VRT Paddock Information Folder

Mallee soils can vary greatly both within and between paddocks, including:

- deep sandy rises, with poor water retention and low fertility, and high risk of crop failure,
- mid-slope sands, with greater yield potential, but often higher nutrient requirements required to yield well,
- loamy flats which are fairly reliable with good nutrition and plant roots able to access deep moisture,
- heavy flats with high subsoil constraints, which are highly fertile, but have low plant available water (PAW) in dry years,
- stony flats, which are high in pH and nutrient tie up, can have limited rooting depth and soil moisture.

Each of these soil types vary greatly in their:

1. Natural fertility
2. Ability to retain and supply plant available water (PAW) to crops
3. Yield potential and fertiliser requirements to meet that yield
4. Risk to producing good crop/pasture outcomes in a variety of seasons

It is logical that different soil types require different fertiliser and seed rates to most efficiently achieve the best outcomes for the farming business.

The skill in applying Variable Rate Technology (VRT) is to know:

- **what the optimal rates to apply are,**
- **into which soil types or areas,**
- **in what years or seasonal conditions.**

Successful VRT is therefore not necessarily about evening up paddock yields across soil types, although this may be an outcome in some circumstances. It is more about applying appropriate amounts of inputs to suit each paddock zones' needs while accounting for the risks involved and resources available, so that farmers can most efficiently distribute their resources for maximum benefit.

There are many different methods and resources that can be used to achieve these outcomes, and this project is using, developing and refining techniques that suit the SA Mallee and those involved. Whatever methods are used to achieve successful VRT, the following principles are believed to be important:

1. **Paddock mapping and zoning according to soil potential, risks and needs, including adequate soil testing and ground truthing with the farmer to understand soils inherent characteristics.**
2. **An estimation of paddock zone yield potentials or targets as a basis for working out suitable input requirements and distribution.**
3. **The ability to convert maps and paddock rate plans to a format that works within the machinery involved. (Lack of farmer technical support here is a major impediment to the growth of VRT).**
4. **It is preferable if actual inputs and yields results can be spatially mapped, including test strips across zones, so that soil responses can be analysed (in terms of production and financial value) and improvements made for following years.**

This Project is jointly funded through the South Australian Murray-Darling Basin Natural Resources Management Board and the Australian Governments National Landcare Programme

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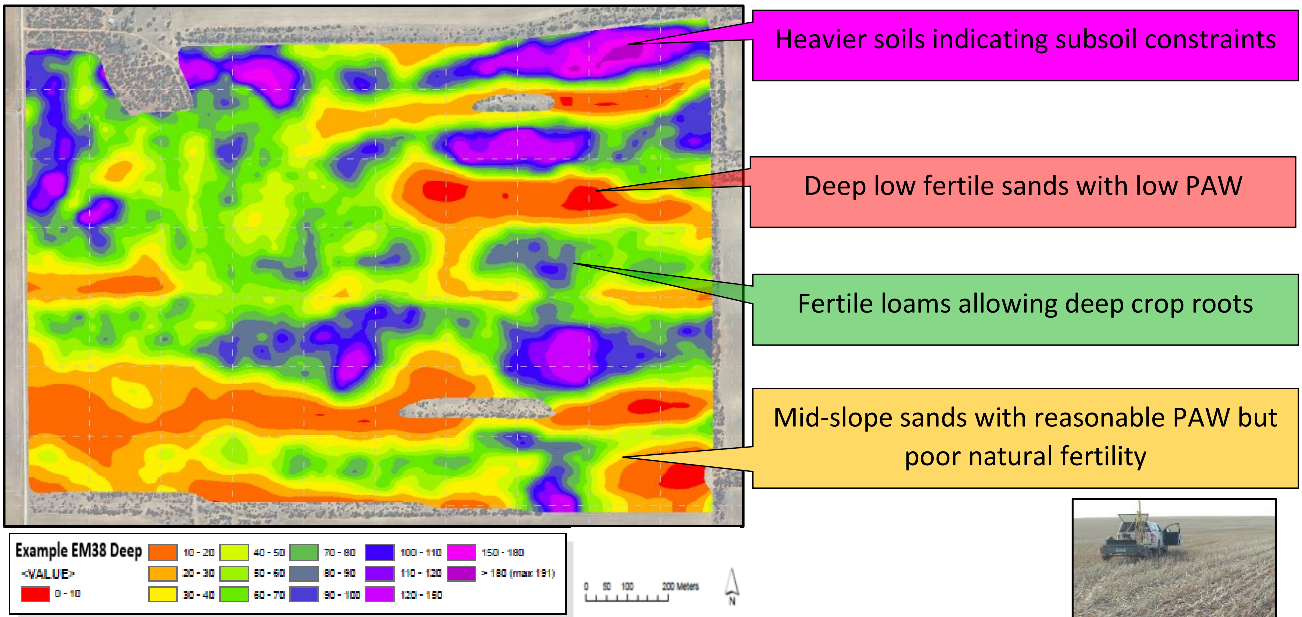
The VRT Project Methodology Guide

