AERIAL APPLICATION ASSOCIATION OF AUSTRALIA LTD.

CROP CONSULTANTS AUSTRALIA

AGRONOMIST

GUIDE TO AERIAL APPLICATION

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LEGAL DISCLAIMER:

The content of this manual forms only a part of the basic knowledge required for aerial application. Additional competencies, skills and knowledge are attained through training conducted for the issuing of CASA aviation licences. ratings and endorsements, through the mandatory supervision of new application pilots by their employers and through the applicator's pursuit of ongoing professional development throughout their career.

The information provided is of a general nature only and agronomists, landholders, farmers or others should seek their own professional advice and/or training before undertaking chemical application or related activities.

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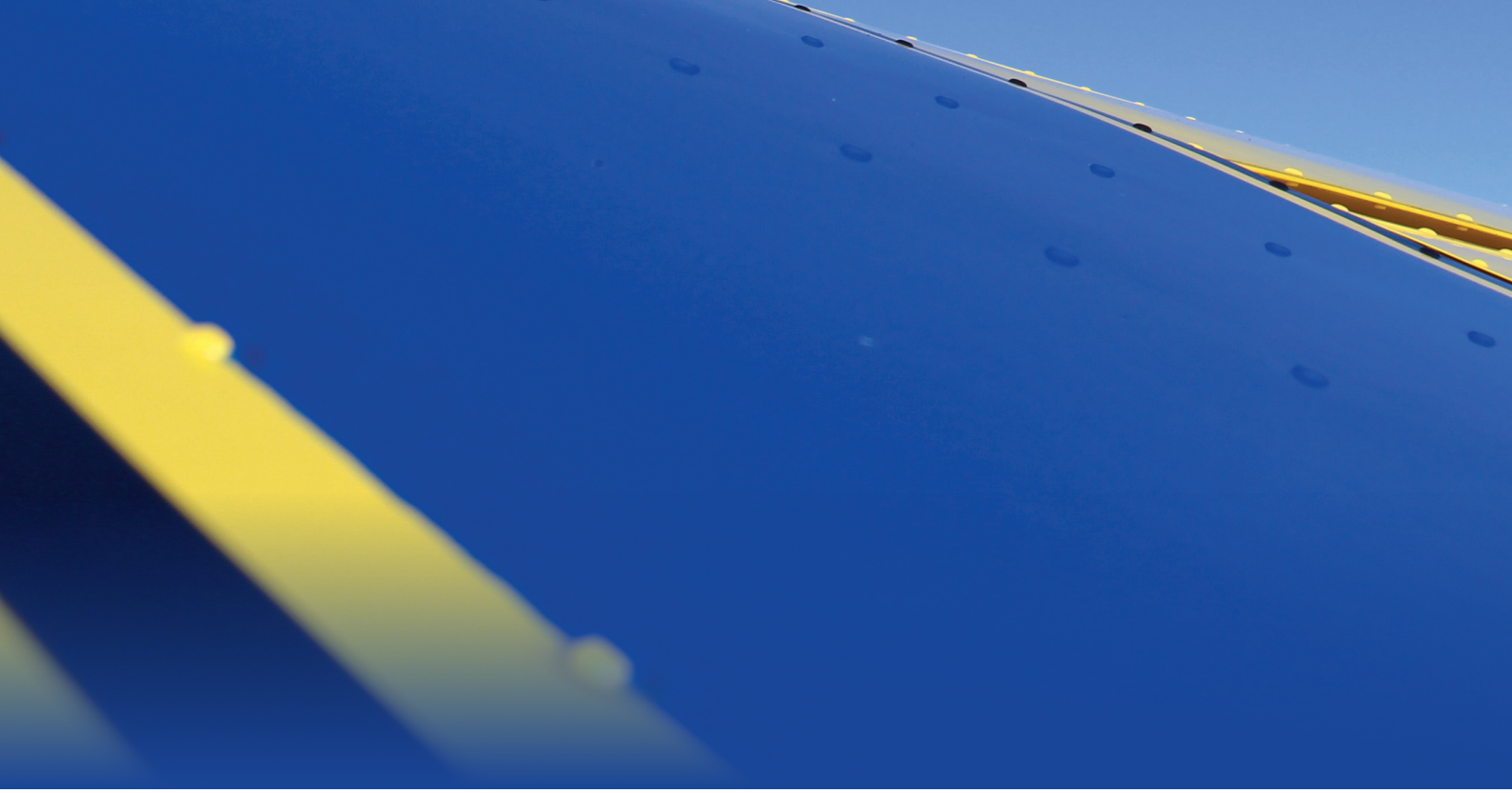


1. INTRODUCTION

AERIAL APPLICATION ASSOCIATION OF AUSTRALIA ('FOUR AS')

The Aerial Application Association of Australia was formed in July 1958 at a meeting jointly convened by the then Department of Civil Aviation and the Bureau of Agricultural Economics. AAAA was formerly the Aerial Agricultural Association and changed its name in 2015 to better reflect the members' operations in ag, fire, health, environmental and other sectors.

AAAA's mission is to promote a sustainable aerial application industry based on the professionalism of operators, pilots and staff and the pursuit of industry best practice.

Membership of the AAAA consists of aerial application businesses, pilots and supporting associate members including trade. There are about 130 active aerial application businesses in Australia and about 300 aerial application pilots. AAAA has business membership controlling over 90% of aircraft in use.

The industry uses more than 300 specialist aircraft with supporting vehicles and equipment, together with established aircraft maintenance facilities throughout the agricultural areas of the country.

The Association has its national office in Canberra and is governed by a Board of Directors. The Board is in constant consultation with the CEO and local application operators and pilots.

Today's application or 'ag' pilot is highly trained and licensed under both Federal and State legislation. No other applicator of agricultural chemicals has the degree of training of the ag pilot, who is required to have a commercial pilot's license, an application rating and a chemical distribution license.

One of AAAA's key roles is to enhance education and professional development throughout the industry. The Association therefore conducts a comprehensive program of conference and training activities to keep members up-to-date with legislation, practices and other developments, supported by research, publications and accreditation programs.

AAAA'S COMMITMENT

AAAA advocates for continuing access to agricultural chemicals based on the professionalism, accountability and science-driven commitment of our members.

AAAA works cooperatively with other organisations, government agencies and individuals to continuously improve the services available to Australian agricultural producers.

AAAA recognises that professional agronomists play a key role in supporting our mutual clients and make a significant contribution to the productivity and effectiveness of Australian agriculture.

AAAA has produced this manual in cooperation with Crop Consultants Australia to ensure all agronomists have relevant information on how to effectively recommend and use aerial application.

Our goals are to:

- Help our clients
- Support current agronomists
- Educate new generations of agronomists
- Ensure aircraft stay in the agronomic toolbox
- Facilitate communications between AAAA members and CCA members

ENVIRONMENTAL PROTECTION

AAAA is committed to protecting the environment through the responsible and legal use of agricultural chemicals, fertilisers and other products.

AAAA is also committed to stewardship of the products used by the industry through sound knowledge of conditions of use, expertise in application and responsible waste management.

The industry takes its responsibility for protecting the environment from unintentional consequences very seriously and has comprehensive programs in place that include technical and advisory publications, training, management systems, audits and inspections, examinations, and accreditations.

In addition, AAAA strongly supports the following policies:

- The use of registered products only
- Compliance with label and permit directions
- Employing staff with appropriate qualifications to ensure accurate applications and responsible use of products
- Training staff where required to ensure they have the necessary skills to conduct operations safely
- Maintaining a comprehensive application planning, execution and recording system that incorporates drift management principles and matches risk assessment and management to appropriate application equipment and techniques
- Maintaining a comprehensive quality and safety reporting system that enables the company to fix problems before they become threats to the environment
- Maintaining comprehensive emergency response capabilities that will also minimise impact on the environment.

ACKNOWLEDGEMENTS

Produced by AAAA with the support of:

Crop Consultants Australia Incorporated (CCA) is a professional network for agronomists and those with an interest in agronomy. Members are based predominantly across the cotton, grain, pulse and oilseed producing regions of Queensland and New South Wales. CCA assists both those that are building an agronomy career and those that already have extensive experience.

The Association provides avenues for members to stay up to date with industry information, news and research as well as providing networking opportunities. CCA represents the crop consulting sector at relevant industry forums and works in partnership with other industry organisations to address key issues.

The Agronomist Guide to Aerial Application is not only an important resource for less experienced agronomists, it provides a useful refresher for those that have been in the industry for some time. CCA is pleased to collaborate with AAAA to ensure best practice and professional standards are maintained for chemical application in the cropping industry.

For more information about Crop Consultants Australia visit https://cropconsultants.com.au/.

Note: *Reference in this guide to 'aircraft' includes both fixed wing and rotary wing (helicopters) aircraft. Reference to 'aeroplane' or 'plane' refers to fixed wing aircraft and helicopter means rotary wing aircraft.*

2. IN BRIEF

10 STEPS TO A SUCCESSFUL AERIAL JOB

1. **ON LABEL** – always recommend on label
2. **REGISTERED** – Considering the crop, target and timing – is the product you want to use registered for aerial application? Get the plane in your toolbox
3. **SELECT** an operator – CASA and State/Territory licenced, AAAA member, Spraysafe Accredited, AIMS Accredited
4. **PLAN** the job:
    a. consider the hazards and risk management (powerlines, traveling irrigators, neighbouring crops, sensitive areas, bees)
    b. consult with your client and operator
    c. select the correct label rate for your crop, target and timing
5. **REQUEST** the job:
    a. fill out the industry standard application request form and discuss the job
        i. target pest / crop / area
        ii. spray quality / appropriate water rates / coverage – more water is not necessarily 'better'
    b. communicate hazards and risks and provide a good map to your operator from your client including the target area (eg Google Earth)
6. **EXECUTE** the job. Be organized with information and product supply to reduce the possibility of errors or misunderstanding
9. **REVIEW** the job. Confirm the job went well with the operator and client
10. **FEEDBACK** – to the operator on the results – good or bad

GOLDEN RULES

- In aviation, safety always comes first. This is non-negotiable
- Always recommend on label – 'aerial', 'target', 'crop' and 'rate' on label?
- Always use the appropriate water rate – backed up by science. Higher water rates may increase application costs
- Complete a written recommendation and application request form and link these to the completed records
- Communicate with your applicator regularly
- Tell your applicator what you are trying to achieve – there may be a better way
- Encourage your clients to have a well-maintained airstrip on farm to help reduce ferry costs
- Encourage your clients to work with you in marking powerlines with the commercially available markers for around $200 each installed
- Encourage your clients to communicate with their neighbours about spraying to reduce the chances of misunderstanding or conflict
- Always look for ways to make the plane more productive – less turns and longer runs by putting paddocks together can make a big difference to cost

DEADLY SINS

- **Pressure** – Do not apply pressure to the applicator to work in poor application conditions or to 'hurry up'. This can translate directly into an impact on the pilot's safety. Aviation human factors research has clearly established the importance of teamwork to a safe flight – don't become part of the problem. AAAA research indicates that a pilot's perception of client pressure frequently contributes to the aviation accident chain. How would that make you feel after an accident?
- **Second Guessing** – Do not try and overrule the applicator's judgement about aircraft set-up, application conditions, method of paddock treatment or protecting downwind susceptibles. By all means, discuss the reasons behind certain approaches, but seek to understand, not command. The operator and pilot are juggling a whole range of competing priorities to get the best job for your client – including pilot safety, protecting the environment and complying with both aviation and chemical use laws.
- **Speak up** – Do not be silent. If you know of a hazard or problem, speak up. Raise a 'red flag' with your operator to help keep them safe and the job on track.
- **No off-label** – Do not recommend off label. That will put the pilot and operator at risk of prosecution as well as yourself. Work with your operator for an alternative fix.
- **No substitution** – Do not substitute or provide products that are different to your recommendation as the label may be different and may result in not being able to be applied.
- **Compatibility** – Do not recommend tank mixes that are not known to be compatible on label – experimentation on your part can lead to significant problems with equipment.

SAFETY

Safety is a critical component of every application, but for aerial application the severe potential consequences demand particular attention. Every aerial applicator takes a mission planning approach to each job, so the agronomist's and client's roles in providing good information is very important.

- **Maps** – please provide an accurate map with clear identification of the treatment area and hazards. Google Earth files are very welcome and an easy way to identify what the pilot might see.
- **Hazards** – there are lots of hazards to aircraft identified in this guide and on the AAAA Standard Application Request Form. Powerlines, dwellings, susceptibles, waterways, bees and people can all influence the conduct of a job. Please keep your eyes open for anything that might be useful and pass it onto your aerial applicator.
- **Improvements** – removing hazards such as trees in cultivation, marking powerlines (talk to AAAA about how) and putting an airstrip closer to the job are all ways to improve both safety and productivity. Get free advice from your aerial applicator.
- **Drones** – if you have a drone as part of your crop assessment toolbox, always fly within the CASA rules and let aerial applicators know you are using one. If you hear or see an application aircraft approaching while using your drone, please put it on the ground.

3. THE ADVANTAGES OF AIRCRAFT

WHY USE AN AIRCRAFT?

- Speed / timing / efficiency - over 6 ha / minute for a typical turbine powered application aircraft
- Faster protection = less yield loss
- Optimum weather windows maximised
- Efficacy increased with optimal windows
- Flexibility – different spray quality easily and accurately achieved
- Efficient use of your time and your clients' time in peak work- load periods
- Costs compare favourably when you count the real costs of ground rigs – time/fuel
- Licenced, qualified, accountable personnel who participate in ongoing professional development
- Wet paddocks – no bogging, tracks or compaction
- No yield loss from late spray trampling of crops – could be as high as 5% loss
- No disease or weed transfer
- Tall crops easily covered

SOME DISTINCT AIRCRAFT ADVANTAGES

- Downwash from the wing or rotor blade pushes chemical directly onto the crop, moves the crop and increases recovery of chemical onto the target
- Downwash and turbulence combine with spray quality to target different parts of the canopy (including under leaves)
- Aircraft can use vortices to apply chemical at a wider swath than the boom

PROFESSIONALISM

- Minimum Application Pilot Training = Commercial Pilots licence + Application Rating = total investment by each pilot of over $100,000 ***before*** they get to spray a crop or fertilise pasture
- Pilots must also hold a State Government Chemical Distribution Licence
- Most pilots also hold AAAA Spraysafe Accreditation – a program that ensures operators, pilots and loader/mixers meet high standards and competencies for chemical control, aircraft set-up and operation, mission planning and record keeping, and the safe handling and disposal of pesticides
- Most pilots participate in the AAAA Professional Pilot Program - a continuing education program for application pilots that requires them to keep up to date with the latest developments in the industry
- AAAA runs the AIMS program that provides companies with an independently audited certification that they have critical systems covering risk management, WH&S, quality assurance, spray quality, communication and drift management

STRONG REGULATION

- All chemicals used are approved by the Commonwealth Government's Australian Pesticide and Veterinary Medicines Authority (APVMA) which puts them through a comprehensive assessment including human health and environmental impacts
- State EPA's or Departments of Agriculture control the application of chemicals by aircraft
- Operators and individual pilots are licenced by State government chemical distribution licences
- CASA regulates all ag-flying activities and licences all pilots and operators
- WH&S State regulations guide ground support staff and operators

ACCOUNTABLE

- Each spraying, sowing or topdressing job is meticulously planned to manage the risks
- Every operator is legally bound to keep comprehensive records of each application
- Every operator and pilot is heavily regulated
- The industry uses a AAAA standard application request form, or customised version, to ensure consistent information is provided from clients and agronomists to aid planning, safety and record keeping

ENVIRONMENTALLY RESPONSIBLE

- Licenced by regulators - both chemical and flying
- Use only licenced and approved chemicals
- Very detailed planning for each job that protects environmentally sensitive areas
- Use of aerial ag ensures that applications are made by highly trained professionals
- The use of aerial ag reduces the number of people involved in the application of chemicals and thereby reduces the exposure of workers to the chemicals used

FLEXIBLE

- Whatever the job required, whatever the cropping situation, aircraft are flexible enough to deliver chemical where you want it
- Aircraft operators and pilots use their knowledge of aerodynamics, their aircraft and their spray systems, combined with both sophisticated modelling and real-world pattern testing, to deliver the spray quality and performance you need
- From ultra-low volume spraying through to large droplet placement spraying, aircraft operators can target different parts of the crop as required to ensure thorough coverage
- From bananas in Far North Queensland to cotton, rice, wheat and all other cropping and pasture situations, aerial application offers great flexibility and accuracy
- Being able to adjust spray quality easily by taking advantage of the airflow around the nozzle tip as well as selecting different nozzle types and altering operating pressure gives the pilot a wide range of flexibility at their fingertips

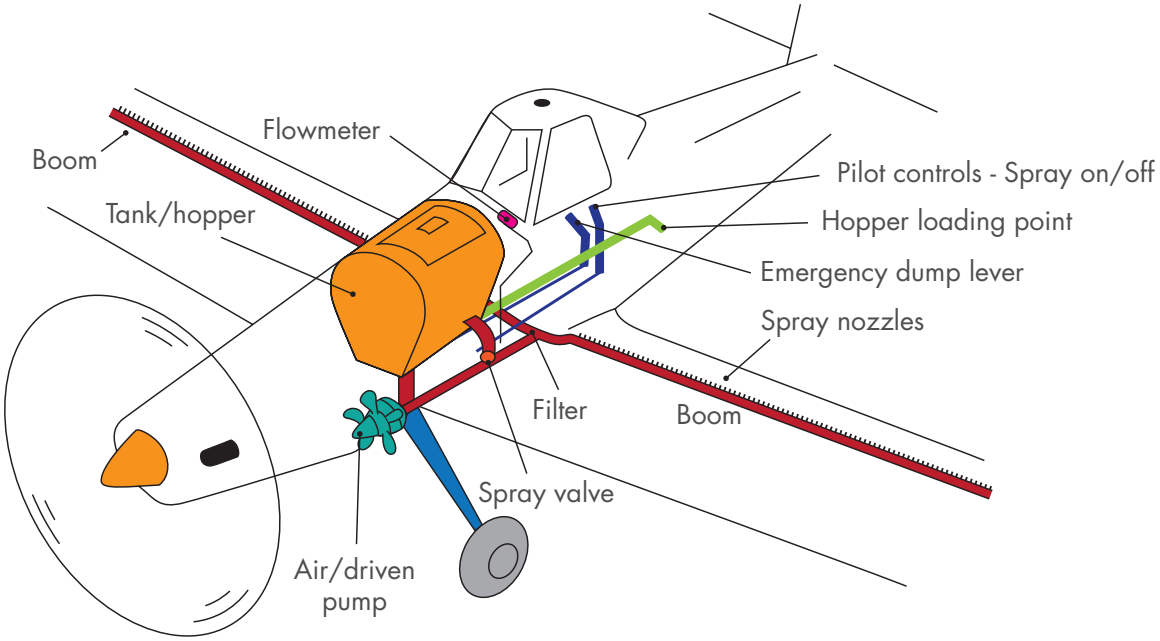
AIRCRAFT

- Fixed wing aircraft designed for the task and purpose built
- Rotary wing aircraft highly flexible platforms
- Safe for the pilot and ground crew
- The largest application aircraft can carry over 3000 litres (3 tonnes) and cruise at over 250 km/h

Application aircraft are generally multi-purpose and can be configured for spraying liquids or spreading solid fertiliser. With the addition of 'bomber doors', the aircraft can additionally be configured to conduct water bombing activities on a fire-ground.

Figure 3.1 below identifies the parts of a typical application aeroplane.

Figure 3.1: Typical agricultural aircraft layout



The aircraft can be configured with either rotary atomisers or nozzles for spraying applications or with a spreader for fertiliser application.

Switching between each application can be easily done by one or two people and in this section, we take a closer look at each part of the aircraft application system.

Similar equipment is used on helicopters for spraying, often with a belly tank being fitted with a small separate pump providing spray pressure. Solids application from a helicopter is often conducted using a bucket suspended underneath the helicopter.

BENEFITS TO AGRICULTURE

- Aerial application is unaffected by wet ground
- Aerial application is unaffected by crop canopy closure
- Great speed to cover large areas
- No disease transfer as the aircraft does not touch the crop
- No soil compaction.
- No trampling of the crop like tractors, spray rigs or ATV's.
- Reduced exposure to weather variations – able to take greater advantage of short weather windows – less likely than ground rigs to be spraying in poor conditions
- Aircraft can spray at night in certain areas to take advantage of better weather conditions when inversions are not present
- Improved efficacy – aircraft utilise disturbance of the crop from wake turbulence to ensure good penetration of chemicals into the crop and better coverage
- No costs to irrigators of removing channels/banks/rotobucks
- Bring their own fuel

ADVANCED TECHNOLOGY

- GPS used by every operator in the industry to give sub-meter accuracy
- Automatic flow control to maintain a constant application rate
- Pilots apply material guided by a 'light bar' that ensures they remain exactly on track
- State of the art aircraft valued at close to $2 million each
- Nozzle calculators developed by academic research allow pilots to predict accurately the performance of different nozzles under different conditions
- Models available to assist pilots in predicting drift profiles
- Increasing use of GIS (Geographical Information Systems) and digital information to allow more information to be included in planning, such as accurate positions of powerlines, environmentally sensitive areas, and prescription farming
- Variable rate technology now available to allow the application rate to be varied as the aircraft flies over a field - changes accurate to within a few metres of the prescription farming map
- Onboard computers and equipment now available to allow variation of droplet size, swath width and other parameters while the aircraft is in flight

HUGE RESEARCH SUPPORT

- Over $20 million invested in research into controlling spray drift by the US EPA, US Dept of Agriculture and chemical companies alone over the last 30 years.
- All pilots have a solid understanding of the theory behind droplet behaviour as part of their application rating and Spraysafe qualifications.
- AAAA participates in the development of appropriate spray quality assessment standards including the American Society of Agricultural and Biological Engineers Standards ASABE S572.1 and S641
- Australian operators invest significant resources in pattern testing, a process that ensures their aircraft are set-up in the most efficient and productive way to give the least drift and best efficacy
- Australian aerial applicators have access to a wide range of international researchers, facilities and models including:
  - *Agdrift* model
  - *AgDisp* model – being used by APVMA
  - AAAA Spray Quality and Water Volume Calculators
  - Nozzle manufacturer research
  - CPAS (University of Qld) / Nebraska University / USDA ARS TX Wind Tunnel research
  - Chemical company research
  - Field Air – yield loss calculator – www.fieldair.com.au
  - International aircraft pattern test experts brought to Australia by AAAA

OTHER BENEFITS

- A professional industry available for emergency services use - firefighting, oil spills, plague control, exotic pest and disease outbreak control
- A professional industry peak body that participates in a wide range of forums including the National Working Party on Pesticide Application, and which works closely with regulators and other industry bodies across the nation and all agricultural sectors
- A significant employer in rural and regional Australia
- A ready pool of highly experienced low-level qualified pilots
- A provider of aircraft maintenance services for general aviation across regional Australia
- A key partner committed to innovation, ensuring farmers have access to world class technology.

Variable Rate and Precision Applications

Aerial application equipment and techniques continue to advance and variable rate aerial application is now a reality.

Developing prescription maps should be done in conjunction with your aerial applicator to ensure compatibility of mapping systems.

Yield Loss Is Real

Aircraft are a great partner in zero-till farming systems.

You can reduce yield loss through crop trampling by ground equipment by using an aircraft.

Yield loss can be significant – especially in more mature crops. If you want to gain a potential 5% yield gain for your client's crops, then an aircraft should be in your agronomy toolbox.

See the Field Air Yield Loss Calculator at https://www.fieldair.com.au/ground-vs-air.php

Figure 3.2: Ground trampling yield loss is real and expensive (see: https://www.fieldair.com.au/ground-vs-air.php***)***

Figure 3.3: Time-loss should also be accounted for... *(Photo: Fiona Hill)*

4. THE LABEL, THE LAW AND US

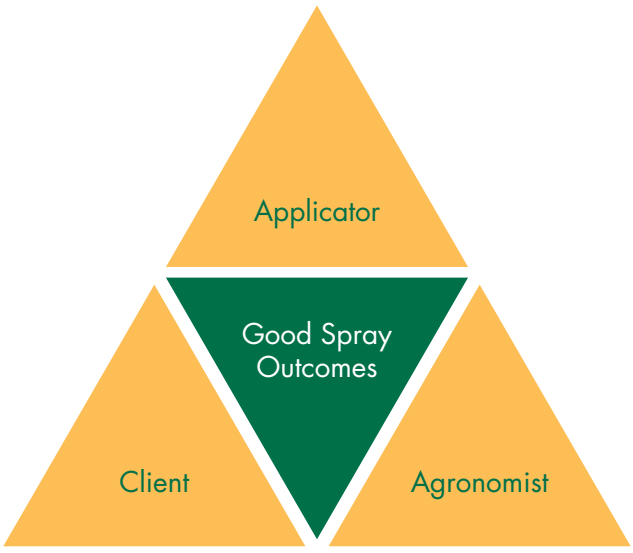
THE LABEL

The chemical label (or an APVMA permit) is a legally binding document that works within chemical control-of-use laws in each State and Territory to create significant responsibilities for all members of the application management team. The requirements of the label must be understood and followed.

Applicators, clients and agronomists operate within a triangle of responsibilities, using their specific skills and due diligence, where each member of the application team is reliant on others for sound and legally binding information, judgement and performance.

Following label directions helps maximise the product's effectiveness and minimises your risk of exposure to the chemical—while helping protect people, animals, crops and the environment.

Figure 4.1: Triangle of Responsibilities.



A key outcome of every application job is that due diligence has been completed to ensure pesticides are not misused and there is no harm to non-target susceptibles outside the treatment area.

