# Airblast Industry Guide

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# Contents

# 1 Introduction

This guide has been developed by SwarmFarm Robotics together with Silvan Australia and Raven Applied Technology to pass on the technical expertise that has been developed over the past 3 years. A series of sprayers have been developed, built and tested in conjunction with the flower stage detection and mapping technology as part of the Hort Innovation project. This guide will outline in detail the method to update a new or used Silvan Airblast sprayer with a Raven Hawkeye control system to be able to execute the prescription maps generated via the Flower stage detection technology. Specifically this guide will be based on using a new stock standard Silvan Supaflo 2000. This may be a specific guide for one type of sprayer and control system, however this method can be used as a general guide to update various types of orchard sprayers.

# 2 Parts List

## 2.1 Description

This section will outline every aftermarket part used on the sprayer to update it with the Raven control system. Lots of these parts are interchangeable with common plumbing fittings. The only important parts that should not be changed unless they are substituted with parts that have the same input/output signal types are the flow meter, dump/bypass valve, regulator control valve and the pressure transducer.

## 2.2 Silvan

This is the exact shopping list used to build the airblast sprayer SwarmFarm used in testing at Batlow during the 2021 flowering season. This list excludes the stock Supaflow 2000 Airblast orchard sprayer.

| Part Name | Amount Needed | Part Number |
|---|---|---|
| Conveyor | 1 | D99-110 |
| Boom Recirculation Valve (dump valve) | 1 | G8388015 |
| Proportion Control Valve | 1 | G8386010 |
| Wolf Flow Meter 5-100L/min | 1 | 46263A0 |
| Teejet Nozzle Body Quick | 24 | QJ8369-NYB |
| Blue Hollow Cone Ceramic EQV ATR-28 | 24 | HCC050 |
| $\frac{1}{4}$" M BSP to $\frac{1}{4}$" F BSP (20mm long) Adapter | 24 | 474-050L |
| $\frac{1}{4}$" M BSP to $\frac{1}{4}$" F BSP 90 degree elbow | 24 | 474-130 |
| $\frac{3}{4}$" F BSP to $\frac{3}{4}$" F BSP 90 degree elbow | 4 | 474-156 |
| $\frac{3}{4}$" M BSP Hose Barb Suit 1" Hose | 4 | G8001205 |
| $\frac{3}{4}$" F BSP to $\frac{3}{4}$" M BSP 90 degree elbow | 2 | 474-158 |
| 1" M BSP Hose Bard suit 1" Hose | 8 | G8001252 |
| 1" Tee piece FFF | 2 | G8026251 |
| 1$\frac{1}{4}$" Tee piece FFF | 1 | G8026301 |
| 1$\frac{1}{4}$" BSP FF 90 degree Elbow | 2 | G8019301 |
| 1$\frac{1}{4}$" BSP M Hose Barb suit 1$\frac{1}{4}$" Hose | 2 | G8001303 |
| 1$\frac{1}{4}$" (32mm) Black Chem Hose | 5m | 186-32M |
| 1" (25mm) Black Chem Hose | 10m | 186-25M |

## 2.3 ARAG

The is the list of ARAG part not available through Silvan that can be purchased through most Spray parts suppliers. Again this list can be substituted for other parts and other configurations can be used.

| Part Name | Amount Needed | Part Number |
|---|---|---|
| 463 series inlet ($1\frac{1}{4}$" BSP M) | 2 | 463 000.050 |
| 463 series outlet ($1\frac{1}{4}$" BSP M) | 2 | 463 000.150 |
| $1\frac{1}{4}$" BSP M Hose Barb suit 1" Hose | 2 | 1032525 |
| $1\frac{1}{4}$" BSP F Hose Barb suit $1\frac{1}{4}$" Hose | 2 | 100533 |

## 2.4 Raven

The Raven system we used was a Hawkeye Nozzle Control system with a CR7 display. Some of the wiring used on this sprayer were custom made to suitable length for this specific sprayer (with Raven Industries permission). This system could be substituted for Hawkeye 2 and a Viper 4 display very easily, these are newer and more common control systems avaliable from Raven.

| Part Name | Amount Needed | Part Number |
|---|---|---|
| Hawkeye generic cabling for pull type sprayer (option 1) | 1 | |
| CR7 Field Computer | 1 | 117-2295-001UN |
| Hawkeye Nozzle Control Valve | 24 | 063-0173-672 |