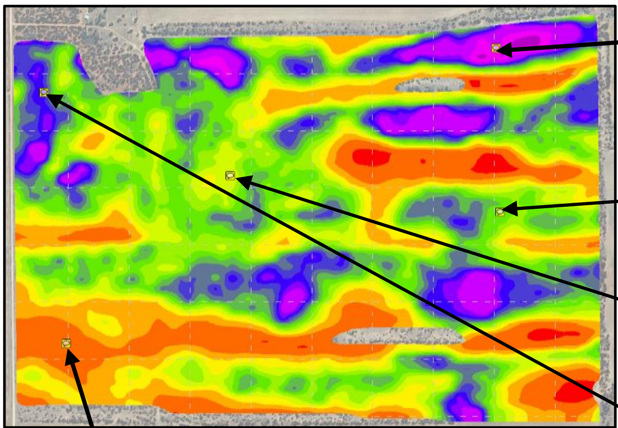
The following process has been developed for Natural Resources South Australian Murray-Darling Basin (Natural Resources SAMDB) 2015 VRT in the SA Mallee: Making it Work project. This involves 15 farms across the SAMDB region and the following process has been developed as a guide for farmers to achieve success with VRT.

While these general principles are being used, there are always a wide range of factors influencing decisions, and some flexibility is required to achieve practical outcomes that best suit each farmers own set of circumstances, capabilities, preferences, budgets and aspirations. This is an important strength of this program as is builds on a participatory farmer based approach, and not just adhering to "one size fits all" formulas.

1. **Paddock soil mapping using EM38 spatial analysis. In the Mallee we find that generally EM38 gives a very good correlation with soils ranges in crop lower limits based on water holding capacity and subsoil constraints. Stony soil have, however, shown some inconsistencies which require a heavier dependence on ground truthing.**



2. **These EM38 maps are used to target 5 key soil testing areas to ground test the map information. The deep soil testing is done at 4 depths to 80cm, and analysed for texture, fertility, moisture content and subsoil constraints.**



Hv	Water			Field	Nitrogen					pH		Cation %					
Depth	Total	Unavail.	Avail.	Capa.	Total	Avail.	Text	Sulpur	EC 1:5	CaCl	H20	Ca	Mg	Na	K	CEC	Boron
0-10	7.1	7.6	-0.4	16.5	2.1	1.8	SL	4.8	0.097	7.7	8.5						
10-32	15.1	16.1	-0.9	31.4	5.5	4.2	SCL	26.796	0.182	8.3	9.5	54	11	11	7	17	5.1
32-60	38.1	44.3	-6.2	66.6	19.6	7.9	SCL	66.64	0	8.5	10	32	31	29	8	17	13.96
60-80	28.2	31.2	-3.0	47.6	19.0	7.9	SCL	80.08	0.439	8.5	10	34	26	28	8	15	13.17
Total	88.6	99.1	-10.5	162.2	46.3	21.8	EM38	150	P	13	OC	0.4					

Md	Water			Field	Nitrogen					pH		Cation %					
Depth	Total	Unavail.	Avail.	Capa.	Total	Avail.	Text	Sulpur	EC 1:5	CaCl	H20	Ca	Mg	Na	K	CEC	Boron
0-10	0.8	8.0	-7.2	17.4	6.0	5.1	SL	3.45	0.028	6.2	6.9						
10-25	1.3	6.4	-5.1	14.7	6.4	5.6	S	4.845	0.028	6.9	7.6	77	1	1	6	3	0.41
25-65	13.6	31.8	-18.2	69.6	30.0	19.5	SL	9	0.032	7.4	8.2	73	17	3	7	2	0.3
65-80	27.5	14.8	12.8	26.1	10.5	5.5	SL	39.375	0.343	8.5	9.9	36	31	24	6	16	9.09
Total	43.2	60.9	-17.7	127.8	52.9	35.6	EM38	70	P	24	OC	0.4					