No matter which pesticide you use or where you use it, you must always read and understand the label instructions and use it only as directed.

For aerial application there are two critical considerations:

- Does the chemical label have an overt approval for aerial application?
- Does the chemical label specifically ban use of the product for aerial application or types of aerial application by inclusion of the phrase 'Do not apply from aircraft' or similar?

In addition, the use of language on a label is very precise and must be understood.

- Use of the phrase 'must' or 'do not' is a clear direction that is mandatory.
- Use of the phrase 'should' is advisory, however, 'should' statements must be considered in the context of how non-compliance may affect any 'due diligence' defence.

If there is either a clear approval for aerial application or no 'DO NOT APPLY BY AIRCRAFT' statement on the label, then the product can be applied by air.

CONTROL-OF-USE REGULATION BY THE STATES AND TERRITORIES

State and Territory governments are responsible for controlling the use of pesticides and beyond the point of retail sale to the end-user. In some States, more than one agency is involved.

While State and Territory legislation has some variation, there are a range of common features:

- Provisions that raise pesticide 'misuse' offences
- Provisions that make 'harm' an offence
- Chemical label compliance and investigations
- Licencing of businesses and / or individuals
- Competence/training of licence holders
- Record keeping

THE CONCEPT OF PESTICIDE 'MISUSE' AND 'HARM'

All registered pesticides are assessed by the APVMA to minimise potential harm across:

- Human health
- Animal health
- Non-target plant / crop health
- Environment
- Trade

Label statements communicate this risk minimisation approach by requiring a wide range of use directions which can include (but are not limited to):

- Approval or not for certain application methods
- Rates of use in different situations (growth stage, soil type, export vs. domestic)
- Spray quality
- Limits on wind speed and other environmental conditions (ie; inversion conditions)
- Spray zone buffers required (ie; downwind, terrestrial, waterways, dwellings)

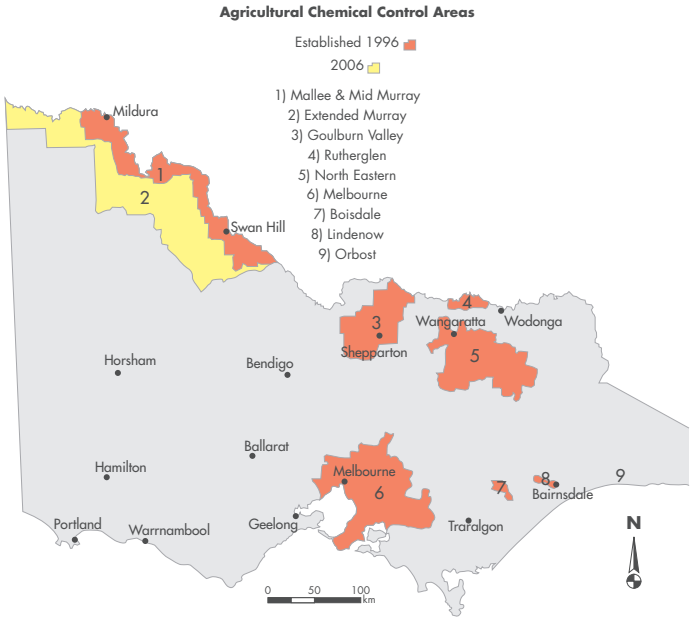
However, under State and Territory control of use legislation, offence provisions are raised based not only on label compliance, but also on whether pesticides were misused, or the spray application caused any 'harm'.

For example, the NSW EPA lists the following as pesticide 'misuse':

- failing to follow label or permit instructions
- injuring people or damaging property, or using pesticides in a way that is likely to do so
- harming a non-target plant or animal
- using an unregistered pesticide, or possessing one and intending to use it
- storing pesticides in containers that do not have the approved label attached
- disposing of a pesticide or its container illegally, for example, pouring pesticide waste down a drain
- spraying pesticides from aircraft without relevant EPA licences
- spraying pesticide from an aircraft within 150 metres of a home, school, factory or other public place without the written consent of the occupier – this **does not apply** to roads, travelling stock reserves and RailCorp land (Pesticide Order Air #1)
- placing pesticides or empty pesticide containers in waterways

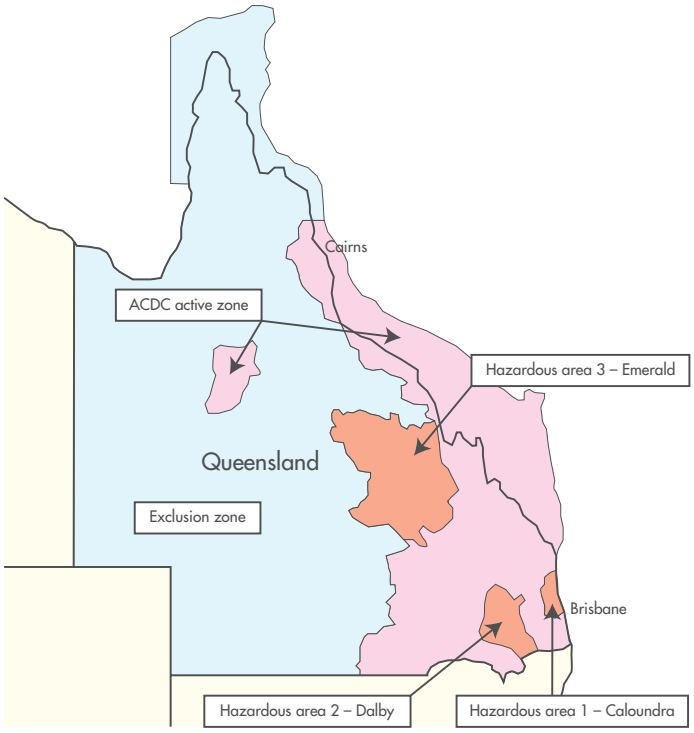
Misuse also relates to *where* applications occur. For example, Victoria has Agricultural Chemical Control areas and Queensland has areas excluded from the Chemical Distribution Act and three specific Hazardous areas around #1 Caloundra, #2 Dalby and #3 Emerald.

Figure 4.2: Victoria's Agricultural Chemical Control Areas.



Victoria's Agricultural Chemical Control Areas (ACCAs)

Figure 4.3: Queensland's Hazardous areas and exclusion zones



Legislation creating pesticide 'misuse' or 'harm' provisions are different across State/Territory jurisdictions and may even be administered by different government areas.

In some jurisdictions, this leads to health or workplace safety departments only looking at impacts on people and agriculture departments looking at impacts on other crops or pasture (eg SA and Qld).

Generally speaking, 'harm' means there has been a negative impact on a non-target species. For example, under the *NSW Pesticide Act 1999*, 'harm' is defined as follows:

> **"harm"** an animal or plant includes poison, injure, contaminate, infect, distress, maim, impair or kill the animal or plant.

In some jurisdictions, 'injury' to a person is another concept used to create an offence. Again, in the *NSW Pesticide Act 1999*, 'injury' is defined as:

> **"injury"** to a person includes any kind of physical or psychological injury whether temporary or permanent, including conditions such as nausea, allergic reaction, dizziness, headache, stress, and running nose or eyes.

While offences relating to aerial application are rare, the common scenarios where these offences may occur include:

- Pesticide drift outside the target area
- Pesticide use in 'adverse' weather conditions
- Pesticide use in inversion conditions
- Use of chemicals off-label
- Incorrect or incomplete information provided to an applicator
- Lack of communication between neighbours

Consequently, it is important for all applicators and others in the application team to understand their responsibilities and liabilities, and to ensure they undertake due diligence in all pesticide application planning and execution.

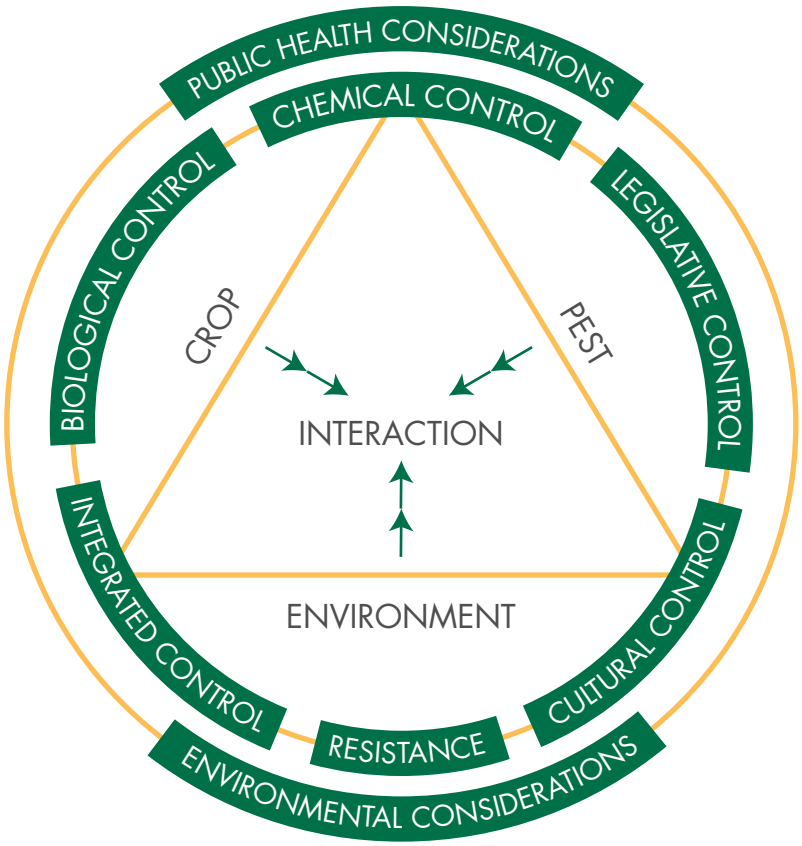
COMMUNITY LICENCE TO OPERATE

In any application of agricultural chemicals, it is critical for all players on the application team to act with due diligence to maintain the community licence to continue to operate.

For all agricultural chemical applications, this includes the development of an effective Application Management Plan that includes:

- excellent planning to identify any risk to people, dwellings, farm workers or others being within a situational awareness zone as well as pilot safety
- a system for spray drift management
- legal recommendations on-label followed to maintain access to chemicals
- appropriate aircraft set-up to support both efficacy, efficiency and environmental protection
- application in suitable weather
- a strong focus on monitoring the job to maintain safety and efficacy
- 'flying neighbourly' to maintain good will across the community – not just across the paddock

Figure 4.4: The agricultural chemical application environment



AGRONOMIST LIABILITY AND LABEL COMPLIANCE

Teamwork is at the heart of good application outcomes - and critical to teamwork is your own professionalism and technical knowledge, effective communication and your willingness to accept the expertise of others.

Agronomists share liability with others in the application decision-making chain.

For example, recommending off-label is a direct breach of chemical control of use legislation in every State and Territory. The following is from the *NSW Pesticide Act 1999* - but similar liability exists in both black letter and common law in all States:

> ***NSW Pesticide Act 1999 – Section 111 Causing or permitting offence***
>
> *A person who causes or permits, by act or omission, another person to commit an offence under a provision of this Act or the regulations is guilty of an offence under that provision and is liable, on conviction, to the same penalty applicable to an offence under that provision.*

Similarly, the National Ag and Vet Code includes provisions creating offences against making claims inconsistent with a label - see Section 84 of the AgVet Code — https://www.legislation.gov.au/Details/C2016C00999.

The law, the Courts and regulators take a very hard line against applicators – or others in the team - who cause or contribute to harm to people, crops or the environment. The maximum fines are significant (up to $120,000 for an individual and $250,000 for a corporation in NSW) and this is on top of the thousands of dollars needed to defend yourself.

Recommendations that are 'off-label' will not be accepted by any professional applicator – a protection for you as well as them.

Experimental tank mixes are another example of increasing risk for yourself and the applicator – especially where the impact on spray quality ('formulation effect') is unknown and could lead to negative outcomes ranging from antagonistic effects between chemicals, mixing and filtration issues to outright failure or increased drift.

Get it right before and during the job to protect yourself from this trauma. The inconvenience of doing a risk assessment, complying with the label and completing sound records is a small price to pay for establishing your due diligence.

KEY LEGAL CONCEPTS

As much as we may not enjoy it, the law weaves its tangled web around all involved in application – including agronomists.

It is critical in everyday operations that all of the application team are aware of the laws that apply to them.

In addition to the potential of prosecution by a government agency using 'black letter' law (eg an offence created by an Act or regulations), there is also the civil litigation system (ie. being 'sued').

To further complicate matters, some offences are created as 'strict liability', whereby mental intent does not have to be proven for the prosecution to be successful – just that you actually committed the offence.

There are also difference standards of evidence for these different legal pathways (eg 'beyond reasonable doubt' versus 'on the balance of probabilities') that can significantly change potential outcomes.

Knowledge of this system and its implications is important in understanding the responsibilities placed on all members of the application team.

There are some key principles every member of the team should keep in mind when assessing their proposed actions:

- **Negligence** – you have not done what a 'reasonable' person would have done, or you have been reckless (ie a lack of care)
- **Duty of care** – what a 'reasonable' person would be expected to do and what you owe to yourself, your boss, your colleagues, your client, regulators and the community
- **Due diligence** – you have made a 'reasonable' effort to take care and can prove it.

These are critical and everyday concepts for the application management team to understand as these are the tests that will be applied should something go wrong.

A strong 'due diligence' defence may actually stop a possible prosecution in its tracks – but a strong 'due diligence' defence may be difficult to prove if you have not created evidence – records – along the way. That is one reason why written records and checklists are so important in aerial application.

Of particular importance is the legal principle that the test of 'reasonableness' is *not* based on a person off the street, but rather, an appropriately qualified and technically savvy person considered to be competent to the relevant industry standards – which may be considered by the Court to include any relevant Codes of Practice, industry standards or accreditation programs.

Note that 'ignorance' is not a defence. In terms of the test of reasonableness, you will be judged by what would be reasonable to an appropriately qualified person.

HEART OF DUE DILIGENCE

- Is science driving my decisions?
- Can my recommendation deliver what the label says?
- Can my recommendations or actions lead to 'harm'?
- Have I complied with the law?
- Do I have evidence (eg records) to prove that?

RECORD KEEPING

In all States/Territories, keeping a record of any pesticide application is compulsory and is enforced with significant penalties. In addition, recent APVMA labels now raise additional record keeping requirements.

Unfortunately, record keeping requirements vary between States/Territories and the APVMA and it is important to check what records are required.

Good record keeping is the basis for evidence of due diligence. All aerial applicators keep detailed records to comply with chemical control of use regulations.

5. A SIMPLE GUIDE TO SELECTING AN OPERATOR

USING AN AIRCRAFT

How do you start?

1. Use a reputable operator
    (a) AAAA Member
    (b) Spraysafe accredited
    (c) AIMS accredited
2. Use a standard application request form – see 'Appendices' in this guide.
3. Increase your vigilance for hazards - drift and safety.
4. Talk to your operator and find out the systems they have to support you.

Figure 5.1: AAAA Accreditations to look for

AERIAL APPLICATION ASSOCIATION OF AUSTRALIA LTD.

AAAA 2018-2020 SPRAYSAFE ACCREDITED

AIMS
AERIAL IMPROVEMENT MANAGEMENT SYSTEM
Accredited for 2018 – 2020

QUESTIONS TO ASK

Selecting a reputable aerial operator is probably the best value-add that any agronomist can make for their client.

Most aerial operators have a base or bases established in their area, often supported by satellite airstrips to reduce costs for clients.

In selecting an operator, there is a range of indicators you can look for and ask about.

Are you licenced as a business and an individual?

The aerial application business must be licenced in every State/Territory (except WA) for chemical distribution. They can only get this licence if they hold the appropriate aviation qualifications issued by the Civil Aviation Safety Authority (CASA).

In Tasmania it is mandatory as a licence condition to hold the business level Spraysafe qualification. In Victoria, business level Spraysafe accreditation or evidence of operating to the same standards is required. Other States/Territories make their own assessments.

The pilots employed by the business must also be licenced in the State/Territory they are operating. All States/Territories recognise the AAAA Spraysafe Pilot Accreditation as the *de facto* national competency standard for issuing a pilot chemical distribution licence.

Are you a AAAA Member?

AAAA membership is voluntary.

Being a current member of AAAA is a strong signal that they take their professionalism and their industry seriously.

As members, they have access to a wide range of supporting research, safety, education, training and accreditation programs. AAAA runs regular conferences, technical workshops and a National Convention to ensure the latest research and thinking from around the world is brought to Australia, and that our innovations are shared.

As AAAA members, a business may also hold additional accreditations that provide a useful indicator as to the type of systems the company operates.

Professional operators will proudly volunteer this information.

AAAA membership improves client outcomes by making professionalism easier to recognise.

Are you currently Spraysafe accredited as a business and an individual pilot?

Spraysafe is the intermediate level program that brings together minimum legal requirements into a checklist for the business and training and assessment for pilots and mixers.

The AAAA Spraysafe program has three levels of accreditation:

- Business – 3 yearly audit conducted by a knowledgeable person independent from the company – often an agronomist

- Pilots – requires passing a Spraysafe examination based on the 420 page Spraysafe Manual. Maintaining the accreditation after initial issue requires either participation in the AAAA Professional Pilot Program and gaining acceptable education credits across the three-year validity of the accreditation or resitting a Spraysafe exam. This accreditation is recognised by all States and Territories for licencing.
- Mixers – requires passing an examination based on relevant elements of the Spraysafe Manual and is also supported by a Loader/Mixer Guide and a short training video.

Is your company currently AIMS Accredited?

The AAAA AIMS program (Aerial Improvement Management System) has membership and Spraysafe as prerequisites. AIMS is AAAA's advanced level program based on significant training, the implementation of a range of systems for risk management, spray quality, safety and drift management and independent audit.

AIMS has the following features:

- Holistic – a whole of company approach to policies, procedures and continuous improvement that is brought to life through improved company communication and systems.
- Systems based – risk management, quality assurance, drift management, communication, WH&S, DG, chemical storage and HR are just some of the AIMS systems.
- Independently audited – every three years AIMS companies are independently audited, in addition to ongoing oversight and health checks from AAAA to support participants.
- Recognised – AIMS is now recognised by insurers, government agencies managing firefighting and CASA.

ADDITIONAL AAAA TRAINING AND PROGRAMS

In addition to and in support of the accreditations above, AAAA provides a range of training programs and publications to members including:

- Professional Pilot Program - ongoing professional development
- Aviation safety training - covering human factors, crew resource management, wire risk management and safety thinking systems
- Chemical application training – including our 'Label to Nozzle' course
- Spray quality calculators – based on wind tunnel testing conducted at the University of Qld at Gatton, AAAA has a number of calculators to support decision making in the field, including for popular nozzle types and chemicals including 24D and glyphosate across a wide range of operating parameters including airspeed, pressure, angle of orientation to the airstream etc.
- Water volume calculator – based on clear science, a calculator that allows consideration of both coverage and water volume – essential for sensible discussions on economy versus efficacy
- Pattern testing – AAAA facilitates the use of expert pattern testers from the US in assessing and improving aircraft patterns
- Conferences – AAAA runs a national Convention, State conferences and technical working meetings by sector (including rice, cotton and bananas) to ensure members have regular access to the latest research and expertise
- Lobbying – to maintain access to chemistry and to simplify regulation

6. PROFESSIONALISM AND TEAMWORK

Professional agronomists must attain a high level of expertise be effective in their field.

Pilots must be highly skilled, licenced and accredited to operate in the aerial application sector.

This combination of two professional careers should deliver significant benefits to clients, and the mechanism for this synergistic relationship is teamwork.

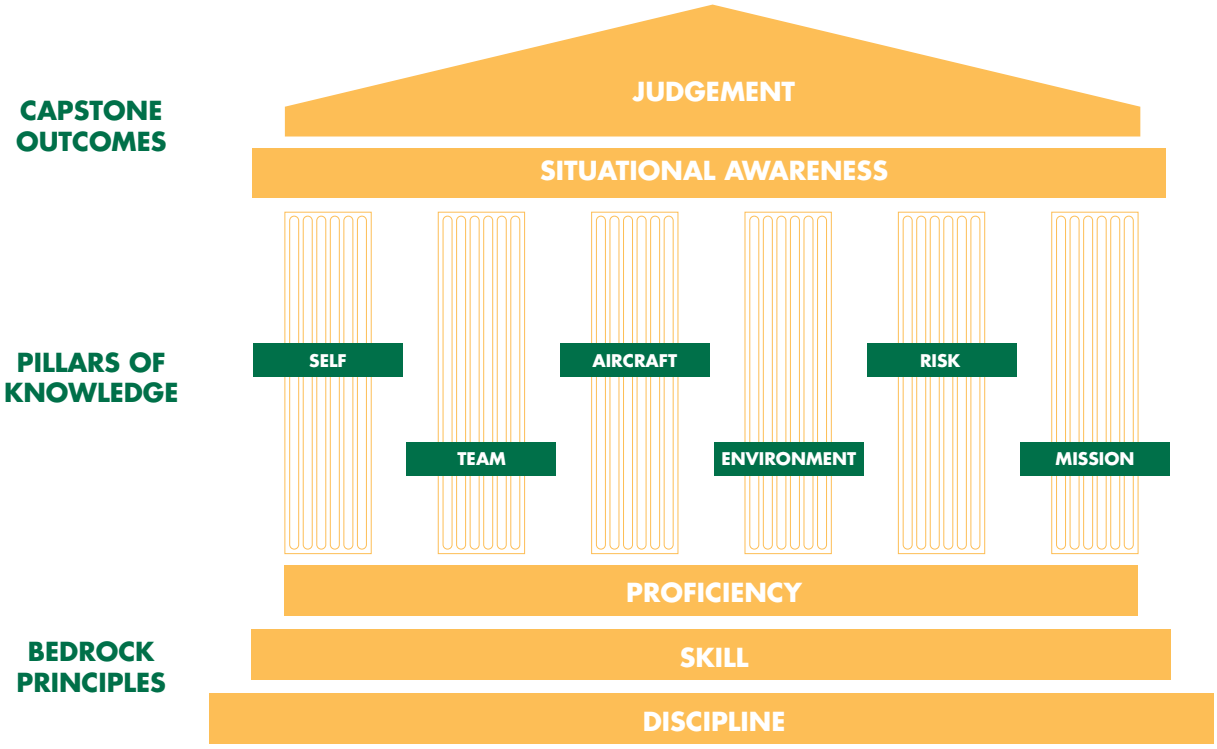
COMPETENCE AND DECISION-MAKING

Competence underpins good application decision-making.

In aviation, Crew Resource Management (CRM) is the critical model used to create safe, effective and efficient application outcomes. Sound communication skills, a willingness to consult others and a commitment to improving outcomes as part of a team are all critical CRM attributes.

This is demonstrated by the 'Kern Model of Airmanship' that identifies the foundation stones of competence and recency and the pillars of knowledge to ensure good decisions.

Figure 6.1: 'Airmanship Redefined' by Dr Tony Kern



This model is used extensively in AAAA training for low-level operations and is also a roadmap for safety, effectiveness and professional development.

COGNITIVE BIAS

There is a wide range of cognitive biases that affect us all – regardless of how we may assume we are rational and cold decision makers. Human factor training for all pilots includes awareness of these issues that can have a powerful effect on the outcomes of any aviation mission.

A few of these biases include:

- **Confirmation bias** – favouring information that confirms your already held beliefs – or alternatively, ignoring relevant information that challenges your beliefs
- **Availability bias** – taking examples that come readily to mind as more representative that they really are
- **Framing and anchoring bias** – deciding on options based on how the options are presented - either positively or negatively e.g. as a loss or as a gain. You may tend to avoid risk when a positive frame is presented but seek risks when a negative frame is presented
- **Gamblers fallacy** – using short-term observations to predict longer-term trends or events
- **Sunk-cost effect** – continuing with a behaviour because of invested resources, often despite evidence that a different behaviour is required
- **Group think** – where the desire for harmony or conformity in the group results in irrational or dysfunctional decision-making, or where a lack of diversity within the group homogenises and reduces potential outcomes.

These are only a handful of a wide range of cognitive biases that may skew decision-making processes.

Awareness of these biases is a good defence against them – especially in application and agronomy where we all have a tendency to become mission-driven by a 'can-do' culture and pressure – often blanking out equally relevant information. Some biases require specific remedies, but generally, simple awareness of them can make a significant difference.

Agronomists and pilots are as susceptible to these cognitive biases as anyone which is why we need heightened awareness of our decision-making processes – and we must keep open the best possible communication between client, agronomist and applicator.

NORMALISED DEVIANCY

In aviation, considerable training effort is put into managing 'human factors' that range from human physiology (eg fatigue, dehydration, nutrition), to thinking systems (cognitive bias, risk management) to behaviour. Over 80% of aviation accidents feature human factors – and so AAAA also places considerable importance on these influences for good application outcomes.

Normalised deviancy describes behaviour that, over time, can lead to poor outcomes by incremental shifts away from good/proven practice.

It often starts as a small deviance from normal activity (eg. standard operating procedures or checklists – a 'shortcut' or 'work-around') and when nothing 'bad' happens, can then become the new 'normal' behaviour – ignoring the still existing risks that are now unmanaged.

Safety buffers have been eroded.