# 3 Overall Design

The main idea behind the redesign of the Orchard sprayers to include the Raven Hawkeye control system is to turn sections on and off much faster than regular section control valves, to increase the accuracy of application. The Raven Hawkeye control system uses Nozzle Control Valves (NCVs) to switch the flow of the liquid on and off instead of the regular section valves. These NCVs utilise PWM (Pulse Width Modulation) technology which pulse at 30 Hz, which means they can open and close 30 times per second. This is compared to regular section valves which can take up to 2 seconds to open or close. The NCVs are also located at the nozzle, so there is much less delay between when the valve is switched to on and the chemical arriving at the nozzle than conventional section valves. The nozzle control valves can also pulse at different duty cycles, allowing the desired rate to be applied at the correct pressure at slower speeds. For example if you were travelling at half the speed your nozzles are suited for, the Raven system will pulse the NCV's at 50%, maintaining the correct rate and pressure.

The Raven Hawkeye system also uses a "Boom Recirculation Valve" which is a valve that opens when all the nozzles are turned off. This allows the system to maintain a flow rate similar to when the nozzles are on, the effect of this is the pump/control valve has to spool up and down less and less often which increases the accuracy of the rate applied out of the nozzles. Below (Figure 1) is a plumbing diagram outlining the basic setup of the upgraded sprayer.

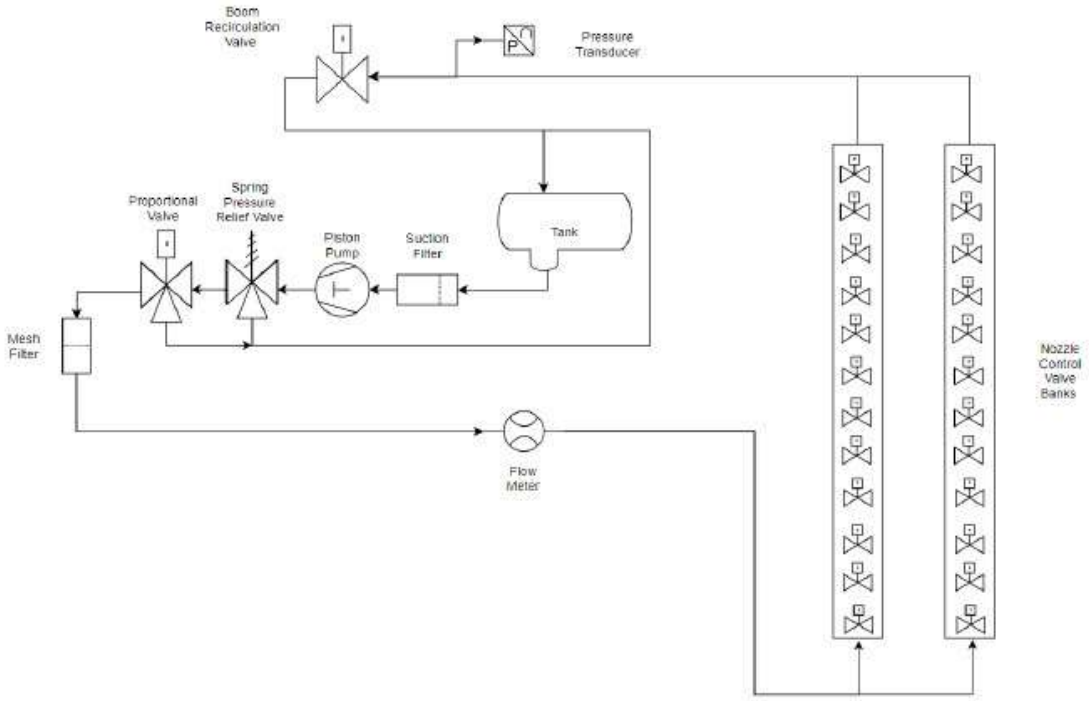


Figure 1: Sprayer Plumbing Diagram

# 4 Build Procedure

## 4.1 Removal of the Silvan Parts

Remove all the Silvan control system located above the pump. All will be not needed except the manual pressure relief valve and the filter. The control valve will have to be replaced with the faster 7 second Proportional control valve to ensure changes in rates will be followed quickly. The Section control valves will not be needed, however the dump/ bypass valve will be moved to the end of the circuit. The following image (Figure 2) shows the stock Silvan control bank.