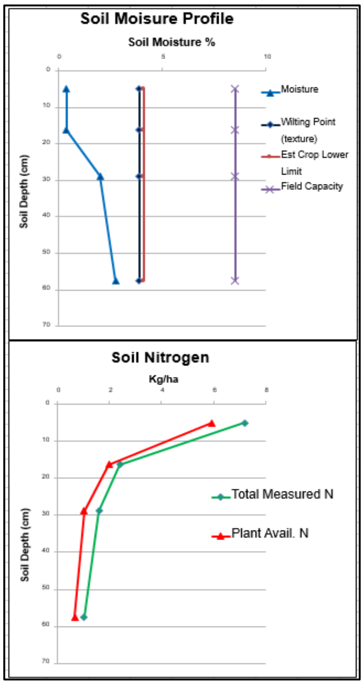
LtMd	Water			Field	Nitrogen					pH		Cation %					
Depth	Total	Unavail.	Avail.	Capa.	Total	Avail.	Text	Sulpur	EC 1:5	CaCl	H20	Ca	Mg	Na	K	CEC	Boron
0-10	2.0	6.4	-4.4	13.6	19.2	15.9	LS	6.4	0.087	7.6	8.8						
10-25	3.1	9.6	-6.5	20.4	6.0	4.9	LS	4.56	0.033	7.8	8.4	67	1	1	5	8	0.37
25-40	5.7	9.6	-3.9	20.4	2.4	1.5	LS	2.4	0.049	7.3	8.4	82	12	0	5	5	0.39
40-80	22.5	25.6	-3.1	54.4	8.0	5.1	LS	9.6	0.062	7.6	8.8	80	14	0	3	7	0.49
Total	33.4	51.2	-17.8	108.8	35.6	27.4	EM38	40	P	24	OC	0.6					

Lt	Water			Field	Nitrogen					pH		Cation %					
Depth	Total	Unavail.	Avail.	Capa.	Total	Avail.	Text	Sulpur	EC 1:5	CaCl	H20	Ca	Mg	Na	K	CEC	Boron
0-10	0.6	6.4	-5.8	13.6	7.2	5.9	LS	3.52	0.033	7.1	7.7						
10-22.5	0.8	8.0	-7.2	17.0	3.0	2.5	LS	1	0.028	7.9	8.4	76	1	0	4	4	0.41
22.5-35	4.0	8.0	-4.0	17.0	2.0	1.3	LS	1	0.07	8.1	8.8	80	15	0	4	4	0.37
35-80	19.8	28.8	-9.0	61.2	4.6	2.9	LS	12.96	0.049	8	8.9	78	14	0	3	7	0.55
Total	25.2	51.2	-26.0	108.8	16.8	12.6	EM38	10	P	16	OC	0.1					

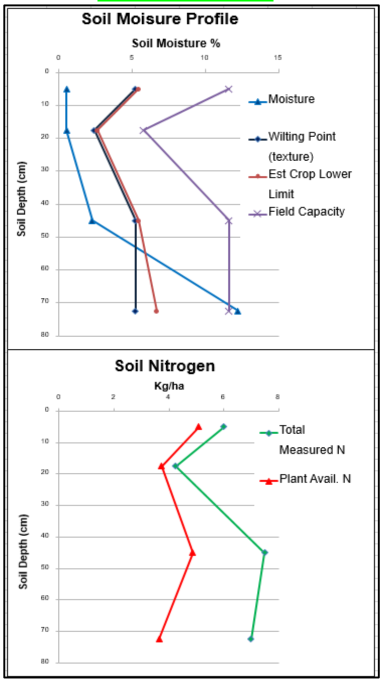
MdHv	Water			Field	Nitrogen					pH		Cation %					
Depth	Total	Unavail.	Avail.	Capa.	Total	Avail.	Text	Sulpur	EC 1:5	CaCl	H20	Ca	Mg	Na	K	CEC	Boron
0-10	2.6	8.0	-5.4	17.4	21.0	17.8	SL	4.95	0.054	6.1	6.9						
10-22.5	3.2	9.9	-6.8	21.8	20.6	17.4	SL	15	0.128	7.8	8.6	67	7	7	8	10	1.24
22.5-50	36.7	41.3	-4.6	76.8	11.0	6.1	LC	80.08	0.324	8.4	9.7	45	26	21	6	20	6.15
50-80	30.2	33.2	-3.0	52.9	15.6	7.0	LC	380.52	0.538	8.3	9.5	39	22	27	5	18	11.1
Total	72.6	92.4	-19.8	168.9	68.2	48.2	EM38	110	P	19	OC	0.5					

3. **The soil test results are analysed for key soil characteristics through the "Your Soil Potential" Program to estimate crop lower limits (CLL), PAW and plant available nitrogen based on soil textures, chemical constraints and measured moisture and N levels. This helps to characterise differences in yield potential, inherent fertility and the risk profile of the various soil types.** (NB. Actual numbers must be treated as more indicative than precise given the nature of the testing procedure and natural soil variation, while still providing key foundational data to base paddock zone to general management requirement upon.)