Potential Normalised Deviancy in Application

Agronomists and Growers

- Gradually increasing water rates
- Gradually increasing pesticide rates
- Off label recommendations

Pilots

- Gradually reducing water rates
- Gradually increasing swath widths
- Gradually increasing spray heights

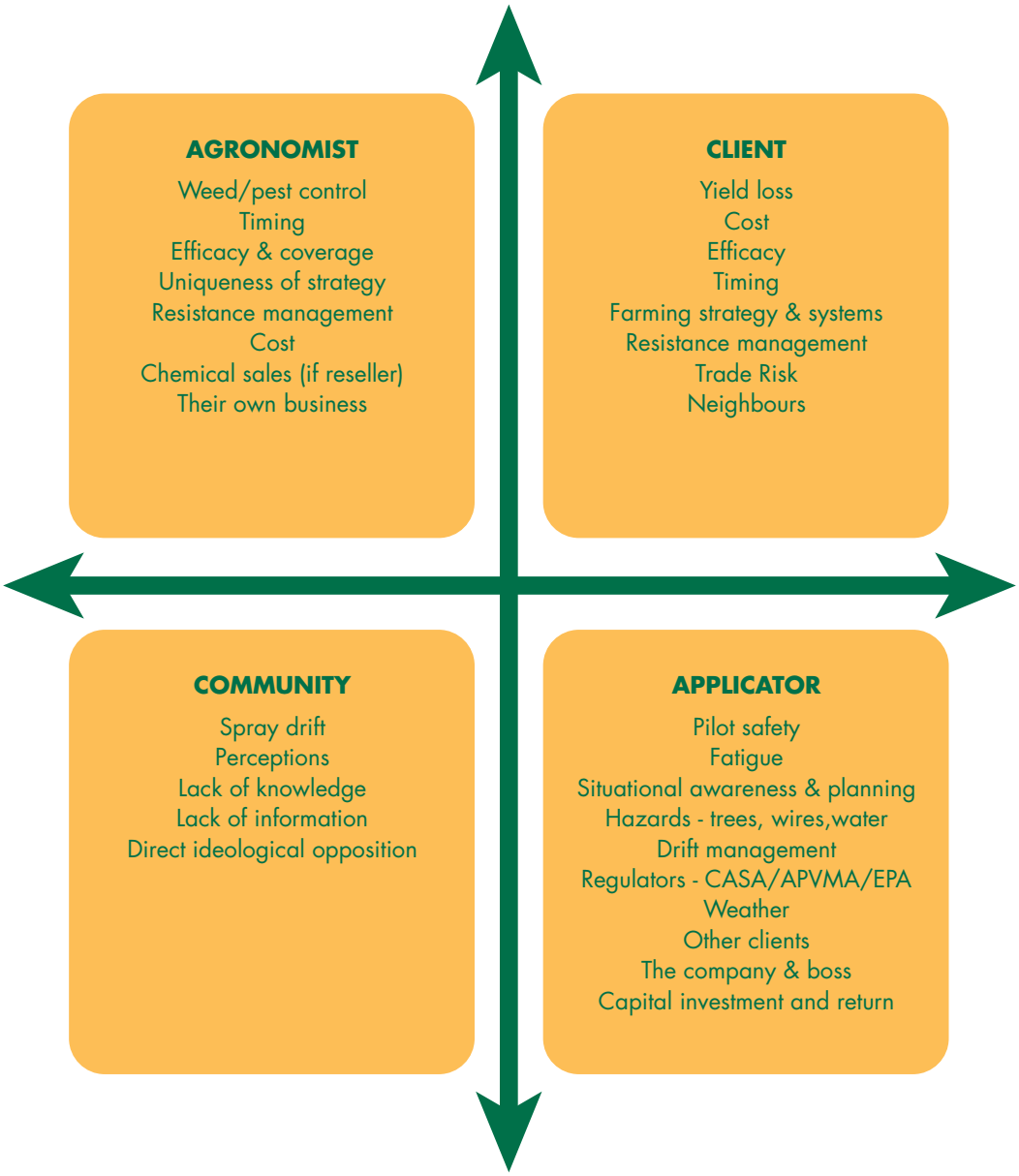
Key antidotes to normalised deviancy include:

- Company and personal standard setting
- Checking and training (mandatory in aviation)
- Benchmarking against others
- Re-engagement with good science and proven technique
- Consistent and open communication

UNDERSTANDING COMPETING PRIORITIES

Competing priorities are a reality in almost every application job. Understanding the priorities of others within the team can improve individual and team performance.

Figure 6.2: Understanding Competing Priorities



Professionals try to understand the competing priorities of others so they can improve their own performance.

TEAMWORK

Teamwork in an aviation setting is encouraged by all pilots being trained on the principles of Crew Resource Management (CRM).

The following components make up good CRM:

- Individual competence and professionalism
- A willingness to use all available resources and expertise to get a good outcome
- An operational culture focussed on problem solving and learning - not blame
- Effective and open communication including a willingness to listen as well as talk
- Accountability for your actions (also known as a 'just' culture)
- Appropriate gradient of authority – who is best placed for different inputs
- A willingness to speak up to get a better outcome and reduce risk (ie appropriate assertiveness)

All of this leads to a learning organisation and appropriate trust that improves performance and resilience.

COMMUNICATION

Communication is a critical component of teamwork.

The aim of all communication is to express yourself with clarity, built trust, get results and improve the overall performance of the team. Good communicators are always looking for win/win outcomes.

For communication to be effective, it must firstly take place within a gradient of authority that encourages and supports open communication. This simply means that all participants in the application system are willing to listen to and respect the concerns of others, accept the expertise of others where warranted and act as a team where overall outcomes are important to each member of the team – not just their own goals.

It is generally accepted that there are seven principles required for effective communication by being:

- Clear
- Concise
- Concrete
- Correct
- Coherent
- Complete
- Courteous

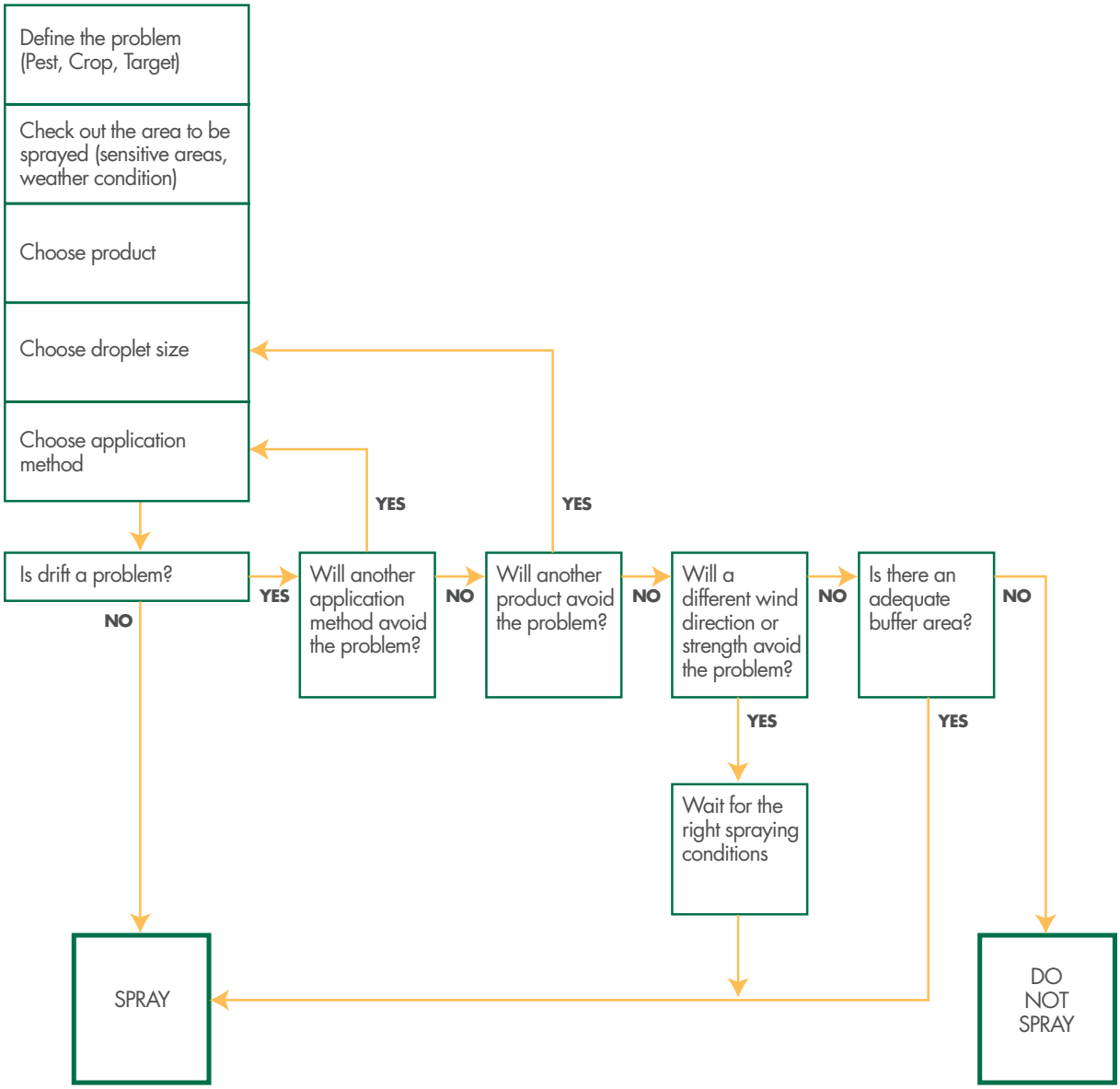
In addition, the communication quality test and questions below will assist in making communication as effective as possible.

Figure 6.3: Effective Communication is critical to teamwork

Communication quality tests:

- ☑ **GOAL** – What is my communication goal and have I clearly defined it – what action/ response do I want? Have I thought hard enough to be clear, concise, concrete, correct, coherent and complete?
- ☑ **LISTEN** – Have I listened? Have I invited and welcomed feedback? Do I understand what the other person will need and what their goals might be?
- ☑ **REASONABLE** – Am I being reasonable? What is the wider context of my request? Is it legal? Aim to identify and resolve competing priorities, time pressure and efficiency/ thoroughness trade-offs through flexibility, openness and honesty.
- ☑ **SUPPORT** – Have I provided all the information that will support my request?
- ☑ **FOCUS** – Focus and refocus on the goal or outcome – not on blame, problems or obstacles.
- ☑ **PRIORITISE** – Make communication a key priority with people who can help you. What is most important?
- ☑ **TRANSPARENT** – Handle conflict, objections or resistance openly – seek to understand and resolve, not dominate or 'win'.
- ☑ **FEEDBACK** – Ask for feedback and improvements

Figure 6.4: Spraying Options Are Improved by Communication



In aviation, the following operational communication structure is highly effective and very common:

- Opening or attention getter
- State your concern
- State the problem as you see it
- State a solution
- Obtain agreement (or buy-in)

In the application environment, it is important that written communication be used wherever possible to support the clarity of verbal communication.

For this reason, all AAAA members prefer written agronomist recommendations in addition to any verbal arrangements made. In particular, AAAA members prefer agronomists to use the standard Aerial Application Request Form which is included in the appendices of this guide.

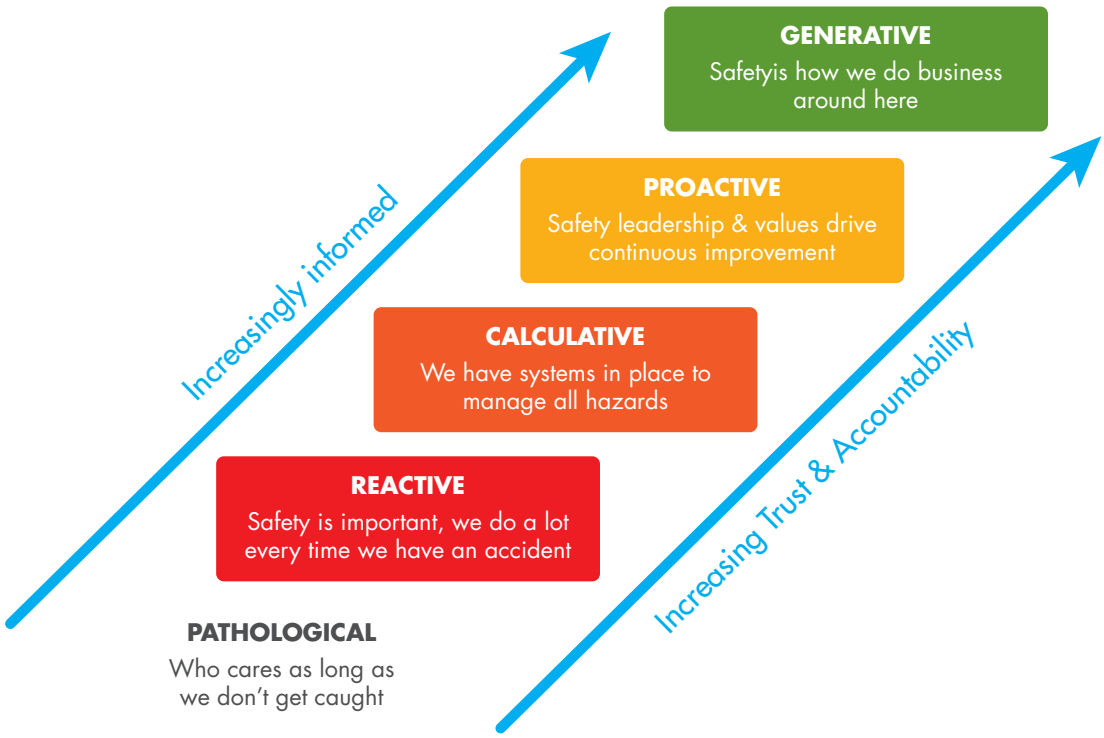
CULTURE AND ATTITUDE

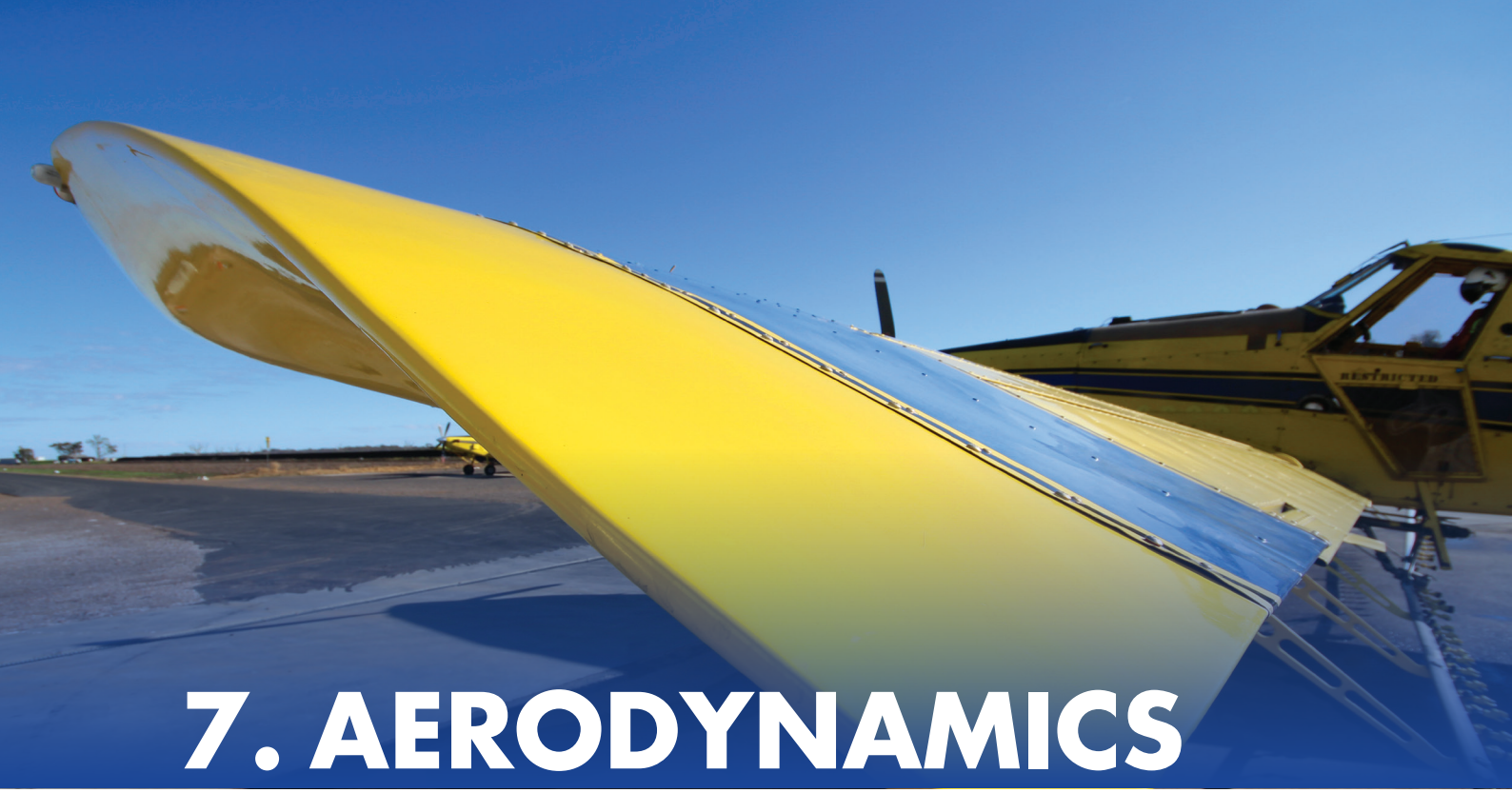
Teamwork – and safety - can either be built or destroyed on the back of culture of the group or the attitudes and behaviour of individuals.

A good culture, built on strong communication and 'smart trust', has been identified as a key component of aviation safety. The parallels with positive application outcomes are obvious from the culture ladder below.

Understanding how your culture and attitudes contribute to the safety and productivity of those around you is a critical component of the improved self-awareness that comes from Crew Resource Management principles and training.

Figure 6.5: The Culture Ladder – Professor Patrick Hudson





7. AERODYNAMICS

A well set-up and operated aircraft can match or better a ground rig for performance, spray quality, drift control and safety.

While all spray platforms have certain things in common, aircraft have an additional set of advantages and challenges due to the airflow caused by speed, propellers, rotors and other aerodynamic effects.

Application pilots receive comprehensive training in aircraft set-up, AAAA conducts ongoing research into spray quality and many operators pattern test their aircraft to ensure particular set-ups deliver known performance.

There are some simple things to look for with a well set-up aircraft:

- Spray booms shorter than wingspan or rotor diameter (generally less than 75%)
- Spray booms dropped below the wing on higher speed turbine aircraft
- Appropriate nozzles for the job, oriented in the right direction (ie for sensitive low drift jobs, hydraulic nozzles oriented straight back relative to the airflow)
- No leaks from any nozzles / booms / fittings

AIRCRAFT ARE DIFFERENT

'Different' in no way means 'difficult'.

There is plenty of support, training and tools that are available to support the reputable aerial applicator.

It is important that agronomists add value for clients by recommending the aircraft when it is the best tool for the job.

A range of issues that may be relevant for ground application can actually have the opposite –negative effect – when applied to aircraft:

Water volumes – aircraft can safely and effectively operate with lower volumes while still attaining good coverage. Higher water rates do not necessarily mean a 'better' job. Requirements to treat with very high-water volumes can lead to a significant and unnecessary cost for clients.

Nozzle selection – aircraft nozzles are generally purposely designed and tested at aircraft operating speeds. Spray quality data is attained from high speed wind-tunnels or in-field aircraft pattern testing and the data is available through either manufacturers' websites or AAAA.

Appropriate water volume and droplet size is important to coverage and the attraction of lower water rates and probable lower cost must be balanced with the clear need for efficacy through adequate coverage and drift control. This guide provides information on how to achieve this balance.

Nozzle orientation – orientation of nozzles on aircraft will have a big impact on spray quality. By pointing nozzles backwards relative to the airflow around the spray-boom, larger droplets will be created as the shear forces around the nozzle tip will be reduced. Orienting nozzles downwards or even into the oncoming airstream will significantly reduce droplet size. Knowledge of these effects allows aircraft to make a significant variation in spray quality from the same nozzle.

Operating pressures – by increasing spray system pressure to a nozzle-oriented rearward to the oncoming airstream, droplet size can be further increased as the differential speed between the spray stream and the surrounding airflow is reduced.

Your aerial applicator has been trained in all of these variables and all AAAA members have access to a range of supporting information, nozzle calculators and predictive modelling to help match aircraft set-up and spray quality to do the required job.

AERODYNAMIC BASICS

It is important to have an understanding of simple aerodynamics of an aircraft to understand what will lead to a positive spray outcome.

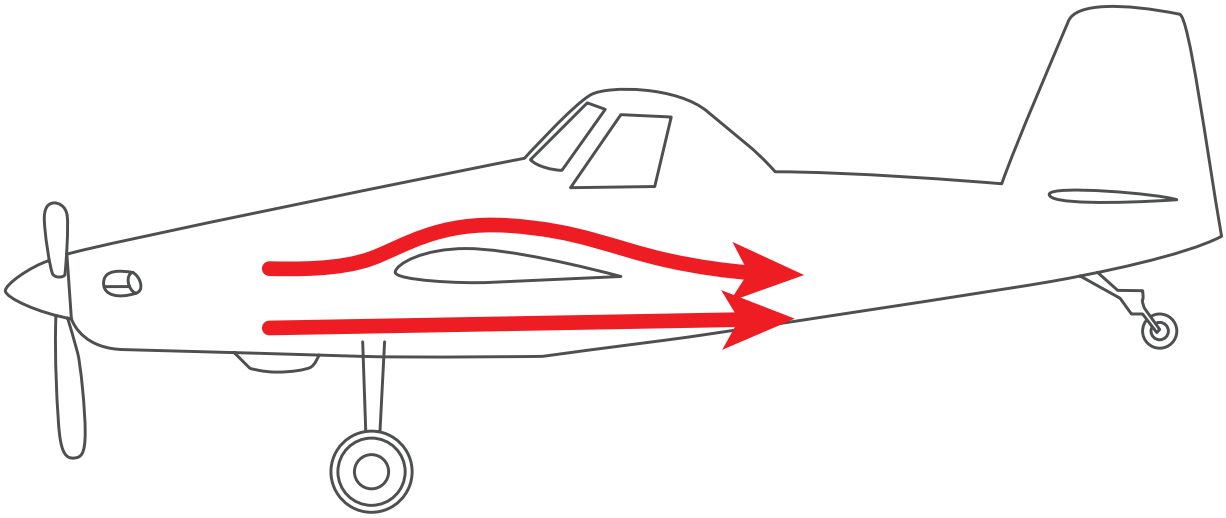
There is a lot of air movement around an aircraft that can also move droplets.

This is entirely manageable and you can put it to great use for efficacy and productivity - as well as drift control.

Aircraft rely on lift generated by the wing or rotor to offset the weight of the aircraft. Aerodynamic drag is offset by thrust provided by the propeller or rotor, which in turn pushes or pulls the wing/rotor through the air to create lift.

Once a wing or rotor reaches adequate airspeed and angle of attack, the aerofoil shape of the wing/rotor creates a high-pressure zone under the wing and a low-pressure zone on top of the wing. Lift is produced by both "suck" due to lower air pressure on top of the wing and deflection of air through angle of attack of the wing. The result is a lot of movement of high-speed air around the aircraft.

Figure 7.1: Creating lift – the forces are similar for fixed-wing or helicopters

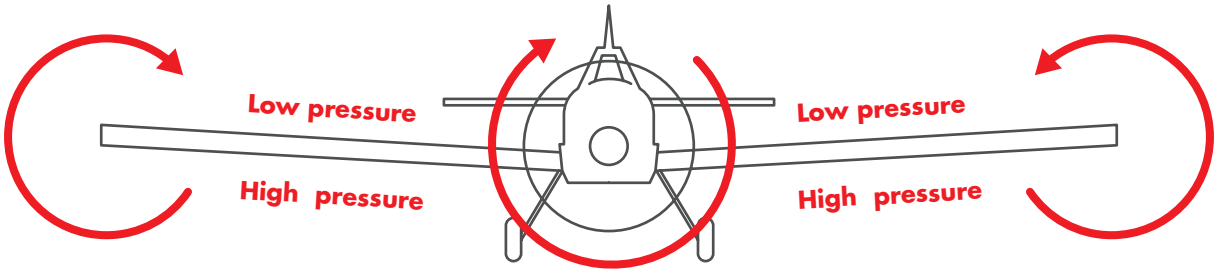


However, if the angle of attack of the wing is increased too much relative to the airflow (above about 15 degrees), the wing will 'stall' – meaning that laminar airflow over the wing is disrupted and the wing ceases to produce lift.

Air also moves from high to low pressure around the wing tips. The result is 'wing tip vortices' or 'corkscrews' and turbulence behind the aircraft. The propeller also causes a "corkscrew" airflow around the aircraft.

Wing tip vortices also cause the spray pattern to spread out behind the aircraft. The spray pattern may be wider than the wing width, even if the spray boom is shorter than the wing width.

