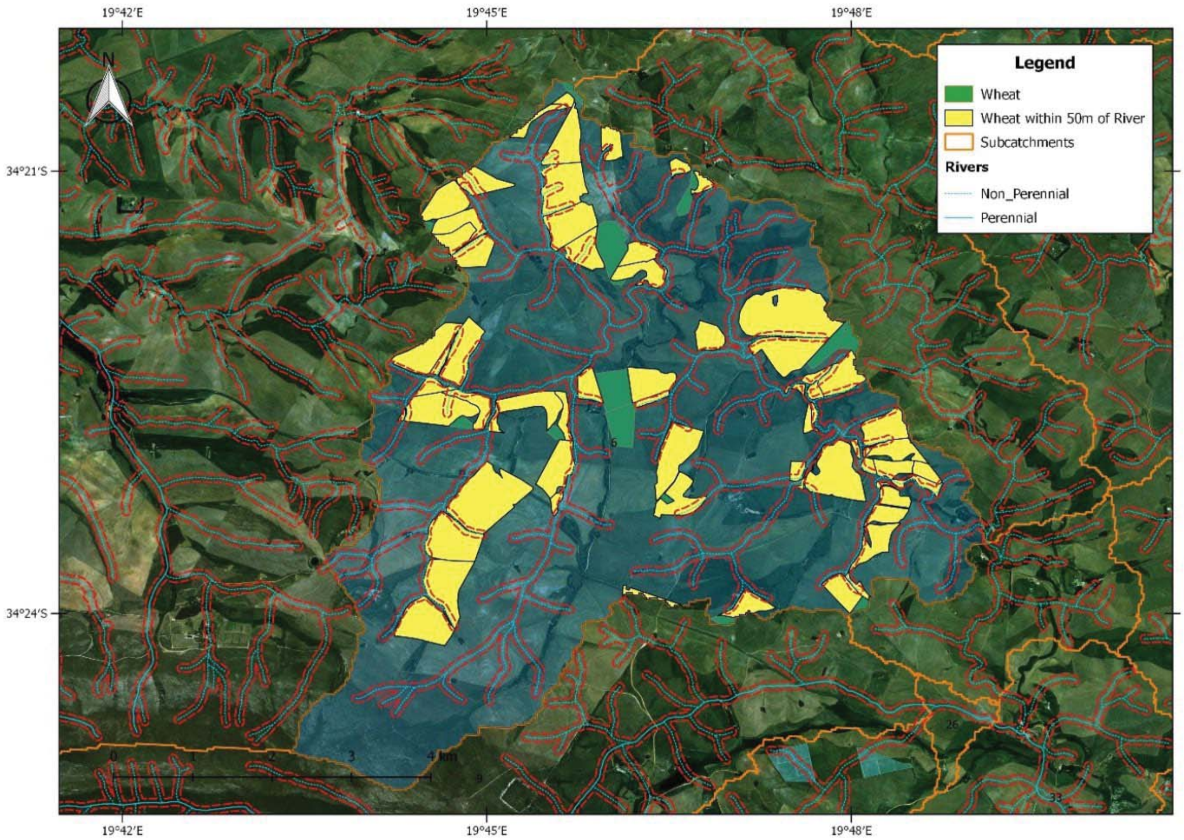

Figure 2-4: Example of a GIS map showing wheat fields that fall within 50 m (dotted red lines) of watercourses in a sub-catchment from which the TAS and TP can be calculated.

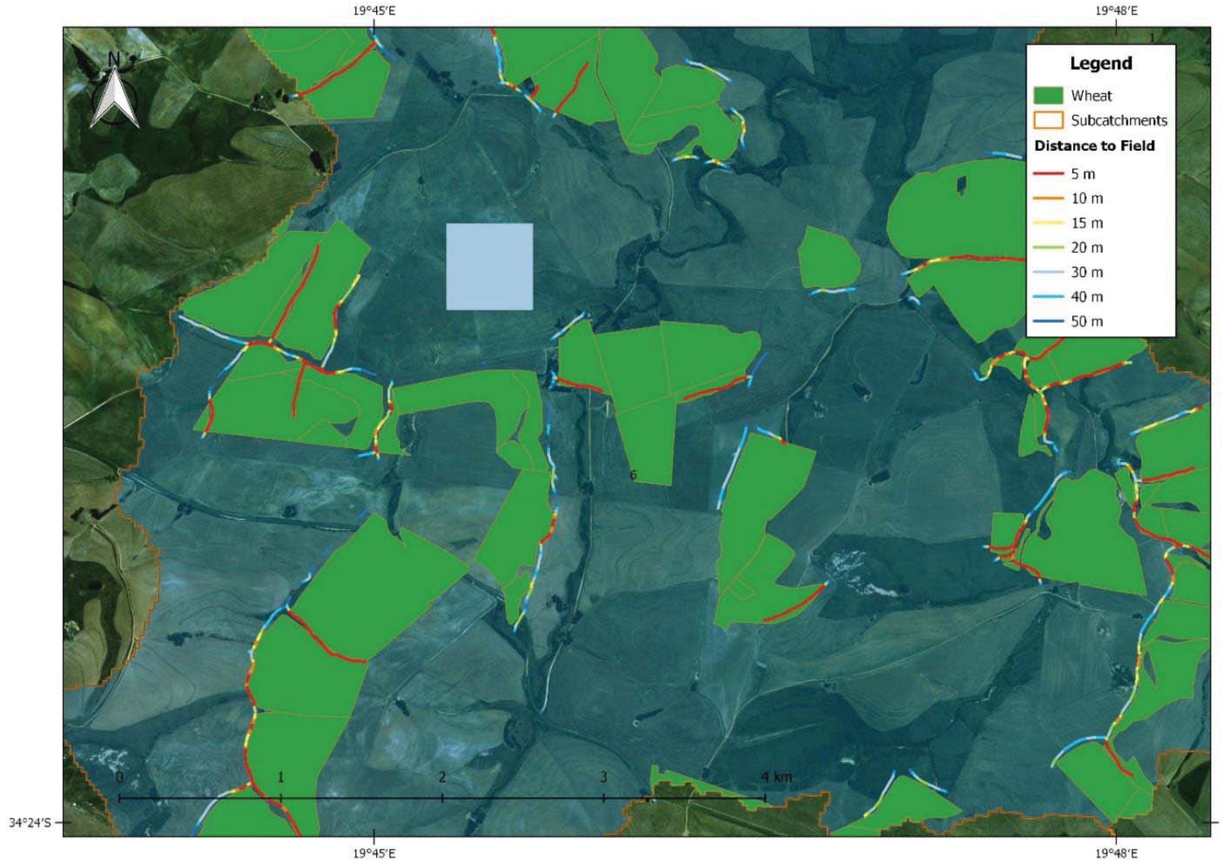

Figure 2-5: Example of a GIS map showing the length of watercourses within 5, 10, 15, 20, 30, 40 and 50 m of adjacent wheat fields from which the average distance between fields and watercourses can be calculated (see Table 2-7).

Table 2-7: Example of calculating the average distance of a wheat fields from watercourses based on output of GIS analysis displayed in Figure 2-5.

Distance (D) between field and watercourse (m)	Stream Length (SL) (m)	SL x D	Average Distance between field and watercourse (m)
5	11745	58725	= 558050/28624 = 19.5 m
10	1964	19640	
15	1987	29805	
20	2324	46480	
30	4575	137250	
40	3530	141200	
50	2499	124950	
TOTAL	28624[1]	558050	

[1]*Total Stream Length (TSL) as defined in Figure 2-2*

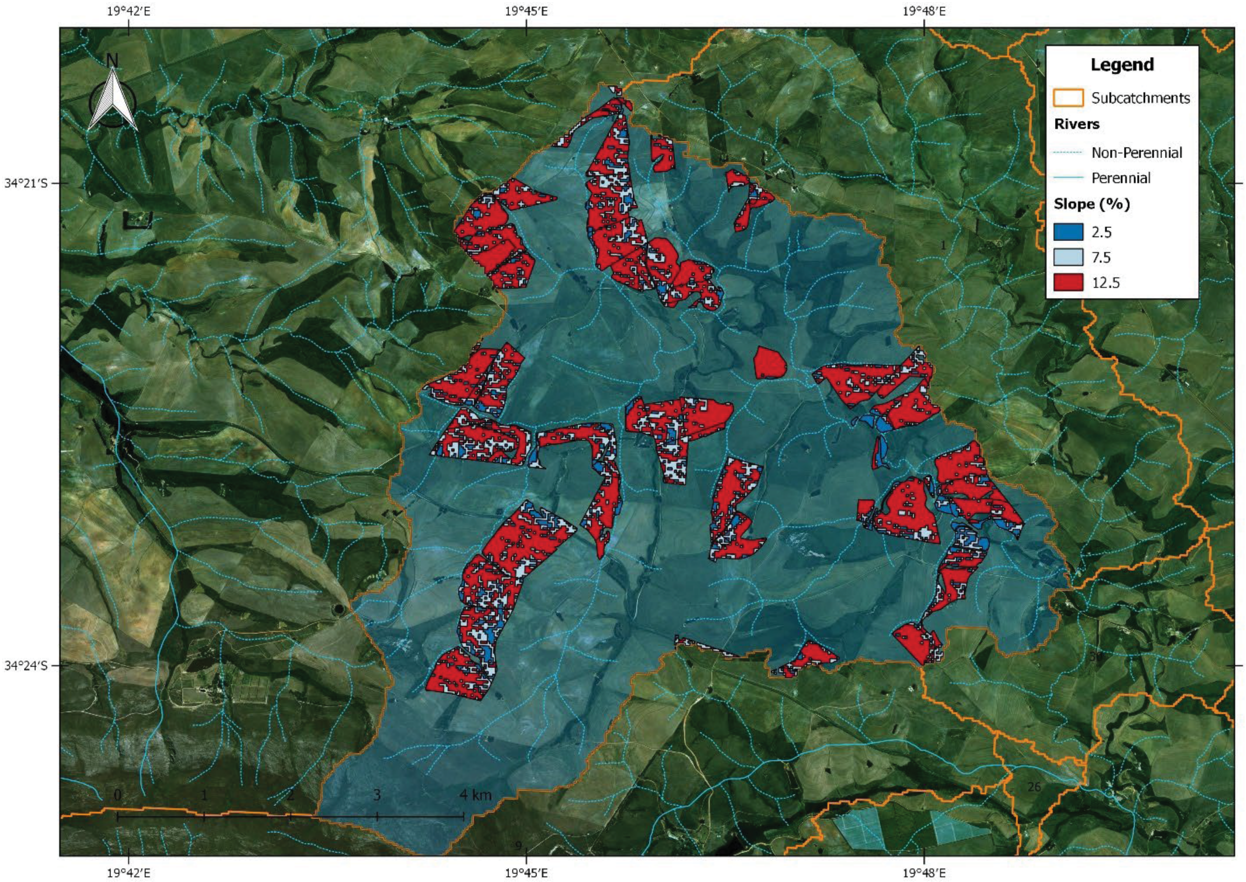

Figure 2-6: Example of a GIS map showing the area of different slope categories of wheat fields in a sub-catchment from which the total area of each slope category can be calculated and used to estimate the average slope of fields under wheat (see Table 2-8).

Table 2-8: Example of calculating the average slope of wheat fields based on the output of GIS analysis displayed in

Slope (%)	Area (ha)	Slope x Area	Average Slopes (%)
2.5	120	300	= 8903/892 = 10%
7.5	212	1590	
12.5	561	7013	
TOTAL	892	8903	

2.7.1.2 Specific risk indicator

As mentioned above the Specific Risk Indicator can be used when the user has some knowledge of which pesticides are applied to a particular crop in a catchment or can also be used to assess the relative risk of several specific pesticides of interest. In addition to the catchment data input that is required for the Generic Risk Indicator an additional input box is provided where specific pesticides can be selected (up to ten active ingredients can be selected) and the application rate can be included (Figure 2-7). An application rate calculator is included in the spreadsheet for calculating application rates as per Section 2.5.1.1.

Select Pesticides from Dropdown Lists:	Enter Application Rate (kg/ha):
cypermethrin	0.02
chlorpyrifos	0.96
thiacloprid	0.3
paraquat	1
fenoprop	0.5
triclopyr	2
profenofos	2
carbaryl	1
alpha-cypermethrin	0.1
imidacloprid	5

Figure 2-7: Example of additional data input required in the Specific Risk Indicator.

2.7.2 Risk indicator outputs

2.7.2.1 Generic risk indicator

The Generic indicator provides the following outputs:

- Pesticide Use & Risk Summary (Figure 2-8): Table showing:
  - A summary the different pesticides typically applied to the crop and ranked according to their total application (kg).
  - The application rate used in risk calculations;
  - The relative risk of pesticides applied to the crop to algae, invertebrates and fish.
  - Risks are differentiated between runoff and spray drift.
- Toxicity and Physicochemical Data (Figure 2-9): Table showing the toxicity and physicochemical data used in risk predictions; and
- Ranked Risk Table (Figure 2-10): Tables showing the relative risks of each pesticide to algae, invertebrates and fish, ranked from highest to lowest.

Crop:	Peaches			RELATIVE RISK ESTIMATES					
				Algae		Invertebrates		Fish	
Active Ingredient	Total Application (kg)	Application Rate (kg/ha)	Class	Spray Drift	Runoff	Spray Drift	Runoff	Spray Drift	Runoff
Mancozeb	211 500	1.763	Fungicides	1.91E-02	5.74E-02	2.87E-01	8.65E-01	4.56E-02	1.37E-01
Glyphosate	97 200	1.080	Herbicides	2.92E-03	1.31E-04	1.17E-03	5.26E-05	1.57E-03	7.05E-05
Copper-oxychloride	85 000	2.550	Fungicides	No Data	No Data	No Data	No Data	No Data	No Data
Paraquat	32 720	0.394	Herbicides	2.04E+01	1.69E-02	1.07E-03	8.84E-07	2.47E-04	2.05E-07
Sulphur	32 000	2.400	Fungicides	2.86E-04	9.66E-05	5.71E-06	1.93E-06	1.59E-04	5.37E-05
Copper-hydroxide	26 900	1.614	Fungicides	No Data	No Data	No Data	No Data	No Data	No Data
Thiram	13 600	1.813	Fungicides	2.16E-02	2.36E-02	1.03E-01	1.12E-01	5.39E-01	5.89E-01
Oxamyl	7 750	1.240	Insecticides	1.59E-02	8.15E-02	4.63E-02	2.38E-01	4.71E-03	2.42E-02
Chlorpyrifos	7 680	0.480	Insecticides	1.19E-02	1.11E-02	3.36E+00	3.13E+00	8.16E-01	7.59E-01
Azinphos-methyl	7 000	0.595	Insecticides	9.90E-04	8.42E-04	6.44E+00	5.47E+00	3.54E-01	3.01E-01
Pirimicarb	5 000	0.250	Insecticides	2.13E-05	3.07E-05	1.75E-01	2.53E-01	3.77E-05	5.44E-05
Chlorfenapyr	4 680	0.180	Insecticides	No Data	No Data	No Data	No Data	No Data	No Data
Propyzamide	4 000	0.250	Herbicides	1.06E-03	9.20E-04	5.31E-04	4.60E-04	6.33E-04	5.48E-04
Copper-sulphate	3 200	0.800	Fungicides	No Data	No Data	No Data	No Data	No Data	No Data
Carbaryl	3 000	0.500	Insecticides	9.92E-03	2.28E-02	9.92E-01	2.28E+00	2.29E-03	5.25E-03
Propargite	2 950	0.295	Insecticides	3.25E-03	4.93E-05	3.57E-02	5.42E-04	2.98E-02	4.51E-04
Indoxacarb	2 938	0.150	Insecticides	1.62E-02	2.28E-03	2.98E-03	4.19E-04	2.75E-03	3.87E-04
Prochloraz	2 500	0.500	Fungicides	1.08E+00	3.76E-01	1.38E-03	4.81E-04	3.97E-03	1.38E-03
Fenamiphos	2 400	4.000	Insecticides	1.25E-02	8.70E-02	2.51E+01	1.74E+02	5.29E+00	3.67E+01
Chlorpyrifos-e	2 400	0.480	Insecticides	No Data	No Data	No Data	No Data	No Data	No Data
Methomyl	2 000	0.198	Insecticides	3.92E-05	1.94E-04	3.10E-01	1.53E+00	3.74E-03	1.85E-02
MCPA	1 600	0.600	Herbicides	2.01E-04	6.99E-04	7.14E-05	2.48E-04	3.08E-05	1.07E-04
Fenbutatin-oxide	1 600	0.419	Insecticides	9.97E+00	4.52E-02	1.04E-01	4.71E-04	4.53E+00	2.06E-02
Glufosinate-ammonium	1 200	0.400	Herbicides	1.02E-04	5.20E-04	7.13E-06	3.62E-05	6.70E-06	3.41E-05
Cypermethrin	1 200	0.030	Insecticides	3.57E-03	4.00E-05	2.38E+00	2.67E-02	5.17E-01	5.80E-03
Acephate	975	0.750	Insecticides	9.11E-06	2.99E-04	1.33E-04	4.36E-03	8.11E-05	2.66E-03

Figure 2-8: Example of the Pesticide Use & Risk Summary for peaches.

Pesticide Application Data		Physicochemical Data		Toxicity Data		
Active Ingredient	Class	Half-Life (days)	KOC	Algae (Acute EC50)	Daphnia (Acute EC50)	Fish (Acute LC50)
Mancozeb	Fungicides	1	2000	1.1	0.073	0.46
Glyphosate	Herbicides	12	21699	4.4	11	8.2
Copper-oxychloride	Fungicides	100000		0.55	3.5	2.2
Paraquat	Herbicides	3000	1000000	0.00023	4.4	19
Sulphur	Fungicides	1000	2255	100	5000	180
Copper-hydroxide	Fungicides			0.55	6.5	0.08
Thiram	Fungicides	15.2	670	1	0.21	0.04
Oxamyl	Insecticides	7	17	0.93	0.319	3.13
Chlorpyrifos	Insecticides	1	6925	0.48	0.0017	0.007
Azinphos-methyl	Insecticides	10	1000	7.15	0.0011	0.02
Pirimicarb	Insecticides	86	388	140	0.017	79
Chlorfenapyr	Insecticides			0	0.0061	0.007
Propyzamide	Herbicides	47	800	2.8	5.6	4.7
Copper-sulphate	Fungicides			0.026	2.3	0.017
Carbaryl	Insecticides	16	211	0.6	0.006	2.6
Propargite	Insecticides	56	56500	1.08	0.0982	0.118
Indoxacarb	Insecticides	17	6450	0.11	0.6	0.65
Prochloraz	Fungicides	120	2225	0.0055	4.3	1.5
Fenamiphos	Insecticides	1	754	3.8	0.0019	0.009
Chlorpyrifos-e	Insecticides					
Methomyl	Insecticides	7	25.2	60	0.0076	0.63
MCPA	Herbicides	15	74	35.49	100	232
Fenbutatin-oxide	Insecticides	365	183550	0.0005	0.048	0.0011
Glufosinate-ammonium	Herbicides	7.4	16	46.5	668	710
Cypermethrin	Insecticides	60	76344	0.1	0.00015	0.00069
Acephate	Insecticides	1	2	980	67.2	110

Figure 2-9: Example of the Toxicity & Physicochemical output table, providing relevant data used to determine the PEC.

Rank	Active Ingredient	Class	Spray Drift Risk	Runoff Risk
1	Fenamiphos	Insecticides	2.51E+01	1.74E+02
2	Malathion	Insecticides	8.50E+00	1.35E+02
3	Azinphos-methyl	Insecticides	6.44E+00	5.47E+00
4	Chlorpyrifos	Insecticides	3.36E+00	3.13E+00
5	Carbaryl	Insecticides	9.92E-01	2.28E+00
6	Cypermethrin	Insecticides	2.38E+00	2.67E-02
7	Methomyl	Insecticides	3.10E-01	1.53E+00
8	Fenthion	Insecticides	1.14E+00	6.10E-01
9	Mancozeb	Fungicides	2.87E-01	8.65E-01
10	Pirimicarb	Insecticides	1.75E-01	2.53E-01
11	Alpha-cypermethrin	Insecticides	3.97E-01	6.00E-03
12	Oxamyl	Insecticides	4.63E-02	2.38E-01
13	Methamidophos	Insecticides	2.58E-02	2.13E-01
14	Lambda-cyhalothrin	Insecticides	2.29E-01	1.31E-03
15	Thiram	Fungicides	1.03E-01	1.12E-01
16	Propiconazole	Fungicides	1.08E-01	7.04E-02
17	Deltamethrin	Insecticides	1.28E-01	2.69E-04
18	Beta-cyfluthrin	Insecticides	1.23E-01	1.86E-03
19	Fenbutatin-oxide	Insecticides	1.04E-01	4.71E-04
20	Dinocap	Fungicides	8.33E-02	1.13E-02

Figure 2-10: Example of the ranked risks of pesticides to invertebrates for pesticides applied to peaches/

The outputs of the Generic Pesticide Risk Indicator are based on crop-specific application rates obtained from the pesticide use database as described in Section 1.2 and provided in the Appendix to this report.

The utility of the outputs can be summarised as follows:

- Provides a best guess of which pesticides could be applied in a catchment area where no detailed pesticide application information is available;
- Provides an indication of the relative risks these pesticides may pose to algae, invertebrates and fish;
- The outputs differentiate risks associated with runoff and spray drift and therefore provide guidance on monitoring strategies as well as which management interventions are most likely needed to control the source of pesticides in the catchment (i.e. spray drift will require different management interventions in comparison to runoff).
- The outputs can identify which pesticides are likely to be used in high quantities and the risk associated with these pesticides and can therefore be used to identify target pesticides for further monitoring/screening/management; and
- The indicator can be applied in different sub-catchments or tributaries in order to identify specific hotspot areas within a larger catchment area.

2.7.2.2 Specific indicator

For the Specific Risk Indicator, relative risks of only the selected pesticides are provided. The Specific Risk indicator provides the following outputs:

- Table showing the PEC for pesticides that originate from runoff and spray drift (Figure 2-11).
- Relative risk tables illustrating the relative risk of each pesticide to algae, invertebrates and fish (for runoff and spray drift) (Figure 2-12).

PECs (µg/L)		
Pesticide	**Runoff**	**Spray Drift**
chlorpyrifos	1.474	9.208
mancozeb	11.448	2.877
fenarimol	0.536	0.460
cypermethrin	0.011	0.767
trifloxystrobin	0.548	0.959
abamectin	0.001	0.017
bupirimate	0.418	0.360
lambda-cyhalothrin	0.001	0.192
deltamethrin	0.007	0.384

Figure 2-11: Example of the Specific Risk Indicator output providing an indication of estimated pesticide concentrations associated with runoff and spray drift.

Spray Drift Risk			
Pesticide	Algae	Invertebrates	Fish
cypermethrin	0.0058	3.8400	0.8348
chlorpyrifos	0.0576	16.2635	3.9497
thiacloprid	0.0001	0.0001	0.0003
paraquat	125.2174	0.0065	0.0015
fenoprop	No Data	No Data	0.0010
triclopyr	0.0008	0.0004	0.0005
profenofos	No Data	0.1152	0.7200
carbaryl	0.0000	4.8000	0.0111
alpha-cypermethrin	0.0000	9.6000	1.0286
imidacloprid	0.0000	0.0017	0.0017

Runoff Risk			
Pesticide	Algae	Invertebrates	Fish
cypermethrin	0.0000	0.0147	0.0032
chlorpyrifos	0.0024	0.6749	0.1639
thiacloprid	0.0001	0.0000	0.0001
paraquat	0.0355	0.0000	0.0000
fenoprop	No Data	No Data	0.0001
triclopyr	0.0009	0.0005	0.0006
profenofos	No Data	0.0198	0.1240
carbaryl	0.0000	3.7719	0.0087
alpha-cypermethrin	0.0000	0.3750	0.0402
imidacloprid	0.0000	0.0012	0.0013

Integrated Risk	
cypermethrin	3.8400
chlorpyrifos	16.2635
thiacloprid	0.0003
paraquat	125.2174
fenoprop	0.0010
triclopyr	0.0009
profenofos	0.7200
carbaryl	4.8000
alpha-cypermethrin	9.6000
imidacloprid	0.0017

Figure 2-12: Example of output provided by the Specific Risk Indicator.