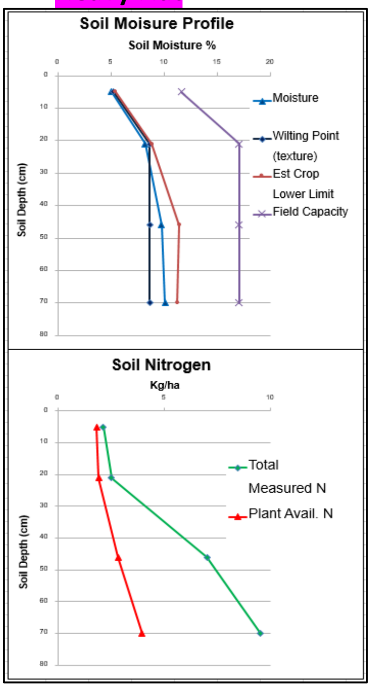
Deep Sand



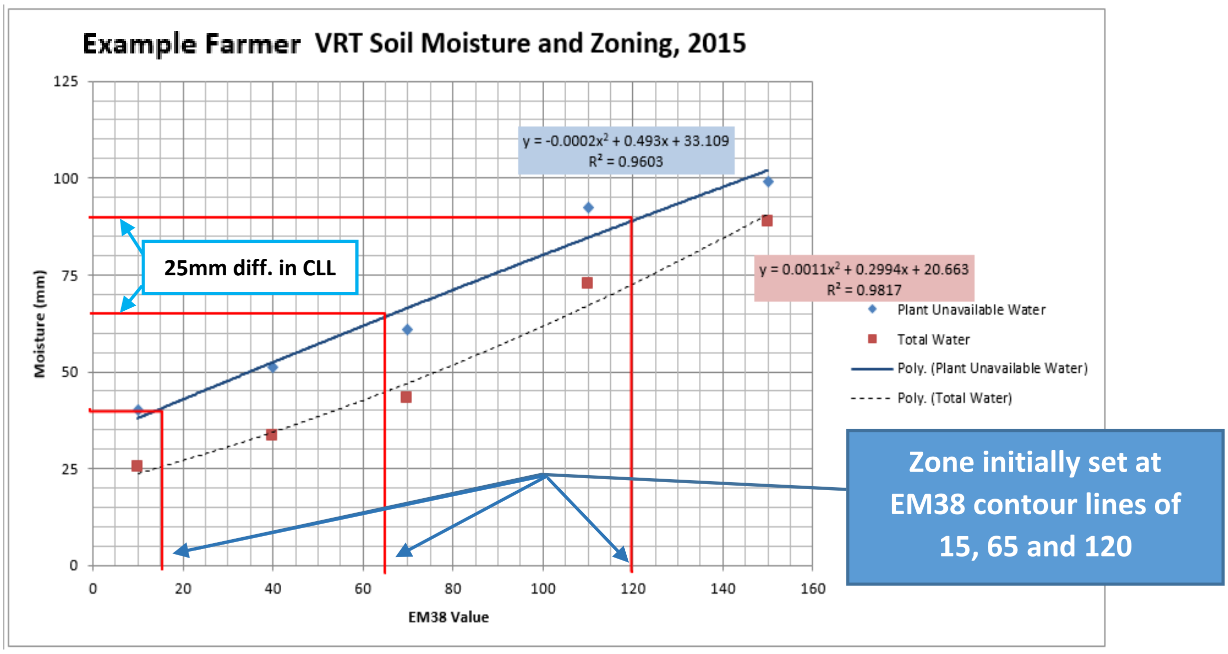
Medium Loam



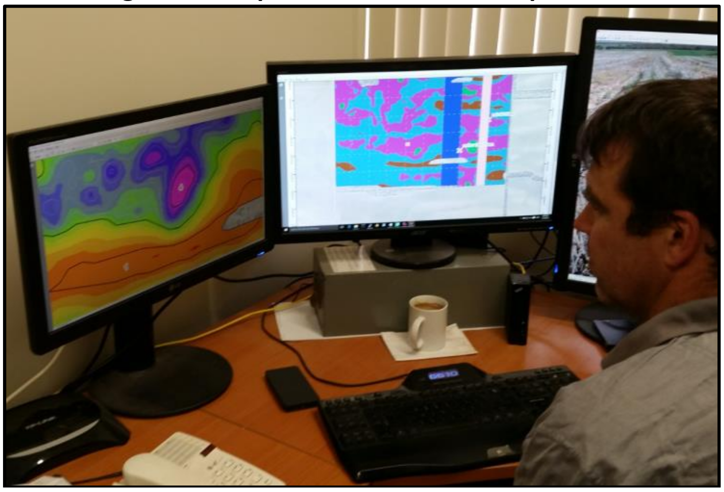
Heavy Flat



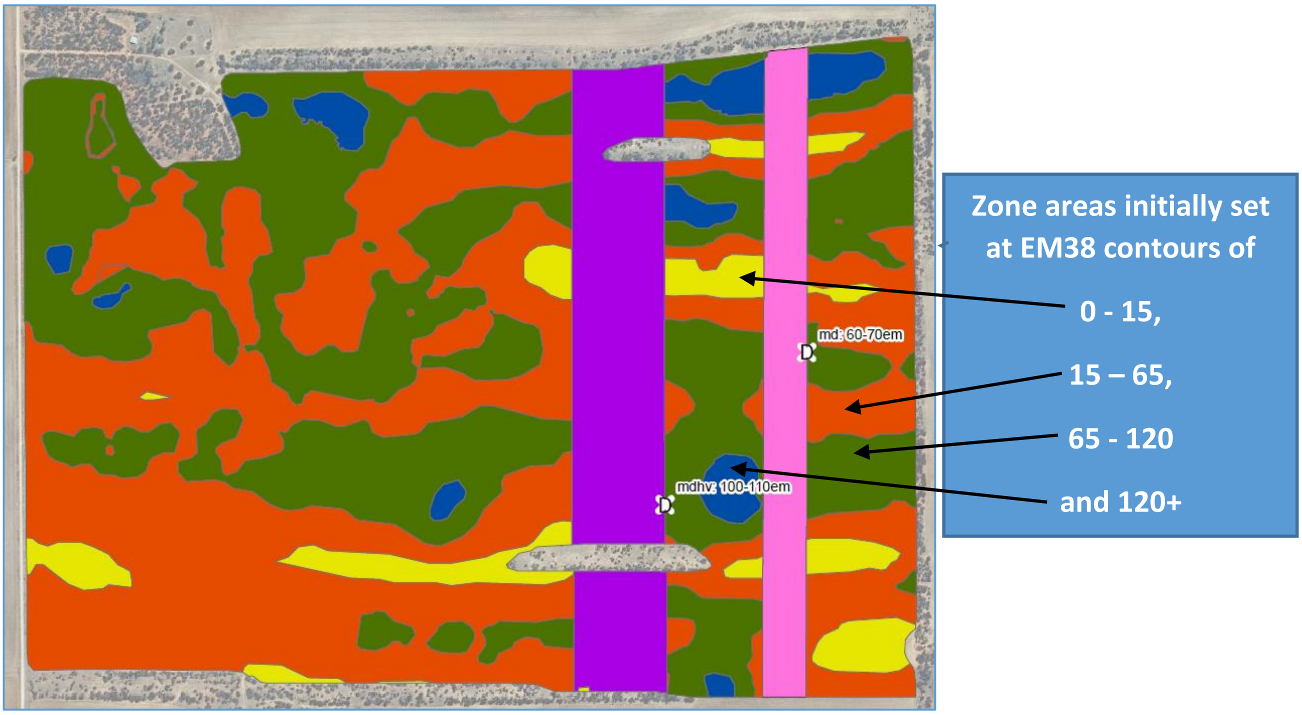
The program is then used to find a line of best fit between the estimated plant unavailable water (or CLL – Crop Lower Limit) and EM38 values at each soil testing site. Every 25mm difference CLL can theoretically mean a 0.5t/ha difference in yield potential and worthwhile treating differently. This then becomes the initial basis for separating paddock zones. (NB. This method may well not be as suitable in other regions and higher rainfall areas, but has been useful in the SA mallee. It is only the first step in this zoning method, and requires ground truthing to verify and adjust.)



Converting EM38 map to Paddock Zone Map



This data is then used to convert the EM38 map into a zone map, with potential high and low rate strip areas indicated that pass across all zones. Maps are produced and also placed on a GPS tablet to assist in ground truthing the paddocks with the farmers.



Paddock EM38 and zone maps on GPS tablet to assist with ground truthing information.