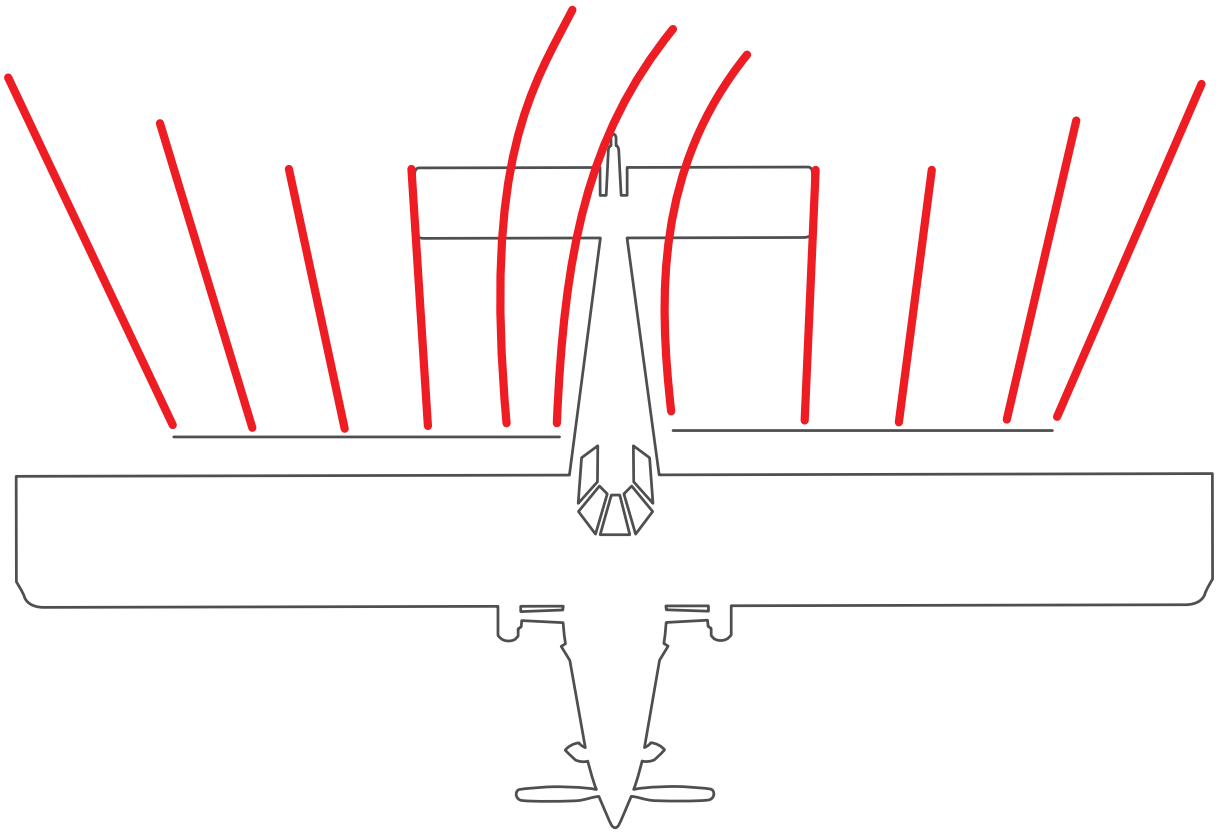
Figure 7.2: The creation of vortices



Turbulent airflow behind the aircraft:

- Can increase swath width
- Can increase deposition in the crop
- Can reduce even deposition if unmanaged
- Can increase drift potential if unmanaged

Figure 7.3: Taking advantage of vortices for a wider swath

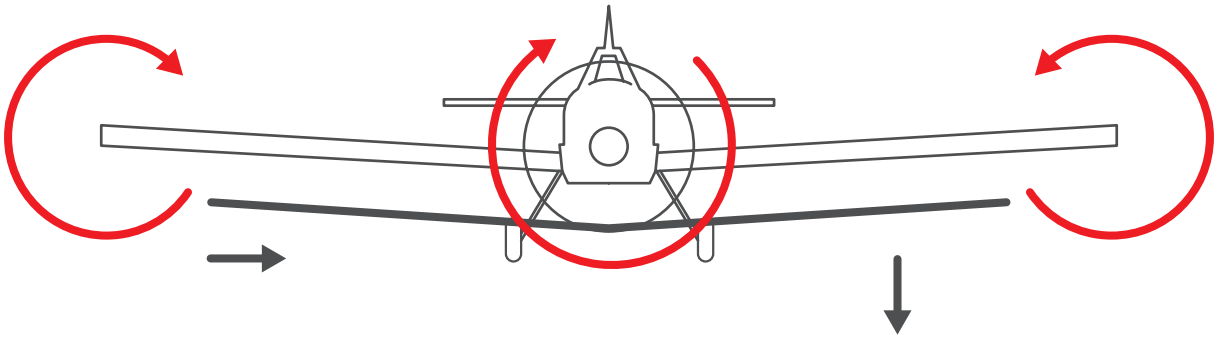


There are simple mechanical methods to reduce the effects of turbulence that professional aerial applicators use:

- Reducing boom width moves spray further from wing tip vortices
- Lowering the boom moves the spray pattern away from all aircraft turbulence
- Larger droplets are less likely to be affected by turbulence

This is why drop booms, short booms and bigger droplets all have an impact on drift and deposition.

Figure 7.4: Managing airflows



The reason for this is that the greater mass of the larger droplets forces them to fall to ground quickly and not be affected by the aerodynamics surrounding an aircraft.

One of the key issues in managing drift is to control how many droplets are fed into wing-tip vortices. The vortice core at the wing-tip is relatively strong and has the potential to entrain even large droplets if the aircraft is poorly set-up.

Vortice strength also increases with any increase in 'g' - so that harsh levelling out into a paddock or pull-ups over obstacles or at the end of runs may increase the vortice and consequently droplet release height from the vortice and thereby - drift.

Aircraft speed should also be managed as higher speeds may increase vortice energy - especially on let-downs into paddocks - as well as decreasing droplet size.

Aircraft set-up and operation are both important to drift control.

Figure 7.5: Vortice entrainment if unmanaged

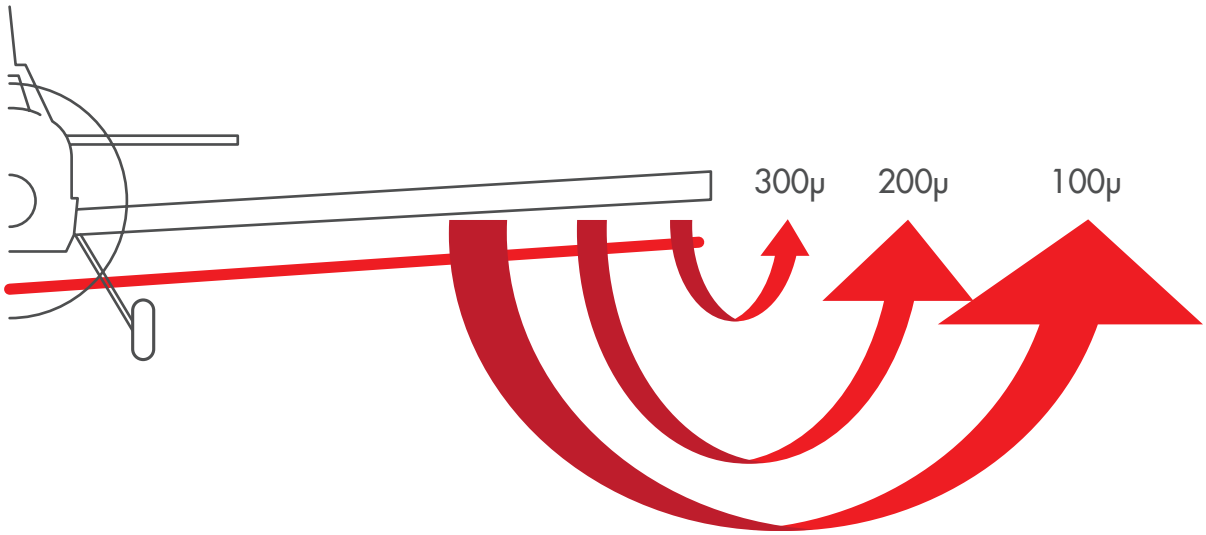


Figure 7.6: Aircraft set-up makes a big difference which is why pattern testing is used extensively *(Photo: Adam Hooper)*

AIRCRAFT SWATH WIDTH

Swath width is the term used to define how wide the coverage of an aircraft is on each single run.

The effective swath width of an aircraft will vary depending on:

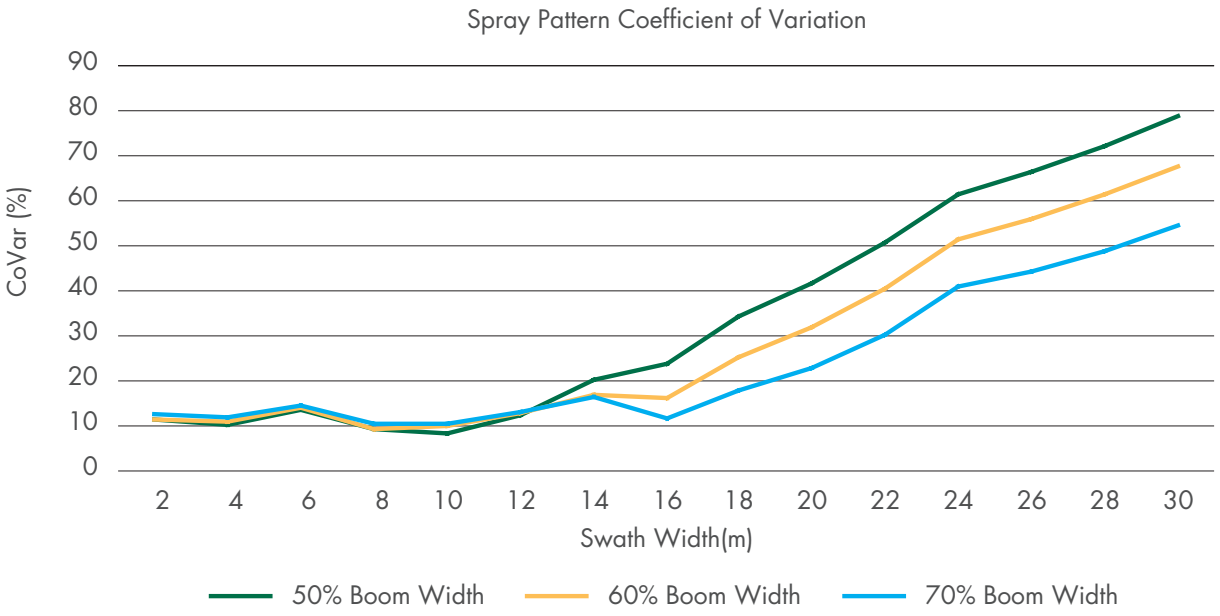
- aircraft type
- aircraft wingspan / rotor length
- aircraft boom length and position relative to wingspan / rotor length
- spray quality (droplet size and spectrum) being produced
- release height
- amount of overlap allowed for on subsequent runs

Understanding the acceptable Coefficient of Variation for the task being undertaken can have a significant impact on swath width.

The Coefficient of Variation (C.V.) of an aircraft is a measurement of the 'evenness of pattern' being produced by the aircraft and is generally described as a percentage variation around the desired output of the spray system. Consequently, the lower the CV the better and the closer the spray system is – at any selected point – to the targeted spray volume being delivered.

The CV is established through pattern testing or can be modelled using AgDrift or AgDisp software.

Figure 7.7: Calculating swath width options using AgDrift software



Once the acceptable CV is established for the aircraft and task, decisions can be made regarding swath width for a particular aircraft with a particular set-up.

The pattern from aircraft immediately behind the boom may appear uneven, but due to turbulent airflow in the aircraft wake there is considerable mixing of droplets and the pattern generally 'fills in' and provides excellent coverage.

MODELLING

Aerial application is also supported by a sound bank of research to take the guesswork out of establishing the most effective set-up for a particular job in a particular aircraft.

Various predictive models, underpinned by field trial verification, are available to aerial applicators in Australia:

AgDrift was the first predictive model developed especially for aircraft at a cost of some $15 million by the US EPA, US Department of Agriculture and chemical companies. AgDrift includes the ability to input a range of variables (such as aircraft type, boom length, release height, spray quality, surface capture efficiency, weather etc) and produce very useful and reliable – if quite conservative - predictions for a range of operational parameters. AgDrift outputs include:

- spray quality
- 'evenness' of the spray pattern (ie the coefficient of variation)
- swath width
- buffer distances required (if toxicological end points are known)

AgDisp was subsequently developed for forestry and other applications in addition to cropping situations and is now the most commonly used model by government agencies such as APVMA in assessing chemicals and setting use patterns on label – including mandatory buffers.

PATTERN TESTING

Aircraft can be tested for spray quality to assess swath width, droplet size, CV and distribution efficiency and is regularly conducted in Australia by trained professionals.

Pattern testing is very effective in identifying and correcting aerodynamic effects on spray quality and distribution that can be caused by aircraft equipment such as pumps, wheels, booms, plumbing, boom length, drop and hanger placement, as well as propeller and vortice effects.

Solids pattern testing also occurs for seeding, solid granular herbicides and fertiliser applications.

Ask your applicator if you would like more information.

Figure 7.8: AAAA pattern testing fixed-wing aircraft.

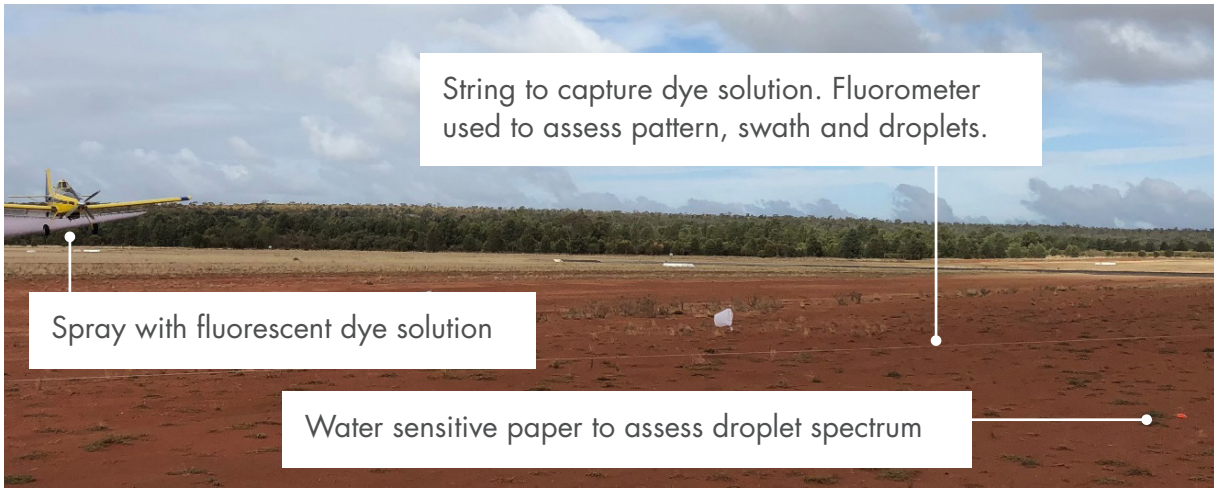
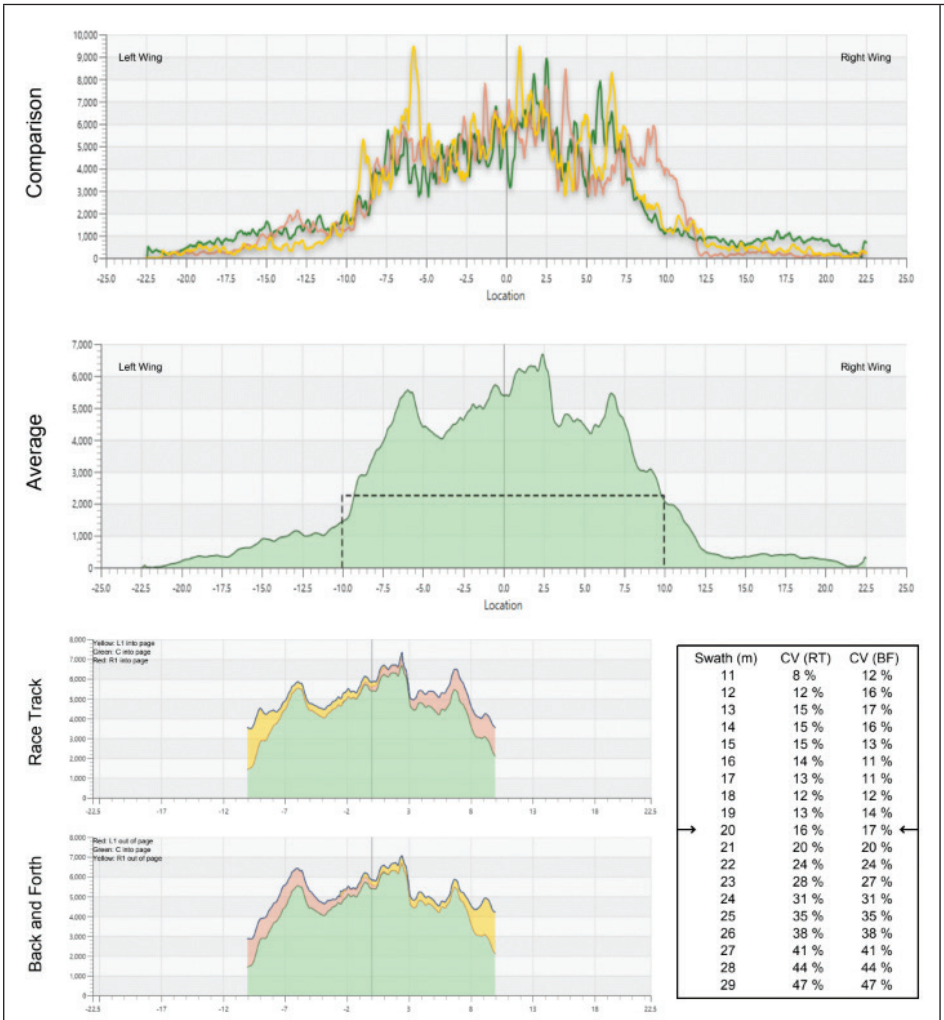


Figure 7.9: Pattern testing results fixed-wing aircraft
(courtesy of Agri-Spray Consulting)



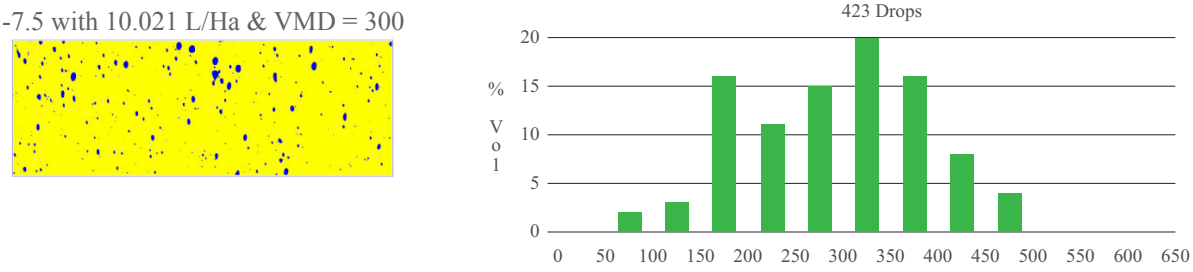
Swath (m)	CV (RT)	CV (BF)
11	8 %	12 %
12	12 %	16 %
13	15 %	17 %
14	15 %	16 %
15	15 %	13 %
16	14 %	11 %
17	13 %	11 %
18	12 %	12 %
19	13 %	14 %
20	16 %	17 %
21	20 %	20 %
22	24 %	24 %
23	28 %	27 %
24	31 %	31 %
25	35 %	35 %
26	38 %	38 %
27	41 %	41 %
28	44 %	44 %
29	47 %	47 %

Three passes are assessed.

Average of three passes. Dashed box represents acceptable Coefficient of Variation (CoV) and swath width for set-up.

Comparison of race-track and back and forth application method.

Figure 7.10: Pattern testing – droplet assessment
(courtesy of Agri-Spray Consulting)



8. EFFICACY, COVERAGE AND WATER RATES

As with any good team, individuals bring different skills to the table.

It is important to understand that it is the bringing together of expertise that produces the best outcome:

- the farmers' or agronomists' knowledge of the crop, the target pest and the chemical to be used
- the pilot's safety risk management, drift management, meteorology and aircraft set-up knowledge

Arriving at the best possible outcome for each application is intrinsically linked to a discussion that brings all of the available expertise to bear – efficacy, economy and environmental protection.

The calculation of water rate required is then a simple result of earlier transparent decisions and mathematics.

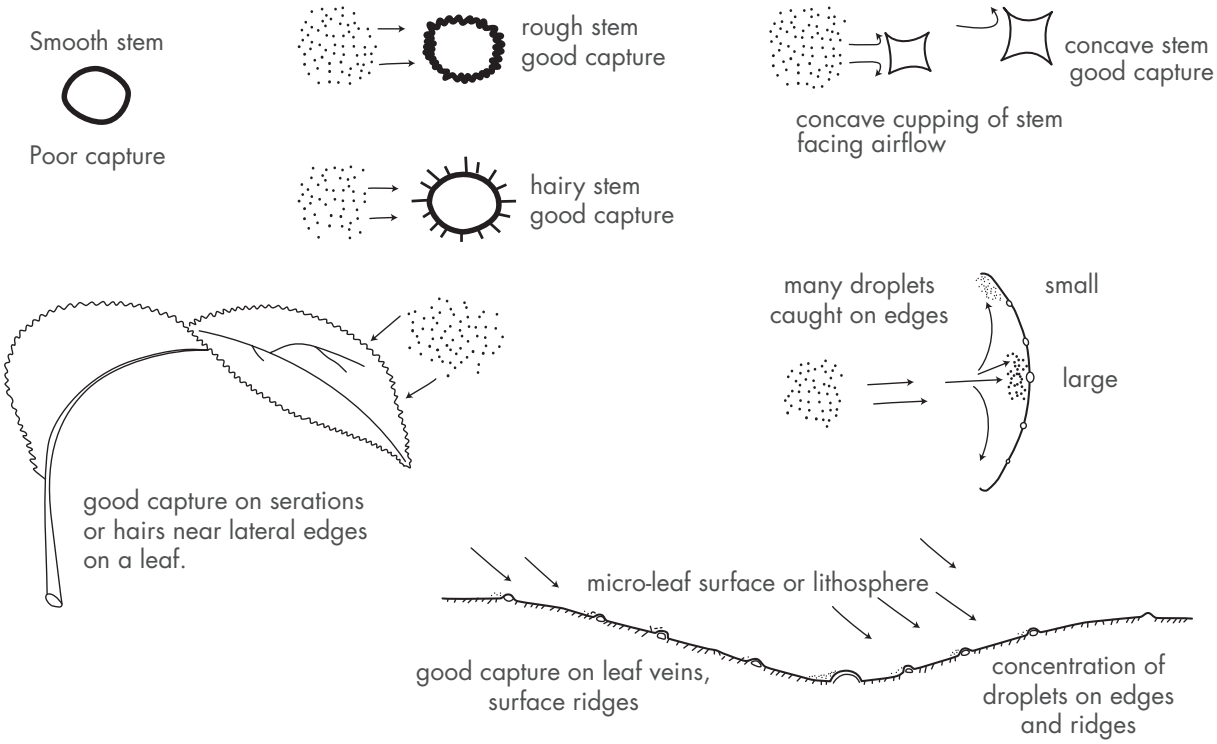
EFFICACY - WHAT'S BEING CONSIDERED?

There is a wide range of considerations in any application job. In terms of ensuring efficacy as a starting point, knowledge regarding the following – and how they interact - is essential:

- Target
  - narrow leaf versus broad
  - vertical versus horizontal catching surface
  - hairy versus smooth leaves / recovery efficiency
- Position of pest
  - under leaf
  - top of canopy, whole plant or earth

- Mode of action of chemical
  - systemic or contact
  - protectant or eradicant

Figure 8.1: Understanding capture efficiency of different surfaces



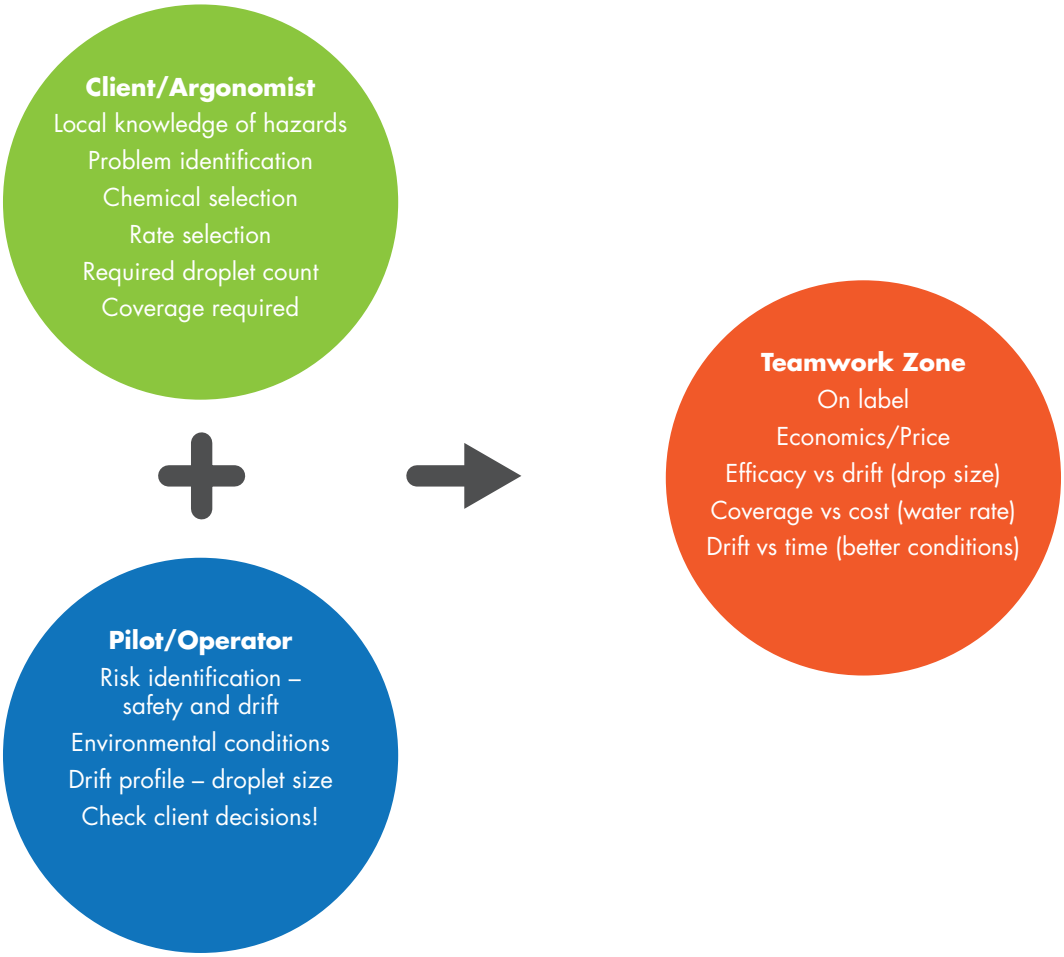
Knowledge of all of these issues leads to a discussion of coverage of the target required, often expressed in droplets per square centimetre.