The outputs of the Specific Pesticide Risk Indicator are based on user defined pesticides and associated application rates. The utility of the outputs can be summarised as follows:

- Provides a higher confidence estimate of relative risks based on more detailed knowledge of pesticide application programmes in the catchment;

- Provides an indication of the relative risks these pesticides may pose to algae, invertebrates and fish;
- The outputs differentiate risks associated with runoff and spray drift and therefore provide guidance on monitoring strategies as well as which management interventions are most likely needed to control the source of pesticides in the catchment (i.e. spray drift will require different management interventions in comparison to runoff);
- The indicator can be applied in different sub-catchments or tributaries in order to identify specific hotspot areas within a larger catchment area; and
- The indicator can be used to assess how changes in certain crop management inputs (i.e. increased buffer widths, vegetated buffer zones, etc.) can potentially affect the risk associated with the use of a pesticide;
- The indicator can be used to compare specific pesticides of interest with a view to identifying lower risk pesticides (i.e. for application to crops) or higher risk pesticides that might need to be included in a monitoring programme.

2.8 SOFTWARE PRODUCTS

Table 2-9 provides a summary of electronic outputs produced as part of the development of the crop specific risk indicator pesticide risk maps for South Africa.

Table 2-9: Summary of software products.

File Name	Description
GenericRI.xlsx	Excel software tool designed to assess the relative risks of pesticides applied to different crop types in catchments without any detailed knowledge of pesticide application programmes.
SpecificRI.xlsx	Excel software tool designed to assess the relative risks of pesticides applied to different crop types in catchments with some knowledge of pesticides used and their application rates. The tool can also be used to compare the relative risks of pesticides of interest.

2.9 APPLICATION OF RISK INDICATOR

The software is currently in an initial trial phase and will be adapted and improved over the course of the project. In its current form, the following applications are envisaged:

1. Prioritisation of crop specific high priority pesticides for monitoring and management at a catchment scale;

2. Analysis of the risk to aquatic biota of different pesticides registered for use on specific pests targeting specific crops. This allows for improved decision making at a farm management scale; and

3. Changes in risk to aquatic biota can be assessed based on the implementation of specific farm management interventions (e.g. implementation of a vegetative buffer strip, increasing buffer width between fields and the edge of a watercourse, etc.).

An example of the application of the software can be viewed in Volume 1 of this research report.

2.10 REFERENCES

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APPENDIX 1

Plant interception factors for different stages of crop growth according to Linders *et al.* (2000).

Crop	Growth Phase	Interception factor
Beans	Leaf development	0.25
Beans	Stem elongation	0.4
Beans	Flowering	0.7
Beans	Ripening/senescence	0.8
Bulbs	Leaf development/stem elongation I (< 3 weeks)	0.2
Bulbs	Leaf development/stem elongation II (< 3-6 weeks)	0.6
Bulbs	Flowering/senescence	0.5
Cabbage	Leaf development	0.25
Cabbage	Development	0.8
Cabbage	Flowering	0.9
Cabbage	Ripening/senescence	0.9
Carrots	Development of leafs and harvestable plant parts	0.25
Carrots	Inflorescence emergence/flowering	0.5
Carrots	Development of fruits	0.7
Carrots	Ripening/senescence	0.6
Cereals	Leaf development	0.25
Cereals	Tillering	0.5
Cereals	Stem elongation	0.7
Cereals	Booting/senescence	0.9
Citrus	Leaf and shoot development	0.3
Citrus	Inflorescence emergence	0.5
Citrus	Flowering/development of fruit/maturity	0.7
Citrus	Senescence	0.7
Cotton	Leaf development	0.25
Cotton	Side shoots	0.6
Cotton	Stem elongation/crop cover/flowering	0.7
Cotton	Senescence	0.9
Currants	Leaf development	0.3
Currants	Shoot development/inflorescence emergence	0.4
Currants	Flowering/development of fruit/maturity	0.6
Currants	Senescence	0.6
Grass	All phases	0.4
Hops	Leaf development	0.2
Hops	Side shoots/elongation of bines	0.6
Hops	Elongation/emergence/maturity	0.9
Hops	Senescence	0.5
Linseed	Leaf development	0.2
Linseed	Stem elongation	0.6
Linseed	Flowering/ripening	0.7
Linseed	Senescence	0.9
Maize	Leaf development	0.25
Maize	Stem elongation	0.5
Maize	Inflorescence emergence/flowering	0.75
Maize	Development of fruit/ripening	0.9
Oilseed rape	Leaf development	0.4
Oilseed rape	Formation of side shoots/stem elongation	0.8
Oilseed rape	Inflorescence emergence/ripening/senescence	0.9
Onions	Leaf development	0.1
Onions	Stem elongation	0.25
Onions	Flowering	0.4
Onions	Ripening/senescence	0.6
Peas	Stem elongation development	0.35
Peas	Stem elongation/inflorescence emergence	0.55
Peas	Flowering/ripening	0.85

Crop	Growth Phase	Interception factor
Olives	Leaf and shoot development	0.3
Olives	Inflorescence emergence	0.5
Olives	Flowering/development of fruit/maturity	0.7
Olives	Senescence	0.7
Pome fruit	Without leaves	0.2
Pome fruit	Bloom/leaf development	0.4
Pome fruit	Leaf development	0.7
Pome fruit	Full foliage	0.8
Potatoes	Leaf development	0.15
Potatoes	Formation of basal side shoots/main stem elongation	0.5
Potatoes	Inflorescence emergence/ripening	0.8
Potatoes	Senescence	0.5
Rice	Leaf development	0.2
Rice	Booting/inflorescence emergence	0.5
Rice	Flowering/fruit development	0.7
Rice	Ripening/senescence	0.9
Soybean	Development of leafs and harvestable plant parts	0.2
Soybean	Side shoots and development of harvestable plant parts	0.6
Soybean	Inflorescence/senescence	0.9
Sprouts	Leaf development	0.2
Sprouts	Side shoots/rosette growth	0.5
Sprouts	Inflorescence/flowering	0.8
Sprouts	Fruit development/flowering	0.7
Stone fruit	Without leaves	0.2
Stone fruit	Bloom/leaf development	0.4
Stone fruit	Leaf development	0.7
Stone fruit	Full foliage	0.8
Strawberries	Leaf development	0.3
Strawberries	Development of stolons and young plant parts	0.5
Strawberries	Inflorescence emergence/maturity	0.7
Strawberries	Senescence/dormancy	0.6
Sugar beets	Leaf development	0.2
Sugar beets	Rosette growth	0.7
Sugar beets	Development of vegetative plant parts/senescence	0.9
Sunflower	Leaf development/stem elongation	0.4
Sunflower	Inflorescence emergence	0.7
Sunflower	Flowering/ripening	0.9
Sunflower	Senescence	0.8
Tobacco	Transplant	0.1
Tobacco	Layby	0.6
Tobacco	Full flower	0.8
Tobacco	Mature topped	0.9
Tomatoes	Leaf development	0.25
Tomatoes	Side shoots/inflorescence emergence	0.5
Tomatoes	Flowering/fruit development/ripening	0.7
Tomatoes	Senescence	0.6
Vines	Leaf development	0.3
Vines	Inflorescence emergence	0.5
Vines	Flowering/fruit development/ripening	0.8
Vines	Senescence	0.6

National pesticide use data for South Africa for the year 2014 (Data Source: Gfk Kynetec: www.gfk.com/gfk-kynetec)

Active Ingredient	Volume ($x10^3$)	Area ($x10^3$ ha)	Rate (kg or L/ha)
2.4-D-amine	344.5	419.2	0.822
2.4-D-ester	67.2	266.7	0.252
2.4-DP	1.5	60.8	0.025
2.4-D-salt	2.0	8.0	0.250
Abamectin	11.3	3842.3	0.003
Acephate	34.7	65.0	0.535
Acetamiprid	2.4	26.5	0.091
Acetochlor	1578.3	1104.5	1.429
Alachlor	40.7	22.7	1.794
Alpha-cypermethrin	4.9	485.0	0.010
Al-phosphide	5.1	0.9	5.611
Ametryn	90.5	61.0	1.484
Amicarbazone	4.9	14.0	0.350
Atrazine	1126.8	1716.5	0.656
Azinphos-m	47.0	111.1	0.423
Azoxystrobin	60.0	740.6	0.081
Bacillus thuringiensis aizawai	0.1	7.9	0.007
Bacillus thuringiensis	0.7	72.7	0.010
Benfuracarb	1.6	4.5	0.362
Benomyl	49.0	99.0	0.495
Bentazone	91.8	56.3	1.632
Beta-cyfluthrin	4.5	861.7	0.005
Beta-cypermethrin	2.9	447.7	0.007
Bifenthrin	0.7	20.6	0.036
Boscalid	11.1	107.3	0.103
Bromacil	75.9	30.4	2.496
Bromopropylate	2.0	11.7	0.171
Bromoxynil	134.9	373.4	0.361
Bupirimate	3.1	17.4	0.180
Buprofezin	20.0	133.3	0.150
Butralin	3.7	12.5	0.298
Cadusafos	26.4	10.5	2.510
Carbaryl	23.4	28.3	0.826
Carbendazim	18.5	232.5	0.080
Carbofuran	69.5	69.5	1.000
Carbosulfan	13.9	58.0	0.240
Carfentrazone-e	1.5	146.0	0.010
Cartap	43.5	138.3	0.314
Chlorantraniliprole	2.7	132.0	0.021
Chlorfenapyr	20.5	114.0	0.180
Chloridazon	2.0	1.5	1.300

Active Ingredient	Volume ($x10^3$)	Area ($x10^3$ ha)	Rate (kg or L/ha)
Chlorimuron-e	3.8	433.6	0.009
Chlormequat-chloride	11.3	7.1	1.575
Chlorothalonil	337.8	242.8	1.391
Chlorpyrifos	133.9	278.7	0.481
Chlorpyrifos-e	129.6	269.8	0.480
Chlorsulfuron	1.0	37.7	0.026
Clethodim	8.7	95.3	0.091
Clodinafop	1.7	46.7	0.036
Clomazone	3.8	6.0	0.640
Clothianidin	7.0	563.3	0.012
Copper	0.3	0.3	1.250
Copper-carbonate	37.7	11.3	3.344
Copper-hydroxide	81.2	47.7	1.702
Copper-oxide	7.5	4.4	1.688
Copper-oxychloride	330.7	123.4	2.679
Copper-sulphate	33.3	70.8	0.471
Cyanamide	219.3	19.0	11.568
Cycloxydim	2.9	14.4	0.200
Cydia pomonella GV	4.8	1.8	2.650
Cymoxanil	16.9	130.3	0.130
Cypermethrin	32.9	1145.3	0.029
Cyproconazole	5.7	167.1	0.034
Cyprodinil	17.8	79.8	0.223
Cyromazine	16.9	96.2	0.175
Deltamethrin	9.9	1138.3	0.009
Demeton-S-m	7.2	30.0	0.240
Diafenthiuron	1.0	2.3	0.444
Diazinon	3.3	4.0	0.825
Dicamba	25.2	173.4	0.145
Dichlorophen	2.0	4.6	0.445
Diclosulam	0.6	50.0	0.013
Difenoconazole	21.3	291.1	0.073
Dimethenamid-P	61.0	111.4	0.548
Dimethoate	56.4	313.3	0.180
Dimethomorph	4.3	23.9	0.180
Dinocap	1.4	4.0	0.350
Diquat	32.6	119.6	0.273
Dithianon	2.6	17.8	0.148
Diuron	124.0	124.5	0.996
Dodine	6.0	12.5	0.480
Emamectin-benzoate	0.5	74.5	0.006
Endosulfan	1.2	2.5	0.468

Active Ingredient	Volume ($x10^3$)	Area ($x10^3$ ha)	Rate (kg or L/ha)
Epoxiconazole	21.3	288.4	0.074
EPTC	120.6	51.6	2.338
Esfenvalerate	6.1	612.0	0.010
Ethephon	41.8	65.8	0.634
Ethoprophos	17.7	73.1	0.242
Ethylene-dibromide	82.8	3.7	22.278
Etoxazole	0.8	21.1	0.036
Famoxadone	4.1	32.9	0.125
Fenamidone	1.5	16.8	0.092
Fenamiphos	122.7	40.2	3.053
Fenbuconazole	0.4	3.5	0.100
Fenbutatin-oxide	6.9	19.5	0.354
Fenoxaprop-P-e	0.2	2.5	0.096
Fenpropathrin	2.5	35.7	0.070
Fenpyroximate	1.7	12.7	0.134
Fenthion	8.1	12.5	0.653
Fipronil	8.2	263.0	0.031
Florasulam	1.3	340.0	0.004
Fluazifop-P-b	4.0	14.1	0.285
Flubendiamide	8.0	160.7	0.050
Fludioxonil	2.7	1285.1	0.002
Flufenoxim	0.2	83.3	0.002
Flufenoxuron	1.2	9.0	0.133
Flumetsulam	2.8	392.3	0.007
Flumioxazin	0.6	8.3	0.076
Fluopicolide	1.2	74.7	0.016
Fluopyram	1.7	20.2	0.084
Fluquinconazole	0.8	12.3	0.068
Flurochloridone	1.4	1.8	0.761
Fluroxypyr	2.6	19.0	0.137
Flusilazole	23.8	276.9	0.086
Flutriafol	4.6	29.9	0.155
Folpet	2.0	1.8	1.090
Fosetyl-Al	50.3	105.7	0.476
Furfural	451.8	20.1	22.500
Gamma-cyhalothrin	2.4	708.4	0.003
Gibberellic-acid	2.9	277.4	0.011
Glufosinate-ammonium	15.2	34.2	0.445
Glyphosate	9503.2	9206.1	1.032
Guazatine	0.4	0.5	0.800
Halosulfuron-m	7.5	200.0	0.038
Haloxyfop-r-m	2.5	17.0	0.146

Active Ingredient	Volume ($x10^3$)	Area ($x10^3$ ha)	Rate (kg or L/ha)
Hexaconazole	0.1	5.1	0.015
Hexazinone	102.0	192.5	0.530
Hydramethylnon	0.0	4.0	0.004
Imazalil	0.8	0.8	0.938
Imazamox	6.0	12.5	0.480
Imazapyr	5.9	33.9	0.173
Imazethapyr	0.7	16.5	0.040
Imidacloprid	130.2	2145.6	0.061
Indoxacarb	13.4	192.9	0.069
Iodosulfuron-methyl-sodium	0.8	72.5	0.011
Ioxynil	1.3	2.0	0.625
Iprodione	3.5	4.8	0.728
Iprovalicarb	3.7	116.0	0.032
Isoxadifen-e	2.5	100.0	0.025
Isoxaflutole	15.0	100.0	0.150
Kresoxim-m	10.4	95.0	0.110
Lambda-cyhalothrin	33.6	5429.3	0.006
Linuron	1.3	1.1	1.160
Lufenuron	1.1	39.2	0.028
Malathion	69.6	124.1	0.561
Mancozeb	1545.9	936.4	1.651
Mandipropamid	3.4	28.1	0.119
Maneb	35.2	39.5	0.891
MCPA	257.5	440.3	0.585
Mefenpyr-diethyl	2.4	72.5	0.034
Mepiquat-chloride	0.5	40.0	0.013
Mesosulfuron-m	0.1	12.0	0.008
Mesotrione	276.0	2361.4	0.117
Metalaxyl	8.2	74.9	0.109
Metalaxyl-M	5.8	1527.7	0.004
Metaldehyde	21.9	30.1	0.726
Metazachlor	10.0	13.7	0.732
Methamidophos	160.3	364.7	0.440
Methidathion	2.1	2.5	0.840
Methiocarb	6.4	20.2	0.319
Methomyl	181.0	873.5	0.207
Methoxyfenozide	3.1	22.3	0.140
Metiram	28.0	32.5	0.862
Metolachlor	2362.9	2513.8	0.940
Metrafenone	6.5	52.0	0.125
Metribuzin	78.8	74.4	1.058
Metsulfuron-m	5.2	472.0	0.011

Active Ingredient	Volume ($x10^3$)	Area ($x10^3$ ha)	Rate (kg or L/ha)
Mevinphos	5.5	26.0	0.212
Milbemectin	0.1	10.0	0.006
Mineral-oil	621.5	11.9	52.154
MSMA	97.2	44.3	2.194
Myclobutanil	1.0	33.3	0.030
Nicosulfuron	1.4	30.0	0.045
Omethoate	4.0	62.5	0.064
Oxadiazon	4.7	6.6	0.720
Oxamyl	156.5	139.6	1.121
Oxyfluorfen	3.6	7.4	0.489
Paraquat	456.2	1062.4	0.429
Parathion-e	11.5	36.8	0.313
Parathion-m	5.4	9.6	0.563
Penconazole	4.5	207.7	0.022
Pencycuron	7.0	1.2	5.833
Pendimethalin	10.8	10.3	1.045
Petroleum-oil	2618.8	67.6	38.746
Picloram	32.0	36.0	0.889
Picoxystrobin	4.5	57.6	0.078
Pinoxaden	2.5	102.1	0.024
Pirimicarb	9.0	36.0	0.250
Potassium-phosphite	61.0	35.6	1.716
Prochloraz	7.1	42.3	0.167
Procymidone	22.1	118.0	0.187
Profenofos	48.5	100.7	0.482
Prohexadione-Ca	0.7	3.5	0.200
Propamocarb-HCl	13.7	8.8	1.556
Propaquizafop	8.0	105.0	0.076
Propargite	8.4	18.8	0.445
Propiconazole	47.0	376.5	0.125
Propineb	64.7	137.4	0.471
Propoxur	0.8	2.0	0.400
Propyzamide	7.0	10.5	0.667
Prosulfocarb	124.0	51.7	2.400
Prosulfuron	0.6	38.8	0.016
Prothioconazole	5.2	143.9	0.036
Prothiofos	17.0	68.0	0.250
Pymetrozine	3.1	14.8	0.209
Pyraclostrobin	19.0	306.8	0.062
Pyraflufen-e	0.0	8.2	0.003
Pyridalyl	1.8	15.0	0.117
Pyrimethanil	9.6	47.5	0.202

Active Ingredient	Volume (x10^3)	Area (x10^3 ha)	Rate (kg or L/ha)
Pyriproxifen	9.6	285.6	0.034
Quaternary-Ammonium-salts	1.9	15.0	0.126
Quinoxyfen	2.8	31.0	0.089
Quizalofop-P-e	0.2	3.6	0.050
Quizalofop-P-t	3.2	79.0	0.040
Rimsulfuron	0.6	26.2	0.023
Simazine	59.6	72.3	0.825
s-metolachlor	661.5	903.8	0.732
Spinosad	2.6	16.4	0.159
Spirodiclofen	0.5	20.0	0.024
Spirotetramat	6.1	156.9	0.039
Spiroxamine	19.8	109.3	0.181
Sulcotrione	32.5	212.3	0.153
Sulfentrazone	0.5	0.7	0.720
Sulfosulfuron	2.6	142.9	0.018
Sulphur	1458.1	606.5	2.404
Tau-fluvalinate	3.8	22.2	0.173
Tebuconazole	104.0	806.1	0.129
Tebuthiuron	95.0	18.7	5.089
Tefluthrin	2.1	86.7	0.024
Tembotrione	5.0	100.0	0.050
Tepraloxydim	2.3	45.0	0.050
Terbufos	227.3	916.4	0.248
Terbuthylazine	982.3	1383.7	0.710
Tetraconazole	0.2	5.0	0.040
Tetradifon	6.1	14.2	0.432
Thiabendazole	8.5	212.5	0.040
Thiacloprid	7.0	47.7	0.146
Thiamethoxam	31.7	838.4	0.038
Thifensulfuron-m	0.1	40.7	0.002
Thiodicarb	0.8	2.0	0.375
Thiophanate	1.9	0.4	4.800
Thiram	35.6	19.2	1.850
Tolclofos-m	1.0	0.4	2.500
Topramezone	1.0	26.9	0.036
Triadimefon	4.3	39.2	0.111
Triadimenol	0.4	16.0	0.024
Triasulfuron	1.1	99.6	0.011
Triazines	12.1	335.0	0.036
Tribenuron-m	0.7	70.0	0.010
Trichlorfon	5.7	60.0	0.095
Triclopyr	50.4	26.2	1.924

Active Ingredient	**Volume ($x10^3$)**	**Area ($x10^3$ ha)**	**Rate (kg or L/ha)**
Trifloxystrobin	10.3	185.6	0.055
Trifluralin	50.7	82.5	0.615
Triforine	0.6	3.0	0.190
Triticonazole	1.7	125.5	0.014
Uniconazole	0.2	0.1	1.500
Uniconazole-P	0.3	0.2	1.500
Zinc-oxide	0.1	14.5	0.009

Summary of active ingredient use for agricultural crops in South Africa for the year 2014 (Data Source: GfK Kynetec: www.gfk.com/gfk-kynetec)

Crop	Sector	AI	Crop area ($x10^3$ ha)	Base area ($x10^3$ ha)	AI Area Treated ($x10^3$ ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Barley	Insecticides	Chlorpyrifos	95.00	80.00	10.00	0.480	4.800
Barley	Insecticides	Chlorpyrifos-e	95.00	80.00	10.00	0.480	4.800
Barley	Insecticides	Dimethoate	95.00	80.00	66.67	0.300	20.000
Barley	Fungicides	Azoxystrobin	95.00	75.00	5.25	0.100	0.525
Barley	Fungicides	Carbendazim	95.00	75.00	76.67	0.068	5.200
Barley	Fungicides	Cyproconazole	95.00	75.00	19.56	0.037	0.720
Barley	Fungicides	Cyprodinil	95.00	75.00	6.00	0.375	2.250
Barley	Fungicides	Epoxiconazole	95.00	75.00	49.75	0.088	4.375
Barley	Fungicides	Flusilazole	95.00	75.00	50.00	0.100	5.000
Barley	Fungicides	Flutriafol	95.00	75.00	1.00	0.125	0.125
Barley	Fungicides	Picoxystrobin	95.00	75.00	14.29	0.088	1.250
Barley	Fungicides	Propiconazole	95.00	75.00	47.78	0.120	5.750
Barley	Fungicides	Prothioconazole	95.00	75.00	37.86	0.051	1.925
Barley	Fungicides	Pyraclostrobin	95.00	75.00	16.00	0.063	1.000
Barley	Fungicides	Spiroxamine	95.00	75.00	18.18	0.138	2.500
Barley	Fungicides	Tebuconazole	95.00	75.00	99.18	0.105	10.405
Barley	Fungicides	Triadimefon	95.00	75.00	3.67	0.113	0.415
Barley	Fungicides	Trifloxystrobin	95.00	75.00	22.00	0.050	1.100
Barley	Herbicides	2.4-D-amine	95.00	75.00	12.00	0.720	8.640
Barley	Herbicides	Bromoxynil	95.00	75.00	26.00	0.338	8.775
Barley	Herbicides	Carfentrazone-e	95.00	75.00	44.00	0.010	0.440
Barley	Herbicides	Chlorsulfuron	95.00	75.00	25.00	0.012	0.300
Barley	Herbicides	Diquat	95.00	75.00	2.00	0.120	0.240
Barley	Herbicides	Iodosulfuron-methyl-sodium	95.00	75.00	12.50	0.010	0.125
Barley	Herbicides	MCPA	95.00	75.00	43.33	0.535	23.200
Barley	Herbicides	Mefenpyr-diethyl	95.00	75.00	12.50	0.030	0.375
Barley	Herbicides	Metsulfuron-m	95.00	75.00	64.40	0.008	0.488