4. **Paddocks are ground truthed with farmers using GPS tablets with paddock maps and a gouge auger, which often leads to an adjustment of zone boundaries. Key points to clarify include:**

- **How poor is the sand and at what point does it change from deep sand where it is too risky to apply high rates of fertiliser, and where it becomes a mid-slope sand that can more safely reach yield potentials with higher inputs.**
- **Where stony areas have distorted EM38 readings in ways that do not adequately reflect yield potential and risk, and may need to be manually draw and overlayed into zone maps.**
- **Where the shallow EM38 mapping may be more appropriate to use than the deep EM38 maps for best delineating paddock zones.**
- **Are the highest EM38 areas heavily textured and fertile enough to warrant significantly lower seeding and fertiliser rates.**

5. **Fertiliser and seeding rates for each zone are discussed and established for each zone with the farmers, using tools such as the "Your Soils Potential" model, the Mallee Calculator and fertiliser rates and costing guides. These work through the basic principles of:**

   a. **What is the yield potential or target yield of the intended crop in each zone given its PAW at the start of the growing season and the average or targeted growing season rainfall decile for that district,**

   b. **What nutrition inherently is available to the crop (derived from soil test results of P, N, Organic Carbon etc. and estimated nutrient mineralisation),**

   c. **What extra nutrition needs to be applied to meet the crops requirements to meet its' target yield (which can be based on growing season rainfall decile data),**

   d. **What adjustments need to be made to manage the risks for each zone, including input levels and nitrogen timing strategies (ie. How much needs to be applied up front in each zone, and how much may be spread later if sufficient rainfall or subsoil moisture is available).**

   The final zone rates and strategy plans are established with each farmer taking into account these paddock zone potentials, needs and risks, as well as the farmers' available resources, capabilities and preferences.

Estimating yield potential and crop needs to reach that potential using the “Mallee Calculator” program as a general guide.

Calculator for estimating attainable yield and nitrogen fertiliser requirements

Name: Example farmer
Paddock: Loam
Year: 2015

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Inputs

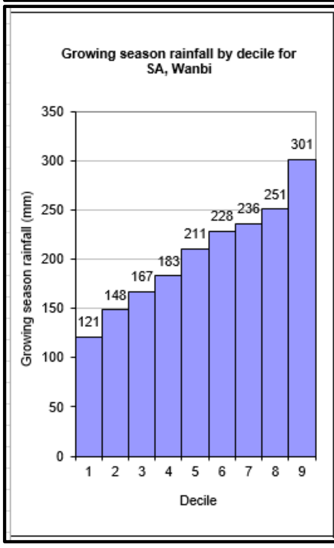
Location	SA Wanbi	
Rainfall risk (decile)	5	
Crop	Wheat	
Target grain protein (%)	10.5	
Optimum sowing date (defined by crop and available water for growing season)	15-05-15	Restore default optimum sowing
Yield penalty for late sowing (kg grain/day) (default value is 15 kg/day)	15.0	Restore default sowing penalty
Actual or planned sowing date	Month	May
	Day	5
Previous crop	Wheat	
Previous crop yield (kg/ha)	1000	
Percent stubble removed	0	
Surface soil type	sandy loam	
Plant available soil water on 1 April (mm)	0	
Plant available soil N at sowing (kg/ha)	58	
% Organic carbon (0-10 cm layer)	1.0	
Phosphorus soil test (mg P/kg soil or ppm)	19	
Soil N mineralisation percentage	3	

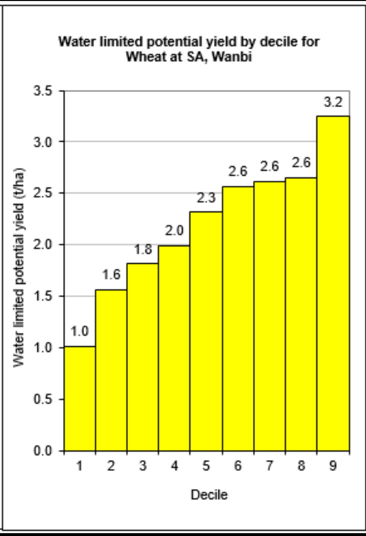
Outputs

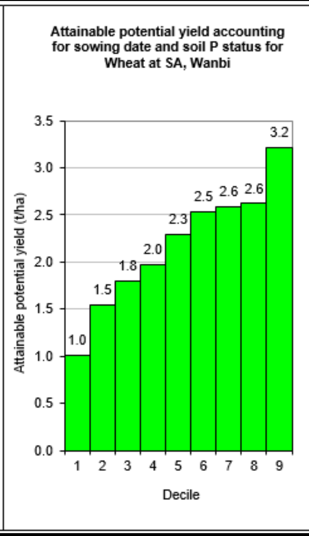
Growing season rainfall (Apr-Oct mm)	211
Total available water (mm)	211
Potential yield with given rainfall and soil water (t/ha)	2.3
ntial yield accounting for sowing date (t/ha)	2.3
ntial yield accounting for soil P status and sowing date (t	2.3
Attainable yield (accounts for maximum and all constraints) (t	2.3
N requirement to achieve the attainable yield/protein (kg/ha)	116
Plant available soil N at sowing (kg N/ha)	58
N from in-crop mineralisation of soil organic matter (kg/ha)	39
N contribution or uptake due to stubble (kg/ha)	-7
Total available N (soil profile + stubble + soil) (kg/ha)	91
Estimated fertiliser requirement (kg N/ha) - if this is<0, some fertiliser N should be applied at sowing to optimise crop establishment	25