However, efficacy alone is seldom the sole consideration in getting a safe, compliant and effective application.

Consequently, it is important for all agronomists and clients to approach every application job as a team, in combination with the aerial applicator.

As part of building an effective application management team and having a well-informed discussion regarding coverage and water volumes, it is important for each of the players to understand their role and what they can bring to the table.

Figure 8.2: The Application Teamwork Model.



In cooperation with agronomists, AAAA has developed an Application Decision Flow Chart for Agronomists and Pilots and an Agronomist's Aerial Application Checklist – copies of both can be found in the Appendices at the back of this guide.

WHY IS WATER VOLUME SO CRITICAL TO AIRCRAFT?

There are two aspects to this question:

1. A wing's lift is finite; aircraft are certified to a certain weight for safe operations. This means that in addition to the weight of the airframe itself, the aircraft must be able to lift the weight of fuel, the pilot and the load within the confines of the certified all-up weight.

   Consequently, the less water the aircraft has to carry as part of its load, the more efficient and productive it can be. It also means the aircraft can be safer because of a greater safety buffer for take-off, manoeuvring and turns.

   Requiring an aircraft to carry additional water volume when it is not required for coverage purposes is essentially an inefficient application.

2. Aircraft are very good at making smaller droplets. Actual coverage on the target is normally adequate at lower water volumes than what may be recommended for ground application. Obviously, the other side of this issue is that aircraft need to be well set-up and operated for sound drift control.

DECIDING WATER VOLUME

There are 3 key considerations in calculating water rates:

- Required droplet count (coverage)
- Required droplet size (drift control and coverage)
- Leaf Area Index ('bushiness' of the crop)

By assessing and establishing each of these variables, water volume calculations are then a simple mathematical function to establish a starting point for further discussion.

Figure 8.3: Roles and information source

What each of us need	What we can vary to get the result	Simple maths
The client / agronomist needs to determine: • Pest size and location • Mode of action of pesticide • Target	• Droplet count • Leaf Area Index	Water volume
The Pilot needs to determine: • Drift profile • Environmental conditions	• Droplet size	

DROPLET COUNT

Droplet Count influences the efficacy of the applied pesticide. While few chemical labels provide useful coverage information in terms of a target number of droplets per cm^2, there has been a significant level of research put into this issue by chemical companies to back their product assessments through APVMA processes.

While any mandatory label requirements trump all other information, the Centre for Pesticide Application Safety at the University of Queensland included the following approximate guide in the AAAA Spraysafe manual.

Figure 8.4: 'Rule of Thumb Only' - General Coverage Guide

Product type	Droplet numbers
Herbicides	20-30 droplets/cm^2
Insecticides	20-40 droplets/cm^2
Fungicides	40-60 droplets/cm^2

Disclaimer: *The table above is advice of a general nature only and should not be relied upon for operational planning.*

However, the label trumps everything.

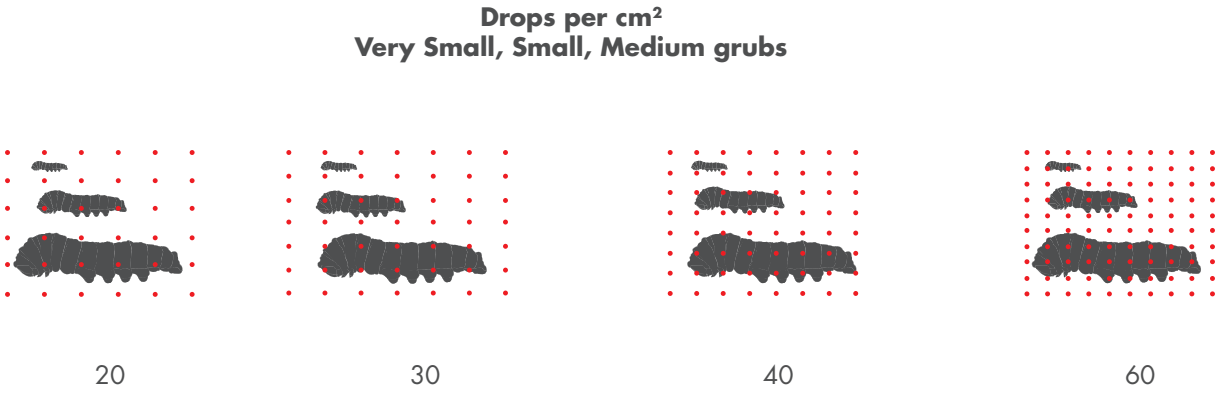
In addition, the 'rules of thumb' must be considered along with discussion of at least these other important factors:

- Dilution rate of active/ha – ie 'potency' of each droplet
- Droplet size, mix of sizes (spectrum)
- Target capture efficiency
- Likely recovery rate on the target
- Mode of Action - Systemic / translocated versus contact

If you are able to access particular information from the chemical label or technical notes from the registrant, that is clearly preferable guidance material to arrive at a recommendation due to the highly variable interplay between product mode of action, pest stage of growth, pest location, canopy type and density and other factors.

In the figure below relating to the variable grub size, the challenge is clear in establishing what coverage is required to get enough active onto the pest or other target to be effective.

Figure 8.5: Droplet count. How many is enough?



While experience counts for a lot in making effective recommendations, at least considering the issues in this section will help you identify probable limits of coverage required.

LEAF AREA INDEX (LAI)

LAI is a simple tool for estimating area of the plant surface you are targeting with a spray.

It can provide useful information on potential issues including coverage and canopy penetration, which in turn can lead to different spray strategies and aircraft set-ups.

In simple terms, LAI is the ratio of the leaf area to ground area.

An increase in leaf area may require an increase in the spray volume to maintain coverage, but not always.

LAI by itself is not enough information and must be coupled with consideration of:

- the target pest or plant
- likely chemical recovery on the leaves, pest or fungus
- knowledge of chemical mode of action (eg. is it translocated)
- understanding of any particular challenges such as canopy penetration
- location/behaviour of the pest – eg. only the top of the crop may require treatment

The critical role of understanding LAI is for use in calculating likely water volume required.

LAI is one of the key inputs to the AAAA Water Volume Calculator available to all AAAA members. For that purpose, generally an input figure of 1, 2 or 3 for LAI is sufficient to begin a discussion on coverage and water rates.

For example, fallow treatments with a herbicide would probably be evaluated at a LAI of 1. So would a treatment of sorghum where the insect being targeted is known to be found in the sorghum head only – ie only the top of the canopy needs treatment.

As a rough guide, the following figures provide a useful ground-truthing of LAI.

Figure 8.6: Indicative LAI on cotton *(Source: CRDC)*

LAI = 0.87	LAI = 1.70	LAI = 2.46
		

DROPLET SIZE

Selection of a particular droplet size is the responsibility of the aerial applicator due to the importance of droplet size to drift control as well as efficacy.

However, in addition to drift management, droplet size selection can also be used to target different parts of the canopy.

For example, with a thick, difficult to penetrate canopy, larger droplets are more likely to penetrate because of their additional mass and then shatter into smaller droplets on impact. Smaller droplets rely on turbulence to be carried into the canopy but can be very effective in coverage terms including on the underside of leaves.

All nozzles produce a range of droplet sizes. It is this mixture of droplet sizes from any nozzle that may aid coverage and improve the efficacy of the job, even though a larger spray quality category is selected for drift control.

However, at very large droplet spectrum (such as a 'very coarse' spray quality required for 2,4-D applications), there may be very few if any droplets smaller than 190 microns available to drift.

Effect of droplet size on water volume

Droplet size affects the amount of water required. The number of droplets also affects water volume required. Changing droplet size can have a dramatic effect on water volume required.

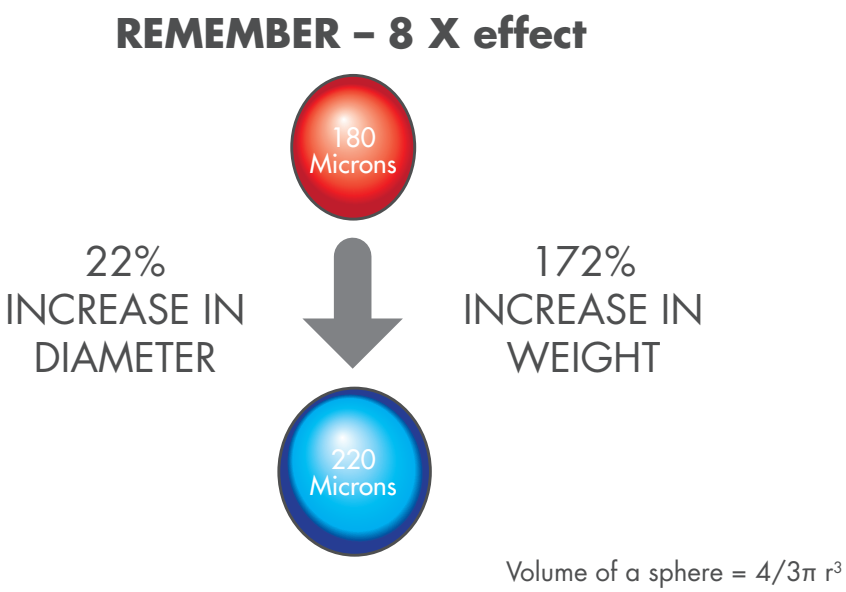
Figure 8.7: Inter-relationship between droplet size, coverage and volume

Droplet Size (µm)	Drops per cm^2	Water Volume (L/Ha)
250 µm	20 cm^2	16 L/Ha
250 µm	40 cm^2	33 L/Ha
250 µm	60 cm^2	49 L/Ha

When considering water volume, it is critical to remember that a small change on droplet size can have a big impact on droplet mass – and water rates.

Consequently, small changes to droplet size can greatly assist with drift control without necessarily impacting severely on efficacy.

Figure 8.8: Small changes in size can make a big difference



As a general guide, the AAAA Spraysafe manual provides the following information and, of course, label directions must be complied with:

Ultra-low volume (ULV) spraying:

80-150µm VMD Up to 5L/Ha
- Fungicides and Insecticides
- Need non-volatile formulations

Low volume (LV) spraying:

150-250µm VMD 5 – 30L/Ha
- Most Insecticides and Fungicides
- Droplet count / water volume important

High volume reduced drift placement spraying:

250-500µm VMD >30L/Ha
- Low drift placement spraying
- Important to note the fines produced at Dv0.1 as well as VMD (Dv0.5)

BRINGING THE SCIENCE TOGETHER – AAAA WATER VOLUME CALCULATOR

By bringing together an improved understanding of what should go into deciding water volume, it is now possible to have a much more refined and science-based discussion.

AAAA simplified the above processes by developing a water volume and coverage calculator that provides an approximate indication of outcomes.

The water volume/coverage calculator is based on a relatively simple formula that included the following:

Water volume = $4/3\pi r^3$ x droplet count x LAI x C

Where:

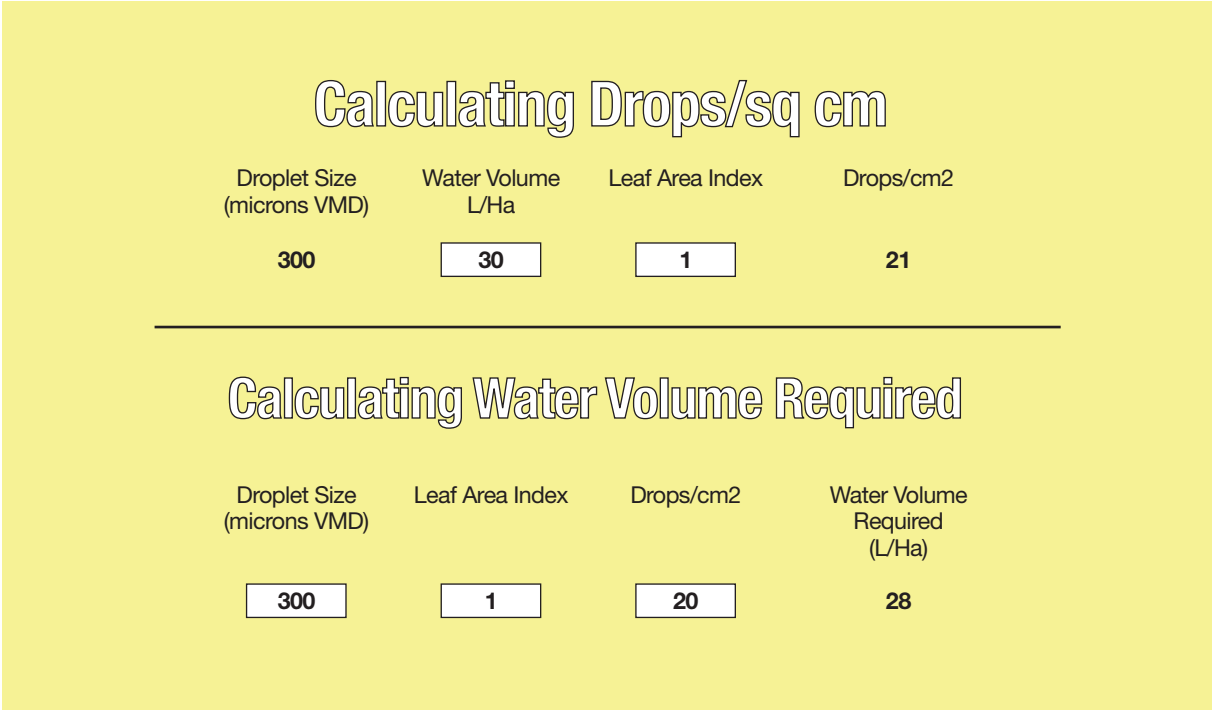
Volume of a sphere = $4/3\pi r^3$ - where 'r' is radius of the VMD (ie half VMD)

Droplet count = droplets per cm^2

LAI = Leaf area index rated as 1,2 or 3

C = a constant to return the answer to the relevant units of litres /Ha

Figure 8.9: screen shot of the AAAA Water Volume / Coverage Calculator.



This simple calculator does not take a range of considerations into account, such as the catching efficiency of the target surface or the limitations of using VMD as a surrogate for droplet size / spray quality or evaporation impacts. However, it is a useful tool for facilitating discussion about the different objectives around the table.

WATER VOLUME – IT'S TEAMWORK

By using the principles above, agronomists and the aerial applicator can work together to get the best possible outcome for the particular spray circumstances:

- What's the target?
- What's the LAI?
- What's the mode of action?
- Droplet size – drift, efficacy, economy
- Drops / cm^2 – efficacy, economy
- Water volume – drift, efficacy, economy

USING SPRAY ADJUVANTS

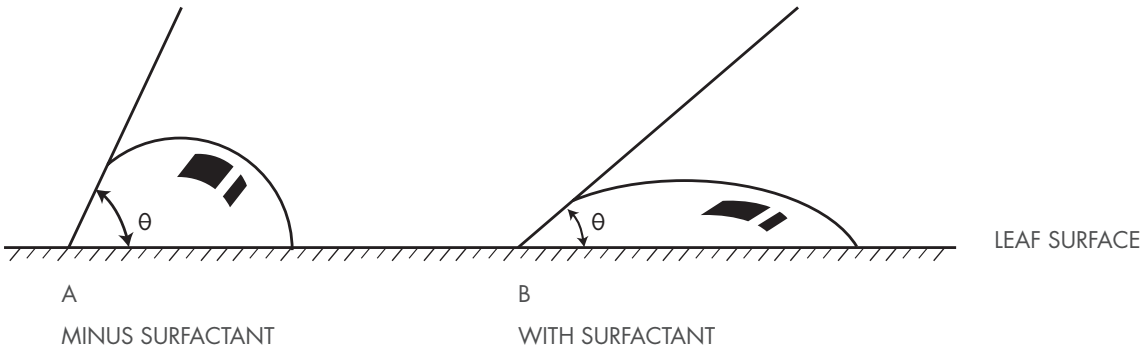
There is a massive range of spray additives: anti-drift adjuvants, surfactants, spreaders, stickers and spray oils amongst others.

The bottom line is that if it has not been independently tested using accepted scientific principles, including a high-speed wind tunnel or field trials at typical aircraft speeds, then it should be regarded with considerable caution.

For example, spreaders that rely on reducing surface tension may also have a significant impact on droplet formation and spray quality, including an increase in smaller droplets.

Aerial application introduces high speed air to spraying that may create additional challenges in managing untested products. Only products that have been satisfactorily tested at representative aerial application speeds should be added to spray mixes.

Figure 8.10: Possible impact of a 'spreader' adjuvant



9. DROPLETS AND NOZZLES

OPERATIONAL CONSIDERATIONS

There is a wide range of operational considerations that will affect applications including:

- Aircraft and pilot safety
- Crop situation
- Pest / disease / weed being targeted
- Label requirements
- Drift management requirements
- Weather
- Hazards and sensitive areas
- All of these can be managed through the selection of droplet size and the correct nozzles.

The combination of nozzle design and aircraft aerodynamics allows for a wide range of variables to tailor spray quality to the job.

What size droplet do we need?

- Large droplets
  - Reduced drift
  - Better penetration through a canopy
  - Horizontal surfaces
  - Reduced influence from turbulence
  - Less effect from evaporation
  - Lower droplet count
  - Lower Efficacy?? – not necessarily!

The heavier the droplet the quicker it will fall to the target and the less likely it is to be affected by airflow.

However, if you increase droplet size too far and then introduce it to the violent airflow around an aircraft, the droplet is likely to shatter into many smaller droplets, making drift control more difficult.

- Small Droplets
  - More susceptible to drift
  - Vertical surfaces
  - Increased droplet count
  - Better Efficacy?? – not necessarily!

The other side of this coin is that smaller droplets require close management - in terms of planning, hazard and susceptible identification and protection, communication and weather conditions.

How do you know?

Your professsional aerial applicator is a member of AAAA, Spraysafe accredited and can attend AAAA's technical training days held around the country every year.

They have access to the AAAA nozzle calculator, our water volume calculator and our training.

UNDERSTANDING DROPLETS

When considering the performance of different nozzles and trying to match them to the job, it is important to consider the nozzles' whole spray spectrum and its characteristics – not just the simplistic shorthand of 'VMD'.

There are lots of ways to understand spray quality and they can include references to the following terms:

- **Spray quality** – categories from 'extremely fine' to 'medium' and 'ultra-coarse', measured at 3 points (Dv0.1, Dv0.5 & Dv0.9) in accordance with a standard called ASABE S572.1 (see below). The APVMA permits aerial applicators to use modelling that is only required to meet the Standard at the lower measuring points which are more indicative of droplets with potential to drift
- **VMD** – Volume Median Diameter – the point at which half of the spray volume has a droplet size larger/smaller than the number
- **Relative span** – the larger the relative span number, the wider the range of droplet spectra generated. In a (theoretical) mono-sized spectrum, relative span is zero
- **Dv0.1** – droplet size at which 10% of the spray is in droplets smaller than this number (fines). Useful indication of small droplets which are prone to drift
- **Dv0.5** – droplet size at which 50% of the spray is in droplets smaller than this. Same as VMD
- **Dv0.9** – droplet size at which 90% of the spray is in droplets smaller than this number. Useful indication of large droplets which can be wasteful of chemical
- **% of Fines** – this is a largely US-used measurement that describes the total percentage of volume of the spray that is in droplets smaller than, say, 200µm.

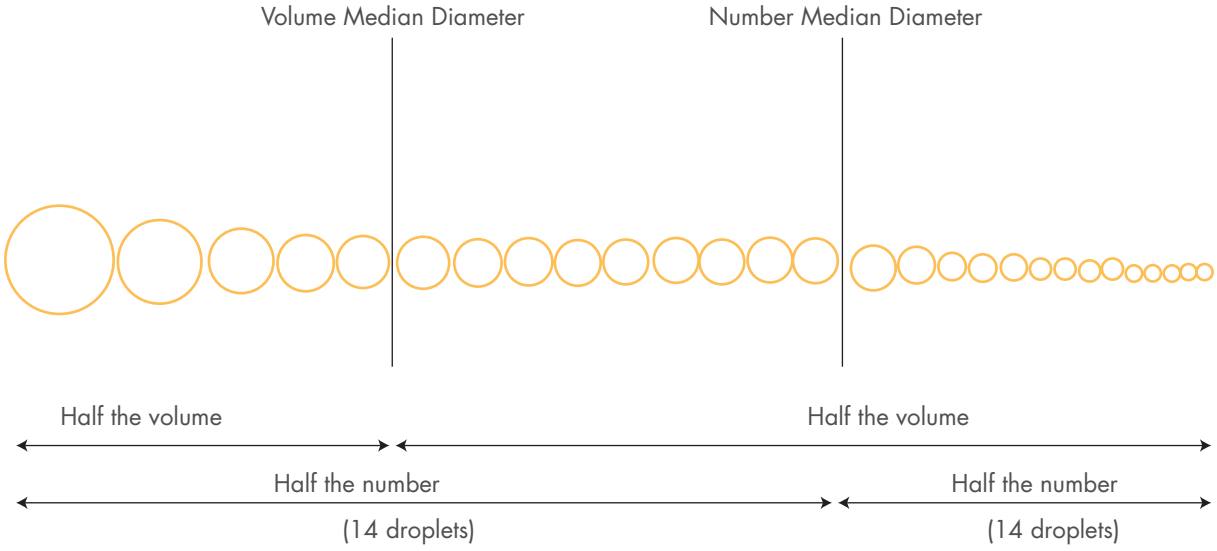
All of the terms above are useful in describing the full spectrum produced by any nozzle. However, the use of 'spray quality' terms as explained below is the best approach and in keeping with modern label language.

VMD – a limited measurement

Volume Median Diameter - VMD - simply indicates the droplet size in a spray spectrum at which 50% of the volume of the droplets are of a value smaller than that size.

It makes no direct indication of the number or percentage of fines in a spray or their likely 'driftability'. You use VMD alone at your peril!

Figure 9.1: Understanding VMD does not describe the full spectrum



SPRAY QUALITY AND ASABE STANDARDS S572.1 AND S641

The American Society of Agricultural and Biological Engineers (ASABE) had adapted the British Crop Protection Council (BCPC) standard for ground spraying nozzles and added a number of categories at the 'coarse' end of the spectrum.

ASABE S572.1 grades spray quality (and nozzles) by measuring droplet size at three points of the spectrum (Dv0.1, Dv0.5 and Dv0.9) and then classifies the spray into:

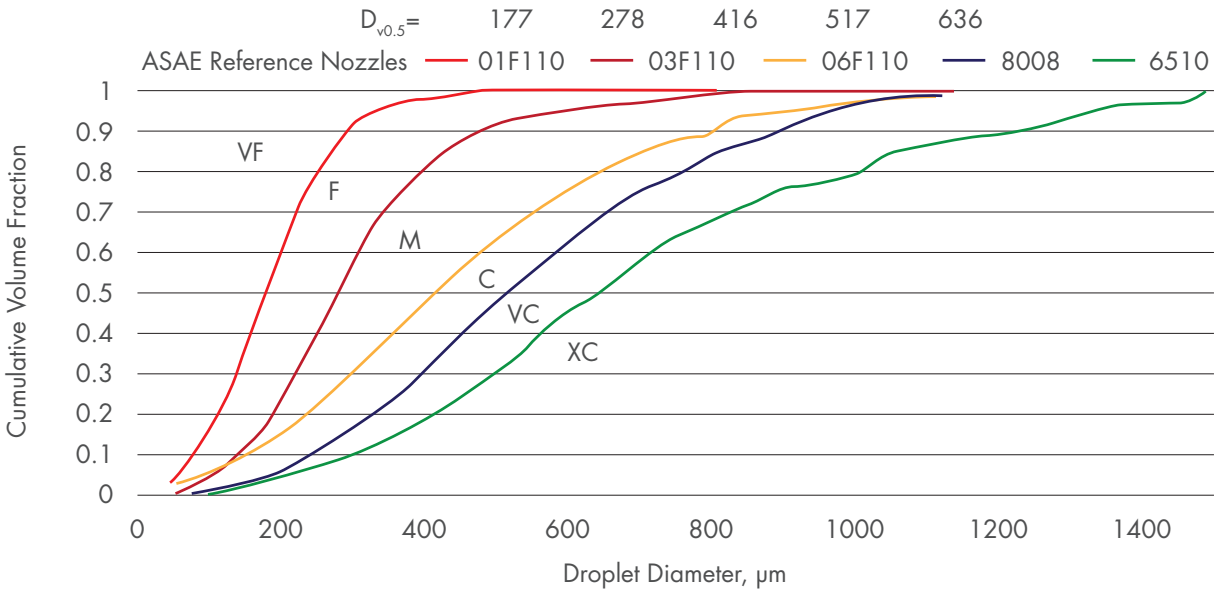
- extremely fine
- very fine
- fine
- medium
- course
- very course
- extremely course
- ultra coarse

Many people mistakenly believe that VMD is in some way equal to the ASABE S572 spray quality categories. It is not, as ASABE S572 is based on measurements at 3 points of the spectrum and then the mathematical modelling of a spray curve from those measurements. One of those points is VMD (otherwise known as Dv0.5) but trying to use VMD alone simply makes no sense of what is happening at other points of the spectrum - most critically for drift control at Dv0.1 - the point at which 10% of the spray volume is smallest.