Crop	Sector	AI	Crop area (x10³ ha)	Base area (x10³ ha)	AI Area Treated (x10³ ha)	AI dose rate (kg or L/ha)	AI volume (x 10³ kg/L)
Barley	Herbicides	Paraquat	95.00	75.00	24.50	0.382	9.360
Barley	Herbicides	Pinoxaden	95.00	75.00	30.00	0.023	0.675
Barley	Herbicides	Prosulfuron	95.00	75.00	10.00	0.015	0.150
Barley	Herbicides	Pyraflufen-e	95.00	75.00	6.67	0.003	0.020
Barley	Herbicides	Thifensulfuron-m	95.00	75.00	1.82	0.015	0.028
Barley	Herbicides	Triasulfuron	95.00	75.00	26.67	0.011	0.300
Barley	Herbicides	Tribenuron-m	95.00	75.00	21.33	0.010	0.210
Barley	Herbicides	Trifluralin	95.00	75.00	5.33	0.495	2.640
Barley	Seed dressing	Prothioconazole	95.00	20.00	10.53	0.010	0.100
Barley	Seed dressing	Tebuconazole	95.00	20.00	3.10	0.002	0.008
Barley	Seed dressing	Triticonazole	95.00	20.00	7.02	0.014	0.100
Wheat-winter	Insecticides	Alphacypermethrin	481.00	350.00	5.00	0.010	0.050
Wheat-winter	Insecticides	Betacyfluthrin	481.00	350.00	33.33	0.005	0.175
Wheat-winter	Insecticides	Betacypermethrin	481.00	350.00	76.92	0.007	0.500
Wheat-winter	Insecticides	Carbofuran	481.00	350.00	0.20	1.000	0.200
Wheat-winter	Insecticides	Chlorpyrifos	481.00	350.00	21.00	0.480	10.080
Wheat-winter	Insecticides	Chlorpyrifos-e	481.00	350.00	41.00	0.480	19.680
Wheat-winter	Insecticides	Cypermethrin	481.00	350.00	33.33	0.030	1.000
Wheat-winter	Insecticides	Deltamethrin	481.00	350.00	58.33	0.009	0.550
Wheat-winter	Insecticides	Demeton-S-m	481.00	350.00	30.00	0.240	7.200
Wheat-winter	Insecticides	Dimethoate	481.00	350.00	67.67	0.301	20.400
Wheat-winter	Insecticides	Esfenvalerate	481.00	350.00	80.00	0.010	0.800
Wheat-winter	Insecticides	Gamma-cyhalothrin	481.00	350.00	83.33	0.004	0.300
Wheat-winter	Insecticides	Lambda-cyhalothrin	481.00	350.00	133.33	0.006	0.800
Wheat-winter	Insecticides	Malathion	481.00	350.00	1.00	0.500	0.500
Wheat-winter	Insecticides	Methomyl	481.00	350.00	56.11	0.258	14.500
Wheat-winter	Insecticides	Mevinphos	481.00	350.00	10.00	0.195	1.950
Wheat-winter	Insecticides	Omethoate	481.00	350.00	62.50	0.064	4.000

Crop	Sector	AI	Crop area ($x10^3$ ha)	Base area ($x10^3$ ha)	AI Area Treated ($x10^3$ ha)	AI dose rate (kg or L/ha)	AI volume ($x 10^3$ kg/L)
Wheat-winter	Insecticides	Parathion-e	481.00	350.00	24.00	0.313	7.500
Wheat-winter	Insecticides	Pirimicarb	481.00	350.00	6.00	0.250	1.500
Wheat-winter	Fungicides	Azoxystrobin	481.00	300.00	35.00	0.096	3.375
Wheat-winter	Fungicides	Carbendazim	481.00	300.00	12.20	0.098	1.200
Wheat-winter	Fungicides	Cyproconazole	481.00	300.00	65.56	0.038	2.480
Wheat-winter	Fungicides	Cyprodinil	481.00	300.00	20.00	0.375	7.500
Wheat-winter	Fungicides	Epoxiconazole	481.00	300.00	24.58	0.097	2.375
Wheat-winter	Fungicides	Fenbuconazole	481.00	300.00	3.50	0.100	0.350
Wheat-winter	Fungicides	Flusilazole	481.00	300.00	14.70	0.111	1.625
Wheat-winter	Fungicides	Flutriafol	481.00	300.00	5.67	0.154	0.875
Wheat-winter	Fungicides	Propiconazole	481.00	300.00	209.56	0.123	25.750
Wheat-winter	Fungicides	Prothioconazole	481.00	300.00	31.67	0.064	2.025
Wheat-winter	Fungicides	Spiroxamine	481.00	300.00	76.00	0.188	14.250
Wheat-winter	Fungicides	Tebuconazole	481.00	300.00	245.67	0.151	37.194
Wheat-winter	Fungicides	Triadimefon	481.00	300.00	3.67	0.113	0.415
Wheat-winter	Fungicides	Triadimenol	481.00	300.00	9.33	0.032	0.301
Wheat-winter	Herbicides	2.4-D-amine	481.00	450.00	59.50	0.847	50.400
Wheat-winter	Herbicides	2.4-D-ester	481.00	450.00	6.67	0.600	4.000
Wheat-winter	Herbicides	Bentazone	481.00	450.00	5.00	1.920	9.600
Wheat-winter	Herbicides	Bromoxynil	481.00	450.00	245.29	0.350	85.875
Wheat-winter	Herbicides	Carfentrazone-e	481.00	450.00	76.00	0.010	0.760
Wheat-winter	Herbicides	Chlorsulfuron	481.00	450.00	6.40	0.094	0.600
Wheat-winter	Herbicides	Clodinafop	481.00	450.00	46.67	0.036	1.680
Wheat-winter	Herbicides	Dicamba	481.00	450.00	62.55	0.080	5.000
Wheat-winter	Herbicides	Diquat	481.00	450.00	10.00	0.160	1.600
Wheat-winter	Herbicides	Fenoxaprop-P-e	481.00	450.00	2.50	0.096	0.240
Wheat-winter	Herbicides	Florasulam	481.00	450.00	300.00	0.004	1.125
Wheat-winter	Herbicides	Flumetsulam	481.00	450.00	300.00	0.005	1.500

Crop	Sector	AI	Crop area (x10³ ha)	Base area (x10³ ha)	AI Area Treated (x10³ ha)	AI dose rate (kg or L/ha)	AI volume (x 10³ kg/L)
Wheat-winter	Herbicides	Fluroxypyr	481.00	450.00	8.00	0.200	1.600
Wheat-winter	Herbicides	Glyphosate	481.00	450.00	691.67	1.057	731.000
Wheat-winter	Herbicides	Halosulfuron-m	481.00	450.00	30.00	0.038	1.125
Wheat-winter	Herbicides	Iodosulfuron-methyl-sodium	481.00	450.00	60.00	0.012	0.690
Wheat-winter	Herbicides	MCPA	481.00	450.00	147.06	0.680	100.000
Wheat-winter	Herbicides	Mefenpyr-diethyl	481.00	450.00	60.00	0.035	2.070
Wheat-winter	Herbicides	Mesosulfuron-m	481.00	450.00	12.00	0.008	0.090
Wheat-winter	Herbicides	Metolachlor	481.00	450.00	10.00	0.960	9.600
Wheat-winter	Herbicides	Metsulfuron-m	481.00	450.00	398.25	0.009	3.724
Wheat-winter	Herbicides	Paraquat	481.00	450.00	50.00	0.391	19.540
Wheat-winter	Herbicides	Pinoxaden	481.00	450.00	72.07	0.025	1.800
Wheat-winter	Herbicides	Prosulfocarb	481.00	450.00	51.67	2.400	124.000
Wheat-winter	Herbicides	Prosulfuron	481.00	450.00	20.00	0.015	0.300
Wheat-winter	Herbicides	Pyraflufen-e	481.00	450.00	1.50	0.004	0.006
Wheat-winter	Herbicides	Sulfosulfuron	481.00	450.00	142.86	0.018	2.625
Wheat-winter	Herbicides	Thifensulfuron-m	481.00	450.00	33.33	0.001	0.035
Wheat-winter	Herbicides	Triasulfuron	481.00	450.00	66.67	0.011	0.750
Wheat-winter	Herbicides	Tribenuron-m	481.00	450.00	48.67	0.010	0.503
Wheat-winter	Herbicides	Trifluralin	481.00	450.00	36.00	0.512	18.420
Wheat-winter	Growth regulators	Chlormequat-chloride	481.00	5.00	7.14	1.575	11.250
Wheat-winter	Growth regulators	Ethephon	481.00	5.00	4.00	0.480	1.920
Wheat-winter	Seed dressing	Fluquinconazole	481.00	250.00	12.35	0.068	0.835
Wheat-winter	Seed dressing	Imidacloprid	481.00	250.00	8.89	0.158	1.400
Wheat-winter	Seed dressing	Prochloraz	481.00	250.00	12.35	0.014	0.170
Wheat-winter	Seed dressing	Prothioconazole	481.00	250.00	55.56	0.009	0.500
Wheat-winter	Seed dressing	Tebuconazole	481.00	250.00	32.68	0.002	0.075
Wheat-winter	Seed dressing	Thiamethoxam	481.00	250.00	27.78	0.108	3.000
Wheat-winter	Seed dressing	Triticonazole	481.00	250.00	118.52	0.014	1.600

Crop	Sector	AI	Crop area ($x10^3$ ha)	Base area ($x10^3$ ha)	AI Area Treated ($x10^3$ ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Citrus	Insecticides	Abamectin	62.00	60.00	333.33	0.011	3.600
Citrus	Insecticides	Acetamiprid	62.00	60.00	18.50	0.086	1.600
Citrus	Insecticides	Alphacypermethrin	62.00	60.00	19.00	0.010	0.190
Citrus	Insecticides	Azinphos-m	62.00	60.00	4.17	0.420	1.750
Citrus	Insecticides	Bacillus-thuringiensis	62.00	60.00	33.33	0.010	0.320
Citrus	Insecticides	Betacypermethrin	62.00	60.00	76.92	0.007	0.500
Citrus	Insecticides	Bromopropylate	62.00	60.00	5.00	0.200	1.000
Citrus	Insecticides	Buprofezin	62.00	60.00	113.33	0.150	17.000
Citrus	Insecticides	Cadusafos	62.00	60.00	1.00	1.500	1.500
Citrus	Insecticides	Carbaryl	62.00	60.00	0.17	0.600	0.100
Citrus	Insecticides	Chlorantraniliprole	62.00	60.00	20.00	0.070	1.403
Citrus	Insecticides	Chlorfenapyr	62.00	60.00	38.00	0.180	6.840
Citrus	Insecticides	Chlorpyrifos	62.00	60.00	45.00	0.480	21.600
Citrus	Insecticides	Chlorpyrifos-e	62.00	60.00	50.00	0.480	24.000
Citrus	Insecticides	Clothianidin	62.00	60.00	13.33	0.030	0.400
Citrus	Insecticides	Cypermethrin	62.00	60.00	46.67	0.030	1.400
Citrus	Insecticides	Dimethoate	62.00	60.00	133.33	0.030	4.000
Citrus	Insecticides	Ethoprophos	62.00	60.00	45.00	0.100	4.500
Citrus	Insecticides	Etoxazole	62.00	60.00	11.43	0.035	0.400
Citrus	Insecticides	Fenamiphos	62.00	60.00	1.60	4.625	7.400
Citrus	Insecticides	Fenbutatin-oxide	62.00	60.00	5.64	0.381	2.150
Citrus	Insecticides	Fenpropathrin	62.00	60.00	20.00	0.080	1.600
Citrus	Insecticides	Fenpyroximate	62.00	60.00	6.67	0.075	0.500
Citrus	Insecticides	Fipronil	62.00	60.00	229.52	0.030	6.960
Citrus	Insecticides	Hydramethylnon	62.00	60.00	4.00	0.004	0.015
Citrus	Insecticides	Imidacloprid	62.00	60.00	194.29	0.155	30.100
Citrus	Insecticides	Indoxacarb	62.00	60.00	20.00	0.075	1.500
Citrus	Insecticides	Malathion	62.00	60.00	77.00	0.598	46.060

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Citrus	Insecticides	Metaldehyde	62.00	60.00	0.77	0.352	0.270
Citrus	Insecticides	Methidathion	62.00	60.00	0.50	0.840	0.420
Citrus	Insecticides	Methiocarb	62.00	60.00	4.60	0.709	3.260
Citrus	Insecticides	Methomyl	62.00	60.00	557.22	0.201	112.000
Citrus	Insecticides	Methoxyfenozide	62.00	60.00	6.67	0.144	0.960
Citrus	Insecticides	Mevinphos	62.00	60.00	8.00	0.240	1.920
Citrus	Insecticides	Parathion-e	62.00	60.00	12.80	0.313	4.000
Citrus	Insecticides	Petroleum-oil	62.00	60.00	60.40	41.750	2 521.700
Citrus	Insecticides	Profenofos	62.00	60.00	65.00	0.500	32.500
Citrus	Insecticides	Pyriproxifen	62.00	60.00	264.44	0.033	8.600
Citrus	Insecticides	Spinosad	62.00	60.00	1.67	0.360	0.600
Citrus	Insecticides	Spirodiclofen	62.00	60.00	20.00	0.024	0.480
Citrus	Insecticides	Spirotetramat	62.00	60.00	50.00	0.048	2.400
Citrus	Insecticides	Sulphur	62.00	60.00	15.00	1.600	24.000
Citrus	Insecticides	Terbufos	62.00	60.00	2.00	1.500	3.000
Citrus	Insecticides	Tetradifon	62.00	60.00	3.00	0.400	1.200
Citrus	Insecticides	Thiacloprid	62.00	60.00	6.67	0.144	0.960
Citrus	Insecticides	Thiamethoxam	62.00	60.00	11.11	0.043	0.480
Citrus	Insecticides	Trichlorfon	62.00	60.00	60.00	0.095	5.700
Citrus	Fungicides	Azoxystrobin	62.00	60.00	250.00	0.050	12.500
Citrus	Fungicides	Benomyl	62.00	60.00	37.50	1.000	37.500
Citrus	Fungicides	Carbendazim	62.00	60.00	5.00	0.200	1.000
Citrus	Fungicides	Copper-hydroxide	62.00	60.00	2.00	1.688	3.376
Citrus	Fungicides	Copper-oxide	62.00	60.00	2.78	1.350	3.750
Citrus	Fungicides	Copper-oxychloride	62.00	60.00	5.00	2.550	12.750
Citrus	Fungicides	Copper-sulphate	62.00	60.00	4.08	0.862	3.520
Citrus	Fungicides	Difenoconazole	62.00	60.00	23.93	0.094	2.250
Citrus	Fungicides	Flutriafol	62.00	60.00	2.40	0.156	0.375

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Citrus	Fungicides	Fosetyl-Al	62.00	60.00	0.05	16.000	0.800
Citrus	Fungicides	Guazatine	62.00	60.00	0.50	0.800	0.400
Citrus	Fungicides	Imazalil	62.00	60.00	0.80	0.938	0.750
Citrus	Fungicides	Kresoxim-m	62.00	60.00	3.57	0.700	2.500
Citrus	Fungicides	Mancozeb	62.00	60.00	142.50	1.577	224.750
Citrus	Fungicides	Maneb	62.00	60.00	4.90	1.509	7.395
Citrus	Fungicides	Metalaxyl	62.00	60.00	25.00	0.050	1.250
Citrus	Fungicides	Metalaxyl-M	62.00	60.00	4.55	0.317	1.440
Citrus	Fungicides	Petroleum-oil	62.00	60.00	0.73	24.780	18.172
Citrus	Fungicides	Potassium-phosphite	62.00	60.00	6.50	5.020	32.632
Citrus	Fungicides	Prochloraz	62.00	60.00	1.00	0.450	0.450
Citrus	Fungicides	Pyraclostrobin	62.00	60.00	30.00	0.125	3.750
Citrus	Fungicides	Quaternary-Ammonium-salts	62.00	60.00	10.00	0.126	1.260
Citrus	Fungicides	Tebuconazole	62.00	60.00	3.75	0.200	0.750
Citrus	Fungicides	Thiabendazole	62.00	60.00	212.50	0.040	8.500
Citrus	Fungicides	Thiophanate	62.00	60.00	0.40	4.800	1.920
Citrus	Fungicides	Triadimefon	62.00	60.00	5.00	0.165	0.825
Citrus	Fungicides	Zinc-oxide	62.00	60.00	2.50	0.009	0.024
Citrus	Herbicides	Bromacil	62.00	60.00	6.99	2.448	17.100
Citrus	Herbicides	Carfentrazone-e	62.00	60.00	8.00	0.010	0.080
Citrus	Herbicides	Cycloxydim	62.00	60.00	1.50	0.200	0.300
Citrus	Herbicides	Diquat	62.00	60.00	12.50	0.160	2.000
Citrus	Herbicides	Fluazifop-P-b	62.00	60.00	1.50	0.283	0.425
Citrus	Herbicides	Flumioxazin	62.00	60.00	1.25	0.100	0.125
Citrus	Herbicides	Glufosinate-ammonium	62.00	60.00	5.00	0.400	2.000
Citrus	Herbicides	Glyphosate	62.00	60.00	243.33	1.039	252.900
Citrus	Herbicides	Oxadiazon	62.00	60.00	0.17	1.500	0.250
Citrus	Herbicides	Oxyfluorfen	62.00	60.00	0.40	0.600	0.240

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Citrus	Herbicides	Paraquat	62.00	60.00	82.50	0.422	34.800
Citrus	Herbicides	Propaquizafop	62.00	60.00	4.00	0.075	0.300
Citrus	Herbicides	Quizalofop-P-e	62.00	60.00	1.00	0.050	0.050
Citrus	Herbicides	Simazine	62.00	60.00	3.33	0.900	3.000
Citrus	Herbicides	s-metolachlor	62.00	60.00	8.00	0.206	1.645
Citrus	Herbicides	Terbuthylazine	62.00	60.00	8.00	0.994	7.955
Citrus	Growth regulators	2.4-DP	62.00	40.00	60.80	0.025	1.500
Citrus	Growth regulators	2.4-D-salt	62.00	40.00	8.00	0.250	2.000
Citrus	Growth regulators	Gibberellic-acid	62.00	40.00	47.06	0.022	1.047
Corn	Insecticides	Alphacypermethrin	2 652.00	2 500.00	70.00	0.010	0.700
Corn	Insecticides	Al-phosphide	2 652.00	2 500.00	0.90	5.611	5.050
Corn	Insecticides	Benfuracarb	2 652.00	2 500.00	2.50	0.484	1.210
Corn	Insecticides	Betacyfluthrin	2 652.00	2 500.00	166.67	0.007	1.100
Corn	Insecticides	Betacypermethrin	2 652.00	2 500.00	76.92	0.007	0.500
Corn	Insecticides	Bifenthrin	2 652.00	2 500.00	0.80	0.050	0.040
Corn	Insecticides	Carbaryl	2 652.00	2 500.00	5.00	0.850	4.250
Corn	Insecticides	Carbofuran	2 652.00	2 500.00	61.10	1.000	61.100
Corn	Insecticides	Carbosulfan	2 652.00	2 500.00	44.00	0.240	10.560
Corn	Insecticides	Chlorpyrifos	2 652.00	2 500.00	45.00	0.480	21.600
Corn	Insecticides	Chlorpyrifos-e	2 652.00	2 500.00	3.00	0.480	1.440
Corn	Insecticides	Cypermethrin	2 652.00	2 500.00	253.33	0.030	7.600
Corn	Insecticides	Deltamethrin	2 652.00	2 500.00	400.00	0.011	4.275
Corn	Insecticides	Endosulfan	2 652.00	2 500.00	0.80	1.188	0.950
Corn	Insecticides	Esfenvalerate	2 652.00	2 500.00	200.00	0.010	2.000
Corn	Insecticides	Fenpyroximate	2 652.00	2 500.00	3.71	0.175	0.650
Corn	Insecticides	Gamma-cyhalothrin	2 652.00	2 500.00	250.00	0.004	0.900
Corn	Insecticides	Indoxacarb	2 652.00	2 500.00	60.00	0.038	2.250
Corn	Insecticides	Lambda-cyhalothrin	2 652.00	2 500.00	3 172.62	0.006	20.050

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Corn	Insecticides	Methomyl	2 652.00	2 500.00	32.11	0.202	6.500
Corn	Insecticides	Propargite	2 652.00	2 500.00	0.50	0.800	0.400
Corn	Insecticides	Terbufos	2 652.00	2 500.00	884.00	0.207	182.550
Corn	Insecticides	Thiodicarb	2 652.00	2 500.00	1.00	0.375	0.375
Corn	Fungicides	Azoxystrobin	2 652.00	500.00	191.25	0.104	19.925
Corn	Fungicides	Carbendazim	2 652.00	500.00	35.15	0.108	3.813
Corn	Fungicides	Cyproconazole	2 652.00	500.00	30.00	0.040	1.200
Corn	Fungicides	Difenoconazole	2 652.00	500.00	109.01	0.068	7.438
Corn	Fungicides	Epoxiconazole	2 652.00	500.00	179.09	0.072	12.875
Corn	Fungicides	Flusilazole	2 652.00	500.00	23.33	0.188	4.375
Corn	Fungicides	Flutriafol	2 652.00	500.00	8.00	0.156	1.250
Corn	Fungicides	Picoxystrobin	2 652.00	500.00	33.33	0.075	2.500
Corn	Fungicides	Propiconazole	2 652.00	500.00	30.00	0.125	3.750
Corn	Fungicides	Pyraclostrobin	2 652.00	500.00	150.00	0.063	9.375
Corn	Fungicides	Tebuconazole	2 652.00	500.00	68.00	0.117	7.960
Corn	Fungicides	Trifloxystrobin	2 652.00	500.00	4.00	0.100	0.400
Corn	Herbicides	2.4-D-amine	2 652.00	2 500.00	187.00	0.839	156.840
Corn	Herbicides	2.4-D-ester	2 652.00	2 500.00	260.00	0.243	63.200
Corn	Herbicides	Acetochlor	2 652.00	2 500.00	968.10	1.397	1 352.750
Corn	Herbicides	Alachlor	2 652.00	2 500.00	0.73	1.822	1.325
Corn	Herbicides	Atrazine	2 652.00	2 500.00	1 675.20	0.637	1 066.830
Corn	Herbicides	Bentazone	2 652.00	2 500.00	13.25	1.709	22.640
Corn	Herbicides	Bromoxynil	2 652.00	2 500.00	88.79	0.414	36.750
Corn	Herbicides	Clethodim	2 652.00	2 500.00	40.00	0.090	3.600
Corn	Herbicides	Dicamba	2 652.00	2 500.00	48.86	0.083	4.040
Corn	Herbicides	Dimethenamid-P	2 652.00	2 500.00	93.33	0.540	50.400
Corn	Herbicides	EPTC	2 652.00	2 500.00	35.00	2.160	75.600
Corn	Herbicides	Flumetsulam	2 652.00	2 500.00	0.83	0.024	0.020

Crop	Sector	AI	Crop area (x10³ ha)	Base area (x10³ ha)	AI Area Treated (x10³ ha)	AI dose rate (kg or L/ha)	AI volume (x 10³ kg/L)
Corn	Herbicides	Fluroxypyr	2 652.00	2 500.00	1.00	0.200	0.200
Corn	Herbicides	Glyphosate	2 652.00	2 500.00	4 110.12	1.063	4 370.850
Corn	Herbicides	Halosulfuron-m	2 652.00	2 500.00	160.00	0.038	6.000
Corn	Herbicides	Isoxadifen-e	2 652.00	2 500.00	100.00	0.025	2.520
Corn	Herbicides	MCPA	2 652.00	2 500.00	9.23	0.520	4.800
Corn	Herbicides	Mesotrione	2 652.00	2 500.00	2 330.29	0.115	267.385
Corn	Herbicides	Metolachlor	2 652.00	2 500.00	1 862.50	0.849	1 581.580
Corn	Herbicides	Nicosulfuron	2 652.00	2 500.00	30.00	0.045	1.350
Corn	Herbicides	Paraquat	2 652.00	2 500.00	101.00	0.419	42.300
Corn	Herbicides	Propaquizafop	2 652.00	2 500.00	26.67	0.075	2.000
Corn	Herbicides	Quizalofop-P-t	2 652.00	2 500.00	45.00	0.040	1.800
Corn	Herbicides	Simazine	2 652.00	2 500.00	5.00	0.825	4.125
Corn	Herbicides	s-metolachlor	2 652.00	2 500.00	577.36	0.651	376.022
Corn	Herbicides	Sulcotrione	2 652.00	2 500.00	208.33	0.150	31.250
Corn	Herbicides	Tembotrione	2 652.00	2 500.00	100.00	0.050	5.040
Corn	Herbicides	Terbuthylazine	2 652.00	2 500.00	1 201.25	0.617	741.336
Corn	Herbicides	Topramezone	2 652.00	2 500.00	26.95	0.036	0.961
Corn	Herbicides	Triazines	2 652.00	2 500.00	335.00	0.036	12.060
Corn	Seed dressing	Abamectin	2 652.00	2 500.00	3 076.92	0.001	3.200
Corn	Seed dressing	Clothianidin	2 652.00	2 500.00	550.00	0.012	6.600
Corn	Seed dressing	Fludioxonil	2 652.00	2 500.00	1 250.00	0.001	0.625
Corn	Seed dressing	Imidacloprid	2 652.00	2 500.00	1 280.00	0.033	42.400
Corn	Seed dressing	Metalaxyl-M	2 652.00	2 500.00	1 250.00	0.000	0.250
Corn	Seed dressing	Tefluthrin	2 652.00	2 500.00	86.67	0.024	2.080
Corn	Seed dressing	Thiamethoxam	2 652.00	2 500.00	443.81	0.046	20.200
Cotton	Insecticides	Abamectin	10.00	10.00	10.00	0.011	0.108
Cotton	Insecticides	Acetamiprid	10.00	10.00	4.00	0.100	0.400
Cotton	Insecticides	Alphacypermethrin	10.00	10.00	20.00	0.010	0.200