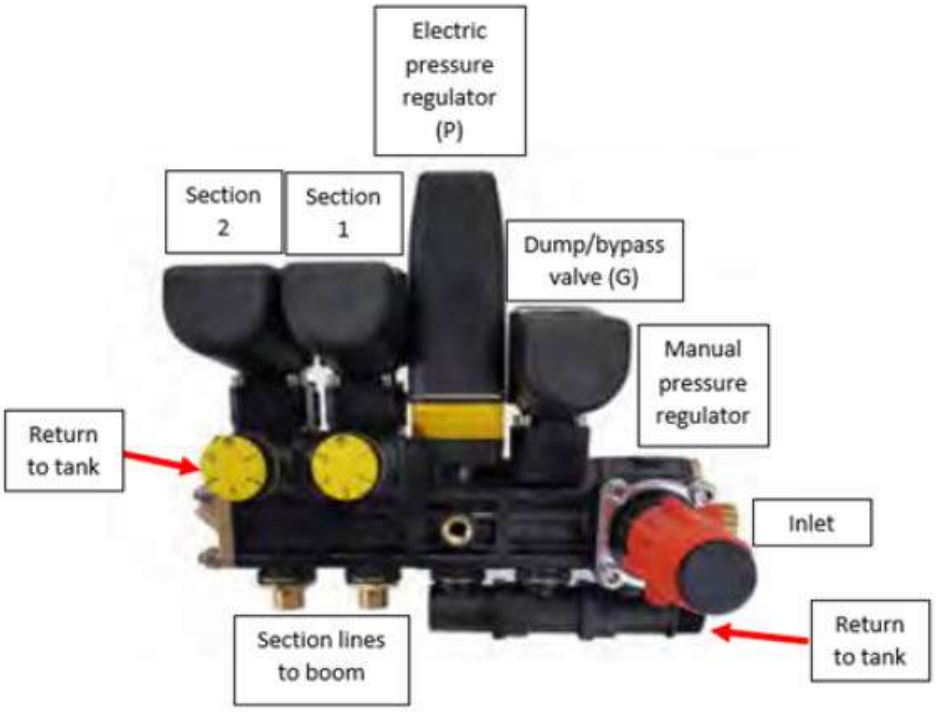


Figure 2: Control System used by Silvan

## 4.2 New Raven Control System

As the Raven Hawkeye control system uses individual nozzle valve the section control valves are not needed. The new control bank will incorporate a manual pressure regulator (as a safe guard), the electric proportional control valve to regulate flow/pressure in the system, a fine mesh filter and on the return line a boom recirculation valve (or dump valve).

This method allows the system to maintain pressure and flow to the nozzles, as the dump valve only opens when all the nozzles are turned off. This in turn then allows for much more accurate application of chemicals

in regard to the rate and accuracy of the location of application. Each nozzle can turn on and off or 'pulse' in a fraction of the time that a section control valve can open or close, allowing for much more accurate section control at higher speeds.


Figure 3: Control System now used

## 4.3 Plumbing

Remove the original section lines that feed chemical to each side. The outlet from the new control bank leads to the spray bars via a flow meter which fits conveniently inside the chassis of the Supaflo 2000. This hose is 1 ¼" black chemical hose and runs to the back of the sprayer where it splits to each side. This hose goes into a T piece under the PTO shaft at the start of the fan where it splits into 2 1 inch hoses to go to each side.

Figure 4: Flow meter located inside the chassis rail

Figure 5: Pressure side T piece, under the fan bearing block

## 4.4 Original Spray Bars

The original spray bars can be removed to make way for a conveyor. The conveyor is added to improve the accuracy of the spray delivery and to concentrate the airflow to the selected part of the trees. The conveyor is attached to the sprayer fan frame by M6 bolts on the front and rear of the conveyor.