ASABE published a new standard in 2018 specifically for the classification of spray quality for aerial application – ASABE S641.

While it may take the APVMA some time to formally adopt the new standard, the outcomes and principles in use by APVMA and industry are already largely in line with the standard.

Figure 9.2: Droplet diameter across droplet size spectrum according to ASABE S572.1



DROPLET FORMATION

Droplets are formed by either hydraulic nozzles or rotary atomisers on aircraft. Both methods will be further affected by the shear velocities of the airstream passing the nozzle tip or atomiser cage.

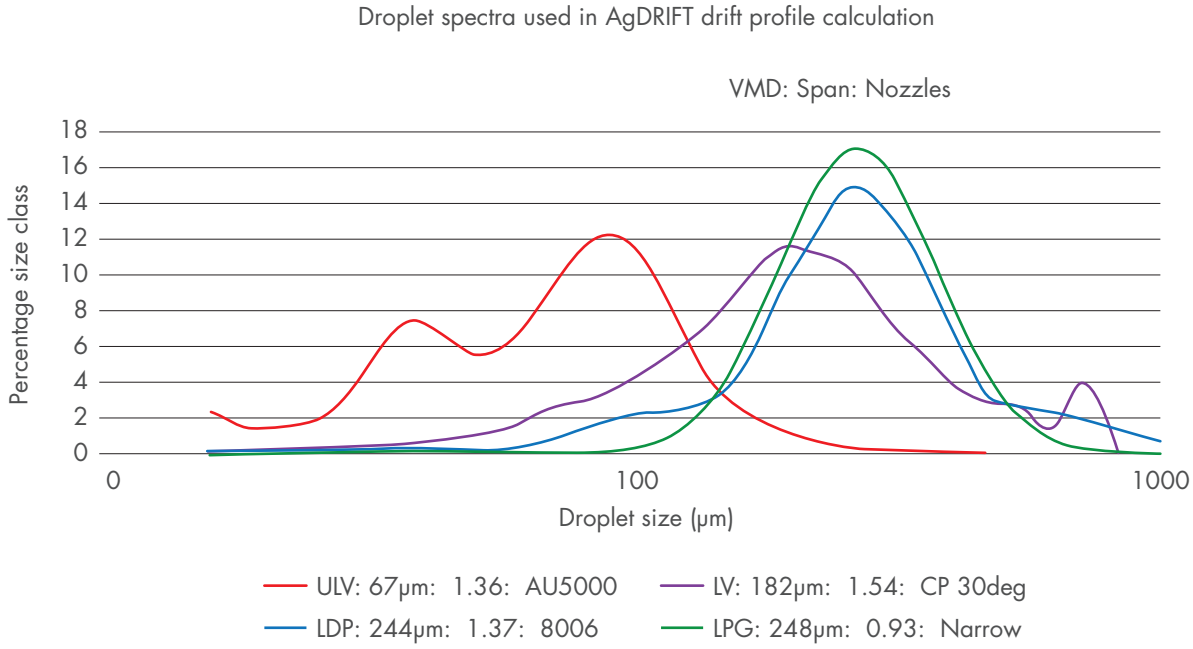
Aircraft-specific nozzles deliver very different spray quality depending on set-up and operation.

Rotary atomisers, for example, can adjust cage rotation speed by varying the impeller blade angle to the airstream.

Hydraulic nozzles can be adjusted by either pointing them backwards relative to the airflow (larger droplets due to decreased angle of orientation) or angled down into the airstream (smaller droplets due to increased shear from the airstream).

Accurate testing information of most aerial nozzles is available from either the manufacturer's website, AAAA (for members through its Nozzle Calculator program) or by using AgDrift / AgDisp models.

Figure 9.3: All nozzles produce a range of droplet sizes.



The image below is a good example of droplet formation as it is affected by the shear effect of the airstream, in this case using a JARBA boom, which is adjustable in-flight.

By angling the droplet backwards with the airstream, the spray quality is fundamentally altered.

For even larger droplets, the spray operating pressure is increased to further reduce the shear effect of the airstream passing the nozzle tip.

Figure 9.4: Droplet formation using shear effect from a JARBA Rotating Boom
(Photo: Jones Air)

Angle = 0 deg	Angle = 90 deg
Course droplets	Fine droplets

HYDRAULIC / FLAT FAN NOZZLES

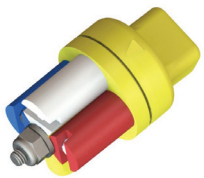
These are now the most common type of nozzle used because of their versatility on an aircraft and provide significant flexibility for the pilot and agronomist.

The combination of nozzle design and aircraft allows for a wide range of variables to tailor spray quality to the job:

- increasing pressure on a rearward facing nozzle will increase droplet size
- angling the nozzle into the slipstream decreases droplet size through shatter
- adjusting angle of orientation varies droplet size

Figure 9.5: Flat fan nozzles on a JARBA boom

Figure 9.6: A selection of aircraft nozzle types

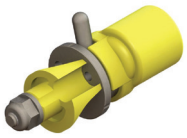


CP11TT

CP-11TT holds THREE FLAT FAN TIPS and has a SHUT OFF.

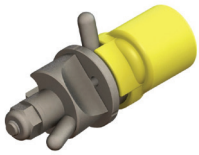
CP-03

Poly Aerial Nozzle



CP093P

Poly Straight Stream Nozzle with Stainless Selector , Poly Deflector w/ 5° & 30° Deflection



CP093E

Poly Straight Stream Nozzle with Stainless Selector / Deflector w/ 5° & 30° Deflection

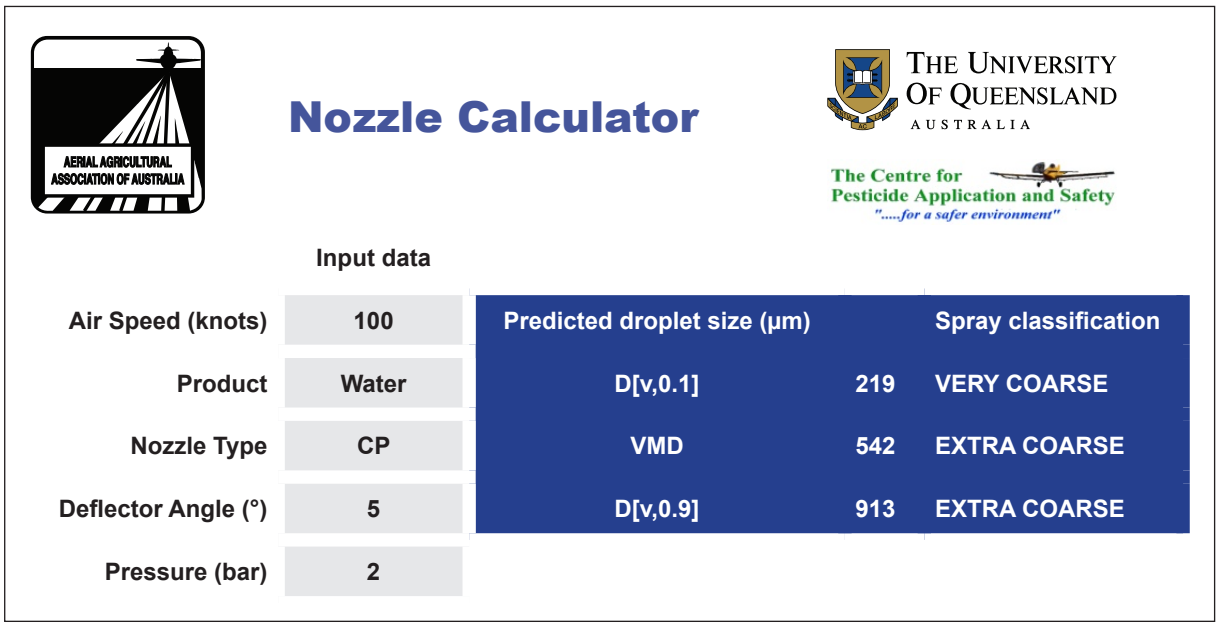
In general terms, common aerial application nozzles / rotary atomisers have the following characteristics:

Nozzle / Atomiser	Spray quality range	Aircraft type	Volume	Use
Micronair AU 5000	Very Fine – Medium Fine on faster (turbine) aircraft	Any, but the faster the cage spins, the smaller the droplets. Rotational speed can be varied by varying the blade pitch. Various types – including independently powered versions - available also for helicopter use due to the slower forward airspeed.	Ultra-low volume to medium volume spraying	Flying insects (locusts etc). More general use where there are no drift concerns including fungicides, insecticides and herbicides. Care must be taken with drift management due to the fine spray quality.
CP 03	Fine to coarse on slower aircraft depending on set- up. Fine spray quality on faster aircraft.	The original aerial nozzles from this US manufacturer work well for airspeeds of 193 km/h or less (ie slower aircraft) depending on the application. At higher airspeeds, these nozzles will produce more driftable fines than CP-11TT's or CP-07/09's. They have the same four orifices as the CP07/09's but the deflector angles are 30°, 55° and 90°	Medium to high volume depending on the spray tips / orifices selected	On slower aircraft (non-turbine powered) the CP03 is a useful nozzle. It should not be used on faster aircraft.
CP09	Fine to very coarse – dependent on set-up and aircraft speed.	CP-07's and CP-09's are nozzles with four orifices (0.062, 0.078, 0.125 and 0.172) and three-way deflectors with a straight stream setting and 5° and 30° deflection. These nozzles were designed for aircraft flying at speeds of 209 km/h and higher.	Medium to high volume depending on the spray tips / orifices selected	The straight stream nozzle tip will deliver very large droplets for placement spraying. Selection of other deflectors will make finer droplets.
CP 11 TT	Fine to very coarse – dependent on set-up and aircraft speed.	CP-11TT's are the most versatile nozzles for the full range of airspeeds. In most instances, flat fan tips offer the best drift control and narrowest relative spans. The wide range of tips styles available make both large and small droplet spectra possible. Nozzles are set up with tips meeting the specific needs of each aircraft. Tips are colour coded for flow rate and click into place with a clip, spring and ball.	Medium to high volume depending on the spray tips / orifices selected	Due to the flexibility of nozzle and its variable geometry mounting, most spray quality and use situations are covered. The use of flat fan tips (as distinct from deflectors) further reduces fines, depending on other variables.

AIRCRAFT NOZZLE CALCULATORS

AAAA members have access to a Nozzle Calculator specific to the Australian aerial application industry. This has been developed in conjunction with the University of Queensland and sponsors including Nufarm and Dow, and provides applicators with research-supported evidence when selecting nozzles.

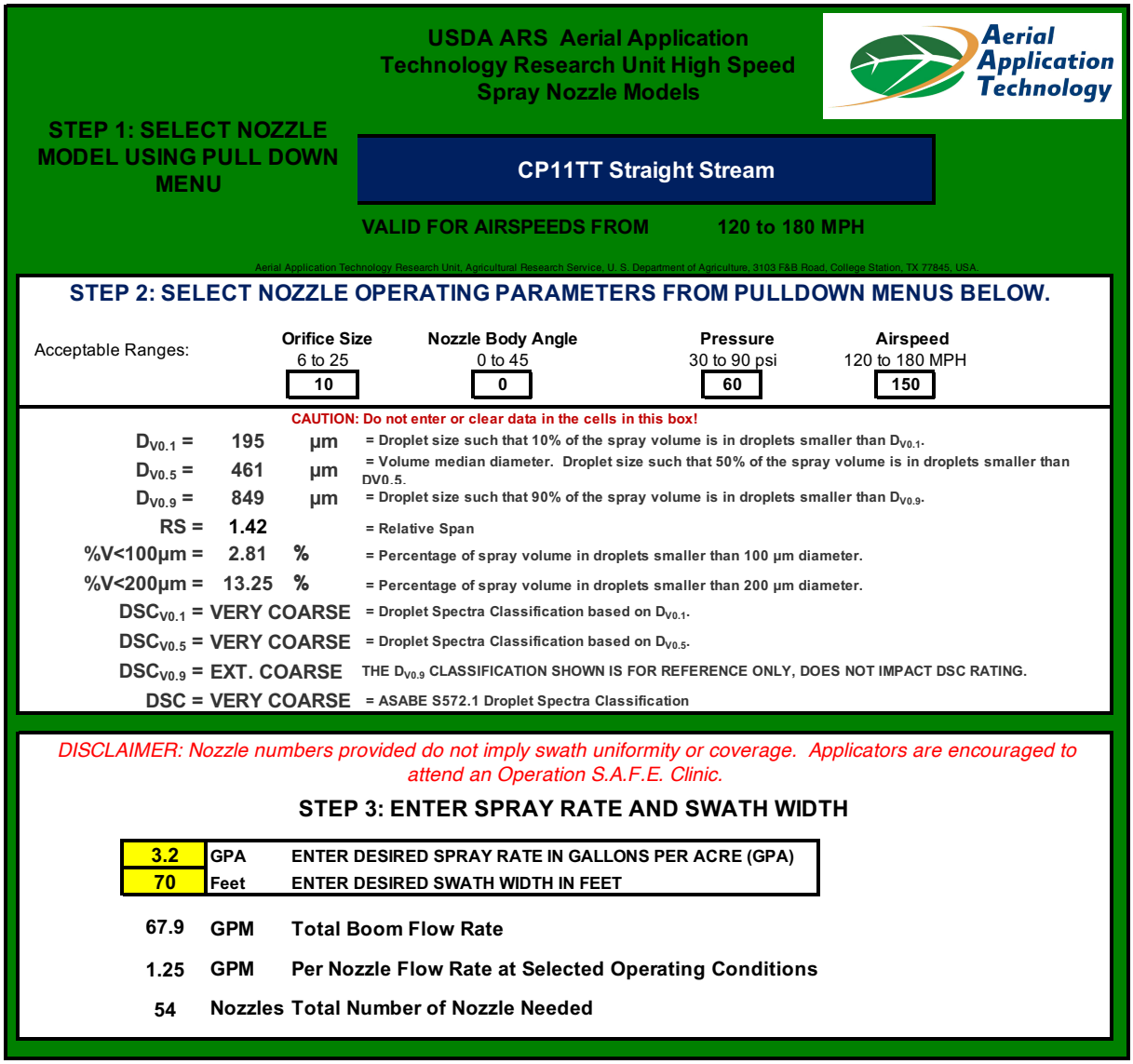
Figure 9.7: AAAA Nozzle Spray Quality Calculator – screen shot



The AAAA nozzle calculator and its extensions have been recognised by the APVMA and AAAA continues to work on updates, including commissioning additional wind tunnel research on products and nozzles.

Other aircraft nozzle calculators are also available from the USDA on-line.

Figure 9.8: USDA Nozzle Calculators – screen shot



USDA ARS Aerial Application Technology Research Unit High Speed Spray Nozzle Models

Aerial Application Technology

STEP 1: SELECT NOZZLE MODEL USING PULL DOWN MENU

CP11TT Straight Stream

VALID FOR AIRSPEEDS FROM 120 to 180 MPH

Aerial Application Technology Research Unit, Agricultural Research Service, U. S. Department of Agriculture, 3103 F&B Road, College Station, TX 77845, USA.

STEP 2: SELECT NOZZLE OPERATING PARAMETERS FROM PULLDOWN MENUS BELOW.

Acceptable Ranges:	Orifice Size	Nozzle Body Angle	Pressure	Airspeed
	6 to 25	0 to 45	30 to 90 psi	120 to 180 MPH
	10	0	60	150

CAUTION: Do not enter or clear data in the cells in this box!

$D_{V0.1}$ =	195	µm	= Droplet size such that 10% of the spray volume is in droplets smaller than $D_{V0.1}$.
$D_{V0.5}$ =	461	µm	= Volume median diameter. Droplet size such that 50% of the spray volume is in droplets smaller than DV0.5.
$D_{V0.9}$ =	849	µm	= Droplet size such that 90% of the spray volume is in droplets smaller than $D_{V0.9}$.
RS =	1.42		= Relative Span
%V<100µm =	2.81	%	= Percentage of spray volume in droplets smaller than 100 µm diameter.
%V<200µm =	13.25	%	= Percentage of spray volume in droplets smaller than 200 µm diameter.
$DSC_{V0.1}$ =	VERY COARSE		= Droplet Spectra Classification based on $D_{V0.1}$.
$DSC_{V0.5}$ =	VERY COARSE		= Droplet Spectra Classification based on $D_{V0.5}$.
$DSC_{V0.9}$ =	EXT. COARSE		THE $D_{V0.9}$ CLASSIFICATION SHOWN IS FOR REFERENCE ONLY, DOES NOT IMPACT DSC RATING.
DSC =	VERY COARSE		= ASABE S572.1 Droplet Spectra Classification

DISCLAIMER: Nozzle numbers provided do not imply swath uniformity or coverage. Applicators are encouraged to attend an Operation S.A.F.E. Clinic.

STEP 3: ENTER SPRAY RATE AND SWATH WIDTH

3.2	GPA	ENTER DESIRED SPRAY RATE IN GALLONS PER ACRE (GPA)
70	Feet	ENTER DESIRED SWATH WIDTH IN FEET

67.9	GPM	Total Boom Flow Rate
1.25	GPM	Per Nozzle Flow Rate at Selected Operating Conditions
54	Nozzles	Total Number of Nozzle Needed

Note: USDA calculators are based on the US system of measurement not metric.

10. PLANNING AND DRIFT MANAGEMENT

Sound planning and drift management is incorporated into all operations by competent aerial applicators.

The development of a sound **Application Management Plan (AMP)** is a key responsibility of every applicator for every job.

PLANNING = SITUATIONAL AWARENESS

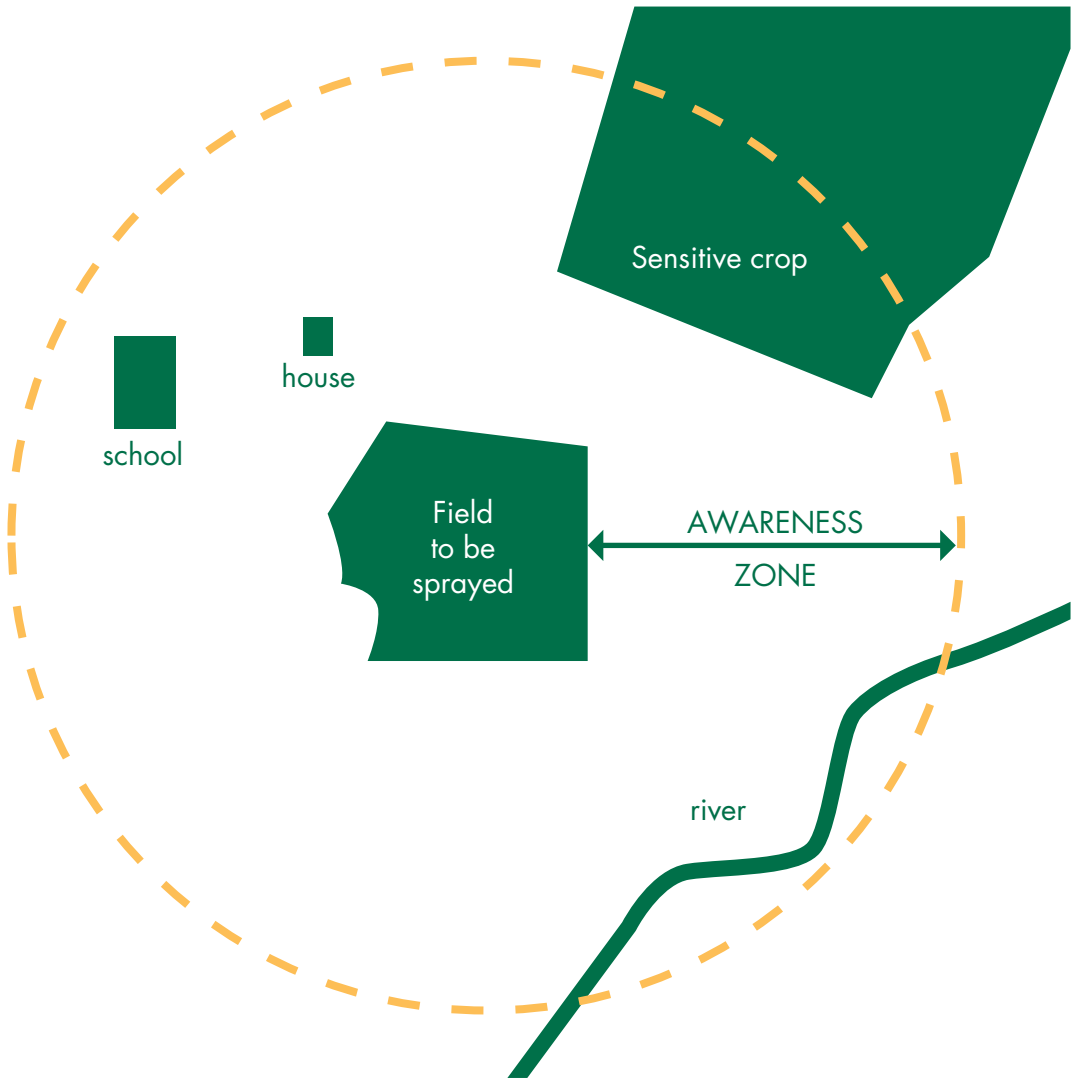
Planning contributes to better situational awareness for all concerned.

Situational awareness is best defined by Dr Tony Kern as:

> *"An accurate mental model of reality and… projection of potential courses of action against likely future scenarios"*

If your situational awareness is compromised (e.g. you don't know what is downwind) then your ability to plan a safe application job is also compromised.

Figure 10.1: Spraying situational awareness
(Source: National Spray Drift Management Guidelines, CSIRO Publishing)



HAZARD IDENTIFICATION

The agronomist and client play a critical role in helping the aerial applicator form a mind-picture (situational awareness) of the application task by helping to identify hazards and situational considerations for every job.

Using the AAAA Standard Application Request form can greatly assist the application team, as many of the common hazards have already been identified and all that is required is a tick of the relevant box and provision of an accurate map.

The Standard Application Request form includes the following possible hazards:

- Downwind susceptible crops
- Powerlines
- Organic farms
- Aquatic farms
- Channels
- Rivers
- Dams
- Roads
- Livestock
- Vines
- Gardens
- Trees
- Flora / Fauna
- Dwellings/ houses/ workplaces
- Schools / bus runs
- Workers / contractors
- Towns
- Pasture
- Bees

In addition to this non-exhaustive list of common hazards, neighbours may require notification.

The AAAA Standard Application Request form simplifies this process as much as possible and will be augmented by additional planning by your aerial applicator which may include the use of:

- Google Earth
- powerline company overlays (if available in your State/Territory)
- client files / records / maps if farm previously treated
- Application Management Plan
- Aerial survey

TIMING OF APPLICATION REQUESTS

While every applicator will try and get your product onto your area as quickly as possible, it is worthwhile considering some of the competing priorities that may not be immediately apparent.

If you are discussing a likely upcoming application with your client, don't forget to include your applicator in that conversation so they can schedule your job ahead of time.

If you are seeing a particular problem with your clients' crops, there is a reasonable chance that the issue is area-wide. This may result in a backlog of treatment requests for aerial applicators – especially if there is also general rain and wet paddocks.

Similarly, if you are intending to get away for a break, for example over Christmas, don't forget that you may not be the only one with that plan – resulting in a backlog of treatment requests for your aerial applicator.

Early requests are always appreciated, as is patience and understanding.

If you have the option of going early to get in front of a potential rush, that approach will also be appreciated.

As an integral part of aviation's commitment to safety, all application pilots and companies are required by law to comply with flight and duty time limitations to manage fatigue. Do not be surprised if aerial application pilots have to have time free from all duties – normally at least 36 hours off in any 14 days during a season – as this is of critical safety importance.

The role of the agronomist as part of the aerial application team is critical and must be approached responsibly.

Placing additional pressure on top of application pilots and companies is simply unsafe.

DRIFT MANAGEMENT

Drift management is a key part of application planning and requires information from all members of the application team, ranging from farm planning decisions to knowledge of neighbouring susceptibles to integrated pest management and application risk management.

All drift management systems should include:

- Pre-planning information gathering
- Situational awareness of hazards – including people, the environment and assets
- Knowledge of the target pest, crop and the chemicals
- Application in appropriate meteorological conditions
- Diligent monitoring of applications
- Regular and clear communication including written requests and maps

It is worthwhile noting that in every State and Territory, chemical control of use regulators report that ground rig complaints regarding spray drift significantly outnumber complaints regarding aerial application every year – often by an order of magnitude.

It is clear that the higher levels of training and accountability for aerial applicators has a positive effect on drift management.

'BAD' DRIFT AND 'GOOD' DRIFT

Not all 'drift' is bad.

While that sounds like heresy, it is important to understand that movement of droplets around the aircraft can be advantageous for recovery of the product onto the target – as long as it does not venture beyond the target area.

'Bad' drift is:

- Off field
- Impacts on others

'Good' drift is:

- Within the target field
- Causes no harm downwind
- Has no implications including residue
- Aids coverage, efficacy and productivity

THE DRIVERS OF DRIFT

The following considerations are the key issues in addressing drift management:

- Wind speed and direction
- Inversions
- Spray height
- Droplet size
- Evaporation

Wind Speed and Direction

Wind speed and direction together are our biggest problem and one of our best management tools.