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Cotton	Insecticides	Azinphos-m	10.00	10.00	0.83	0.420	0.350
Cotton	Insecticides	Betacyfluthrin	10.00	10.00	100.00	0.007	0.675
Cotton	Insecticides	Betacypermethrin	10.00	10.00	15.38	0.007	0.100
Cotton	Insecticides	Bifenthrin	10.00	10.00	2.00	0.050	0.100
Cotton	Insecticides	Bromopropylate	10.00	10.00	3.33	0.150	0.500
Cotton	Insecticides	Carbaryl	10.00	10.00	1.00	0.850	0.850
Cotton	Insecticides	Carbosulfan	10.00	10.00	2.00	0.240	0.480
Cotton	Insecticides	Chlorfenapyr	10.00	10.00	4.00	0.180	0.720
Cotton	Insecticides	Cypermethrin	10.00	10.00	53.33	0.030	1.600
Cotton	Insecticides	Deltamethrin	10.00	10.00	33.33	0.005	0.175
Cotton	Insecticides	Diafenthiuron	10.00	10.00	1.00	0.500	0.500
Cotton	Insecticides	Dimethoate	10.00	10.00	14.33	0.056	0.800
Cotton	Insecticides	Esfenvalerate	10.00	10.00	20.00	0.010	0.200
Cotton	Insecticides	Fenamiphos	10.00	10.00	0.05	2.000	0.100
Cotton	Insecticides	Fenpropathrin	10.00	10.00	4.00	0.050	0.200
Cotton	Insecticides	Gamma-cyhalothrin	10.00	10.00	1.67	0.004	0.006
Cotton	Insecticides	Imidacloprid	10.00	10.00	8.57	0.163	1.400
Cotton	Insecticides	Indoxacarb	10.00	10.00	8.00	0.038	0.300
Cotton	Insecticides	Lambda-cyhalothrin	10.00	10.00	33.33	0.006	0.200
Cotton	Insecticides	Pirimicarb	10.00	10.00	2.00	0.250	0.500
Cotton	Insecticides	Profenofos	10.00	10.00	1.00	0.500	0.500
Cotton	Insecticides	Propargite	10.00	10.00	1.00	0.800	0.800
Cotton	Insecticides	Pymetrozine	10.00	10.00	4.00	0.188	0.750
Cotton	Insecticides	Tetradifon	10.00	10.00	0.50	0.160	0.080
Cotton	Insecticides	Thiodicarb	10.00	10.00	1.00	0.375	0.375
Cotton	Herbicides	Glyphosate	10.00	10.00	26.67	1.080	28.800
Cotton	Herbicides	MSMA	10.00	10.00	4.00	2.160	8.640
Cotton	Herbicides	Pendimethalin	10.00	10.00	0.40	1.250	0.500

Crop	Sector	AI	Crop area ($x10^3$ ha)	Base area ($x10^3$ ha)	AI Area Treated ($x10^3$ ha)	AI dose rate (kg or L/ha)	AI volume ($x 10^3$ kg/L)
Cotton	Herbicides	Trifluralin	10.00	10.00	6.67	0.720	4.800
Cotton	Growth regulators	Mepiquat-chloride	10.00	8.00	40.00	0.013	0.500
Cotton	Seed dressing	Thiamethoxam	10.00	9.00	9.80	0.092	0.900
Pasture	Insecticides	Alphacypermethrin	2 400.00		50.00	0.010	0.500
Pasture	Insecticides	Chlorpyrifos-e	2 400.00		1.00	0.480	0.480
Pasture	Insecticides	Cypermethrin	2 400.00		6.67	0.030	0.200
Pasture	Herbicides	2.4-D-amine	2 400.00	125.00	90.00	0.960	86.400
Pasture	Herbicides	Cycloxydim	2 400.00	125.00	0.50	0.200	0.100
Pasture	Herbicides	Glyphosate	2 400.00	125.00	10.00	0.990	9.900
Pasture	Herbicides	MCPA	2 400.00	125.00	26.67	0.600	16.000
Pasture	Herbicides	Propyzamide	2 400.00	125.00	0.33	0.750	0.250
Forestry	Insecticides	Alphacypermethrin	1 500.00	90.00	20.00	0.010	0.200
Forestry	Insecticides	Bacillus-thuringiensis	1 500.00	90.00	4.00	0.008	0.032
Forestry	Insecticides	Betacyfluthrin	1 500.00	90.00	16.67	0.008	0.125
Forestry	Insecticides	Betacypermethrin	1 500.00	90.00	15.38	0.007	0.100
Forestry	Insecticides	Chlorpyrifos-e	1 500.00	90.00	3.00	0.480	1.440
Forestry	Insecticides	Cypermethrin	1 500.00	90.00	26.67	0.030	0.800
Forestry	Insecticides	Deltamethrin	1 500.00	90.00	8.33	0.012	0.100
Forestry	Insecticides	Lambda-cyhalothrin	1 500.00	90.00	16.67	0.006	0.100
Forestry	Fungicides	Propamocarb-HCl	1 500.00	2.02	0.02	72.200	1.444
Forestry	Fungicides	Propiconazole	1 500.00	2.02	2.00	0.125	0.250
Forestry	Herbicides	Acetochlor	1 500.00	250.00	3.50	1.920	6.720
Forestry	Herbicides	Clethodim	1 500.00	250.00	5.67	0.095	0.540
Forestry	Herbicides	Cycloxydim	1 500.00	250.00	0.50	0.200	0.100
Forestry	Herbicides	Fluazifop-P-b	1 500.00	250.00	1.30	0.308	0.400
Forestry	Herbicides	Flumioxazin	1 500.00	250.00	0.50	0.100	0.050
Forestry	Herbicides	Fluroxypyr	1 500.00	250.00	10.00	0.080	0.800
Forestry	Herbicides	Glyphosate	1 500.00	250.00	176.67	1.263	223.200

Crop	Sector	AI	Crop area (x10³ ha)	Base area (x10³ ha)	AI Area Treated (x10³ ha)	AI dose rate (kg or L/ha)	AI volume (x 10³ kg/L)
Forestry	Herbicides	Hexazinone	1 500.00	250.00	2.53	1.468	3.720
Forestry	Herbicides	Imazapyr	1 500.00	250.00	17.50	0.080	1.400
Forestry	Herbicides	Metsulfuron-m	1 500.00	250.00	3.75	0.240	0.900
Forestry	Herbicides	Oxyfluorfen	1 500.00	250.00	0.17	0.720	0.120
Forestry	Herbicides	Paraquat	1 500.00	250.00	1.50	0.635	0.952
Forestry	Herbicides	Picloram	1 500.00	250.00	10.00	0.080	0.800
Forestry	Herbicides	Propaquizafop	1 500.00	250.00	1.33	0.075	0.100
Forestry	Herbicides	s-metolachlor	1 500.00	250.00	5.62	1.081	6.068
Forestry	Herbicides	Terbuthylazine	1 500.00	250.00	1.00	1.492	1.492
Forestry	Herbicides	Triclopyr	1 500.00	250.00	22.20	2.011	44.640
Groundnuts/peanuts	Insecticides	Alphacypermethrin	58.00	45.00	5.00	0.010	0.050
Groundnuts/peanuts	Insecticides	Betacyfluthrin	58.00	45.00	1.67	0.003	0.005
Groundnuts/peanuts	Insecticides	Betacypermethrin	58.00	45.00	1.54	0.007	0.010
Groundnuts/peanuts	Insecticides	Carbofuran	58.00	45.00	0.10	1.000	0.100
Groundnuts/peanuts	Insecticides	Cypermethrin	58.00	45.00	53.33	0.030	1.600
Groundnuts/peanuts	Insecticides	Deltamethrin	58.00	45.00	3.33	0.012	0.040
Groundnuts/peanuts	Insecticides	Fenamiphos	58.00	45.00	0.51	4.000	2.040
Groundnuts/peanuts	Insecticides	Fenpyroximate	58.00	45.00	2.00	0.250	0.500
Groundnuts/peanuts	Insecticides	Furfural	58.00	45.00	0.40	22.500	9.000
Groundnuts/peanuts	Insecticides	Gamma-cyhalothrin	58.00	45.00	16.67	0.004	0.060
Groundnuts/peanuts	Insecticides	Lambda-cyhalothrin	58.00	45.00	75.00	0.006	0.450
Groundnuts/peanuts	Insecticides	Oxamyl	58.00	45.00	17.92	0.433	7.750
Groundnuts/peanuts	Insecticides	Terbufos	58.00	45.00	2.44	1.847	4.500
Groundnuts/peanuts	Fungicides	Azoxystrobin	58.00	35.00	14.60	0.085	1.243
Groundnuts/peanuts	Fungicides	Benomyl	58.00	35.00	20.00	0.250	5.000
Groundnuts/peanuts	Fungicides	Carbendazim	58.00	35.00	14.39	0.066	0.950
Groundnuts/peanuts	Fungicides	Chlorothalonil	58.00	35.00	2.76	1.172	3.240
Groundnuts/peanuts	Fungicides	Dichlorophen	58.00	35.00	0.08	0.500	0.040

Crop	Sector	AI	Crop area (x10³ ha)	Base area (x10³ ha)	AI Area Treated (x10³ ha)	AI dose rate (kg or L/ha)	AI volume (x 10³ kg/L)
Groundnuts/peanuts	Fungicides	Difenoconazole	58.00	35.00	4.77	0.064	0.306
Groundnuts/peanuts	Fungicides	Epoxiconazole	58.00	35.00	10.83	0.075	0.813
Groundnuts/peanuts	Fungicides	Flusilazole	58.00	35.00	12.29	0.092	1.125
Groundnuts/peanuts	Fungicides	Mancozeb	58.00	35.00	3.50	1.600	5.600
Groundnuts/peanuts	Fungicides	Maneb	58.00	35.00	1.00	1.305	1.305
Groundnuts/peanuts	Fungicides	Procymidone	58.00	35.00	2.67	0.188	0.500
Groundnuts/peanuts	Fungicides	Propiconazole	58.00	35.00	1.00	0.500	0.500
Groundnuts/peanuts	Fungicides	Tebuconazole	58.00	35.00	8.65	0.124	1.070
Groundnuts/peanuts	Fungicides	Zinc-oxide	58.00	35.00	1.00	0.014	0.014
Groundnuts/peanuts	Herbicides	Acetochlor	58.00	55.00	40.48	1.071	43.360
Groundnuts/peanuts	Herbicides	Alachlor	58.00	55.00	0.66	1.601	1.056
Groundnuts/peanuts	Herbicides	Bentazone	58.00	55.00	1.63	1.920	3.120
Groundnuts/peanuts	Herbicides	Clethodim	58.00	55.00	2.00	0.090	0.180
Groundnuts/peanuts	Herbicides	Cycloxydim	58.00	55.00	0.50	0.200	0.100
Groundnuts/peanuts	Herbicides	Diclosulam	58.00	55.00	50.00	0.013	0.630
Groundnuts/peanuts	Herbicides	Dimethenamid-P	58.00	55.00	4.20	0.360	1.512
Groundnuts/peanuts	Herbicides	Flumetsulam	58.00	55.00	46.47	0.021	0.980
Groundnuts/peanuts	Herbicides	Flumioxazin	58.00	55.00	2.00	0.050	0.100
Groundnuts/peanuts	Herbicides	Glyphosate	58.00	55.00	60.00	1.020	61.200
Groundnuts/peanuts	Herbicides	Metazachlor	58.00	55.00	1.67	0.600	1.000
Groundnuts/peanuts	Herbicides	Metolachlor	58.00	55.00	134.17	0.775	103.950
Groundnuts/peanuts	Herbicides	Propaquizafop	58.00	55.00	2.67	0.075	0.200
Groundnuts/peanuts	Herbicides	Quizalofop-P-e	58.00	55.00	0.40	0.050	0.020
Groundnuts/peanuts	Herbicides	Quizalofop-P-t	58.00	55.00	2.00	0.040	0.080
Groundnuts/peanuts	Herbicides	s-metolachlor	58.00	55.00	7.00	0.768	5.376
Groundnuts/peanuts	Herbicides	Trifluralin	58.00	55.00	13.33	0.720	9.600
Industrial Mkts	Herbicides	Bromacil	250.00	200.00	19.42	2.647	51.400
Industrial Mkts	Herbicides	Diquat	250.00	200.00	1.67	0.240	0.400

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Industrial Mkts	Herbicides	Glyphosate	250.00	200.00	273.00	1.046	285.640
Industrial Mkts	Herbicides	Imazapyr	250.00	200.00	16.00	0.250	4.000
Industrial Mkts	Herbicides	Paraquat	250.00	200.00	1.67	0.360	0.600
Industrial Mkts	Herbicides	Picloram	250.00	200.00	26.00	1.200	31.200
Industrial Mkts	Herbicides	Simazine	250.00	200.00	22.50	0.200	4.500
Industrial Mkts	Herbicides	Tebuthiuron	250.00	200.00	18.67	5.089	95.000
Industrial Mkts	Herbicides	Terbuthylazine	250.00	200.00	32.50	0.249	8.100
Oil Seeds	Insecticides	Betacyfluthrin	77.50	50.00	25.00	0.008	0.188
Oil Seeds	Insecticides	Deltamethrin	77.50	50.00	16.67	0.008	0.125
Oil Seeds	Insecticides	Gamma-cyhalothrin	77.50	50.00	8.33	0.004	0.030
Oil Seeds	Insecticides	Lambda-cyhalothrin	77.50	50.00	16.67	0.006	0.100
Oil Seeds	Insecticides	Metaldehyde	77.50	50.00	0.50	0.200	0.100
Oil Seeds	Insecticides	Methiocarb	77.50	50.00	0.50	0.100	0.050
Oil Seeds	Fungicides	Penconazole	77.50	8.00	1.00	0.040	0.040
Oil Seeds	Fungicides	Prothioconazole	77.50	8.00	8.33	0.075	0.625
Oil Seeds	Fungicides	Tebuconazole	77.50	8.00	8.33	0.075	0.625
Oil Seeds	Herbicides	Alachlor	77.50	65.00	0.50	1.728	0.864
Oil Seeds	Herbicides	Atrazine	77.50	65.00	7.50	1.000	7.500
Oil Seeds	Herbicides	Clethodim	77.50	65.00	6.67	0.090	0.600
Oil Seeds	Herbicides	Cycloxydim	77.50	65.00	0.25	0.200	0.050
Oil Seeds	Herbicides	Glyphosate	77.50	65.00	2.00	0.720	1.440
Oil Seeds	Herbicides	Imazamox	77.50	65.00	12.50	0.480	6.000
Oil Seeds	Herbicides	Propaquizafop	77.50	65.00	0.67	0.075	0.050
Oil Seeds	Herbicides	Propyzamide	77.50	65.00	1.33	0.750	1.000
Oil Seeds	Herbicides	s-metolachlor	77.50	65.00	0.13	3.840	0.480
Oil Seeds	Herbicides	Tepraloxydim	77.50	65.00	45.00	0.050	2.250
Oil Seeds	Seed dressing	Fludioxonil	77.50	16.67	16.67	0.001	0.016
Oil Seeds	Seed dressing	Metalaxyl-M	77.50	16.67	16.67	0.004	0.067

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Oil Seeds	Seed dressing	Thiamethoxam	77.50	16.67	16.67	0.034	0.560
Beans	Insecticides	Alphacypermethrin	55.82	55.00	23.00	0.010	0.230
Beans	Insecticides	Bacillus-thur.-aizawai	55.82	55.00	1.00	0.008	0.008
Beans	Insecticides	Betacyfluthrin	55.82	55.00	3.33	0.005	0.018
Beans	Insecticides	Betacypermethrin	55.82	55.00	15.38	0.007	0.100
Beans	Insecticides	Carbaryl	55.82	55.00	1.00	0.850	0.850
Beans	Insecticides	Chlorpyrifos	55.82	55.00	1.00	0.480	0.480
Beans	Insecticides	Cypermethrin	55.82	55.00	23.33	0.030	0.700
Beans	Insecticides	Deltamethrin	55.82	55.00	18.33	0.008	0.145
Beans	Insecticides	Esfenvalerate	55.82	55.00	20.00	0.010	0.200
Beans	Insecticides	Ethoprophos	55.82	55.00	0.80	0.500	0.400
Beans	Insecticides	Lambda-cyhalothrin	55.82	55.00	44.17	0.009	0.389
Beans	Insecticides	Malathion	55.82	55.00	0.10	0.500	0.050
Beans	Insecticides	Methomyl	55.82	55.00	19.67	0.207	4.080
Beans	Insecticides	Terbufos	55.82	55.00	4.00	1.500	6.000
Beans	Fungicides	Azoxystrobin	55.82	55.00	6.00	0.075	0.450
Beans	Fungicides	Carbendazim	55.82	55.00	5.60	0.063	0.350
Beans	Fungicides	Chlorothalonil	55.82	55.00	3.07	1.080	3.312
Beans	Fungicides	Copper-oxychloride	55.82	55.00	5.67	2.550	14.450
Beans	Fungicides	Cyproconazole	55.82	55.00	2.00	0.040	0.080
Beans	Fungicides	Difenoconazole	55.82	55.00	8.57	0.088	0.750
Beans	Fungicides	Epoxiconazole	55.82	55.00	3.33	0.075	0.250
Beans	Fungicides	Flusilazole	55.82	55.00	23.27	0.105	2.450
Beans	Fungicides	Mancozeb	55.82	55.00	16.00	1.600	25.600
Beans	Fungicides	Maneb	55.82	55.00	8.83	0.542	4.785
Beans	Fungicides	Picoxystrobin	55.82	55.00	10.00	0.075	0.750
Beans	Fungicides	Procymidone	55.82	55.00	9.73	0.092	0.900
Beans	Fungicides	Propiconazole	55.82	55.00	2.00	0.125	0.250

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Beans	Fungicides	Tebuconazole	55.82	55.00	3.33	0.150	0.500
Beans	Fungicides	Zinc-oxide	55.82	55.00	0.50	0.009	0.005
Beans	Herbicides	Alachlor	55.82	55.00	3.00	1.536	4.608
Beans	Herbicides	Bentazone	55.82	55.00	17.45	1.458	25.440
Beans	Herbicides	Clethodim	55.82	55.00	0.67	0.090	0.060
Beans	Herbicides	Dimethenamid-P	55.82	55.00	1.13	0.540	0.612
Beans	Herbicides	Fluazifop-P-b	55.82	55.00	0.67	0.225	0.150
Beans	Herbicides	Flumetsulam	55.82	55.00	0.83	0.024	0.020
Beans	Herbicides	Imazethapyr	55.82	55.00	15.00	0.040	0.600
Beans	Herbicides	Metazachlor	55.82	55.00	3.33	0.600	2.000
Beans	Herbicides	Metolachlor	55.82	55.00	125.83	1.149	144.630
Beans	Herbicides	Propaquizafop	55.82	55.00	4.00	0.075	0.300
Beans	Herbicides	Quizalofop-P-e	55.82	55.00	0.80	0.050	0.040
Beans	Herbicides	Quizalofop-P-t	55.82	55.00	0.50	0.040	0.020
Beans	Herbicides	s-metolachlor	55.82	55.00	30.00	0.768	23.040
Beans	Herbicides	Trifluralin	55.82	55.00	3.20	0.720	2.304
Apples	Insecticides	Abamectin	22.93	22.93	80.33	0.009	0.738
Apples	Insecticides	Acephate	22.93	22.93	1.67	0.900	1.500
Apples	Insecticides	Alphacypermethrin	22.93	22.93	15.00	0.010	0.150
Apples	Insecticides	Azinphos-m	22.93	22.93	36.67	0.404	14.800
Apples	Insecticides	Bacillus-thuringiensis	22.93	22.93	13.33	0.010	0.128
Apples	Insecticides	Betacyfluthrin	22.93	22.93	33.33	0.003	0.100
Apples	Insecticides	Betacypermethrin	22.93	22.93	76.92	0.007	0.500
Apples	Insecticides	Cadusafos	22.93	22.93	0.07	1.500	0.100
Apples	Insecticides	Carbaryl	22.93	22.93	0.14	1.000	0.140
Apples	Insecticides	Chlorantraniliprole	22.93	22.93	32.00	0.017	0.540
Apples	Insecticides	Chlorfenapyr	22.93	22.93	7.00	0.180	1.260
Apples	Insecticides	Chlorpyrifos	22.93	22.93	15.00	0.480	7.200

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Apples	Insecticides	Chlorpyrifos-e	22.93	22.93	26.00	0.480	12.480
Apples	Insecticides	Cydia pomonella GV	22.93	22.93	1.80	2.650	4.770
Apples	Insecticides	Cypermethrin	22.93	22.93	6.67	0.030	0.200
Apples	Insecticides	Deltamethrin	22.93	22.93	100.00	0.008	0.825
Apples	Insecticides	Emamectin-benzoate	22.93	22.93	57.47	0.004	0.250
Apples	Insecticides	Esfenvalerate	22.93	22.93	60.00	0.010	0.600
Apples	Insecticides	Etoxazole	22.93	22.93	2.86	0.035	0.100
Apples	Insecticides	Fenbutatin-oxide	22.93	22.93	1.41	0.373	0.525
Apples	Insecticides	Fenthion	22.93	22.93	0.39	1.000	0.389
Apples	Insecticides	Flufenoxuron	22.93	22.93	3.00	0.300	0.900
Apples	Insecticides	Gamma-cyhalothrin	22.93	22.93	16.67	0.014	0.240
Apples	Insecticides	Imidacloprid	22.93	22.93	80.00	0.179	14.350
Apples	Insecticides	Indoxacarb	22.93	22.93	24.00	0.075	1.800
Apples	Insecticides	Lambda-cyhalothrin	22.93	22.93	158.33	0.006	0.950
Apples	Insecticides	Malathion	22.93	22.93	15.00	0.500	7.500
Apples	Insecticides	Metaldehyde	22.93	22.93	1.44	0.326	0.470
Apples	Insecticides	Methiocarb	22.93	22.93	1.30	0.100	0.130
Apples	Insecticides	Methoxyfenozide	22.93	22.93	1.67	0.144	0.240
Apples	Insecticides	Milbemectin	22.93	22.93	1.67	0.006	0.010
Apples	Insecticides	Parathion-m	22.93	22.93	9.60	0.563	5.400
Apples	Insecticides	Petroleum-oil	22.93	22.93	2.86	14.534	41.525
Apples	Insecticides	Propargite	22.93	22.93	5.00	0.590	2.950
Apples	Insecticides	Spinosad	22.93	22.93	1.50	0.240	0.360
Apples	Insecticides	Tau-fluvalinate	22.93	22.93	15.56	0.216	3.360
Apples	Insecticides	Tetradifon	22.93	22.93	3.75	0.640	2.400
Apples	Insecticides	Thiacloprid	22.93	22.93	20.00	0.168	3.360
Apples	Insecticides	Thiamethoxam	22.93	22.93	20.00	0.024	0.480
Apples	Fungicides	Benomyl	22.93	22.93	14.00	0.250	3.500