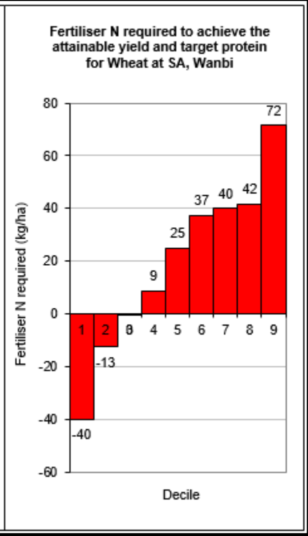
Potential yield associated with decreasing fertiliser N application (assuming constant grain protein)

Percentage of estimated fertiliser N requirement	N rate (kg/ha)	Predicted yield (t/ha)
100%	25	2.3
75%	19	2.2
50%	12	2.0
25%	6	1.9
0%	0	1.8
N required for penalty (ie cool wet Spring & high P applied*)	26	2.3







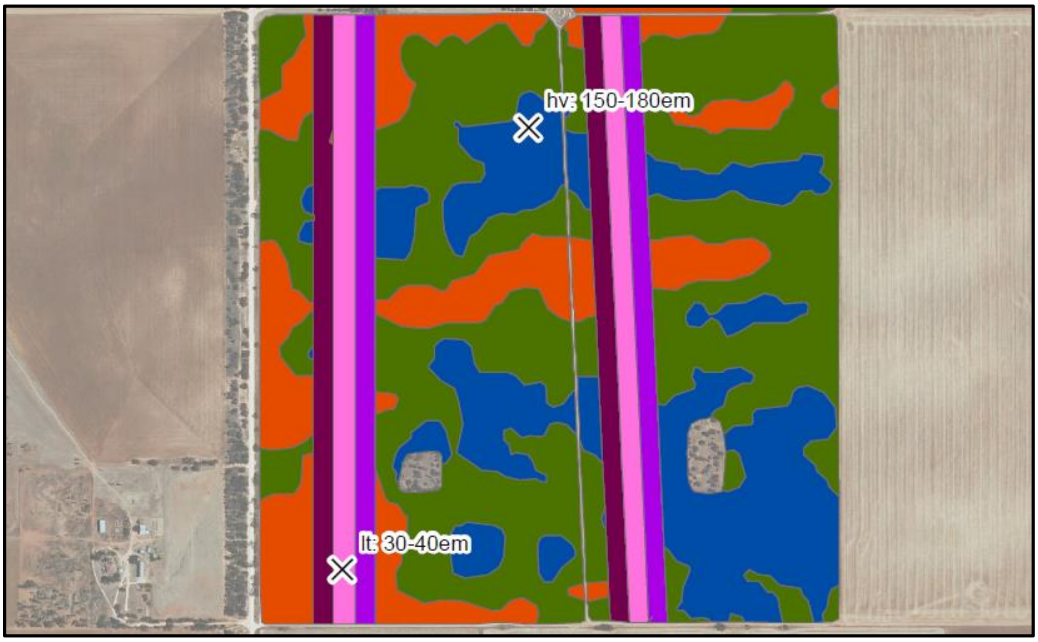


Extract from Zone Fertiliser calculator excel sheet

Paddock Zone Fertiliser Summary Sheet			Farmer	Example 2						
Zone	Description	Area	Fert Target (Kg/ha)		DAP		Urea		Fert Costs	
		ha	N	P	kg/ha	Tonnes	Kg/ha	Tonnes	Cost $/ha	Total
1	Deep Sand	25	14	7.5	37.5	0.94	16	0.39	35	$880
2	Mid Slope Sand	95	30	7.5	37.5	3.56	51	4.80	53	$5,062
3	Loam	120	25	6.5	32.5	3.90	42	5.00	44	$5,230
4	Shallow Stone	7	14	5	25	0.18	21	0.14	29	$201
5	Heavy Flat	20	10	4	20	0.40	14	0.28	22	$433
	Total Area (ha)	267			Total	8.98	Total	10.6	Total Cost	$11,806
					Cost	$6,462	Cost	$5,519		

6. **Paddock input maps are devised (including trial strips across zones of higher and lower inputs) and information translated to appropriate data maps for the farmer's machinery. Using the technology correctly is a barrier for many farmers so expert support is provided to farmers to help configure their machinery for the application of planned variable rates of seed and fertilisers.**