By using techniques such as field splitting, we can use different winds to treat areas without harming nearby susceptible or sensitive areas.

AgDrift modelling shows that:

- High wind speeds (> 30km/hr) increased drift significantly out to and beyond 150 - 200 m
- Low wind speeds (~3km/hr) reduced drift significantly out to 3m

These figures are affected by the droplet size and other environmental factors at the time of application.

There is not a large difference at longer ranges of drift, which indicates that droplets that are already too small to sediment to earth in the first few hundred metres may continue to drift - this is the same result for both ground and aerial application.

Smaller droplets will drift further simply because they have less mass and are able to spend more time airborne and travelling with the prevailing wind.

BUT...

- Wind *direction* determines where drops will go – do you know what is downwind?
- Wind *speed* will determine how far they will go – how far downwind do you check?
- Critical tool for planning and protecting
  - e.g. field splitting
- Higher winds can actually aid deposition through turbulence
- Too little may be an inversion

Inversions

A surface temperature inversion is where air temperature *increases* with height – which is the 'inverse' of 'normal' conditions.

Pilots in aircraft are uniquely placed to recognise inversions as they can measure temperature variations with changes in height.

Inversions occur in very stable atmospheric conditions where there is no mixing of air by wind or other mechanisms such as turbulence. Often, inversions result in a band of warm air close to the surface forming which can entrap small droplets.

Inversions can often be recognised by nil wind conditions. Spraying in nil wind inversion conditions is a significant risk for long distance drift.

If you spray in an inversion, smaller droplets may not sediment out, and may then move off the target area – often in a temperature drainage pattern related to topography – leading to off target drift and potential damage to non-target areas.

Spraying conditions are not 'ideal' if there is NO wind - these are the worst conditions of all!

There is no commonly available 'instrument' to recognise inversions and so you must rely on the secondary indicators below:

- Cool nights
- Clear skies
- Hollows and valleys
- Zero to slight wind
- Smoke or dust 'hanging' in the atmosphere
- MIST & FOG!!!

Various State Departments of Agriculture, Environmental Protection Authorities and the Grains R+D Corporation have excellent surface temperature inversion information.

Spraying Height

Spraying height has an impact on potential drift - both for aerial and ground. However, this does not necessarily mean lower is better – see this guide's 'Aerodynamics' section.

There is a 'sweet spot' for spraying height for an aircraft and the general rule of thumb is around ¼ the wingspan or rotor span of the aircraft. This ensures the aircraft is stable in ground effect, but that the aircraft is not so low as to negatively impact on spray patterns or chemical recovery.

Consequently, larger aircraft may be required to sit higher on a spray run due to increased downwash forces.

Too low and the wing may be too deep in ground effect, leading to increasing entrainment of droplets and their lateral movement outwards and into the wing vortice – resulting in ***higher*** release heights and ***poorer*** coverage.

Droplet size

Increasing droplet size has a big effect in reducing drift – probably more significant than other factors in most situations. More information is available in the 'Droplets and Nozzles' section of this guide.

The following figure provides a summary of how the size of droplets can affect both deposition/coverage and drift potential.

Figure 10.2: Droplet displacement downwind from release point
(Theoretical drift of droplets when released from a height of 3m into a steady wind of 1 m/s (3.6 km/hr)

Droplet Diameter (µm)	Sedimentation Velocity (m/s)	Downwind Displacement (m)
10	0.003	1000
100	0.23	13
250	0.92	3.3
500	2.3	1.3

A small variation in droplet size can have a big impact on drift potential as well as coverage.

Consequently, selecting the correct aircraft nozzle, set-up and operating parameters is a critical component of drift management.

Humidity and evaporation

Most nozzle data is measuring spray quality at or near the nozzle, often in a wind tunnel such as the one at the University of Queensland, Gatton.

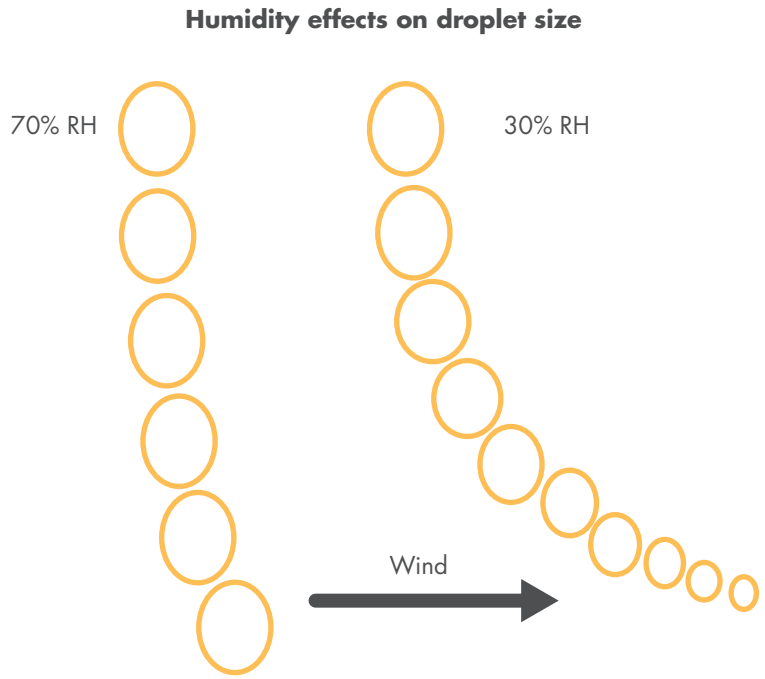
However, once the atmosphere gets to work on a droplet, what actually happens to the droplet may not be what you were intending.

As droplets 'dry-out' due to evaporation they are getting smaller. They may evaporate to the point where they contain little other than a minute quantity of material and are highly susceptible to drift. Some droplets may not reach the target at all.

Higher humidity reduces drift of water-based droplets because it minimises evaporation of droplets to 'driftable' fines.

The figure below makes it clearer that as droplets start to evaporate the effect accelerates as the smaller droplets have a greater surface area exposed to the atmosphere relative to their mass.

Figure 10.3: Humidity impacts on droplets



Delta T

Managing the issue of optimizing spray windows is reasonably straight forward - only spray in conditions that are acceptable and increase droplet size and water rates to minimise drift and aid recovery.

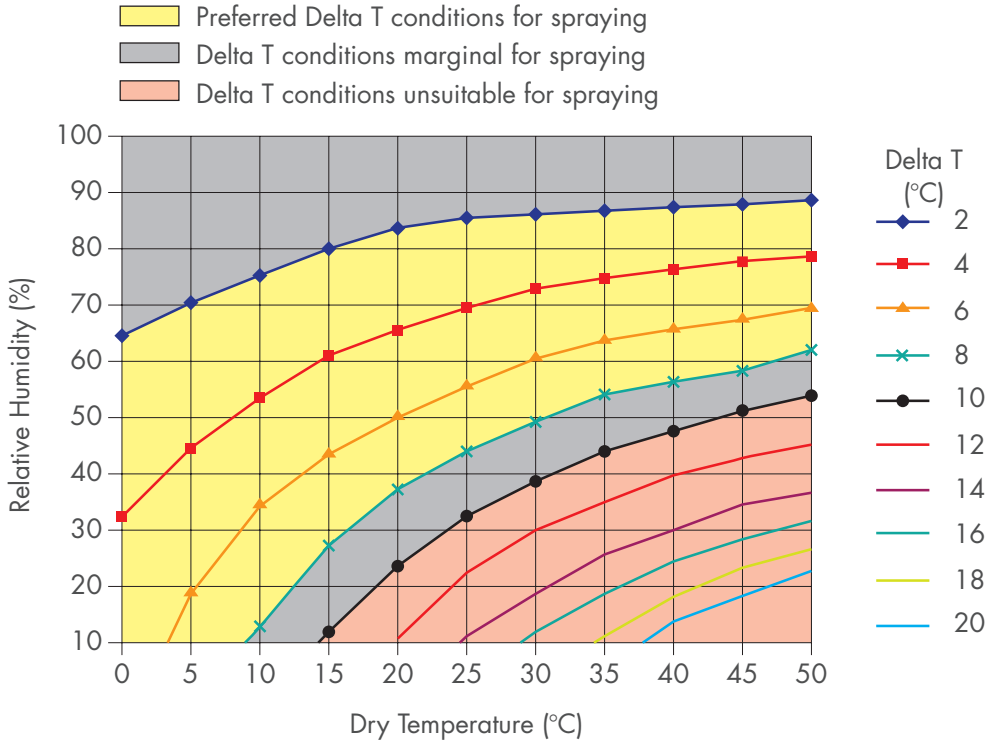
Delta T is the measurement of difference in temperature between wet-bulb and dry-bulb thermometers.

The graph below is available from the Bureau of Meteorology website and various other sources. It allows you to use a weather meter to measure relative humidity and temperature and convert that to Delta T.

Generally speaking, Delta T should be less than 10 for conditions to be acceptable for spraying.

Increasing water rates and droplet size also allow you to manage this problem but remember that most nozzles will be producing some fines.

Figure 10.4: Delta T Graph *(Source: BoM)*



DRIFT MANAGEMENT TOOLS

In addition to the selection of appropriate droplet size, release height and only spraying in acceptable weather conditions, the following additional tools are available to get the job done:

Buffers and field splitting

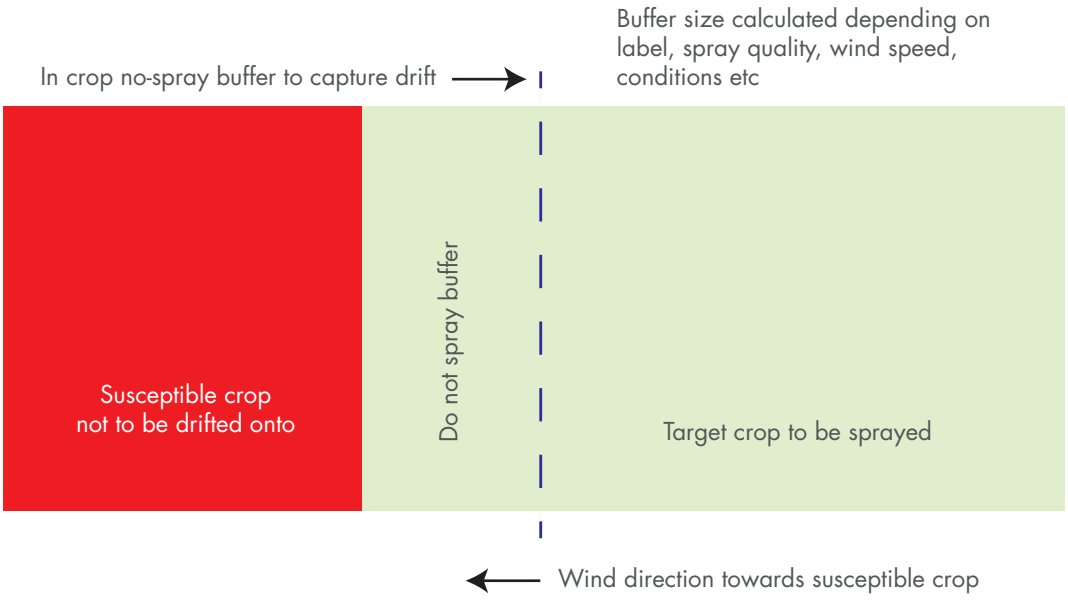
Downwind spray buffers are a useful technique for keeping spray within a treatment area.

Clearly, compliance with any mandatory label requirements for buffers is non-negotiable.

Using wind direction is a critical tool for drift management and keeping spray within the application treatment area.

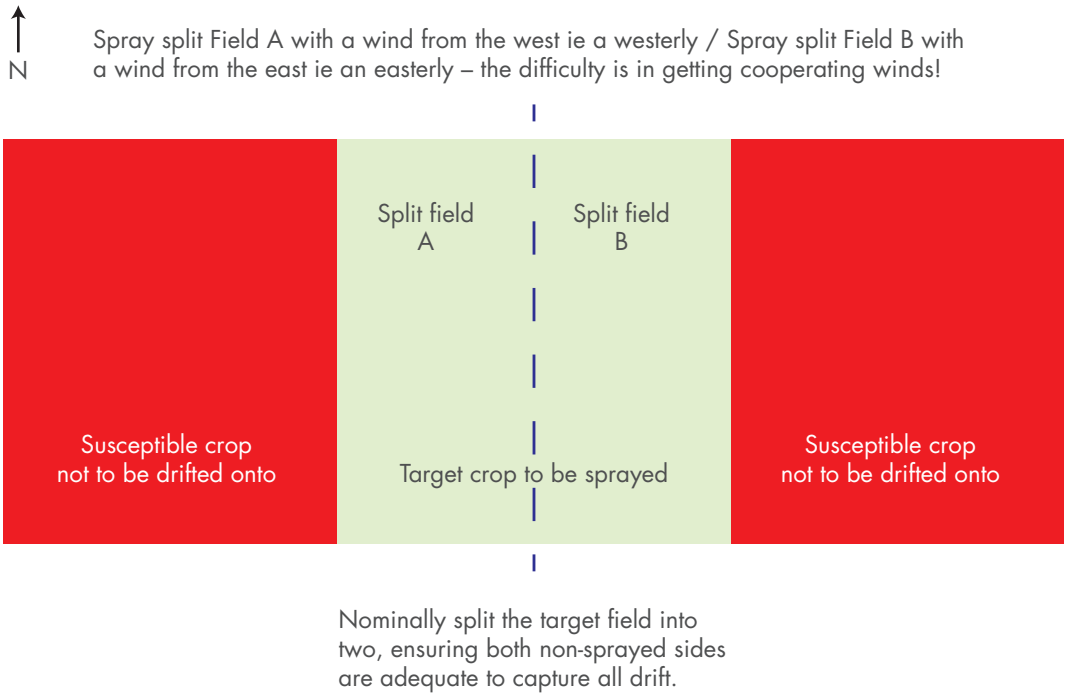
If a target area has hazards on more than one side, it may be possible to conceptually split the field in two or more sections and wait for an optimal wind direction for the different sections to keep spray within the target zone. Where regular applications are required (such as on irrigated cotton or rice), development of an Application Management Plan (AMP) may be a useful management technique to predetermine spray decisions in accordance with changing weather conditions.

Figure 10.5: Using a buffer to protect a sensitive area



In treating larger areas, applicators are able to use different wind directions to treat an entire field by splitting the field and waiting for the correct conditions to treat the two halves – using each segment as a buffer at different times to capture any drifting droplets.

Figure 10.6: Field Splitting



No-spray zones

Some States and Territories have established mandatory no-spray zones to protect dwellings, schools and other sensitive areas.

In NSW, for example, there is a mandatory no-spray zone around dwellings and other areas as a result of Pesticide Order Air 1 (PO Air 1). While notification requirements may be triggered in these circumstances, your qualified aerial applicator will be aware of the requirements. Please note however, that notification requirements in some circumstances may lead to delays in treatment.

CASA also has regulations governing how close an application aircraft can fly to a dwelling, being no closer than 100 metres horizontally or 350ft in height. Again, this may trigger notification requirements.

Awareness and communication with your aerial applicator is critical to managing this and related issues.

Micro-climates

Irrigated fields can often generate micro-climates just above the canopy which may be an advantage for applications based on accurate in-field assessments, especially regarding spray quality, temperature and humidity decisions.

11. IMPROVING PRODUCTIVITY FOR YOUR CLIENTS

Agronomists can add significant value for their clients by suggesting productivity and safety improvements.

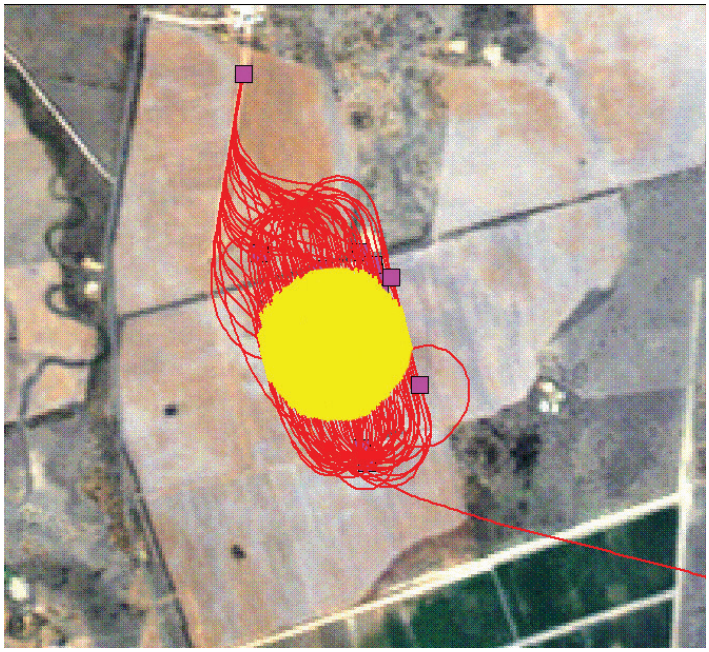
These include:

- Planning ahead - rushing and panic costs money
- Reduce travel time from airstrip to treatment area - less dead flying
- Increase field length - more spraying less turning
- Increase size of fields - economy of scale
- Increase swath - less runs, less turns
- Reduce water volumes - less trips back to the strip

PLANNING IS CRITICAL

- Aircraft can spray up to 6 ha per minute
- Every minute is valuable
- A little extra planning can really change the bottom line

Figure 11.1: Improving productivity by joining fields



1 Pivot Sprayed

2 Pivots Sprayed

REDUCING COSTS

A range of factors will impact on the economy of an application:

- Water Volume – higher volumes may require more loads
- Field size and spray direction – longer and larger fields reduce the ratio of productive application to turning
- Distance to the airstrip – ferry time is a straight increase to cost
- Number of times you use the aircraft – frequent clients become more familiar with aircraft use and more adept at planning to improve aircraft productivity.

You can add value for your clients by making the aircraft even more efficient:

- Spray sensibly
  - Use only required water volumes in line with sound agronomy and the label
  - Recommend the correct rate (label / permit compliant)
  - Discuss coverage with your aerial applicator and use the tools available like the AAAA Water Volume Calculator
- Reduce flying hours
  - Have an airstrip close by or preferably on-farm
  - Put aircraft on larger, longer fields
  - Put jobs together
  - Encourage neighbours to work together
- Remove hazards
  - Removing hazards is good for safety and productivity
  - Trees, aerials, weather monitoring equipment and powerlines are all hazards
  - Mark powerlines – your aerial applicator can advise how

Figure 11.2: Significant application savings are possible

AREA	FIELD LENGTH	DISTANCE TO STRIP	WATER VOLUME	INDICATIVE SAVINGS SCALE
200 ha	800 m	15 km	30 L/ha	100
200 ha	2000 m ↑	15 km	30 L/ha	65 ↓
200 ha	2000 m	15 km	20 L/ha ↓	60
200 ha	2000 m	5 km ↓	20 L/ha	50
200 ha	2000 m	5 km	30 L/ha ↑	52
600 ha ↑	3000 m ↑	5 km	30 L/ha	40

Disclaimer: *The table above is for demonstrative purposes only to give an indication of the possible relative impact and the possible relationships of variables to potential costs. Real world costs and relationships will vary depending on a wider range of factors.*

TAILORING SPRAYS FOR PARTICULAR SCENARIOS

The agronomist's knowledge of what is happening in the target crop is extremely valuable to the applicator for both economic and efficacy reasons.

Every application should involve a science-based discussion with your aerial applicator to arrive at a treatment that is tailored to the particular job goals.

The table below shows the effect of changing one of the required parameters and the consequent effect on water volume. It is critical to know what you want!

Figure 11.3: Targeted applications have significant implications

Crop situation	LAI	Droplet Size (µm VMD)	Drops per cm²	Water Volume (L/Ha)
Weeds in bare fallow	1	250 µm	20	16 L/Ha
Grubs on Sorghum	1	180 µm	40	12 L/Ha
Cotton prior to close	2	160 µm	40	17 L/Ha
Cotton full canopy	3	160 µm	40	26 L/Ha
Cotton full canopy	3	180 µm	40	37 L/Ha

Disclaimer: *The table above is provided for example purposes only and should not be relied on for in-field decisions. Its sole purpose is to highlight how different use scenarios may impact on spray decisions, especially where drift management requirements are not a primary consideration (for example, due to same-farm buffers).*

APPLICATORS ADDING VALUE

Accurate Spray Quality

Applicators use a range of methods to ensure the spray quality required is delivered. These include:

- Using droplet calculators from manufacturers, AAAA or government agencies to ensure nozzles selected are producing the required spray quality based on sound science and assessments
- Pattern testing aircraft to ensure aircraft set-up is optimal and drift potential is minimised
- Having a range of nozzles to select from to deliver different spray quality required for different jobs
- Having well trained pilots and ground support staff to understand what equipment settings produce what result and how to deploy them

Aircraft flow controllers

As aircraft are moving in an air mass, their speed over the ground can vary depending on wind direction and strength – eg a tailwind or a headwind.

Application aircraft manage this by having on-board flow controllers that adjust the flow of spray to ensure the same application rate is achieved regardless of direction and relative ground speed.

Variable rate and precision applications

Aerial application equipment and techniques continue to advance and variable rate aerial application is now a reality. Precision farming and prescription application plans can be developed. Ask your applicator if these technologies are available to meet client needs.

Developing prescription maps should be done in conjunction with your aerial applicator to ensure compatibility of mapping systems.

GPS Guidance Systems

Almost all application aircraft are fitted with application-specific GPS swath guidance via a light bar that tells the pilot whether they are exactly on track or not.

In addition to other features, most modern GPS application aircraft units offer data logging, with some having full wireless and even internet cloud operability.

AGRONOMISTS ADDING VALUE

As a key member of the application team, agronomists can add significant value by providing:

- on-label recommendations
- target information – including pest, size, position in crop, stage, catching surface
- chemical information – mode of action etc
- discuss desired coverage with the operator – more water is not necessarily better!
- tell the applicator what you are trying to achieve.

A key challenge in providing good spraying outcomes is the critical need for accurate agronomy and recommendations. Not only do recommendations need to be legal (ie on label), they need to be based on accurate in-field assessments that are representative of the entire crop – not just the convenient corner where access is easiest.

In larger treatment areas, it is clearly valuable for assessments to be made in a number of parts of the crop so that the treatment – including spray quality and chemical rate decisions – are based on providing the best control.

12. MANAGING THE JOB

The problem has been identified, the recommendation has been made, the chemical has been selected and ordered and the application request form has been completed and sent to the aerial applicator.

Now what?

CONFIRMING THE MAP AND THE AMP

The aerial applicator will now undertake their own due diligence to confirm the requirements of the job.

The practical application of the information gathered and the decisions taken during the preparation of the Application Management Plan (AMP) as well as the confirmation of the AMP and the associated map are a critical phase of the application.

A key part of this process is the applicator checking information provided.

This is not unnecessary duplication. This is part of the industry's professional approach to risk management, sound application and safety in depth.

MONITORING THE APPLICATION

A key part of any plan or risk management approach is to ensure that progress is actively monitored throughout the implementation of the plan. Monitoring of an AMP is a critical component of successful aerial application. Monitoring is carried out at a number of levels and in a number of ways during an application.

If conditions change, a change in the AMP may be required and the pilot may have to change the aircraft set-up to match the conditions. If conditions deteriorate too far, the pilot may have to stop the application and wait for better conditions that are again within the plan's parameters.

Some changes, for example equipment failure or the unexpected appearance of people near the treatment area, may demand a stop to work and a complete reappraisal of the plan.

MONITORING WIND SPEED AND DIRECTION

Many chemical labels have restrictions on spraying in certain wind conditions – both too low and too high.

Pilots are well trained to look for, understand and interpret clues to wind speed and direction. Pilots have a responsibility to not only be able to estimate wind speed accurately, but also to physically note any significant changes on the job record – including if spraying is stopped because of poor wind conditions.

In addition to the pilot's training and use of the aircraft 'smoker', windsocks put in place by farmers also provide excellent information.

The use of 'smokers' fitted to application aircraft, whereby a small amount of light oil is introduced to the exhaust manifold by a switch in the cockpit during a spray pass, is an excellent tool for monitoring wind behaviour.

Surface temperature inversions have enormous potential to significantly increase the lateral movement of spray droplets - drift. Monitoring weather conditions to ensure operations are not conducted in an inversion is critical.

JOB COMPLETION RECORDS

Each State and Territory have specific guidelines as to what records need to be kept post each application. These include (but are not limited to):

- date and times
- complete trade name of product/s
- application rate of product/s
- crop type (at times, growth stage), target or situation of application
- client name, address / location and area treated
- weather data during application
- business operator and pilot details

This record needs to be completed within 24 hrs of the job completion. The agronomist's assistance in accessing this information by use of a Standard Application Request form is greatly appreciated.

13. MYTH-BUSTING AND PROBLEM SOLVING

Aerial application commenced in Australia in 1948. Over the following decades of changing practices, improvements and challenges, there has been ample opportunity for 'myths', confusion and misunderstandings to emerge and sometimes to be exaggerated.

The following section tries to demystify some of the highly persistent misconceptions regarding aerial application.

If you have a particular concern, feel free to raise it with AAAA or your aerial applicator.