Figure 6: Conveyor attached to the Silvan sprayer fan

## 4.5 Fitting out the conveyor's spray bars

First step is to remove the factory nozzles, this should leave a ¼ bsp female thread at every nozzle location. Using the ¼" bsp MF 90 degree elbows and the MF ¼" adapters you should then be able to attach the teejet non drip quick release nozzle body. The non drip cap is then removed and the Raven Nozzle Control Valve (NCV) is put in its place. Hollow cone ceramic (HCC) nozzles with quick release teejet nozzle caps were used in this application.

Figure 7: Assembled elbow, spacer, nozzle body and nozzle cap

Figure 8: Assembled nozzle and NCV

Each spray bar also needs an inlet and an outlet connection to 1" black chem hose. The ¾" BSP caps were removed from the top of the new spray bars and 2 elbows were used to reroute the chemical back down to a tee piece where it is then plumbed back to the boom recirc valve at the front of the sprayer.

Figure 9: Fully Assembled Conveyor

At the bottom the original elbows are used along with an MF ¾ to 1" adapter and a 1" hose barb to create the inlet for the spray bars.

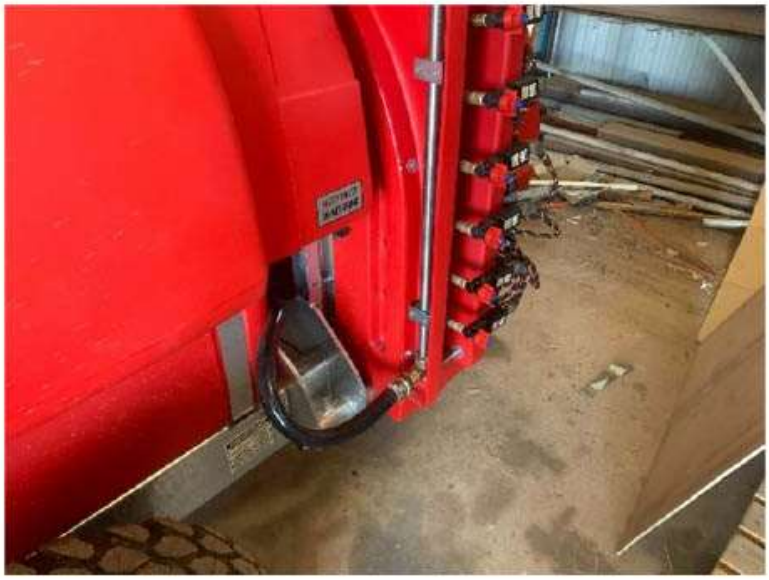

Figure 10: Bottom input to spray bars

## 4.6 Return Line

The outlets from the top of the spray bars join in the middle at the bottom of the conveyor at a Tee piece. A single return line then follows the inlet line back to the control systems at the front of the sprayer. The return line then enters the boom recirc valve, this will allow the pump to continue circulating chemical through the system when all nozzles are turned off. The boom recirc valve also houses the pressure transducer.

Figure 11: Boom control with Incorporated pressure transducer

## 4.7 Hawkeye Controller

The raven Hawkeye uses a single small controller, on this sprayer it is mounted on the rear, between the fan and the tank. A small plate was made to hold the controller which is secured to the sprayer by 2 holes that were drilled and tapped with M6 thread.

Figure 12: Hawkeye Controller

## 4.8 Wiring - Hawkeye generic cabling for pull type sprayer (option 1)

Generic wiring harnesses can be used along with some basic extensions to reach the front of the sprayer. The only sensor cables that are needed are the flow meter, control valve, boom recirc valve and the pressure sensor. Extensions may have to be made for these if the generic wiring harness does not reach. The nozzle harnesses in these photographs are custom made to suit the sprayer however generic ones will also do.

Figure 13: Rear view of fully assembled conveyor

Figure 14: Nozzle wiring harness

The "ISO/Nozzle power extension" cabling that runs from the back of the tractor to the Raven Hawkeye ECU sits inside the left side chassis rail. The only other cables that run from the ECU are to the nozzles which go straight from the bottom of the ECU, between the fan and the tank to the conveyor. There is extensive documentation for the installation of Raven Hawkeye systems on broadacre sprayers which can be easily adapted to suit the plumbing setup of an Air Blast sprayer like this.

## 4.9 Raven Software Setup - UT

There is also extensive documentation for setting up a Raven Field Computer to work with a Raven Hawkeye system. The following will show the setup the worked for this Supaflo 2000 and CR7 Raven Field computer.