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Apples	Fungicides	Bupirimate	22.93	22.93	7.27	0.275	2.000
Apples	Fungicides	Copper-hydroxide	22.93	22.93	0.20	3.430	0.686
Apples	Fungicides	Copper-oxychloride	22.93	22.93	3.33	5.100	17.000
Apples	Fungicides	Cyprodinil	22.93	22.93	28.33	0.150	4.250
Apples	Fungicides	Difenoconazole	22.93	22.93	5.71	0.088	0.500
Apples	Fungicides	Dithianon	22.93	22.93	16.80	0.150	2.520
Apples	Fungicides	Dodine	22.93	22.93	12.50	0.480	6.000
Apples	Fungicides	Fludioxonil	22.93	22.93	2.00	0.115	0.230
Apples	Fungicides	Fluopyram	22.93	22.93	2.50	0.080	0.200
Apples	Fungicides	Flusilazole	22.93	22.93	33.33	0.045	1.500
Apples	Fungicides	Kresoxim-m	22.93	22.93	15.79	0.190	3.000
Apples	Fungicides	Mancozeb	22.93	22.93	75.12	2.306	173.250
Apples	Fungicides	Maneb	22.93	22.93	1.89	1.609	3.045
Apples	Fungicides	Metiram	22.93	22.93	3.00	2.800	8.400
Apples	Fungicides	Myclobutanil	22.93	22.93	20.00	0.030	0.600
Apples	Fungicides	Penconazole	22.93	22.93	46.90	0.013	0.600
Apples	Fungicides	Procymidone	22.93	22.93	0.75	0.300	0.225
Apples	Fungicides	Pyraclostrobin	22.93	22.93	16.80	0.050	0.840
Apples	Fungicides	Pyrimethanil	22.93	22.93	15.00	0.160	2.400
Apples	Fungicides	Sulphur	22.93	22.93	11.67	2.400	28.000
Apples	Fungicides	Tebuconazole	22.93	22.93	2.50	0.080	0.200
Apples	Fungicides	Thiram	22.93	22.93	4.00	1.900	7.600
Apples	Fungicides	Trifloxystrobin	22.93	22.93	15.00	0.048	0.720
Apples	Fungicides	Zinc-oxide	22.93	22.93	1.14	0.016	0.019
Apples	Herbicides	Carfentrazone-e	22.93	22.93	4.00	0.010	0.040
Apples	Herbicides	Clethodim	22.93	22.93	0.50	0.120	0.060
Apples	Herbicides	Cycloxydim	22.93	22.93	0.25	0.200	0.050
Apples	Herbicides	Diquat	22.93	22.93	16.67	0.240	4.000

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Apples	Herbicides	Fluazifop-P-b	22.93	22.93	0.45	0.306	0.138
Apples	Herbicides	Flumioxazin	22.93	22.93	0.50	0.100	0.050
Apples	Herbicides	Glufosinate-ammonium	22.93	22.93	2.40	0.500	1.200
Apples	Herbicides	Glyphosate	22.93	22.93	98.57	0.819	80.700
Apples	Herbicides	Haloxyfop-r-m	22.93	22.93	0.67	0.162	0.108
Apples	Herbicides	MCPA	22.93	22.93	2.50	0.480	1.200
Apples	Herbicides	Oxadiazon	22.93	22.93	0.07	1.500	0.100
Apples	Herbicides	Oxyfluorfen	22.93	22.93	1.00	0.240	0.240
Apples	Herbicides	Paraquat	22.93	22.93	58.33	0.478	27.900
Apples	Herbicides	Propaquizafop	22.93	22.93	0.67	0.075	0.050
Apples	Herbicides	Propyzamide	22.93	22.93	1.00	0.500	0.500
Apples	Herbicides	Simazine	22.93	22.93	18.18	1.100	20.000
Apples	Herbicides	s-metolachlor	22.93	22.93	3.33	0.308	1.028
Apples	Herbicides	Terbuthylazine	22.93	22.93	3.33	1.492	4.972
Apples	Growth regulators	Carbaryl	22.93	15.00	0.50	1.700	0.850
Apples	Growth regulators	Cyanamide	22.93	15.00	6.40	10.000	64.000
Apples	Growth regulators	Mineral-oil	22.93	15.00	11.92	52.154	621.500
Apples	Growth regulators	Prohexadione-Ca	22.93	15.00	3.50	0.200	0.700
Peaches/nectarines	Insecticides	Acephate	9.70	9.70	1.30	0.750	0.975
Peaches/nectarines	Insecticides	Alphacypermethrin	9.70	9.70	36.00	0.010	0.360
Peaches/nectarines	Insecticides	Azinphos-m	9.70	9.70	11.76	0.595	7.000
Peaches/nectarines	Insecticides	Betacyfluthrin	9.70	9.70	16.67	0.003	0.050
Peaches/nectarines	Insecticides	Betacypermethrin	9.70	9.70	15.38	0.007	0.100
Peaches/nectarines	Insecticides	Cadusafos	9.70	9.70	2.67	1.500	4.000
Peaches/nectarines	Insecticides	Carbaryl	9.70	9.70	0.20	0.500	0.100
Peaches/nectarines	Insecticides	Chlorfenapyr	9.70	9.70	26.00	0.180	4.680
Peaches/nectarines	Insecticides	Chlorpyrifos	9.70	9.70	5.00	0.480	2.400
Peaches/nectarines	Insecticides	Chlorpyrifos-e	9.70	9.70	16.00	0.480	7.680

Crop	Sector	AI	Crop area ($x10^3$ ha)	Base area ($x10^3$ ha)	AI Area Treated ($x10^3$ ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Peaches/nectarines	Insecticides	Cypermethrin	9.70	9.70	40.00	0.030	1.200
Peaches/nectarines	Insecticides	Deltamethrin	9.70	9.70	50.00	0.006	0.300
Peaches/nectarines	Insecticides	Dimethoate	9.70	9.70	1.00	0.400	0.400
Peaches/nectarines	Insecticides	Fenamiphos	9.70	9.70	0.60	4.000	2.400
Peaches/nectarines	Insecticides	Fenbutatin-oxide	9.70	9.70	3.82	0.419	1.600
Peaches/nectarines	Insecticides	Fenthion	9.70	9.70	0.92	0.545	0.500
Peaches/nectarines	Insecticides	Gamma-cyhalothrin	9.70	9.70	8.33	0.004	0.030
Peaches/nectarines	Insecticides	Indoxacarb	9.70	9.70	10.00	0.150	1.500
Peaches/nectarines	Insecticides	Lambda-cyhalothrin	9.70	9.70	86.67	0.007	0.600
Peaches/nectarines	Insecticides	Malathion	9.70	9.70	6.00	0.500	3.000
Peaches/nectarines	Insecticides	Metaldehyde	9.70	9.70	0.20	0.750	0.150
Peaches/nectarines	Insecticides	Methamidophos	9.70	9.70	1.00	0.585	0.585
Peaches/nectarines	Insecticides	Methomyl	9.70	9.70	10.11	0.198	2.000
Peaches/nectarines	Insecticides	Oxamyl	9.70	9.70	6.25	1.240	7.750
Peaches/nectarines	Insecticides	Pirimicarb	9.70	9.70	20.00	0.250	5.000
Peaches/nectarines	Insecticides	Propargite	9.70	9.70	10.00	0.295	2.950
Peaches/nectarines	Insecticides	Spinosad	9.70	9.70	0.13	0.360	0.048
Peaches/nectarines	Insecticides	Tetradifon	9.70	9.70	4.80	0.400	1.920
Peaches/nectarines	Insecticides	Thiacloprid	9.70	9.70	2.86	0.168	0.480
Peaches/nectarines	Fungicides	Copper-hydroxide	9.70	9.70	16.67	1.614	26.900
Peaches/nectarines	Fungicides	Copper-oxychloride	9.70	9.70	33.33	2.550	85.000
Peaches/nectarines	Fungicides	Copper-sulphate	9.70	9.70	4.00	0.800	3.200
Peaches/nectarines	Fungicides	Dinocap	9.70	9.70	1.00	0.350	0.350
Peaches/nectarines	Fungicides	Fludioxonil	9.70	9.70	1.00	0.115	0.115
Peaches/nectarines	Fungicides	Mancozeb	9.70	9.70	120.00	1.763	211.500
Peaches/nectarines	Fungicides	Prochloraz	9.70	9.70	1.00	0.500	0.500
Peaches/nectarines	Fungicides	Procymidone	9.70	9.70	2.67	0.281	0.750
Peaches/nectarines	Fungicides	Propiconazole	9.70	9.70	5.00	0.100	0.500

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Peaches/nectarines	Fungicides	Sulphur	9.70	9.70	13.33	2.400	32.000
Peaches/nectarines	Fungicides	Thiram	9.70	9.70	7.50	1.813	13.600
Peaches/nectarines	Herbicides	Carfentrazone-e	9.70	9.70	2.00	0.010	0.020
Peaches/nectarines	Herbicides	Cycloxydim	9.70	9.70	1.00	0.200	0.200
Peaches/nectarines	Herbicides	Diquat	9.70	9.70	3.00	0.160	0.480
Peaches/nectarines	Herbicides	Fluazifop-P-b	9.70	9.70	0.50	0.300	0.150
Peaches/nectarines	Herbicides	Flumioxazin	9.70	9.70	0.50	0.100	0.050
Peaches/nectarines	Herbicides	Flurochloridone	9.70	9.70	0.31	0.800	0.250
Peaches/nectarines	Herbicides	Glufosinate-ammonium	9.70	9.70	3.00	0.400	1.200
Peaches/nectarines	Herbicides	Glyphosate	9.70	9.70	90.00	1.080	97.200
Peaches/nectarines	Herbicides	Haloxyfop-r-m	9.70	9.70	4.00	0.162	0.648
Peaches/nectarines	Herbicides	MCPA	9.70	9.70	2.67	0.600	1.600
Peaches/nectarines	Herbicides	Oxadiazon	9.70	9.70	0.50	0.500	0.250
Peaches/nectarines	Herbicides	Oxyfluorfen	9.70	9.70	1.07	0.450	0.480
Peaches/nectarines	Herbicides	Paraquat	9.70	9.70	83.00	0.394	32.720
Peaches/nectarines	Herbicides	Propaquizafop	9.70	9.70	1.33	0.075	0.100
Peaches/nectarines	Herbicides	Propyzamide	9.70	9.70	2.00	0.250	0.500
Pears	Insecticides	Abamectin	12.21	12.00	103.33	0.011	1.116
Pears	Insecticides	Acephate	12.21	12.00	1.33	1.125	1.500
Pears	Insecticides	Alphacypermethrin	12.21	12.00	20.00	0.010	0.200
Pears	Insecticides	Azinphos-m	12.21	12.00	27.50	0.420	11.550
Pears	Insecticides	Betacyfluthrin	12.21	12.00	16.67	0.003	0.050
Pears	Insecticides	Betacypermethrin	12.21	12.00	15.38	0.007	0.100
Pears	Insecticides	Cadusafos	12.21	12.00	1.33	1.500	2.000
Pears	Insecticides	Carbaryl	12.21	12.00	0.10	1.000	0.100
Pears	Insecticides	Chlorfenapyr	12.21	12.00	4.00	0.180	0.720
Pears	Insecticides	Chlorpyrifos-e	12.21	12.00	30.00	0.480	14.400
Pears	Insecticides	Cypermethrin	12.21	12.00	6.67	0.030	0.200

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Pears	Insecticides	Deltamethrin	12.21	12.00	41.67	0.007	0.275
Pears	Insecticides	Dimethoate	12.21	12.00	2.00	0.400	0.800
Pears	Insecticides	Emamectin-benzoate	12.21	12.00	2.00	0.025	0.050
Pears	Insecticides	Esfenvalerate	12.21	12.00	40.00	0.010	0.400
Pears	Insecticides	Etoxazole	12.21	12.00	2.86	0.035	0.100
Pears	Insecticides	Fenbutatin-oxide	12.21	12.00	3.64	0.289	1.050
Pears	Insecticides	Fenthion	12.21	12.00	0.50	1.000	0.500
Pears	Insecticides	Flufenoxuron	12.21	12.00	6.00	0.050	0.300
Pears	Insecticides	Gamma-cyhalothrin	12.21	12.00	16.67	0.004	0.060
Pears	Insecticides	Imidacloprid	12.21	12.00	14.29	0.172	2.450
Pears	Insecticides	Indoxacarb	12.21	12.00	2.00	0.150	0.300
Pears	Insecticides	Lambda-cyhalothrin	12.21	12.00	76.67	0.007	0.500
Pears	Insecticides	Malathion	12.21	12.00	3.00	0.500	1.500
Pears	Insecticides	Metaldehyde	12.21	12.00	0.10	1.500	0.150
Pears	Insecticides	Methoxyfenozide	12.21	12.00	1.67	0.144	0.240
Pears	Insecticides	Milbemectin	12.21	12.00	1.67	0.006	0.010
Pears	Insecticides	Propargite	12.21	12.00	1.00	0.590	0.590
Pears	Insecticides	Prothiofos	12.21	12.00	2.00	0.250	0.500
Pears	Insecticides	Spinosad	12.21	12.00	0.67	0.360	0.240
Pears	Insecticides	Tau-fluvalinate	12.21	12.00	6.67	0.072	0.480
Pears	Insecticides	Tetradifon	12.21	12.00	0.63	0.640	0.400
Pears	Insecticides	Thiacloprid	12.21	12.00	5.71	0.168	0.960
Pears	Insecticides	Thiamethoxam	12.21	12.00	2.86	0.084	0.240
Pears	Fungicides	Copper-oxychloride	12.21	12.00	6.67	2.550	17.000
Pears	Fungicides	Cyprodinil	12.21	12.00	3.33	0.150	0.500
Pears	Fungicides	Dithianon	12.21	12.00	1.00	0.120	0.120
Pears	Fungicides	Fludioxonil	12.21	12.00	1.00	0.115	0.115
Pears	Fungicides	Fluopyram	12.21	12.00	4.00	0.050	0.200

Crop	Sector	AI	Crop area ($x10^3$ ha)	Base area ($x10^3$ ha)	AI Area Treated ($x10^3$ ha)	AI dose rate (kg or L/ha)	AI volume ($x\ 10^3$ kg/L)
Pears	Fungicides	Flusilazole	12.21	12.00	40.00	0.030	1.200
Pears	Fungicides	Kresoxim-m	12.21	12.00	2.63	0.190	0.500
Pears	Fungicides	Mancozeb	12.21	12.00	66.67	2.400	160.000
Pears	Fungicides	Maneb	12.21	12.00	0.29	1.523	0.435
Pears	Fungicides	Metiram	12.21	12.00	1.50	2.800	4.200
Pears	Fungicides	Myclobutanil	12.21	12.00	13.33	0.030	0.400
Pears	Fungicides	Penconazole	12.21	12.00	16.00	0.025	0.400
Pears	Fungicides	Procymidone	12.21	12.00	2.00	0.250	0.500
Pears	Fungicides	Pyraclostrobin	12.21	12.00	1.00	0.040	0.040
Pears	Fungicides	Pyrimethanil	12.21	12.00	5.00	0.160	0.800
Pears	Fungicides	Quaternary-Ammonium-salts	12.21	12.00	5.00	0.126	0.630
Pears	Fungicides	Sulphur	12.21	12.00	10.00	2.400	24.000
Pears	Fungicides	Tebuconazole	12.21	12.00	4.00	0.050	0.200
Pears	Fungicides	Thiram	12.21	12.00	0.67	2.400	1.600
Pears	Fungicides	Trifloxystrobin	12.21	12.00	5.00	0.048	0.240
Pears	Fungicides	Zinc-oxide	12.21	12.00	0.29	0.016	0.005
Pears	Herbicides	Carfentrazone-e	12.21	10.00	2.00	0.010	0.020
Pears	Herbicides	Clethodim	12.21	10.00	1.00	0.120	0.120
Pears	Herbicides	Cycloxydim	12.21	10.00	0.50	0.200	0.100
Pears	Herbicides	Diquat	12.21	10.00	33.33	0.240	8.000
Pears	Herbicides	Fluazifop-P-b	12.21	10.00	0.50	0.250	0.125
Pears	Herbicides	Flumioxazin	12.21	10.00	0.50	0.100	0.050
Pears	Herbicides	Flurochloridone	12.21	10.00	0.31	0.800	0.250
Pears	Herbicides	Glufosinate-ammonium	12.21	10.00	3.00	0.400	1.200
Pears	Herbicides	Glyphosate	12.21	10.00	73.33	1.080	79.200
Pears	Herbicides	Haloxyfop-r-m	12.21	10.00	4.00	0.108	0.432
Pears	Herbicides	MCPA	12.21	10.00	2.67	0.600	1.600
Pears	Herbicides	Oxadiazon	12.21	10.00	0.67	0.375	0.250

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Pears	Herbicides	Oxyfluorfen	12.21	10.00	0.67	0.360	0.240
Pears	Herbicides	Paraquat	12.21	10.00	108.33	0.388	42.000
Pears	Herbicides	Propaquizafop	12.21	10.00	1.00	0.100	0.100
Pears	Herbicides	Propyzamide	12.21	10.00	0.67	0.750	0.500
Pears	Herbicides	Simazine	12.21	10.00	16.00	1.250	20.000
Pears	Growth regulators	Gibberellic-acid	12.21	12.00	12.00	0.016	0.186
Stone Fruit	Insecticides	Acephate	10.46	10.46	2.00	0.750	1.500
Stone Fruit	Insecticides	Azinphos-m	10.46	10.46	9.17	0.458	4.200
Stone Fruit	Insecticides	Betacyfluthrin	10.46	10.46	25.00	0.003	0.075
Stone Fruit	Insecticides	Betacypermethrin	10.46	10.46	15.38	0.007	0.100
Stone Fruit	Insecticides	Cadusafos	10.46	10.46	0.47	1.500	0.700
Stone Fruit	Insecticides	Carbaryl	10.46	10.46	0.04	1.000	0.040
Stone Fruit	Insecticides	Chlorfenapyr	10.46	10.46	4.00	0.180	0.720
Stone Fruit	Insecticides	Chlorpyrifos	10.46	10.46	2.00	0.480	0.960
Stone Fruit	Insecticides	Chlorpyrifos-e	10.46	10.46	7.00	0.480	3.360
Stone Fruit	Insecticides	Cypermethrin	10.46	10.46	13.33	0.030	0.400
Stone Fruit	Insecticides	Deltamethrin	10.46	10.46	25.00	0.006	0.150
Stone Fruit	Insecticides	Dimethoate	10.46	10.46	1.00	0.400	0.400
Stone Fruit	Insecticides	Fenthion	10.46	10.46	1.50	0.667	1.000
Stone Fruit	Insecticides	Gamma-cyhalothrin	10.46	10.46	25.00	0.004	0.090
Stone Fruit	Insecticides	Indoxacarb	10.46	10.46	8.00	0.075	0.600
Stone Fruit	Insecticides	Lambda-cyhalothrin	10.46	10.46	43.33	0.007	0.300
Stone Fruit	Insecticides	Malathion	10.46	10.46	4.00	0.500	2.000
Stone Fruit	Insecticides	Metaldehyde	10.46	10.46	0.04	1.500	0.060
Stone Fruit	Insecticides	Methidathion	10.46	10.46	1.50	0.840	1.260
Stone Fruit	Insecticides	Oxamyl	10.46	10.46	0.25	1.240	0.310
Stone Fruit	Insecticides	Petroleum-oil	10.46	10.46	0.60	41.750	25.050
Stone Fruit	Insecticides	Spinosad	10.46	10.46	1.00	0.120	0.120

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Stone Fruit	Fungicides	Benomyl	10.46	10.46	4.00	0.125	0.500
Stone Fruit	Fungicides	Bupirimate	10.46	10.46	2.86	0.088	0.250
Stone Fruit	Fungicides	Copper-hydroxide	10.46	10.46	0.33	1.614	0.538
Stone Fruit	Fungicides	Copper-oxychloride	10.46	10.46	7.50	3.400	25.500
Stone Fruit	Fungicides	Copper-sulphate	10.46	10.46	1.17	1.646	1.920
Stone Fruit	Fungicides	Fludioxonil	10.46	10.46	1.20	0.192	0.230
Stone Fruit	Fungicides	Hexaconazole	10.46	10.46	2.86	0.011	0.030
Stone Fruit	Fungicides	Mancozeb	10.46	10.46	17.33	2.368	41.050
Stone Fruit	Fungicides	Prochloraz	10.46	10.46	11.41	0.175	2.000
Stone Fruit	Fungicides	Propiconazole	10.46	10.46	13.00	0.058	0.750
Stone Fruit	Fungicides	Sulphur	10.46	10.46	6.17	3.114	19.200
Stone Fruit	Fungicides	Thiram	10.46	10.46	6.97	1.722	12.000
Stone Fruit	Herbicides	Diquat	10.46	10.46	5.00	0.160	0.800
Stone Fruit	Herbicides	Fluazifop-P-b	10.46	10.46	0.50	0.300	0.150
Stone Fruit	Herbicides	Flumioxazin	10.46	10.46	0.50	0.100	0.050
Stone Fruit	Herbicides	Flurochloridone	10.46	10.46	0.31	0.800	0.250
Stone Fruit	Herbicides	Glufosinate-ammonium	10.46	10.46	3.50	0.400	1.400
Stone Fruit	Herbicides	Glyphosate	10.46	10.46	26.67	1.080	28.800
Stone Fruit	Herbicides	Haloxyfop-r-m	10.46	10.46	2.33	0.139	0.324
Stone Fruit	Herbicides	Oxadiazon	10.46	10.46	0.33	1.125	0.375
Stone Fruit	Herbicides	Oxyfluorfen	10.46	10.46	0.76	0.788	0.600
Stone Fruit	Herbicides	Paraquat	10.46	10.46	15.50	0.378	5.856
Stone Fruit	Herbicides	Propyzamide	10.46	10.46	1.67	0.900	1.500
Stone Fruit	Growth regulators	Cyanamide	10.46	6.36	7.96	12.340	98.230
Potatoes	Insecticides	Abamectin	66.50	65.00	151.67	0.011	1.638
Potatoes	Insecticides	Acephate	66.50	65.00	30.33	0.396	12.000
Potatoes	Insecticides	Alphacypermethrin	66.50	65.00	50.00	0.010	0.500
Potatoes	Insecticides	Azinphos-m	66.50	65.00	10.00	0.350	3.500

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Potatoes	Insecticides	Bacillus-thur.-aizawai	66.50	65.00	2.86	0.005	0.015
Potatoes	Insecticides	Bacillus-thuringiensis	66.50	65.00	2.86	0.011	0.032
Potatoes	Insecticides	Betacyfluthrin	66.50	65.00	66.67	0.004	0.275
Potatoes	Insecticides	Bifenthrin	66.50	65.00	10.00	0.030	0.300
Potatoes	Insecticides	Cadusafos	66.50	65.00	4.25	4.000	17.000
Potatoes	Insecticides	Carbofuran	66.50	65.00	3.00	1.000	3.000
Potatoes	Insecticides	Cartap	66.50	65.00	116.67	0.279	32.500
Potatoes	Insecticides	Chlorantraniliprole	66.50	65.00	80.00	0.010	0.800
Potatoes	Insecticides	Chlorfenapyr	66.50	65.00	20.00	0.180	3.600
Potatoes	Insecticides	Chlorpyrifos	66.50	65.00	25.00	0.480	12.000
Potatoes	Insecticides	Chlorpyrifos-e	66.50	65.00	12.00	0.480	5.760
Potatoes	Insecticides	Cypermethrin	66.50	65.00	80.00	0.030	2.400
Potatoes	Insecticides	Cyromazine	66.50	65.00	72.50	0.150	10.875
Potatoes	Insecticides	Deltamethrin	66.50	65.00	29.17	0.009	0.275
Potatoes	Insecticides	Dimethoate	66.50	65.00	14.33	0.307	4.400
Potatoes	Insecticides	Esfenvalerate	66.50	65.00	60.00	0.010	0.600
Potatoes	Insecticides	Ethoprophos	66.50	65.00	24.00	0.500	12.000
Potatoes	Insecticides	Ethylene-dibromide	66.50	65.00	1.50	36.000	54.000
Potatoes	Insecticides	Fenamiphos	66.50	65.00	26.37	2.709	71.440
Potatoes	Insecticides	Fenbutatin-oxide	66.50	65.00	2.22	0.225	0.500
Potatoes	Insecticides	Flubendiamide	66.50	65.00	120.00	0.048	5.760
Potatoes	Insecticides	Furfural	66.50	65.00	8.00	22.500	180.000
Potatoes	Insecticides	Gamma-cyhalothrin	66.50	65.00	80.00	0.003	0.240
Potatoes	Insecticides	Imidacloprid	66.50	65.00	306.35	0.061	18.550
Potatoes	Insecticides	Indoxacarb	66.50	65.00	17.60	0.136	2.400
Potatoes	Insecticides	Lambda-cyhalothrin	66.50	65.00	413.33	0.006	2.400
Potatoes	Insecticides	Lufenuron	66.50	65.00	13.75	0.040	0.550
Potatoes	Insecticides	Methamidophos	66.50	65.00	360.00	0.439	157.950