PROBLEM SOLVING

We are sometimes confronted with outcomes that we weren't expecting and like many scientific challenges, problem-solving lends itself to a process:

- Keep an open mind
- Clearly identify the problem – not jump to conclusions
- Collect and follow the evidence – don't try and make the evidence fit a theory
- Start a discussion with the applicator/s involved – never lead with an accusation
- Ensure your net is cast wide enough – are there other viable or more likely scenarios that could have led to the issue
- Ask 'why' at least 5 times to get nearer to the underlying cause
- Never be afraid to say 'I don't know'

This approach is a useful set of principles to understand what has occurred, but can be buttressed by reference to a range of established sound aviation practices:

- Aviation investigative model – see https://www.atsb.gov.au/about_atsb/investigation-process/
- Understand relevant human factors including cognitive biases – see Prof Sidney Dekker: The Field Guide to Understanding Human Factors - http://sidneydekker.com/
- Swiss Cheese model – see Prof. James Reason: https://www.flightsafetyaustralia.com/2016/09/safety-in-mind-swiss-cheese-and-bowties/
- Understand cultural influences – see Prof. Patrick Hudson: https://www.safeworkaustralia.gov.au/media-centre/moving-culture-ladder-professor-patrick-hudson

RULE 1 – IT IS NOT ALWAYS THE AIRCRAFT!

Due to their high visibility, aircraft are blamed for many issues that, upon a scientific assessment, are clearly not aircraft related.

Plant damage or contamination can be caused by a range of factors, not just chemical drift from aircraft. For example, water stress, soil and nutrient variation or damage from ground rig application or poor ground-rig decontamination practices are just some of the possible causes that should be considered if looking at unexplained damage.

It is worthwhile noting that in every State and Territory, chemical control of use regulators report that ground rig complaints regarding spray drift significantly outnumber complaints regarding aerial application every year – often by an order of magnitude.

Chemical drift damage can take a number of forms with the following tell-tale signs:

Inversion damage

Inversion damage is generally characterised by damage following a drainage pattern related to topography. In other words, smaller droplets suspended in the inversion will follow the drainage pattern of the surrounding country.

Aerial application pilots receive considerable meteorological training to gain their Commercial Pilots licence and then additional training and examination to gain their application rating. This is further added to by Spraysafe training for their State/Territory chemical licences. This training includes meteorology and the interplay with chemical application and consequently aerial application pilots are well aware of the importance of not spraying when a surface temperature inversion exists, and in identifying inversions and the time required for their break-up.'.

Volatilisation damage

Some chemicals – especially older types that are not applied by air (eg 24D ester) are highly volatile. This means that even though the application was successful, the product may actually lift off from the target area after application and move laterally to cause damage elsewhere. Spraying in the correct anticipated meteorological conditions will avoid volatilisation. More importantly, few if any modern chemicals available for aerial application volatilise.

Direct spray drift damage

Spray drift damage generally has a signature degradation profile across a downwind paddock – this is why buffers are used when required. Closer to the source should reveal more damage and further away, less. Without this typical profile of degradation of impact, it is unlikely to be spray drift – and certainly not aircraft.

There is no way of telling from an in-field inspection alone whether spray drift damage has been caused by an aircraft or ground rig.

A poorly set-up or operated ground rig generating smaller droplets or spraying in an inversion has a significant drift potential when compared to a well set-up and operated aircraft.

Spray drift simply moves downwind propelled by the prevailing breeze until droplets sediment out under their own mass or are captured by a collecting surface. There is no known physical mechanism by which spray drift can move upwind.

In addition, spray drift does not magically disappear and then resume later. In general, while there may be some local effects or 'blanking' around obstacles such as trees, spray drift deposition would be reasonably anticipated to conform to a degradation profile consistent with distance from the source.

If this is not evident, then you may not be looking at spray drift at all, or you may be looking at different instances of spray drift. It is always best to start with a conversation, not an accusation.

TREATMENT DIRECTION

Without doubt, the best treatment direction for aircraft is with a crosswind. This will aid deposition within the target canopy or surface as turbulence from wind across the crop will assist with carriage of droplets into a canopy and with general deposition.

Treating along the rows or across the rows does not appear to provide any particular benefits in terms of deposition when compared with treatment with a crosswind.

The 'stop distance' of a droplet once it leaves the aircraft nozzle is surprisingly short – often less than 50cm. Once the droplet slows to an ambient speed, it will be carried into the crop by the sedimentation due to mass or by the prevailing wind – completely negating any perceived advantage of flying with or across the rows.

In many cases, a client or agronomist requirement to apply with or against the rows will simply add cost and complexity to the job.

While not all treatments may be possible with a crosswind, for example due to paddock shape or the presence of hazards or terrain, this is a decision best left to the pilot to assess in combination with considerations of safety and effectiveness of the application.

TREATMENT HEIGHT

Different aircraft will have different optimal treatment heights, depending largely on the wingspan / rotorspan of the aircraft.

As a well-proven rule of thumb from NASA research and decades of aircraft pattern testing, the optimal flying height for spraying treatments is at approximately ¼ of the wingspan/ rotorspan of the aircraft.

This ensures the aircraft is stable in ground effect, but that the aircraft is not so low as to negatively impact on spray patterns or chemical recovery.

While spraying height has an impact on potential drift - both for aerial and ground - this does not necessarily mean lower is better.

Consequently, larger aircraft may be required to sit higher on a spray run due to increased downwash forces.

Too low and the wing may be too deep in ground effect, leading to increasing entrainment of droplets and their lateral movement outwards and into the wing vortice – resulting in ***higher*** release heights and ***poorer*** coverage.

Many chemical labels place a requirement on pilots for treatment height of 3 metres, but this is to permit drift modelling and buffer setting on label. However, APVMA has recognised the issues created by this requirement and has already moved to offer alternatives on recent 2,4-D permits.

PATTERN STRIPING

If an aircraft has not been pattern tested or is operated differently from known parameters (eg coarser droplets, wider swath or higher release height) this may result in 'striping' (ie a stripe effect) of the job, where uneven spray patterns lead to uneven results.

While rare, striping may be a function of any of the following scenarios:

- swath width not being reduced to take account of a coarser quality spray being used (for example, for improved drift control)
- aircraft being flown too high for the spray quality being used (ie not enough swath overlap being used)
- aircraft being flown too low (leading to stronger vortice entrainment of droplets and disruption of the aircraft Coefficient of Variation and spray quality)
- aircraft not being pattern tested and consequently 'heavy' spots being seen under the aircraft as a result of additional droplet entrainment by the propeller or by upwind vortices dumping additional product into the pattern behind the aircraft
- aircraft not being pattern tested and 'light' spots or 'holes' in the pattern

It is worth noting that the pattern from aircraft immediately behind the boom may appear uneven, but due to turbulent airflow in the aircraft wake there is considerable mixing of droplets and the pattern may 'fill in' and provide excellent coverage.

COTTON DEFOLIATION CHALLENGES

As farming techniques change to improve yields, application techniques and expectations may also have to change.

By developing more robust varieties, keeping cotton well-watered closer to picking, introducing additional nitrogen later in the crop growth cycle, or by growing cotton in southern areas where temperatures may be significantly different, there may be consequences and challenges for defoliation.

As the cotton plant may be more resilient as a consequence of better genes, water and nutrition, it may require more applications to achieve the same defoliation outcome as in previous years.

While cotton aerial applicators are aware of this challenge and continue to adapt techniques to get the best outcome in the least number of passes, agronomists should also adapt expectations and work with their local applicator to get the best defoliation outcome.

While previous experience indicated that for an optimum defoliation, smaller droplets will provide an excellent outcome, thicker, denser canopies as a result of new varieties and new agronomic techniques may require different approaches to achieve improved canopy penetration.

Discussing the outcome you are after with your aerial applicator will assist.

14. APPENDICES

AGRONOMIST AERIAL APPLICATION CHECKLIST

The Agronomists' Aerial Application Checklist

Reputable operator

- AAAA Member
- Spraysafe accredited

Planning

- Accurate Map
- Hazards to the pilot *eg powerlines*
- What's downwind
- Wind required
- Standard spray order form

Agronomy - Add value!

- Accurate field assessments all over
- Identify key label requirements
- Mode of action
- Characteristics of Target Pest
- Rate
- Water range
- Droplet quality required
- Any special needs
- Droplets per square centimeter
- Leaf Area index

Economics

- Airstrip near the job
- Lowest water possible to do the job
- Longer runs
- Book jobs together & link fields
- Remove obstacles - eg trees, wires

Essential data for the Pilot

- Aerial on label
- Product—actual product - not generic name
- Rate
- Target
- Droplets / cm^2
- LAI
- Map
- Standard Spray Order form
- What's downwind - susceptible, sensitive neighbours, bees etc

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APPLICATION DECISION FLOW CHART

AGRONOMISTS START HERE

Steps	Who's Involved	Questions/Information required
THE PROBLEM	Agronomist + Client	• Symptoms. • Insect/disease/Weed/nutrition • Also consider weather/moisture
Select solution	Agronomist + Client	• Consider an aircraft • Consider all costs – time, productivity, trampling… • What is the desired result? • Economics and efficacy • Availability issues • Must be on the label
Select Rate	Agronomist + Client	• Read the label • Usually based on pest size, growth stage, host stage, time of year
Select Coverage	Agronomist	• Leaf Area Index • Mode of Action • Target capture efficiency • Pest location
Recommendation	Agronomist	• Application Request Form • 'On label' • Hazards identified eg bees, susceptibles, sensitive areas
APPLICATION MANAGEMENT PLAN		
Water volume	Agronomist + Operator	• AAAA Water volume calculator
Droplet size / drift profile	Operator + Pilot	• Equipment selection • Environmental conditions • Nearest susceptible areas • Downwind buffer available • Droplet size required to remain in buffer • Alternatives such as wait for wind direction to change
Environmental Conditions	Operator + Client	• Met - Temp, humidity, wind speed and direction • Nil inversion • Weather forecasts • Local weather stations • On farm indicators (smoke, handhelds, windsocks etc)
Susceptible areas and hazards	Operator + Client	• Wetlands, rivers, waterways, National Parks • Crops, livestock, pasture, TSR • Schools, inhabited dwellings • Workplaces, people, other contractors • Roads/traffic, bus stops • Powerlines, towers • Google Earth
APPLICATION REQUEST RECEIVED	Operator + Client/ Agronomist	• Application Request Form • Maps, Google earth • Confirmation of 'on label'

PILOTS START HERE

AERIAL APPLICATION ASSOCIATION OF AUSTRALIA LTD.

AERIAL APPLICATION REQUEST FORM

OFFICE USE ONLY

CLIENT/JOB No. .....

INVOICE No. .....

TRADING NAME _____ CONTACT PERSON _____ PH. No. _____ MOBILE _____

ADDRESS _____ U.H.F. _____ MAP REF. _____ G.P.S _____

_____ P/CODE _____ DATE OF ORDER ___/___/___ PREFERRED TIME _____ PREFERRED WIND DIRECTION _____

AGENT _____ RECOMMENDATION MADE BY _____ VALID FROM ___/___/___ UNTIL ___/___/___

CROP	HA	WEED/PEST	CHEMICAL	SUPPLIER	BATCH No.	APP. RATE/HA	WATER VOLUME/HA	COST PER HA $		
								AIRCRAFT	CHEM	TOTAL

DATE	AREA TREATED	TIME	AIRCRAFT	TACHO			WEATHER			LOADER	PILOT	
				START	FINISH	TOTAL	WIND	TEMP	CONDITIONS			

THE PILOT SIGNING THIS FORM CERTIFIES THAT THIS IS A TRUE AND ACCURATE RECORD OF AERIAL SPRAYING

MEMO

POWERLINES YES / NO (SEE MAP)

OTHER HAZARDS _____

_____

_____

***ENVIRONMENTAL CONSIDERATIONS AND/OR REMARKS FROM REVERSE SIDE**

_____

_____

_____

_____

GUIDELINES & CHECKLIST FOR AERIAL APPLICATION

AERIAL APPLICATION ASSOCIATION OF AUSTRALIA LTD.

Guidelines

A. Complete the Aerial Application Request Form on the reverse side, giving as complete as possible all information requested. Disregard columns with shaded headings.

B. It is mandatory to supply a map of the proposed treatment area. The map must include a clearly drawn NORTH arrow, show any powerlines passing over or adjacent to the treatment area, and include all other information necessary for the pilot to safely locate and carry out the job.

C. The following checklist MUST be completed before any aerial application can be carried out. To ensure the accuracy of this information, all neighbours who may be affected by the proposed aerial application should be consulted before answering the following checklist.

Checklist

	Circle as reqd.	
1. Are the agricultural chemicals you intend to use registered for aerial application and are the required application rates in accordance with the label recommendations?	**YES**	**NO**
2. Have you shown on the accompanying map the land use and vegetation type on ALL sides of the proposed treatment area?	**YES**	**NO**
3. Are there any houses, workplaces or any other inhabited buildings or sensitive areas over or near which the aircraft must not fly?	**NO**	**YES**
4. ENVIRONMENTAL CONSIDERATIONS	**NO**	**YES**

Adjacent to the treatment area, are there any of the following which may be susceptible to, or contaminated by any of the products you intend applying?

(Circle below as appropriate)

CROPS	ORGANIC FARMS	AQUATIC FARMS	DAMS	TREES	SCHOOLS/BUS RUNS
PASTURE	BEES	CHANNELS	ROADS	FLORA/FAUNA	WORKERS/CONTRACTORS
LIVESTOCK	VINES	RIVERS	GARDENS	DWELLINGS	TOWNS

If you have answered in this column, or circled any of the above, please give additional information on the other side of this form.

Please SIGN and return these completed forms and your map to our company or your chemical agent
FAILURE TO CARRY OUT ANY OF THE ABOVE WILL MEAN AERIAL APPLICATION WILL NOT PROCEED.
I certify that the information provided in this checklist is, to the best of my knowledge, complete and correct.

Name: _____ Signature: _____ Date: _____

Thank you for assisting the Aerial Agricultural Industry maintain the highest possible standards.

TERMS & CONDITIONS OF AERIAL APPLICATION

1. The aerial applicator warrants to use its best endeavours to undertake the application based upon the instructions contained in the spray order/work order form. Unless the spray order form is fully completed and signed where indicated the aerial applicator is released and indemnified by the contracting grower/farmer from all actions, suits, claims, demands, costs, damages and expenses due to the application or any pre-application tasks howsoever arising. This clause is a fundamental term of this agreement.
2. If adverse environmental conditions, including adverse weather conditions, cause any delay in the application from that represented in the spray order form (which environmental conditions shall be within the sole discretion of the aerial applicator), the aerial applicator will not be liable for any costs, claims, suits, demands or any consequential damages or losses of the contracting grower/farmer due to the delayed application.
3. Any liability of the aerial applicator for breach of any provisions of or term implied by the *Competition and Consumer Act* 2010 or equivalent state legislation shall not exceed the resupply of the application in question or payment of the cost of resupply.
4. In no event whether as a result of breach of contract, warranty, tort (including negligence) or otherwise shall the aerial applicator be liable for any special, consequential, incidental, exemplary, aggravated or penal damages or expenses including but not limited to loss of profit, goodwill, reliance loss, costs or claims by third parties. This warranty is exclusive of all other warranties or remedies whether written, oral, implied or statutory. Any and all implied warranties of merchantability, fitness for a particular purpose, course of dealing or usage of trade are hereby expressly disclaimed and excluded as allowable under the law.
5. Payment to the aerial applicator shall be made within 14 days of receipt of invoice and must be received by the aerial applicator before any dispute or claim can be made in relation to the application.
6. In consideration of the aerial applicator undertaking the application, the contracting grower/farmer agrees to release and indemnify the aerial applicator, its officers, directors, agents, servants, employees and shareholders and suppliers of any aircraft from any and all liabilities, claims, demands or actions or causes of action whatsoever including any liability imposed by statute, arising out of any damage, loss or injury to the contracting grower/farmer or third parties due to the aerial application or pre-application tasks whether such loss, damage or injury results from negligence of the aerial applicator, its officers, directors, agents, servants, employees or shareholders or from some other cause.
7. The contracting grower/farmer or their agronomist or agent warrants that it will notify the aerial applicator of all relevant and accurate information necessary for the applicator to carry out all appropriate planning and hazard and risk assessments and management. Such information shall include but not be limited to hazards (including power lines and SWER lines in or near the application area) and obstructions; susceptible crops; dwellings; grazing livestock; environmentally susceptible areas; school bus runs and times; staff or contractors working in or near the application area and times of their entry/exit.
8. Any requirement for neighbour notification, either specified on the label or through State legislation, industry code of practice or other means shall be the responsibility of the grower/farmer.
9. The contracting grower/farmer acknowledges that if during the course of the application it is necessary to dump a load of chemical due to requirements of safety there will be no right of action on behalf of the contracting grower/farmer against the aerial applicator.
10. By entering the agreement the contracting grower/farmer warrants and acknowledges that any chemical required by them to be applied by the aerial applicator is a registered chemical for the application required and that the application conforms to the label of the pesticide and to any relevant State legislation.
11. The contracting grower/farmer warrants that the product rate and application is in accordance with the relevant registered label and that the product is registered. If that is not the case the contracting grower/farmer agrees to indemnify the aerial applicator for any loss or damage including any loss of business of the aerial applicator.
12. Any use of odorous chemicals shall be at the sole risk of the contracting grower/farmer and the grower/farmer indemnifies the applicator from any actions arising out of the use of such chemicals.
13. The contracting grower/farmer or their agent accepts that it is at the sole discretion of the aerial applicator what means are taken to ensure the management of chemical drift. Such means could include but not be limited to aircraft set-up, application technique, water rates, use of buffer zones or waiting for better weather conditions.
14. The contracting grower/farmer accepts that there may be some areas of the application site that may not be able to be treated optimally due to the presence of hazards to safe flying including but not limited to trees, power lines and associated infrastructure, paddock shape, environmentally sensitive areas, and waterways. The grower/farmer indemnifies the applicator against any loss of yield or other issues arising from such.
15. The contracting grower/farmer agrees to ensure that all staff, contractors, visitors or others are not permitted to enter or be within the application site or immediate surrounds for the time commencing from 30 minutes before the commencement of application or until 30 minutes after the completion of the application or for the period prescribed for the re-entry into the application site on the chemical label, which-ever is the longer.
16. The contracting grower/farmer specifically acknowledges and accepts that damage may be caused to trees and other vegetation on his property during the application the contracting grower/farmer hereby acknowledges that Clause 6 of these terms and conditions applies to any such damage.
17. If payment for any application by the aerial applicator is outstanding by the contracting grower/farmer, according to the terms and conditions, the aerial applicator is entitled at its option not to undertake any further applications.
18. The contracting grower/farmer represents and warrants that he/she was not induced to enter into this agreement by and did not rely on any representations or warranties made by the aerial applicator or the aerial applicator's servants or agents about the subject matter of this agreement. The contracting grower/farmer further acknowledges and warrants that these conditions of spraying contract are the whole agreement between the parties and may not be varied except in writing.
19. The term "aerial applicator" in these conditions of spraying contract means the owner or the operator of any aircraft used in the application, the pilot of any aircraft used in the application, servants or agents of either the owner, operator or pilot, contractors or subcontractors of the owner, operator or pilot or any associated or subsidiary companies of the owner, operator or pilot.
20. The contracting grower/farmer hereby agrees and warrants that if he/she is approached by any government instrumentality including but not limited to the EPA, WorkCover or CASA or equivalent, the contracting grower/farmer will immediately notify the aerial applicator and provide whatever assistance the aerial applicator may require concerning the government instrumentality's enquiry including but not limited to all documents relating to the application.
21. Upon signing of these terms and conditions the person warrants that they have authority to bind the corporate entity (if applicable) and also acknowledges that if the corporate entity cannot pay the application costs they will be personally liable for the application costs.
22. The person signing these terms and conditions acknowledges that they have read and understood the same.

AERIAL APPLICATION ASSOCIATION OF AUSTRALIA LTD.

I hereby accept these terms and conditions:

Name: _____

Position: _____

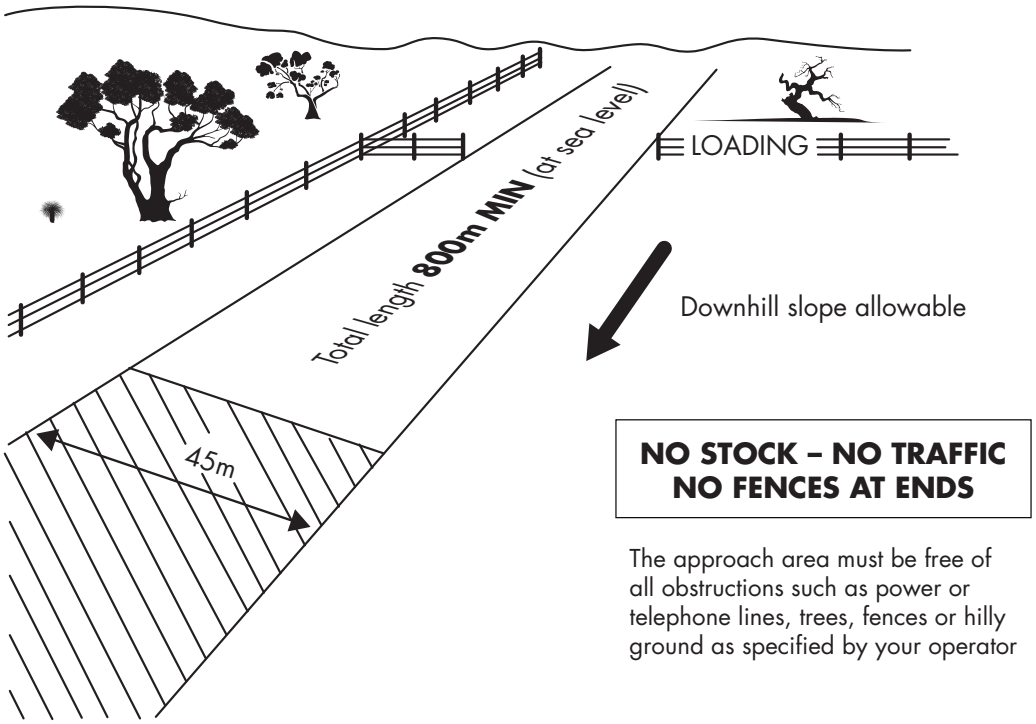
Company: _____

Date: _____

AAAA SAFER AIRSTRIPS SUMMARY

EVERY PILOT DESERVES A SAFE AIRSTRIP AND A SAFE AIRSTRIP IS A VALUABLE ASSET TO EVERY PROPERTY

A TYPICAL ONE-WAY AIRSTRIP



NO STOCK – NO TRAFFIC
NO FENCES AT ENDS

The approach area must be free of all obstructions such as power or telephone lines, trees, fences or hilly ground as specified by your operator

– STRIP LENGTH –

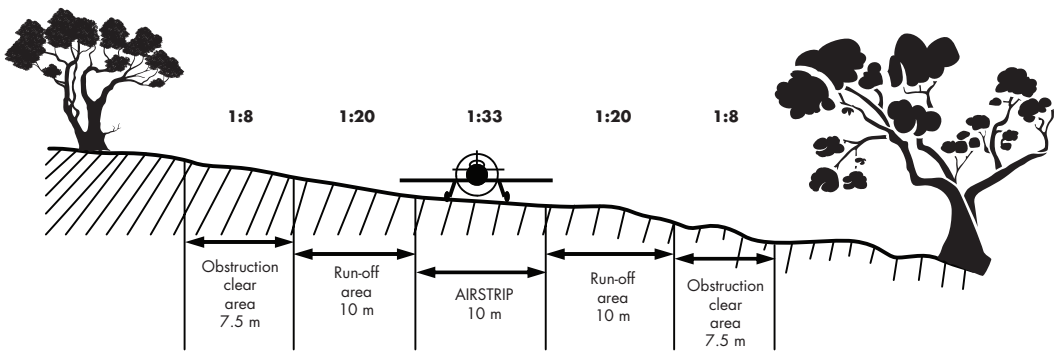
Please check strip length accuratley and discuss exact requirements with your aerial operator. Strip length required will change according to aircraft type and load, surface conditions including grass length, wind, slope etc.

ESSENTIAL FERTILISER AND STRIP SAFETY CHECKLIST:

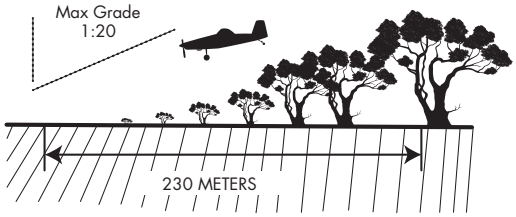
- ☑ Ensure that the loading site is of appropriate size and shape, is free of grass, rocks, sticks and cow manure, and has adequate drainage.
- ☑ This is *critical* as sticks and other contaminants (including moisture) in the product can block the aircraft spreader doors, leading to jamming and misapplication, despite the best endeavours of the pilot. This also puts the safety of the pilot at risk.
- ☑ Remove all stock from the airstrip paddock.
- ☑ Check airstrip surface for erosion - particularly stock pads. Also for wire or other debris dragged onto the strip by livestock.
- ☑ Check the strip surface by driving over it at 100 km/h without pitching or significant bumps.
- ☑ Clear the strip of any rocks, wire, twine or other materials.
- ☑ Cut grass on the airstrip prior to use.
- ☑ Always be aware of propellers

PLEASE advise the pilot of any safety problems before they arrive at your airstrip.

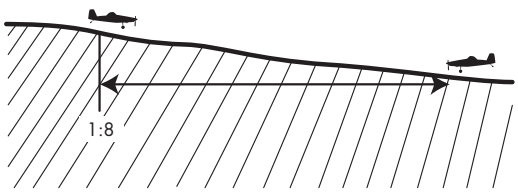
MAXIMUM ALLOWABLE CROSS GRADES



MAXIMUM APPROACH GRADIENT



MAXIMUM ALLOWABLE AVERAGE SLOPE



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CROP
CONSULTANTS
AUSTRALIA