The Field Computer should automatically pick up the Hawkeye ECU on the sprayer the first time it is hooked up together. The ECU should then pick up each individual nozzle control valve. The screen on the Field Computer should look something like this at this stage:

If the total and left nozzle counts are correct proceed, otherwise refer to the Raven Hawkeye documentation for troubleshooting.

Set the Applicator type to Sprayer and continue. Enter the nozzle spacing on the next page. To suit the maps the Swarmfarm Decision Support tool creates, the sprayer needs to match the width of the maps, so the nozzle spacing must be the total width divided by the number of nozzles. This corresponds to having the right number of nozzles turning on and off when spraying the top and bottom sections of trees separately. For the 24 nozzle


Figure 15: First screen of Hawkeye calibration setup


Figure 16: Select the applicator type: Sprayer

supaflo 2000 we entered a nozzle spacing of 16 centimeters is used.


Figure 17: Input Nozzle Spacing

The next step is to select the nozzle size installed on the sprayer. We used HCC050 nozzles, the configuration of this sprayer does not incorporate a Bypass Tip so leave Bypass Tip Size as NA.


Figure 18: Select the tip size on the sprayer

Next the Raven system will find the location of each nozzle in regard to the top and bottom of each side. This is what auto indexing means.


Figure 19: Start Auto Indexing

Leave "Enable Fence Rows" unchecked.


Figure 20: Do not check fence rows

Set the number of sections to 4. This corresponds to the top and bottom half of the tree on the left and right side. The Swarmfarm DST will output maps with 4 sections to spray each area of trees accordingly.


Figure 21: 4 section are used to execute the SwarmFarm maps

Set the width of each section to 96cm.


Figure 22: Set the section widths

Leave the boom offset as 0cm.


Figure 23: Set Boom Offset

Set the Valve Type as "Fast". A fast proportional valve is used in this setup, however a PWM hydraulic control valve has also been used on previous versions of this sprayer with success.


Figure 24: Select type of control valve

Set the pressure sensor range to suit the pressure sensor in the system (the Raven sensor that comes with the Hawkeye kit has a range of 0-250psi with is 0-1725 kPa roughly).


Figure 25: Select pressure sensor range

Fill out the details of the Flow meter installed on the sprayer. The following calibration values suit the Flow meter recommended at the start of this guide.


Figure 26: Flow meter specification

Set the desired target rate (this will only be used when not spraying using prescription maps).


Figure 27: Target rate

The max pressure of the Hawkeye Nozzle control valves is 550kPa, it is suggested to set the pressure to 500 kPa to allow for spikes.


Figure 28: Target pressure

After this the initial setup is complete. This sprayer can then be used as a regular airblast sprayer, the Hawkeye system will regulate pressure and rate like a regular spray control system with section control etc.

## 4.10 Raven Software setup - Machine Dimensions

The next step in the setup will input the dimensions of the tractor and sprayer. If the GPS is mounted on the Sprayer NOT the Tractor, just fill out the new configuration with the dimensions as a Self Propelled sprayer. If the GPS is mounted on the tractor create a new configuration for the tractor and sprayer dimensions. From the main menu select "Machine" and follow the steps.


Figure 29: Main menu with machine dimensions highlighted


Figure 30: Machine configuration page

Once the measurements of the sprayer and tractor have been input, you then have to "Mount Equipment" the sprayer. The controller will automatically pick up the configuration input in section 4.9, it will be called "Sprayer" and you wont be able to edit any measurements or details.

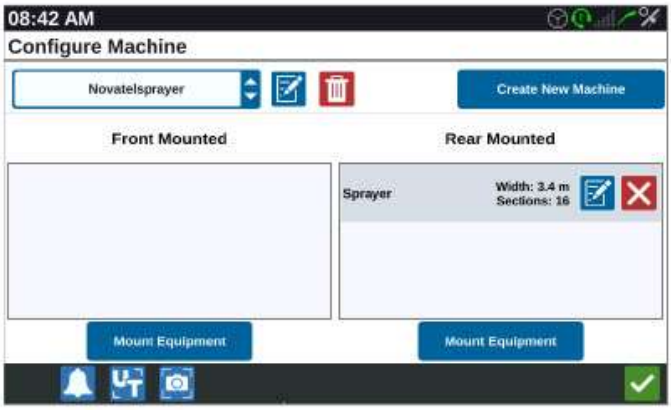


Figure 31: Mounting equipment on machine at selected dimensions

## 4.11 Raven Software setup - Prescription maps

The next step is to load in the prescription map. The way to import the prescription map from the Decision Support Tool website is to save the shapefile prescription map (and associated files) to a USB stick. This USB can be inserted into the back of the field computer and the files can be saved onto the field computer through the File Manager in settings.