Crop	Sector	AI	Crop area (x10³ ha)	Base area (x10³ ha)	AI Area Treated (x10³ ha)	AI dose rate (kg or L/ha)	AI volume (x 10³ kg/L)
Potatoes	Insecticides	Methomyl	66.50	65.00	130.56	0.214	28.000
Potatoes	Insecticides	Oxamyl	66.50	65.00	69.29	1.230	85.250
Potatoes	Insecticides	Pirimicarb	66.50	65.00	8.00	0.250	2.000
Potatoes	Insecticides	Profenofos	66.50	65.00	24.00	0.375	9.000
Potatoes	Insecticides	Pyridalyl	66.50	65.00	10.00	0.100	1.000
Potatoes	Insecticides	Spinosad	66.50	65.00	1.00	0.360	0.360
Potatoes	Insecticides	Spirotetramat	66.50	65.00	53.33	0.036	1.920
Potatoes	Insecticides	Terbufos	66.50	65.00	19.15	1.253	24.000
Potatoes	Insecticides	Thiacloprid	66.50	65.00	7.50	0.096	0.720
Potatoes	Fungicides	Azoxystrobin	66.50	65.00	147.17	0.094	13.850
Potatoes	Fungicides	Boscalid	66.50	65.00	36.67	0.076	2.772
Potatoes	Fungicides	Bupirimate	66.50	65.00	1.00	0.250	0.250
Potatoes	Fungicides	Carbendazim	66.50	65.00	39.00	0.054	2.125
Potatoes	Fungicides	Chlorothalonil	66.50	65.00	181.87	1.416	257.475
Potatoes	Fungicides	Copper-hydroxide	66.50	65.00	11.67	1.804	21.050
Potatoes	Fungicides	Copper-oxychloride	66.50	65.00	12.67	2.550	32.300
Potatoes	Fungicides	Copper-sulphate	66.50	65.00	5.33	0.960	5.120
Potatoes	Fungicides	Cymoxanil	66.50	65.00	55.67	0.138	7.670
Potatoes	Fungicides	Dichlorophen	66.50	65.00	2.00	0.500	1.000
Potatoes	Fungicides	Difenoconazole	66.50	65.00	120.67	0.072	8.688
Potatoes	Fungicides	Dimethomorph	66.50	65.00	1.39	0.180	0.250
Potatoes	Fungicides	Famoxadone	66.50	65.00	20.00	0.125	2.500
Potatoes	Fungicides	Fenamidone	66.50	65.00	3.00	0.100	0.300
Potatoes	Fungicides	Fluopicolide	66.50	65.00	8.00	0.063	0.500
Potatoes	Fungicides	Flusilazole	66.50	65.00	25.00	0.100	2.500
Potatoes	Fungicides	Flutriafol	66.50	65.00	11.20	0.156	1.750
Potatoes	Fungicides	Hexaconazole	66.50	65.00	1.00	0.030	0.030
Potatoes	Fungicides	Iprovalicarb	66.50	65.00	40.00	0.023	0.900

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Potatoes	Fungicides	Mancozeb	66.50	65.00	123.82	1.561	193.280
Potatoes	Fungicides	Mandipropamid	66.50	65.00	11.67	0.150	1.750
Potatoes	Fungicides	Maneb	66.50	65.00	1.85	1.175	2.175
Potatoes	Fungicides	Metalaxyl	66.50	65.00	13.00	0.200	2.600
Potatoes	Fungicides	Metalaxyl-M	66.50	65.00	8.00	0.094	0.755
Potatoes	Fungicides	Pencycuron	66.50	65.00	1.00	2.500	2.500
Potatoes	Fungicides	Potassium-phosphite	66.50	65.00	1.73	1.158	2.007
Potatoes	Fungicides	Prochloraz	66.50	65.00	3.00	0.333	1.000
Potatoes	Fungicides	Procymidone	66.50	65.00	21.67	0.242	5.250
Potatoes	Fungicides	Propamocarb-HCl	66.50	65.00	8.00	0.625	5.000
Potatoes	Fungicides	Propineb	66.50	65.00	48.80	0.439	21.400
Potatoes	Fungicides	Pyraclostrobin	66.50	65.00	36.67	0.038	1.408
Potatoes	Fungicides	Pyrimethanil	66.50	65.00	20.00	0.160	3.200
Potatoes	Fungicides	Tebuconazole	66.50	65.00	175.67	0.173	30.400
Potatoes	Fungicides	Tolclofos-m	66.50	65.00	0.20	2.500	0.500
Potatoes	Fungicides	Trifloxystrobin	66.50	65.00	45.00	0.066	2.960
Potatoes	Fungicides	Zinc-oxide	66.50	65.00	1.85	0.013	0.024
Potatoes	Herbicides	Acetochlor	66.50	65.00	15.00	1.200	18.000
Potatoes	Herbicides	Alachlor	66.50	65.00	1.60	1.920	3.072
Potatoes	Herbicides	Bentazone	66.50	65.00	1.83	1.920	3.504
Potatoes	Herbicides	Clethodim	66.50	65.00	13.33	0.090	1.200
Potatoes	Herbicides	Cycloxydim	66.50	65.00	1.00	0.200	0.200
Potatoes	Herbicides	Dimethenamid-P	66.50	65.00	2.22	0.648	1.440
Potatoes	Herbicides	Diquat	66.50	65.00	3.25	0.400	1.300
Potatoes	Herbicides	EPTC	66.50	65.00	13.00	2.880	37.440
Potatoes	Herbicides	Fluazifop-P-b	66.50	65.00	0.30	0.300	0.090
Potatoes	Herbicides	Flurochloridone	66.50	65.00	0.40	0.625	0.250
Potatoes	Herbicides	Linuron	66.50	65.00	0.40	1.250	0.500

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Potatoes	Herbicides	Metazachlor	66.50	65.00	1.67	0.600	1.000
Potatoes	Herbicides	Metolachlor	66.50	65.00	13.04	1.840	24.000
Potatoes	Herbicides	Metribuzin	66.50	65.00	27.13	0.461	12.510
Potatoes	Herbicides	Paraquat	66.50	65.00	75.00	0.491	36.840
Potatoes	Herbicides	Propaquizafop	66.50	65.00	2.67	0.075	0.200
Potatoes	Herbicides	Rimsulfuron	66.50	65.00	11.11	0.023	0.250
Potatoes	Herbicides	s-metolachlor	66.50	65.00	9.23	1.248	11.520
Potatoes	Growth regulators	Gibberellic-acid	66.50	25.00	50.00	0.003	0.128
Potatoes	Seed dressing	Pencycuron	66.50	0.20	0.20	22.500	4.500
Potatoes: Seed	Insecticides	Acephate	10.00	10.00	3.33	0.450	1.500
Potatoes: Seed	Insecticides	Azinphos-m	10.00	10.00	1.00	0.350	0.350
Potatoes: Seed	Insecticides	Betacyfluthrin	10.00	10.00	16.67	0.003	0.050
Potatoes: Seed	Insecticides	Bifenthrin	10.00	10.00	3.33	0.030	0.100
Potatoes: Seed	Insecticides	Cypermethrin	10.00	10.00	6.67	0.030	0.200
Potatoes: Seed	Insecticides	Deltamethrin	10.00	10.00	8.33	0.012	0.100
Potatoes: Seed	Insecticides	Ethylene-dibromide	10.00	10.00	0.05	36.000	1.800
Potatoes: Seed	Insecticides	Fenamiphos	10.00	10.00	4.05	3.975	16.100
Potatoes: Seed	Insecticides	Imidacloprid	10.00	10.00	2.86	0.245	0.700
Potatoes: Seed	Insecticides	Lambda-cyhalothrin	10.00	10.00	33.33	0.006	0.200
Potatoes: Seed	Insecticides	Methamidophos	10.00	10.00	2.67	0.439	1.170
Potatoes: Seed	Insecticides	Oxamyl	10.00	10.00	2.50	3.448	8.620
Potatoes: Seed	Insecticides	Profenofos	10.00	10.00	1.00	0.500	0.500
Potatoes: Seed	Fungicides	Chlorothalonil	10.00	5.70	3.33	1.500	5.000
Potatoes: Seed	Fungicides	Copper-carbonate	10.00	5.70	8.00	3.305	26.440
Potatoes: Seed	Fungicides	Cymoxanil	10.00	5.70	1.20	0.150	0.180
Potatoes: Seed	Fungicides	Mancozeb	10.00	5.70	0.40	1.875	0.750
Potatoes: Seed	Fungicides	Propineb	10.00	5.70	2.00	1.750	3.500
Potatoes: Seed	Fungicides	Tebuconazole	10.00	5.70	1.33	0.188	0.250

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Potatoes: Seed	Herbicides	Alachlor	10.00	4.00	0.04	1.920	0.077
Potatoes: Seed	Herbicides	EPTC	10.00	4.00	2.67	2.160	5.760
Potatoes: Seed	Herbicides	Fluazifop-P-b	10.00	4.00	0.05	0.300	0.015
Potatoes: Seed	Herbicides	Linuron	10.00	4.00	0.40	1.250	0.500
Potatoes: Seed	Herbicides	Metribuzin	10.00	4.00	1.06	0.451	0.480
Potatoes: Seed	Herbicides	Rimsulfuron	10.00	4.00	11.11	0.023	0.250
Potatoes: Seed	Growth regulators	Gibberellic-acid	10.00	10.00	50.00	0.005	0.256
Soybeans	Insecticides	Betacyfluthrin	502.90	330.00	16.67	0.005	0.088
Soybeans	Insecticides	Chlorpyrifos	502.90	330.00	4.00	0.480	1.920
Soybeans	Insecticides	Cypermethrin	502.90	330.00	93.33	0.030	2.800
Soybeans	Insecticides	Deltamethrin	502.90	330.00	25.00	0.012	0.300
Soybeans	Insecticides	Lambda-cyhalothrin	502.90	330.00	200.00	0.005	1.050
Soybeans	Fungicides	Azoxystrobin	502.90	150.00	70.00	0.071	5.000
Soybeans	Fungicides	Carbendazim	502.90	150.00	10.00	0.050	0.500
Soybeans	Fungicides	Cyproconazole	502.90	150.00	50.00	0.024	1.200
Soybeans	Fungicides	Difenoconazole	502.90	150.00	5.71	0.088	0.500
Soybeans	Fungicides	Epoxiconazole	502.90	150.00	16.67	0.019	0.313
Soybeans	Fungicides	Flusilazole	502.90	150.00	25.00	0.100	2.500
Soybeans	Fungicides	Flutriafol	502.90	150.00	1.60	0.156	0.250
Soybeans	Fungicides	Procymidone	502.90	150.00	50.00	0.075	3.750
Soybeans	Fungicides	Propiconazole	502.90	150.00	42.00	0.125	5.250
Soybeans	Fungicides	Pyraclostrobin	502.90	150.00	16.67	0.019	0.313
Soybeans	Fungicides	Tebuconazole	502.90	150.00	12.00	0.100	1.200
Soybeans	Fungicides	Trifloxystrobin	502.90	150.00	12.00	0.050	0.600
Soybeans	Herbicides	Acetochlor	502.90	480.00	14.67	1.125	16.500
Soybeans	Herbicides	Alachlor	502.90	480.00	1.69	1.920	3.245
Soybeans	Herbicides	Bentazone	502.90	480.00	12.63	1.920	24.240
Soybeans	Herbicides	Chlorimuron-e	502.90	480.00	433.61	0.009	3.750

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Soybeans	Herbicides	Clethodim	502.90	480.00	24.00	0.090	2.160
Soybeans	Herbicides	Clomazone	502.90	480.00	2.67	0.720	1.920
Soybeans	Herbicides	Cycloxydim	502.90	480.00	3.50	0.200	0.700
Soybeans	Herbicides	Dimethenamid-P	502.90	480.00	1.80	0.720	1.296
Soybeans	Herbicides	Fluazifop-P-b	502.90	480.00	0.30	0.300	0.090
Soybeans	Herbicides	Flumetsulam	502.90	480.00	4.17	0.024	0.100
Soybeans	Herbicides	Flumioxazin	502.90	480.00	2.00	0.050	0.100
Soybeans	Herbicides	Glyphosate	502.90	480.00	1 951.67	1.055	2 058.800
Soybeans	Herbicides	Imazethapyr	502.90	480.00	1.50	0.040	0.060
Soybeans	Herbicides	Metazachlor	502.90	480.00	1.00	0.500	0.500
Soybeans	Herbicides	Metolachlor	502.90	480.00	122.74	1.407	172.750
Soybeans	Herbicides	Metribuzin	502.90	480.00	6.67	0.864	5.760
Soybeans	Herbicides	Paraquat	502.90	480.00	5.00	0.552	2.760
Soybeans	Herbicides	Pendimethalin	502.90	480.00	1.20	1.250	1.500
Soybeans	Herbicides	Propaquizafop	502.90	480.00	21.33	0.075	1.600
Soybeans	Herbicides	Quizalofop-P-e	502.90	480.00	1.00	0.050	0.050
Soybeans	Herbicides	Quizalofop-P-t	502.90	480.00	30.00	0.040	1.200
Soybeans	Herbicides	s-metolachlor	502.90	480.00	50.00	0.960	48.000
Soybeans	Herbicides	Trifluralin	502.90	480.00	0.67	0.720	0.480
Soybeans	Seed dressing	Metalaxyl-M	502.90	200.00	205.13	0.003	0.700
Sugar Cane	Insecticides	Alphacypermethrin	450.00	40.00	10.00	0.010	0.100
Sugar Cane	Insecticides	Carbofuran	450.00	40.00	0.30	1.000	0.300
Sugar Cane	Insecticides	Furfural	450.00	40.00	8.00	22.500	180.000
Sugar Cane	Insecticides	Imidacloprid	450.00	40.00	22.86	0.123	2.800
Sugar Cane	Insecticides	Oxamyl	450.00	40.00	4.80	1.138	5.460
Sugar Cane	Herbicides	2.4-D-amine	450.00	450.00	20.00	0.360	7.200
Sugar Cane	Herbicides	Acetochlor	450.00	450.00	62.73	2.248	141.000
Sugar Cane	Herbicides	Alachlor	450.00	450.00	4.00	2.040	8.160

Crop	Sector	AI	Crop area ($x10^3$ ha)	Base area ($x10^3$ ha)	AI Area Treated ($x10^3$ ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Sugar Cane	Herbicides	Ametryn	450.00	450.00	60.00	1.500	90.000
Sugar Cane	Herbicides	Amicarbazone	450.00	450.00	14.00	0.350	4.900
Sugar Cane	Herbicides	Atrazine	450.00	450.00	12.75	1.663	21.200
Sugar Cane	Herbicides	Bromoxynil	450.00	450.00	2.67	0.225	0.600
Sugar Cane	Herbicides	Dicamba	450.00	450.00	20.00	0.120	2.400
Sugar Cane	Herbicides	Diquat	450.00	450.00	7.50	0.160	1.200
Sugar Cane	Herbicides	Diuron	450.00	450.00	124.55	0.996	124.000
Sugar Cane	Herbicides	Fluazifop-P-b	450.00	450.00	4.00	0.281	1.125
Sugar Cane	Herbicides	Glyphosate	450.00	450.00	166.67	0.972	162.000
Sugar Cane	Herbicides	Hexazinone	450.00	450.00	190.00	0.517	98.250
Sugar Cane	Herbicides	Imazapyr	450.00	450.00	0.40	1.200	0.480
Sugar Cane	Herbicides	Isoxaflutole	450.00	450.00	100.00	0.150	15.000
Sugar Cane	Herbicides	MCPA	450.00	450.00	113.33	0.600	68.000
Sugar Cane	Herbicides	Mesotrione	450.00	450.00	31.11	0.278	8.650
Sugar Cane	Herbicides	Metazachlor	450.00	450.00	5.00	1.000	5.000
Sugar Cane	Herbicides	Metolachlor	450.00	450.00	38.89	1.728	67.200
Sugar Cane	Herbicides	Metribuzin	450.00	450.00	36.25	1.589	57.600
Sugar Cane	Herbicides	MSMA	450.00	450.00	36.67	2.160	79.200
Sugar Cane	Herbicides	Paraquat	450.00	450.00	182.50	0.414	75.600
Sugar Cane	Herbicides	s-metolachlor	450.00	450.00	52.07	1.338	69.650
Sugar Cane	Herbicides	Sulcotrione	450.00	450.00	4.00	0.313	1.250
Sugar Cane	Herbicides	Sulfentrazone	450.00	450.00	0.67	0.720	0.480
Sugar Cane	Herbicides	Terbuthylazine	450.00	450.00	13.78	0.233	3.207
Sugar Cane	Herbicides	Triclopyr	450.00	450.00	4.00	1.440	5.760
Sugar Cane	Herbicides	Trifluralin	450.00	450.00	6.67	0.720	4.800
Sugar Cane	Growth regulators	Ethephon	450.00	140.00	46.67	0.720	33.600
Sugar Cane	Growth regulators	Glyphosate	450.00	140.00	100.00	1.020	102.000
Sunflower	Insecticides	Betacyfluthrin	599.00	50.00	11.67	0.003	0.035

Crop	Sector	AI	Crop area ($x10^3$ ha)	Base area ($x10^3$ ha)	AI Area Treated ($x10^3$ ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Sunflower	Insecticides	Carbofuran	599.00	50.00	0.90	1.000	0.900
Sunflower	Insecticides	Cypermethrin	599.00	50.00	46.67	0.030	1.400
Sunflower	Insecticides	Deltamethrin	599.00	50.00	6.67	0.012	0.080
Sunflower	Insecticides	Esfenvalerate	599.00	50.00	12.00	0.010	0.120
Sunflower	Insecticides	Lambda-cyhalothrin	599.00	50.00	225.00	0.006	1.350
Sunflower	Insecticides	Methomyl	599.00	50.00	1.20	0.225	0.270
Sunflower	Insecticides	Terbufos	599.00	50.00	2.80	1.500	4.200
Sunflower	Fungicides	Boscalid	599.00	2.33	2.33	0.076	0.176
Sunflower	Fungicides	Pyraclostrobin	599.00	2.33	2.33	0.038	0.090
Sunflower	Herbicides	Alachlor	599.00	400.00	5.58	1.496	8.352
Sunflower	Herbicides	Cycloxydim	599.00	400.00	0.18	0.200	0.035
Sunflower	Herbicides	Dimethenamid-P	599.00	400.00	4.00	0.720	2.880
Sunflower	Herbicides	Diquat	599.00	400.00	5.50	0.400	2.200
Sunflower	Herbicides	EPTC	599.00	400.00	0.33	2.160	0.720
Sunflower	Herbicides	Flurochloridone	599.00	400.00	0.31	0.800	0.250
Sunflower	Herbicides	Glyphosate	599.00	400.00	40.00	1.080	43.200
Sunflower	Herbicides	Metolachlor	599.00	400.00	200.00	1.248	249.600
Sunflower	Herbicides	Paraquat	599.00	400.00	5.25	0.400	2.100
Sunflower	Herbicides	Pendimethalin	599.00	400.00	0.40	1.250	0.500
Sunflower	Herbicides	Propaquizafop	599.00	400.00	0.67	0.075	0.050
Sunflower	Herbicides	Quizalofop-P-t	599.00	400.00	0.50	0.040	0.020
Sunflower	Herbicides	s-metolachlor	599.00	400.00	133.75	0.768	102.720
Sunflower	Herbicides	Trifluralin	599.00	400.00	9.33	0.720	6.720
Sunflower	Seed dressing	Imidacloprid	599.00	30.00	2.50	0.070	0.175
Sunflower	Seed dressing	Metalaxyl-M	599.00	30.00	24.56	0.020	0.490
Sunflower	Seed dressing	Thiamethoxam	599.00	30.00	4.31	0.070	0.300
Tomatoes	Insecticides	Abamectin	12.00	12.00	53.33	0.011	0.576
Tomatoes	Insecticides	Acephate	12.00	12.00	5.00	0.600	3.000

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Tomatoes	Insecticides	Alphacypermethrin	12.00	12.00	12.00	0.010	0.120
Tomatoes	Insecticides	Bacillus-thur.-aizawai	12.00	12.00	2.00	0.008	0.015
Tomatoes	Insecticides	Bacillus-thuringiensis	12.00	12.00	4.00	0.008	0.032
Tomatoes	Insecticides	Betacyfluthrin	12.00	12.00	33.33	0.005	0.175
Tomatoes	Insecticides	Betacypermethrin	12.00	12.00	15.38	0.007	0.100
Tomatoes	Insecticides	Bifenthrin	12.00	12.00	4.50	0.044	0.200
Tomatoes	Insecticides	Cartap	12.00	12.00	13.33	0.413	5.500
Tomatoes	Insecticides	Chlorfenapyr	12.00	12.00	4.00	0.180	0.720
Tomatoes	Insecticides	Chlorpyrifos	12.00	12.00	5.00	0.480	2.400
Tomatoes	Insecticides	Chlorpyrifos-e	12.00	12.00	3.00	0.480	1.440
Tomatoes	Insecticides	Cypermethrin	12.00	12.00	8.67	0.030	0.260
Tomatoes	Insecticides	Cyromazine	12.00	12.00	13.67	0.165	2.250
Tomatoes	Insecticides	Deltamethrin	12.00	12.00	18.33	0.007	0.130
Tomatoes	Insecticides	Diafenthiuron	12.00	12.00	1.25	0.400	0.500
Tomatoes	Insecticides	Emamectin-benzoate	12.00	12.00	15.00	0.010	0.150
Tomatoes	Insecticides	Endosulfan	12.00	12.00	0.40	0.125	0.050
Tomatoes	Insecticides	Esfenvalerate	12.00	12.00	20.00	0.010	0.200
Tomatoes	Insecticides	Etoxazole	12.00	12.00	2.50	0.040	0.100
Tomatoes	Insecticides	Fenamiphos	12.00	12.00	0.93	3.514	3.280
Tomatoes	Insecticides	Fenpropathrin	12.00	12.00	6.67	0.060	0.400
Tomatoes	Insecticides	Flubendiamide	12.00	12.00	26.67	0.072	1.920
Tomatoes	Insecticides	Furfural	12.00	12.00	2.40	22.500	54.000
Tomatoes	Insecticides	Gamma-cyhalothrin	12.00	12.00	117.65	0.001	0.120
Tomatoes	Insecticides	Imidacloprid	12.00	12.00	21.43	0.139	2.975
Tomatoes	Insecticides	Indoxacarb	12.00	12.00	20.00	0.068	1.350
Tomatoes	Insecticides	Lambda-cyhalothrin	12.00	12.00	172.50	0.005	0.925
Tomatoes	Insecticides	Lufenuron	12.00	12.00	20.00	0.020	0.400
Tomatoes	Insecticides	Malathion	12.00	12.00	2.00	0.500	1.000

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Tomatoes	Insecticides	Methamidophos	12.00	12.00	1.00	0.585	0.585
Tomatoes	Insecticides	Methomyl	12.00	12.00	10.11	0.198	2.000
Tomatoes	Insecticides	Milbemectin	12.00	12.00	1.67	0.006	0.010
Tomatoes	Insecticides	Oxamyl	12.00	12.00	27.58	0.996	27.460
Tomatoes	Insecticides	Profenofos	12.00	12.00	3.67	0.818	3.000
Tomatoes	Insecticides	Propargite	12.00	12.00	1.33	0.521	0.695
Tomatoes	Insecticides	Pyridalyl	12.00	12.00	4.00	0.125	0.500
Tomatoes	Insecticides	Spinosad	12.00	12.00	6.67	0.072	0.480
Tomatoes	Insecticides	Thiamethoxam	12.00	12.00	11.11	0.022	0.240
Tomatoes	Fungicides	Azoxystrobin	12.00	12.00	4.80	0.075	0.360
Tomatoes	Fungicides	Benomyl	12.00	12.00	0.50	1.000	0.500
Tomatoes	Fungicides	Boscalid	12.00	12.00	3.33	0.076	0.252
Tomatoes	Fungicides	Chlorothalonil	12.00	12.00	35.30	1.143	40.350
Tomatoes	Fungicides	Copper-carbonate	12.00	12.00	3.00	3.305	9.915
Tomatoes	Fungicides	Copper-hydroxide	12.00	12.00	4.00	1.799	7.196
Tomatoes	Fungicides	Copper-oxychloride	12.00	12.00	5.92	2.730	16.150
Tomatoes	Fungicides	Copper-sulphate	12.00	12.00	5.42	0.669	3.625
Tomatoes	Fungicides	Cymoxanil	12.00	12.00	13.40	0.164	2.200
Tomatoes	Fungicides	Dichlorophen	12.00	12.00	1.50	0.400	0.600
Tomatoes	Fungicides	Difenoconazole	12.00	12.00	8.57	0.088	0.750
Tomatoes	Fungicides	Famoxadone	12.00	12.00	0.40	1.250	0.500
Tomatoes	Fungicides	Fenamidone	12.00	12.00	1.43	0.140	0.200
Tomatoes	Fungicides	Iprovalicarb	12.00	12.00	0.67	0.405	0.270
Tomatoes	Fungicides	Mancozeb	12.00	12.00	36.12	1.362	49.180
Tomatoes	Fungicides	Mandipropamid	12.00	12.00	6.00	0.125	0.750
Tomatoes	Fungicides	Maneb	12.00	12.00	0.67	1.305	0.870
Tomatoes	Fungicides	Metalaxyl	12.00	12.00	4.97	0.181	0.900
Tomatoes	Fungicides	Metalaxyl-M	12.00	12.00	6.67	0.096	0.643

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Tomatoes	Fungicides	Potassium-phosphite	12.00	12.00	1.67	1.158	1.930
Tomatoes	Fungicides	Procymidone	12.00	12.00	8.00	0.156	1.250
Tomatoes	Fungicides	Propineb	12.00	12.00	5.67	1.553	8.800
Tomatoes	Fungicides	Pyraclostrobin	12.00	12.00	3.33	0.038	0.128
Tomatoes	Fungicides	Sulphur	12.00	12.00	1.67	2.700	4.500
Tomatoes	Fungicides	Tebuconazole	12.00	12.00	3.50	0.214	0.750
Tomatoes	Fungicides	Zinc-oxide	12.00	12.00	0.67	0.014	0.009
Tomatoes	Herbicides	Cycloxydim	12.00	12.00	0.50	0.200	0.100
Tomatoes	Herbicides	Glyphosate	12.00	12.00	0.67	1.080	0.720
Tomatoes	Herbicides	Metribuzin	12.00	12.00	3.33	0.720	2.400
Tomatoes	Herbicides	Paraquat	12.00	12.00	6.50	0.400	2.600
Tomatoes	Herbicides	Propaquizafop	12.00	12.00	2.67	0.075	0.200
Tomatoes	Herbicides	Rimsulfuron	12.00	12.00	4.00	0.025	0.100
Tomatoes	Herbicides	Trifluralin	12.00	12.00	0.67	0.720	0.480
Fruit: Other Tropical	Insecticides	Bacillus-thuringiensis	17.30	15.00	3.33	0.010	0.032
Fruit: Other Tropical	Insecticides	Betacyfluthrin	17.30	15.00	33.33	0.005	0.175
Fruit: Other Tropical	Insecticides	Bromopropylate	17.30	15.00	3.33	0.150	0.500
Fruit: Other Tropical	Insecticides	Buprofezin	17.30	15.00	20.00	0.150	3.000
Fruit: Other Tropical	Insecticides	Cadusafos	17.30	15.00	0.13	1.500	0.200
Fruit: Other Tropical	Insecticides	Deltamethrin	17.30	15.00	25.00	0.006	0.150
Fruit: Other Tropical	Insecticides	Esfenvalerate	17.30	15.00	40.00	0.010	0.400
Fruit: Other Tropical	Insecticides	Fenthion	17.30	15.00	5.50	0.500	2.750
Fruit: Other Tropical	Insecticides	Fipronil	17.30	15.00	24.00	0.033	0.780
Fruit: Other Tropical	Insecticides	Malathion	17.30	15.00	1.50	0.500	0.750
Fruit: Other Tropical	Insecticides	Methoxyfenozide	17.30	15.00	3.33	0.144	0.480
Fruit: Other Tropical	Insecticides	Pymetrozine	17.30	15.00	2.00	0.250	0.500
Fruit: Other Tropical	Insecticides	Pyriproxifen	17.30	15.00	21.11	0.047	1.000
Fruit: Other Tropical	Insecticides	Thiamethoxam	17.30	15.00	2.86	0.084	0.240

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Fruit: Other Tropical	Fungicides	Azoxystrobin	17.30	17.30	2.50	0.100	0.250
Fruit: Other Tropical	Fungicides	Benomyl	17.30	17.30	2.50	0.400	1.000
Fruit: Other Tropical	Fungicides	Bupirimate	17.30	17.30	6.25	0.100	0.625
Fruit: Other Tropical	Fungicides	Carbendazim	17.30	17.30	8.33	0.039	0.325
Fruit: Other Tropical	Fungicides	Copper-carbonate	17.30	17.30	0.27	4.958	1.322
Fruit: Other Tropical	Fungicides	Copper-hydroxide	17.30	17.30	7.53	1.709	12.872
Fruit: Other Tropical	Fungicides	Copper-oxide	17.30	17.30	1.67	2.250	3.750
Fruit: Other Tropical	Fungicides	Copper-oxychloride	17.30	17.30	9.00	2.550	22.950
Fruit: Other Tropical	Fungicides	Copper-sulphate	17.30	17.30	10.42	0.542	5.650
Fruit: Other Tropical	Fungicides	Fludioxonil	17.30	17.30	4.03	0.103	0.414
Fruit: Other Tropical	Fungicides	Flusilazole	17.30	17.30	8.00	0.038	0.300
Fruit: Other Tropical	Fungicides	Fosetyl-Al	17.30	17.30	13.33	0.300	4.000
Fruit: Other Tropical	Fungicides	Hexaconazole	17.30	17.30	1.25	0.012	0.015
Fruit: Other Tropical	Fungicides	Kresoxim-m	17.30	17.30	2.50	0.100	0.250
Fruit: Other Tropical	Fungicides	Mancozeb	17.30	17.30	6.40	1.586	10.150
Fruit: Other Tropical	Fungicides	Metalaxyl-M	17.30	17.30	0.48	1.008	0.480
Fruit: Other Tropical	Fungicides	Prochloraz	17.30	17.30	5.33	0.188	1.000
Fruit: Other Tropical	Fungicides	Propiconazole	17.30	17.30	15.00	0.050	0.750
Fruit: Other Tropical	Fungicides	Quinoxyfen	17.30	17.30	1.43	0.088	0.125
Fruit: Other Tropical	Fungicides	Spiroxamine	17.30	17.30	1.67	0.300	0.500
Fruit: Other Tropical	Fungicides	Sulphur	17.30	17.30	37.83	2.478	93.760
Fruit: Other Tropical	Fungicides	Tebuconazole	17.30	17.30	12.00	0.063	0.750
Fruit: Other Tropical	Fungicides	Tetraconazole	17.30	17.30	2.50	0.040	0.100
Fruit: Other Tropical	Fungicides	Triadimefon	17.30	17.30	1.67	0.099	0.165
Fruit: Other Tropical	Herbicides	Cycloxydim	17.30	12.50	1.00	0.200	0.200
Fruit: Other Tropical	Herbicides	Diquat	17.30	12.50	2.00	0.400	0.800
Fruit: Other Tropical	Herbicides	Fluazifop-P-b	17.30	12.50	0.10	0.300	0.030
Fruit: Other Tropical	Herbicides	Glufosinate-ammonium	17.30	12.50	2.00	0.400	0.800

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Fruit: Other Tropical	Herbicides	Glyphosate	17.30	12.50	13.33	1.080	14.400
Fruit: Other Tropical	Herbicides	Paraquat	17.30	12.50	75.00	0.461	34.560
Fruit: Other Tropical	Herbicides	Propaquizafop	17.30	12.50	2.00	0.100	0.200
Fruit: Other Tropical	Herbicides	s-metolachlor	17.30	12.50	0.67	0.308	0.206
Fruit: Other Tropical	Herbicides	Terbuthylazine	17.30	12.50	0.67	1.492	0.994
Fruit: Other Tropical	Growth regulators	Uniconazole	17.30	0.28	0.10	1.500	0.150
Fruit: Other Tropical	Growth regulators	Uniconazole-P	17.30	0.28	0.18	1.500	0.275
Pineapple	Insecticides	Cadusafos	11.00		0.33	1.500	0.500
Pineapple	Insecticides	Chlorpyrifos-e	11.00		3.00	0.480	1.440
Pineapple	Insecticides	Diazinon	11.00		4.00	0.825	3.300
Pineapple	Insecticides	Dimethoate	11.00		1.00	0.400	0.400
Pineapple	Insecticides	Fenamiphos	11.00		0.87	3.213	2.800
Pineapple	Insecticides	Malathion	11.00		1.00	0.500	0.500
Pineapple	Insecticides	Oxamyl	11.00		6.25	1.240	7.750
Pineapple	Fungicides	Cymoxanil	11.00	10.61	0.50	0.060	0.030
Pineapple	Fungicides	Fosetyl-Al	11.00	10.61	3.00	1.600	4.800
Pineapple	Fungicides	Mancozeb	11.00	10.61	2.56	2.098	5.370
Pineapple	Fungicides	Metalaxyl	11.00	10.61	4.16	0.200	0.830
Pineapple	Fungicides	Metalaxyl-M	11.00	10.61	1.03	0.273	0.280
Pineapple	Fungicides	Potassium-phosphite	11.00	10.61	10.00	1.120	11.200
Pineapple	Herbicides	Alachlor	11.00	8.00	2.00	2.160	4.320
Pineapple	Herbicides	Ametryn	11.00	8.00	1.00	0.500	0.500
Pineapple	Herbicides	Bromacil	11.00	8.00	4.00	1.850	7.400
Pineapple	Herbicides	Cycloxydim	11.00	8.00	0.50	0.200	0.100
Pineapple	Herbicides	Fluazifop-P-b	11.00	8.00	0.75	0.267	0.200
Pineapple	Herbicides	Glyphosate	11.00	8.00	3.33	1.080	3.600
Pineapple	Herbicides	Propaquizafop	11.00	8.00	1.33	0.075	0.100
Pineapple	Growth regulators	Ethephon	11.00	2.67	2.67	1.440	3.840

Crop	Sector	AI	Crop area ($x10^3$ ha)	Base area ($x10^3$ ha)	AI Area Treated ($x10^3$ ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Additional Crops	Insecticides	Abamectin	340.00	300.00	33.33	0.011	0.360
Additional Crops	Insecticides	Acephate	340.00	300.00	12.00	0.750	9.000
Additional Crops	Insecticides	Alphacypermethrin	340.00	300.00	50.00	0.010	0.500
Additional Crops	Insecticides	Azinphos-m	340.00	300.00	10.00	0.350	3.500
Additional Crops	Insecticides	Bacillus-thuringiensis	340.00	300.00	3.92	0.012	0.048
Additional Crops	Insecticides	Benfuracarb	340.00	300.00	2.00	0.210	0.420
Additional Crops	Insecticides	Betacyfluthrin	340.00	300.00	128.33	0.005	0.648
Additional Crops	Insecticides	Betacypermethrin	340.00	300.00	7.69	0.007	0.050
Additional Crops	Insecticides	Cadusafos	340.00	300.00	0.20	1.500	0.300
Additional Crops	Insecticides	Carbaryl	340.00	300.00	4.14	0.782	3.235
Additional Crops	Insecticides	Carbofuran	340.00	300.00	3.40	1.000	3.400
Additional Crops	Insecticides	Chlorfenapyr	340.00	300.00	3.00	0.180	0.540
Additional Crops	Insecticides	Chlorpyrifos	340.00	300.00	9.67	0.497	4.800
Additional Crops	Insecticides	Chlorpyrifos-e	340.00	300.00	31.83	0.483	15.360
Additional Crops	Insecticides	Cypermethrin	340.00	300.00	186.67	0.023	4.200
Additional Crops	Insecticides	Deltamethrin	340.00	300.00	125.00	0.008	0.938
Additional Crops	Insecticides	Dimethoate	340.00	300.00	8.00	0.400	3.200
Additional Crops	Insecticides	Endosulfan	340.00	300.00	0.48	0.125	0.060
Additional Crops	Insecticides	Esfenvalerate	340.00	300.00	20.00	0.010	0.200
Additional Crops	Insecticides	Ethoprophos	340.00	300.00	1.00	0.100	0.100
Additional Crops	Insecticides	Ethylene-dibromide	340.00	300.00	0.50	36.000	18.000
Additional Crops	Insecticides	Etoxazole	340.00	300.00	1.43	0.035	0.050
Additional Crops	Insecticides	Fenamiphos	340.00	300.00	1.81	2.183	3.950
Additional Crops	Insecticides	Fenpropathrin	340.00	300.00	5.00	0.060	0.300
Additional Crops	Insecticides	Fenpyroximate	340.00	300.00	0.29	0.175	0.050
Additional Crops	Insecticides	Fenthion	340.00	300.00	2.00	1.000	2.000
Additional Crops	Insecticides	Fipronil	340.00	300.00	1.50	0.025	0.038
Additional Crops	Insecticides	Furfural	340.00	300.00	0.60	22.500	13.500

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Additional Crops	Insecticides	Gamma-cyhalothrin	340.00	300.00	33.33	0.004	0.120
Additional Crops	Insecticides	Imidacloprid	340.00	300.00	35.71	0.152	5.425
Additional Crops	Insecticides	Indoxacarb	340.00	300.00	2.00	0.113	0.225
Additional Crops	Insecticides	Lambda-cyhalothrin	340.00	300.00	171.67	0.007	1.116
Additional Crops	Insecticides	Lufenuron	340.00	300.00	2.00	0.025	0.050
Additional Crops	Insecticides	Malathion	340.00	300.00	5.50	0.500	2.750
Additional Crops	Insecticides	Metaldehyde	340.00	300.00	2.34	0.312	0.730
Additional Crops	Insecticides	Methiocarb	340.00	300.00	2.00	0.205	0.410
Additional Crops	Insecticides	Methomyl	340.00	300.00	44.44	0.200	8.900
Additional Crops	Insecticides	Methoxyfenozide	340.00	300.00	3.67	0.131	0.480
Additional Crops	Insecticides	Mevinphos	340.00	300.00	3.00	0.210	0.630
Additional Crops	Insecticides	Milbemectin	340.00	300.00	5.00	0.006	0.030
Additional Crops	Insecticides	Oxamyl	340.00	300.00	4.80	1.280	6.150
Additional Crops	Insecticides	Pymetrozine	340.00	300.00	4.80	0.229	1.100
Additional Crops	Insecticides	Spinosad	340.00	300.00	0.07	0.360	0.024
Additional Crops	Insecticides	Terbufos	340.00	300.00	2.00	1.500	3.000
Additional Crops	Insecticides	Tetradifon	340.00	300.00	1.50	0.080	0.120
Additional Crops	Insecticides	Thiamethoxam	340.00	300.00	7.39	0.091	0.675
Additional Crops	Fungicides	Azoxystrobin	340.00	20.10	3.52	0.437	1.538
Additional Crops	Fungicides	Benomyl	340.00	20.10	20.50	0.049	1.000
Additional Crops	Fungicides	Carbendazim	340.00	20.10	9.17	0.120	1.100
Additional Crops	Fungicides	Chlorothalonil	340.00	20.10	6.28	2.867	18.010
Additional Crops	Fungicides	Copper-hydroxide	340.00	20.10	0.33	1.614	0.538
Additional Crops	Fungicides	Copper-oxychloride	340.00	20.10	8.33	2.550	21.250
Additional Crops	Fungicides	Copper-sulphate	340.00	20.10	1.33	0.255	0.340
Additional Crops	Fungicides	Epoxiconazole	340.00	20.10	4.17	0.075	0.313
Additional Crops	Fungicides	Fludioxonil	340.00	20.10	0.42	0.276	0.115
Additional Crops	Fungicides	Fosetyl-Al	340.00	20.10	1.14	1.762	2.000

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Additional Crops	Fungicides	Kresoxim-m	340.00	20.10	2.80	0.214	0.600
Additional Crops	Fungicides	Mancozeb	340.00	20.10	12.80	1.702	21.790
Additional Crops	Fungicides	Metalaxyl-M	340.00	20.10	0.76	0.430	0.328
Additional Crops	Fungicides	Petroleum-oil	340.00	20.10	3.00	4.130	12.390
Additional Crops	Fungicides	Prochloraz	340.00	20.10	5.67	0.168	0.950
Additional Crops	Fungicides	Procymidone	340.00	20.10	0.10	1.250	0.125
Additional Crops	Fungicides	Propamocarb-HCl	340.00	20.10	0.03	54.150	1.444
Additional Crops	Fungicides	Propiconazole	340.00	20.10	9.12	0.378	3.450
Additional Crops	Fungicides	Pyraclostrobin	340.00	20.10	4.00	0.125	0.500
Additional Crops	Fungicides	Quinoxyfen	340.00	20.10	5.71	0.088	0.500
Additional Crops	Fungicides	Spiroxamine	340.00	20.10	9.78	0.153	1.500
Additional Crops	Fungicides	Sulphur	340.00	20.10	3.33	2.520	8.400
Additional Crops	Fungicides	Tebuconazole	340.00	20.10	16.67	0.065	1.084
Additional Crops	Fungicides	Thiram	340.00	20.10	0.08	9.000	0.750
Additional Crops	Fungicides	Tolclofos-m	340.00	20.10	0.20	2.500	0.500
Additional Crops	Fungicides	Triadimefon	340.00	20.10	10.17	0.102	1.033
Additional Crops	Fungicides	Triadimenol	340.00	20.10	6.67	0.013	0.086
Additional Crops	Fungicides	Triforine	340.00	20.10	1.00	0.190	0.190
Additional Crops	Herbicides	2.4-D-amine	340.00	250.00	50.67	0.690	34.980
Additional Crops	Herbicides	Alachlor	340.00	250.00	2.79	1.961	5.472
Additional Crops	Herbicides	Atrazine	340.00	250.00	21.00	1.490	31.300
Additional Crops	Herbicides	Bentazone	340.00	250.00	1.75	0.777	1.360
Additional Crops	Herbicides	Bromoxynil	340.00	250.00	10.67	0.267	2.850
Additional Crops	Herbicides	Carfentrazone-e	340.00	250.00	6.00	0.010	0.060
Additional Crops	Herbicides	Chloridazon	340.00	250.00	1.50	1.300	1.950
Additional Crops	Herbicides	Chlorsulfuron	340.00	250.00	6.25	0.012	0.075
Additional Crops	Herbicides	Clomazone	340.00	250.00	3.33	0.576	1.920
Additional Crops	Herbicides	Copper	340.00	250.00	0.25	1.250	0.313

Crop	Sector	AI	Crop area ($x10^3$ ha)	Base area ($x10^3$ ha)	AI Area Treated ($x10^3$ ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Additional Crops	Herbicides	Cycloxydim	340.00	250.00	2.00	0.200	0.400
Additional Crops	Herbicides	Dicamba	340.00	250.00	42.00	0.328	13.760
Additional Crops	Herbicides	Dimethenamid-P	340.00	250.00	4.67	0.617	2.880
Additional Crops	Herbicides	Diquat	340.00	250.00	0.56	10.000	5.600
Additional Crops	Herbicides	EPTC	340.00	250.00	0.58	1.851	1.080
Additional Crops	Herbicides	Florasulam	340.00	250.00	40.00	0.004	0.150
Additional Crops	Herbicides	Fluazifop-P-b	340.00	250.00	0.58	0.257	0.150
Additional Crops	Herbicides	Flumetsulam	340.00	250.00	40.00	0.005	0.200
Additional Crops	Herbicides	Glufosinate-ammonium	340.00	250.00	3.25	0.431	1.400
Additional Crops	Herbicides	Glyphosate	340.00	250.00	53.06	0.882	46.785
Additional Crops	Herbicides	Halosulfuron-m	340.00	250.00	10.00	0.038	0.375
Additional Crops	Herbicides	Linuron	340.00	250.00	0.28	0.900	0.250
Additional Crops	Herbicides	MCPA	340.00	250.00	92.00	0.442	40.688
Additional Crops	Herbicides	Metazachlor	340.00	250.00	1.00	0.500	0.500
Additional Crops	Herbicides	Metolachlor	340.00	250.00	6.67	1.440	9.600
Additional Crops	Herbicides	Metsulfuron-m	340.00	250.00	5.56	0.012	0.068
Additional Crops	Herbicides	MSMA	340.00	250.00	3.63	2.580	9.360
Additional Crops	Herbicides	Oxadiazon	340.00	250.00	1.17	0.429	0.500
Additional Crops	Herbicides	Paraquat	340.00	250.00	45.00	0.445	20.016
Additional Crops	Herbicides	Pendimethalin	340.00	250.00	5.00	1.000	5.000
Additional Crops	Herbicides	Propaquizafop	340.00	250.00	28.00	0.075	2.100
Additional Crops	Herbicides	Propyzamide	340.00	250.00	2.50	0.800	2.000
Additional Crops	Herbicides	Prosulfuron	340.00	250.00	8.75	0.021	0.188
Additional Crops	Herbicides	Quizalofop-P-e	340.00	250.00	0.40	0.050	0.020
Additional Crops	Herbicides	Quizalofop-P-t	340.00	250.00	1.00	0.040	0.040
Additional Crops	Herbicides	s-metolachlor	340.00	250.00	26.33	0.594	15.632
Additional Crops	Herbicides	Terbuthylazine	340.00	250.00	20.00	1.161	23.218
Additional Crops	Herbicides	Thifensulfuron-m	340.00	250.00	5.56	0.001	0.007

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Additional Crops	Herbicides	Triasulfuron	340.00	250.00	6.25	0.012	0.075
Additional Crops	Growth regulators	Butralin	340.00	9.58	12.50	0.298	3.730
Additional Crops	Growth regulators	Pendimethalin	340.00	9.58	3.33	0.990	3.300
Additional Crops	Seed dressing	Flufenoxim	340.00	300.00	83.33	0.002	0.192
Additional Crops	Seed dressing	Imidacloprid	340.00	300.00	135.00	0.014	1.890
Additional Crops	Seed dressing	Thiamethoxam	340.00	300.00	258.62	0.014	3.600
Vegetables: Other	Insecticides	Acephate	42.54	34.50	6.00	0.375	2.250
Vegetables: Other	Insecticides	Alphacypermethrin	42.54	34.50	40.00	0.010	0.400
Vegetables: Other	Insecticides	Bacillus-thur.-aizawai	42.54	34.50	2.00	0.008	0.015
Vegetables: Other	Insecticides	Bacillus-thuringiensis	42.54	34.50	6.29	0.013	0.080
Vegetables: Other	Insecticides	Betacyfluthrin	42.54	34.50	100.00	0.005	0.488
Vegetables: Other	Insecticides	Betacypermethrin	42.54	34.50	7.69	0.007	0.050
Vegetables: Other	Insecticides	Carbofuran	42.54	34.50	0.50	1.000	0.500
Vegetables: Other	Insecticides	Cartap	42.54	34.50	8.33	0.660	5.500
Vegetables: Other	Insecticides	Chlorpyrifos	42.54	34.50	11.00	0.480	5.280
Vegetables: Other	Insecticides	Chlorpyrifos-e	42.54	34.50	4.00	0.480	1.920
Vegetables: Other	Insecticides	Cypermethrin	42.54	34.50	46.67	0.028	1.300
Vegetables: Other	Insecticides	Cyromazine	42.54	34.50	10.00	0.375	3.750
Vegetables: Other	Insecticides	Deltamethrin	42.54	34.50	79.17	0.005	0.425
Vegetables: Other	Insecticides	Dimethoate	42.54	34.50	2.00	0.400	0.800
Vegetables: Other	Insecticides	Endosulfan	42.54	34.50	0.80	0.125	0.100
Vegetables: Other	Insecticides	Esfenvalerate	42.54	34.50	20.00	0.010	0.200
Vegetables: Other	Insecticides	Ethoprophos	42.54	34.50	2.33	0.300	0.700
Vegetables: Other	Insecticides	Ethylene-dibromide	42.54	34.50	1.67	5.400	9.000
Vegetables: Other	Insecticides	Fenamiphos	42.54	34.50	0.80	3.500	2.800
Vegetables: Other	Insecticides	Fenbutatin-oxide	42.54	34.50	2.82	0.390	1.100
Vegetables: Other	Insecticides	Fenthion	42.54	34.50	1.67	0.600	1.000
Vegetables: Other	Insecticides	Fipronil	42.54	34.50	8.00	0.050	0.400