Figure 32: File Manager screen with USB selected

Select the dropdown location menu that will be on Local and select the name of the USB you have inserted into the field computer, then select Prescription. The prescription map should then be able to be found in the list in the right side of the File Manager.


Figure 33: Prescription selected on USB

Select the file you want and hit the copy bottom and then the green tick. This will save the file to the field computer. Then select the green tick in the bottom right corner of the screen twice to return to the map screen.


Figure 34: Prescription map selected and copy button highlighted

From the map screen hit the field list button (highlighted below) and select or create your field.


Figure 35: Open the field list

Then select your job to continue or select the right arrow to create a new job. After you have created a new job select your prescription map, select the list button highlighted below.


Figure 36: Load in prescription map

Then select the dropdown menu that says "No Rx Map" and select your prescription map.

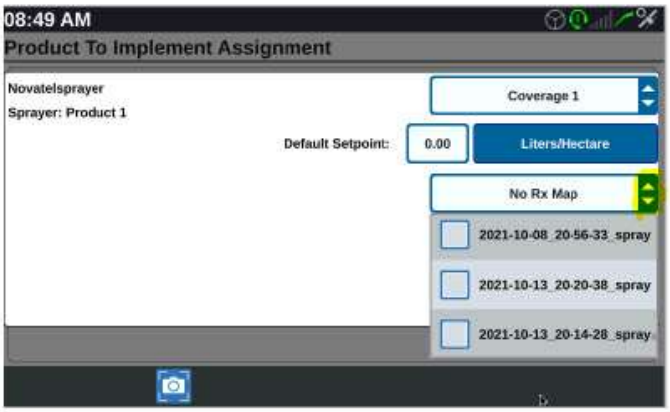


Figure 37: Selecting your prescription map

Then select the dropdown menu "Select Setpoint Column", this will determine the rate that is used in the prescription map. The Decision Support tool setpoint column is called RATE.

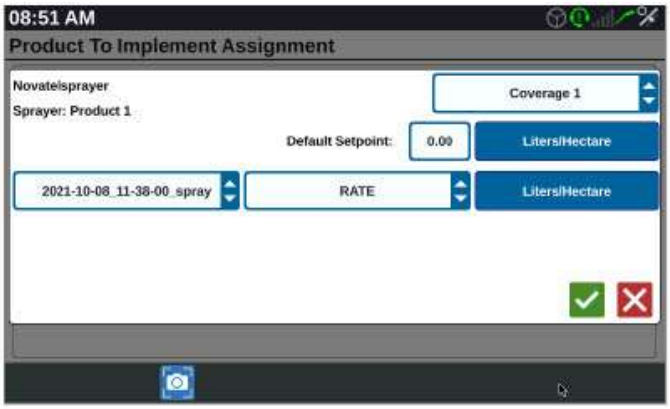


Figure 38: Selecting your prescription map target rate

Then select the green tick and proceed to the map. To turn the system on, press the red switch on the map screen, which will then turn green like the image below.


Figure 39: Main switch off


Figure 40: Main switch on

Then go to the UT, press the pump in the top right of the screen (the pump symbol), this will allow the control valve to work. The PTO can then be engaged to spool up the pump.


Figure 41: Open the UT

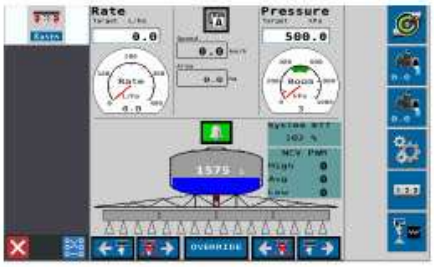


Figure 42: Activate pump control

Then hit the foot switch twice and the nozzles will active when entering the prescription map. You can now spray prescription maps.