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Vegetables: Other	Insecticides	Flubendiamide	42.54	34.50	14.00	0.024	0.336
Vegetables: Other	Insecticides	Furfural	42.54	34.50	0.64	22.500	14.400
Vegetables: Other	Insecticides	Gamma-cyhalothrin	42.54	34.50	26.67	0.004	0.096
Vegetables: Other	Insecticides	Imidacloprid	42.54	34.50	24.29	0.173	4.200
Vegetables: Other	Insecticides	Indoxacarb	42.54	34.50	11.28	0.048	0.540
Vegetables: Other	Insecticides	Lambda-cyhalothrin	42.54	34.50	98.33	0.006	0.550
Vegetables: Other	Insecticides	Lufenuron	42.54	34.50	3.43	0.029	0.100
Vegetables: Other	Insecticides	Malathion	42.54	34.50	8.00	0.500	4.000
Vegetables: Other	Insecticides	Metaldehyde	42.54	34.50	1.00	0.200	0.200
Vegetables: Other	Insecticides	Methiocarb	42.54	34.50	1.00	0.100	0.100
Vegetables: Other	Insecticides	Methomyl	42.54	34.50	12.00	0.225	2.700
Vegetables: Other	Insecticides	Methoxyfenozide	42.54	34.50	5.33	0.135	0.720
Vegetables: Other	Insecticides	Mevinphos	42.54	34.50	4.00	0.195	0.780
Vegetables: Other	Insecticides	Profenofos	42.54	34.50	5.00	0.500	2.500
Vegetables: Other	Insecticides	Prothiofos	42.54	34.50	6.00	0.250	1.500
Vegetables: Other	Insecticides	Pymetrozine	42.54	34.50	4.00	0.188	0.750
Vegetables: Other	Insecticides	Pyridalyl	42.54	34.50	1.00	0.250	0.250
Vegetables: Other	Insecticides	Spinosad	42.54	34.50	3.67	0.098	0.360
Vegetables: Other	Insecticides	Spirotetramat	42.54	34.50	13.60	0.058	0.792
Vegetables: Other	Insecticides	Thiacloprid	42.54	34.50	5.00	0.096	0.480
Vegetables: Other	Insecticides	Thiamethoxam	42.54	34.50	13.71	0.040	0.552
Vegetables: Other	Fungicides	Azoxystrobin	42.54	33.50	3.00	0.090	0.270
Vegetables: Other	Fungicides	Boscalid	42.54	33.50	3.67	0.096	0.352
Vegetables: Other	Fungicides	Carbendazim	42.54	33.50	3.67	0.089	0.325
Vegetables: Other	Fungicides	Chlorothalonil	42.54	33.50	10.23	1.016	10.395
Vegetables: Other	Fungicides	Copper-hydroxide	42.54	33.50	1.67	1.614	2.690
Vegetables: Other	Fungicides	Copper-oxychloride	42.54	33.50	5.00	2.550	12.750
Vegetables: Other	Fungicides	Copper-sulphate	42.54	33.50	2.33	0.255	0.595

Crop	Sector	AI	Crop area ($x10^3$ ha)	Base area ($x10^3$ ha)	AI Area Treated ($x10^3$ ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Vegetables: Other	Fungicides	Cymoxanil	42.54	33.50	2.00	0.025	0.050
Vegetables: Other	Fungicides	Dichlorophen	42.54	33.50	1.00	0.400	0.400
Vegetables: Other	Fungicides	Fluopyram	42.54	33.50	0.67	0.150	0.100
Vegetables: Other	Fungicides	Flusilazole	42.54	33.50	2.00	0.125	0.250
Vegetables: Other	Fungicides	Iprodione	42.54	33.50	0.50	0.510	0.255
Vegetables: Other	Fungicides	Kresoxim-m	42.54	33.50	2.67	0.206	0.550
Vegetables: Other	Fungicides	Mancozeb	42.54	33.50	32.23	1.674	53.950
Vegetables: Other	Fungicides	Mandipropamid	42.54	33.50	2.40	0.146	0.350
Vegetables: Other	Fungicides	Maneb	42.54	33.50	1.00	0.435	0.435
Vegetables: Other	Fungicides	Metalaxyl-M	42.54	33.50	0.50	0.075	0.038
Vegetables: Other	Fungicides	Penconazole	42.54	33.50	17.13	0.041	0.700
Vegetables: Other	Fungicides	Prochloraz	42.54	33.50	2.59	0.386	1.000
Vegetables: Other	Fungicides	Procymidone	42.54	33.50	10.96	0.376	4.125
Vegetables: Other	Fungicides	Propamocarb-HCl	42.54	33.50	0.74	7.841	5.776
Vegetables: Other	Fungicides	Pyraclostrobin	42.54	33.50	2.00	0.064	0.128
Vegetables: Other	Fungicides	Quinoxyfen	42.54	33.50	1.00	0.125	0.125
Vegetables: Other	Fungicides	Spiroxamine	42.54	33.50	2.00	0.250	0.500
Vegetables: Other	Fungicides	Sulphur	42.54	33.50	11.00	2.627	28.900
Vegetables: Other	Fungicides	Tebuconazole	42.54	33.50	30.75	0.093	2.850
Vegetables: Other	Fungicides	Triadimefon	42.54	33.50	1.67	0.099	0.165
Vegetables: Other	Fungicides	Trifloxystrobin	42.54	33.50	12.58	0.040	0.500
Vegetables: Other	Fungicides	Triforine	42.54	33.50	2.00	0.190	0.380
Vegetables: Other	Fungicides	Zinc-oxide	42.54	33.50	1.00	0.005	0.005
Vegetables: Other	Herbicides	Alachlor	42.54	10.10	0.13	1.536	0.192
Vegetables: Other	Herbicides	Bentazone	42.54	10.10	2.75	0.698	1.920
Vegetables: Other	Herbicides	Clethodim	42.54	10.10	0.50	0.120	0.060
Vegetables: Other	Herbicides	Cycloxydim	42.54	10.10	0.25	0.200	0.050
Vegetables: Other	Herbicides	Fluazifop-P-b	42.54	10.10	1.05	0.298	0.313

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Vegetables: Other	Herbicides	Flurochloridone	42.54	10.10	0.16	0.800	0.125
Vegetables: Other	Herbicides	Ioxynil	42.54	10.10	2.00	0.625	1.250
Vegetables: Other	Herbicides	Oxadiazon	42.54	10.10	3.33	0.750	2.500
Vegetables: Other	Herbicides	Oxyfluorfen	42.54	10.10	2.90	0.497	1.440
Vegetables: Other	Herbicides	Paraquat	42.54	10.10	1.00	0.400	0.400
Vegetables: Other	Herbicides	Propaquizafop	42.54	10.10	2.67	0.075	0.200
Vegetables: Other	Herbicides	Propyzamide	42.54	10.10	0.67	0.750	0.500
Vegetables: Other	Herbicides	Trifluralin	42.54	10.10	0.67	0.720	0.480
Vegetables: Other	Seed dressing	Metalaxyl-M	42.54	7.78	7.78	0.032	0.245
Grapes-table	Insecticides	Acephate	26.00	26.00	2.00	0.750	1.500
Grapes-table	Insecticides	Acetamiprid	26.00	26.00	4.00	0.100	0.400
Grapes-table	Insecticides	Alphacypermethrin	26.00	26.00	40.00	0.010	0.400
Grapes-table	Insecticides	Bacillus-thuringiensis	26.00	26.00	1.67	0.010	0.016
Grapes-table	Insecticides	Betacyfluthrin	26.00	26.00	16.67	0.003	0.050
Grapes-table	Insecticides	Betacypermethrin	26.00	26.00	15.38	0.007	0.100
Grapes-table	Insecticides	Cadusafos	26.00	26.00	0.07	1.500	0.100
Grapes-table	Insecticides	Carbaryl	26.00	26.00	13.50	0.804	10.850
Grapes-table	Insecticides	Carbosulfan	26.00	26.00	8.00	0.240	1.920
Grapes-table	Insecticides	Chlorfenapyr	26.00	26.00	4.00	0.180	0.720
Grapes-table	Insecticides	Chlorpyrifos	26.00	26.00	70.00	0.480	33.600
Grapes-table	Insecticides	Chlorpyrifos-e	26.00	26.00	4.00	0.480	1.920
Grapes-table	Insecticides	Cypermethrin	26.00	26.00	73.33	0.030	2.200
Grapes-table	Insecticides	Deltamethrin	26.00	26.00	58.33	0.008	0.475
Grapes-table	Insecticides	Dimethoate	26.00	26.00	2.00	0.400	0.800
Grapes-table	Insecticides	Esfenvalerate	26.00	26.00	20.00	0.010	0.200
Grapes-table	Insecticides	Fenamiphos	26.00	26.00	0.10	4.000	0.400
Grapes-table	Insecticides	Furfural	26.00	26.00	0.04	22.500	0.900
Grapes-table	Insecticides	Imidacloprid	26.00	26.00	8.57	0.163	1.400

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Grapes-table	Insecticides	Lambda-cyhalothrin	26.00	26.00	133.33	0.006	0.800
Grapes-table	Insecticides	Metaldehyde	26.00	26.00	15.75	0.994	15.650
Grapes-table	Insecticides	Methidathion	26.00	26.00	0.50	0.840	0.420
Grapes-table	Insecticides	Methiocarb	26.00	26.00	3.25	0.100	0.325
Grapes-table	Insecticides	Mevinphos	26.00	26.00	1.00	0.240	0.240
Grapes-table	Insecticides	Profenofos	26.00	26.00	1.00	0.500	0.500
Grapes-table	Insecticides	Propoxur	26.00	26.00	1.00	0.400	0.400
Grapes-table	Insecticides	Prothiofos	26.00	26.00	60.00	0.250	15.000
Grapes-table	Insecticides	Spinosad	26.00	26.00	0.07	0.360	0.024
Grapes-table	Insecticides	Sulphur	26.00	26.00	8.00	4.000	32.000
Grapes-table	Fungicides	Azoxystrobin	26.00	26.00	5.00	0.100	0.500
Grapes-table	Fungicides	Boscalid	26.00	26.00	42.08	0.131	5.500
Grapes-table	Fungicides	Carbendazim	26.00	26.00	6.67	0.120	0.800
Grapes-table	Fungicides	Copper-oxychloride	26.00	26.00	18.33	2.550	46.750
Grapes-table	Fungicides	Copper-sulphate	26.00	26.00	33.33	0.255	8.500
Grapes-table	Fungicides	Cymoxanil	26.00	26.00	41.88	0.119	4.980
Grapes-table	Fungicides	Cyprodinil	26.00	26.00	19.58	0.150	2.938
Grapes-table	Fungicides	Dimethomorph	26.00	26.00	10.00	0.180	1.800
Grapes-table	Fungicides	Dinocap	26.00	26.00	1.00	0.350	0.350
Grapes-table	Fungicides	Famoxadone	26.00	26.00	10.00	0.090	0.900
Grapes-table	Fungicides	Fenamidone	26.00	26.00	9.00	0.072	0.644
Grapes-table	Fungicides	Fludioxonil	26.00	26.00	6.25	0.100	0.625
Grapes-table	Fungicides	Fluopicolide	26.00	26.00	66.67	0.010	0.666
Grapes-table	Fungicides	Fluopyram	26.00	26.00	5.00	0.040	0.200
Grapes-table	Fungicides	Flusilazole	26.00	26.00	6.00	0.050	0.300
Grapes-table	Fungicides	Folpet	26.00	26.00	1.07	1.213	1.300
Grapes-table	Fungicides	Fosetyl-Al	26.00	26.00	85.67	0.405	34.668
Grapes-table	Fungicides	Iprodione	26.00	26.00	3.00	0.755	2.265

Crop	Sector	AI	Crop area ($x10^3$ ha)	Base area ($x10^3$ ha)	AI Area Treated ($x10^3$ ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Grapes-table	Fungicides	Iprovalicarb	26.00	26.00	70.00	0.027	1.875
Grapes-table	Fungicides	Kresoxim-m	26.00	26.00	48.33	0.052	2.500
Grapes-table	Fungicides	Mancozeb	26.00	26.00	175.50	1.276	224.000
Grapes-table	Fungicides	Mandipropamid	26.00	26.00	8.00	0.063	0.500
Grapes-table	Fungicides	Maneb	26.00	26.00	11.50	0.757	8.700
Grapes-table	Fungicides	Metalaxyl	26.00	26.00	14.44	0.104	1.500
Grapes-table	Fungicides	Metiram	26.00	26.00	18.00	0.550	9.900
Grapes-table	Fungicides	Metrafenone	26.00	26.00	40.00	0.125	5.000
Grapes-table	Fungicides	Penconazole	26.00	26.00	66.67	0.021	1.400
Grapes-table	Fungicides	Potassium-phosphite	26.00	26.00	10.33	0.850	8.786
Grapes-table	Fungicides	Procymidone	26.00	26.00	4.50	0.500	2.250
Grapes-table	Fungicides	Propineb	26.00	26.00	72.43	0.294	21.288
Grapes-table	Fungicides	Pyraclostrobin	26.00	26.00	18.00	0.050	0.900
Grapes-table	Fungicides	Pyrimethanil	26.00	26.00	2.78	0.288	0.800
Grapes-table	Fungicides	Quinoxyfen	26.00	26.00	14.29	0.088	1.250
Grapes-table	Fungicides	Spiroxamine	26.00	26.00	1.67	0.300	0.500
Grapes-table	Fungicides	Sulphur	26.00	26.00	302.35	2.492	753.300
Grapes-table	Fungicides	Tebuconazole	26.00	26.00	55.00	0.095	5.200
Grapes-table	Fungicides	Tetraconazole	26.00	26.00	2.50	0.040	0.100
Grapes-table	Fungicides	Triadimefon	26.00	26.00	6.67	0.099	0.660
Grapes-table	Fungicides	Trifloxystrobin	26.00	26.00	50.00	0.050	2.500
Grapes-table	Fungicides	Zinc-oxide	26.00	26.00	4.00	0.006	0.024
Grapes-table	Herbicides	Carfentrazone-e	26.00	26.00	4.00	0.010	0.040
Grapes-table	Herbicides	Clethodim	26.00	26.00	1.00	0.120	0.120
Grapes-table	Herbicides	Cycloxydim	26.00	26.00	0.50	0.200	0.100
Grapes-table	Herbicides	Diquat	26.00	26.00	3.33	0.240	0.800
Grapes-table	Herbicides	Fluazifop-P-b	26.00	26.00	0.65	0.308	0.200
Grapes-table	Herbicides	Flumioxazin	26.00	26.00	0.50	0.100	0.050

Crop	Sector	AI	Crop area ($x10^3$ ha)	Base area ($x10^3$ ha)	AI Area Treated ($x10^3$ ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Grapes-table	Herbicides	Glufosinate-ammonium	26.00	26.00	4.00	0.500	2.000
Grapes-table	Herbicides	Glyphosate	26.00	26.00	320.00	0.720	230.500
Grapes-table	Herbicides	Haloxyfop-r-m	26.00	26.00	2.67	0.162	0.432
Grapes-table	Herbicides	MCPA	26.00	26.00	0.83	0.480	0.400
Grapes-table	Herbicides	Oxadiazon	26.00	26.00	0.17	1.500	0.250
Grapes-table	Herbicides	Oxyfluorfen	26.00	26.00	0.40	0.600	0.240
Grapes-table	Herbicides	Paraquat	26.00	26.00	80.83	0.398	32.200
Grapes-table	Herbicides	Propaquizafop	26.00	26.00	1.33	0.075	0.100
Grapes-table	Herbicides	Propyzamide	26.00	26.00	0.33	0.750	0.250
Grapes-table	Herbicides	Simazine	26.00	26.00	4.30	1.163	5.000
Grapes-table	Herbicides	s-metolachlor	26.00	26.00	0.33	0.308	0.103
Grapes-table	Herbicides	Terbuthylazine	26.00	26.00	71.76	1.888	135.497
Grapes-table	Growth regulators	Cyanamide	26.00	26.00	4.60	12.413	57.100
Grapes-table	Growth regulators	Ethephon	26.00	26.00	12.50	0.192	2.400
Grapes-table	Growth regulators	Gibberellic-acid	26.00	26.00	25.00	0.031	0.775
Grapes-wine	Insecticides	Carbaryl	97.00	97.00	2.50	0.800	2.000
Grapes-wine	Insecticides	Carbosulfan	97.00	97.00	4.00	0.240	0.960
Grapes-wine	Insecticides	Chlorpyrifos	97.00	97.00	10.00	0.480	4.800
Grapes-wine	Insecticides	Chlorpyrifos-e	97.00	97.00	25.00	0.480	12.000
Grapes-wine	Insecticides	Cypermethrin	97.00	97.00	40.00	0.030	1.200
Grapes-wine	Insecticides	Deltamethrin	97.00	97.00	8.33	0.012	0.100
Grapes-wine	Insecticides	Fenamiphos	97.00	97.00	2.50	4.000	10.000
Grapes-wine	Insecticides	Gamma-cyhalothrin	97.00	97.00	24.10	0.005	0.120
Grapes-wine	Insecticides	Indoxacarb	97.00	97.00	10.00	0.060	0.600
Grapes-wine	Insecticides	Lambda-cyhalothrin	97.00	97.00	125.00	0.006	0.750
Grapes-wine	Insecticides	Metaldehyde	97.00	97.00	8.00	0.513	4.100
Grapes-wine	Insecticides	Methiocarb	97.00	97.00	7.50	0.287	2.150
Grapes-wine	Insecticides	Propoxur	97.00	97.00	1.00	0.400	0.400

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Grapes-wine	Insecticides	Spirotetramat	97.00	97.00	40.00	0.024	0.960
Grapes-wine	Insecticides	Sulphur	97.00	97.00	3.00	4.000	12.000
Grapes-wine	Insecticides	Thiamethoxam	97.00	97.00	8.33	0.029	0.240
Grapes-wine	Fungicides	Azoxystrobin	97.00	97.00	2.50	0.100	0.250
Grapes-wine	Fungicides	Boscalid	97.00	97.00	19.17	0.104	2.000
Grapes-wine	Fungicides	Carbendazim	97.00	97.00	6.67	0.120	0.800
Grapes-wine	Fungicides	Copper-hydroxide	97.00	97.00	3.33	1.614	5.380
Grapes-wine	Fungicides	Copper-oxychloride	97.00	97.00	2.67	2.550	6.800
Grapes-wine	Fungicides	Copper-sulphate	97.00	97.00	3.33	0.255	0.850
Grapes-wine	Fungicides	Cymoxanil	97.00	97.00	15.63	0.115	1.800
Grapes-wine	Fungicides	Cyprodinil	97.00	97.00	2.50	0.150	0.375
Grapes-wine	Fungicides	Difenoconazole	97.00	97.00	4.17	0.030	0.125
Grapes-wine	Fungicides	Dimethomorph	97.00	97.00	12.50	0.180	2.250
Grapes-wine	Fungicides	Dinocap	97.00	97.00	2.00	0.350	0.700
Grapes-wine	Fungicides	Famoxadone	97.00	97.00	2.50	0.090	0.225
Grapes-wine	Fungicides	Fenamidone	97.00	97.00	3.33	0.120	0.400
Grapes-wine	Fungicides	Fludioxonil	97.00	97.00	2.50	0.100	0.250
Grapes-wine	Fungicides	Fluopyram	97.00	97.00	8.00	0.125	1.000
Grapes-wine	Fungicides	Flusilazole	97.00	97.00	14.00	0.050	0.700
Grapes-wine	Fungicides	Folpet	97.00	97.00	0.72	0.905	0.650
Grapes-wine	Fungicides	Fosetyl-Al	97.00	97.00	2.50	1.600	4.000
Grapes-wine	Fungicides	Iprodione	97.00	97.00	1.33	0.750	1.000
Grapes-wine	Fungicides	Iprovalicarb	97.00	97.00	5.33	0.117	0.625
Grapes-wine	Fungicides	Kresoxim-m	97.00	97.00	16.67	0.030	0.500
Grapes-wine	Fungicides	Mancozeb	97.00	97.00	105.43	1.381	145.630
Grapes-wine	Fungicides	Maneb	97.00	97.00	7.60	0.801	6.090
Grapes-wine	Fungicides	Metalaxyl	97.00	97.00	13.33	0.083	1.100
Grapes-wine	Fungicides	Metalaxyl-M	97.00	97.00	1.60	0.050	0.080

Crop	Sector	AI	Crop area (x10^3 ha)	Base area (x10^3 ha)	AI Area Treated (x10^3 ha)	AI dose rate (kg or L/ha)	AI volume (x 10^3 kg/L)
Grapes-wine	Fungicides	Metiram	97.00	97.00	10.00	0.550	5.500
Grapes-wine	Fungicides	Metrafenone	97.00	97.00	12.00	0.125	1.500
Grapes-wine	Fungicides	Penconazole	97.00	97.00	60.00	0.023	1.400
Grapes-wine	Fungicides	Potassium-phosphite	97.00	97.00	5.33	0.840	4.480
Grapes-wine	Fungicides	Procymidone	97.00	97.00	5.00	0.500	2.500
Grapes-wine	Fungicides	Propineb	97.00	97.00	8.46	1.142	9.663
Grapes-wine	Fungicides	Pyraclostrobin	97.00	97.00	10.00	0.050	0.500
Grapes-wine	Fungicides	Pyrimethanil	97.00	97.00	4.72	0.508	2.400
Grapes-wine	Fungicides	Quinoxyfen	97.00	97.00	8.57	0.088	0.750
Grapes-wine	Fungicides	Sulphur	97.00	97.00	183.17	2.173	398.000
Grapes-wine	Fungicides	Tebuconazole	97.00	97.00	20.00	0.125	2.500
Grapes-wine	Fungicides	Triadimefon	97.00	97.00	6.67	0.099	0.660
Grapes-wine	Fungicides	Trifloxystrobin	97.00	97.00	20.00	0.063	1.250
Grapes-wine	Fungicides	Zinc-oxide	97.00	97.00	1.60	0.006	0.009
Grapes-wine	Herbicides	Diquat	97.00	97.00	13.33	0.240	3.200
Grapes-wine	Herbicides	Fluazifop-P-b	97.00	97.00	0.90	0.306	0.275
Grapes-wine	Herbicides	Glufosinate-ammonium	97.00	97.00	8.00	0.500	4.000
Grapes-wine	Herbicides	Glyphosate	97.00	97.00	675.36	0.874	590.400
Grapes-wine	Herbicides	Haloxyfop-r-m	97.00	97.00	3.33	0.162	0.540
Grapes-wine	Herbicides	Oxadiazon	97.00	97.00	0.17	1.500	0.250
Grapes-wine	Herbicides	Paraquat	97.00	97.00	60.00	0.551	33.080
Grapes-wine	Herbicides	Simazine	97.00	97.00	3.00	1.000	3.000
Grapes-wine	Herbicides	Terbuthylazine	97.00	97.00	31.43	1.766	55.500
Grapes-wine	Growth regulators	Gibberellic-acid	97.00	93.00	93.33	0.006	0.544