Example Paddock Zone Application Plan



Map Colour	*Zone Description* *Both deep and shallow EM38 used to help determine zones for this paddock.*	*Fert1 (kg/ha)*	*Urea (kg/ha)*	*post urea (kg/ha)*	*Area (ha)*
(orange)	**Sand** Requires slightly higher inputs to maximise potential	80	60	80	37
(green)	**Loam** Majority of the paddock fits into this category.	60	50	60	168
(blue)	**Heavy Loam** Reduced inputs on heavier soils are advisable in case of a drier finish.	40	30	40	29
(dark purple)	**High Test Strip** Testing higher inputs across all soil types to identify potential gains.	80	60	80	9
(purple)	**Standard Test Strip**	40	30	40	9
(pink)	**Low Test Strip** Testing lower inputs across all soils to identify potential savings.	60	50	60	9

Assistance provided to farmers for machinery and data application and information storage.

7. **Mid-season monitoring occurs through crop inspections or other tools such as NDVI to assess or confirm the need for post N application. The mallee calculator can also be used to estimate mid-season N requirements by entering up-to-date growing season rainfall. Further data maps are supplied to farmers for post N application if required. All fertiliser applications are recorded for later assessment of the economics of yield results.**

Crop showing signs of N deficiencies and need for post N application

Further extract from Mallee Calculator program showing potential N requirements for given decile finishes

Reassessing N requirements during the growing season

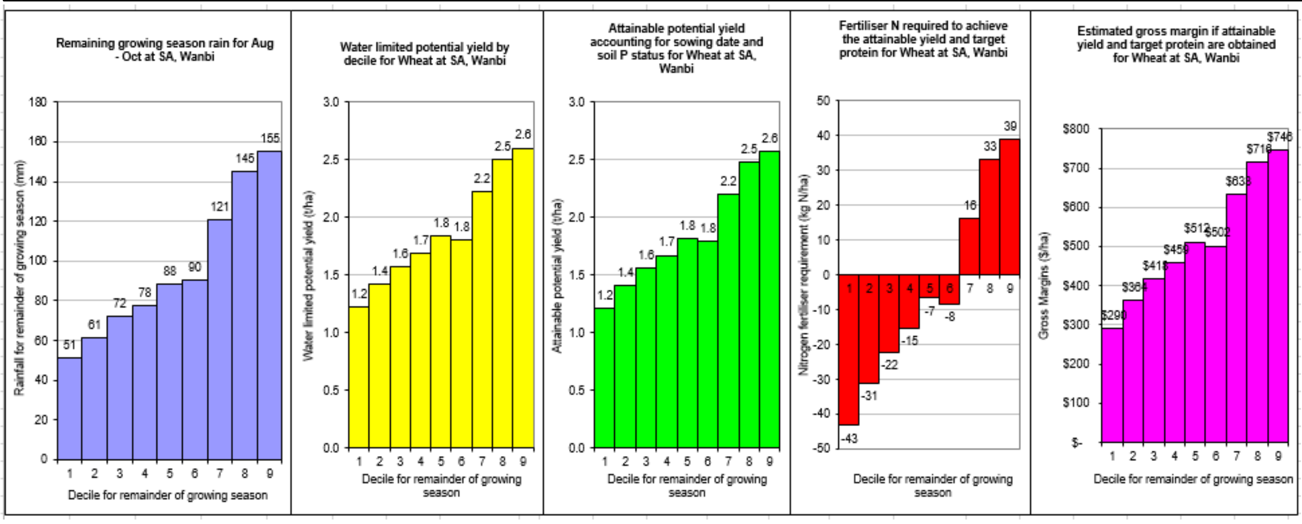
Input data from the start of the growing season	
Location	SA, Wanbi
Crop grown	Wheat
Surface soil type	sandy loam
Plant available water at sowing (mm)	0
Plant available N (soil+stubble+Nmin) (kg/ha)	91
Phosphorus soil test (mg P/kg soil or ppm)	19
Optimum sowing date	15-05-15
Actual sowing date	05-05-15
Yield penalty for late sowing (kg/day)	15

Inputs required for revison of targeted grain yield and protein	
Growing season remaining	Aug - Oct
Growing season rain received to date (mm)	80
Initial fertiliser N applied (kg N/ha)	25
Revised grain protein target (%)	12.5

Inputs required for calculation of gross margins							
At silo/port base prices for grain quality classes							
Wheat		Barley		Oats		Canola	
Feed	$ 350	Feed	$ 283	feed	$ 150	class1	$ 250
ASW	$ 357	Malting1	$ 346	class1	$ 160	class2	$ 300
APW	$ 362	Malting3	$ 321	class2	$ 170		
Hard	$ 366						
Durum	$ 600						
Grain type and quality class targeted				Wheat - APW			

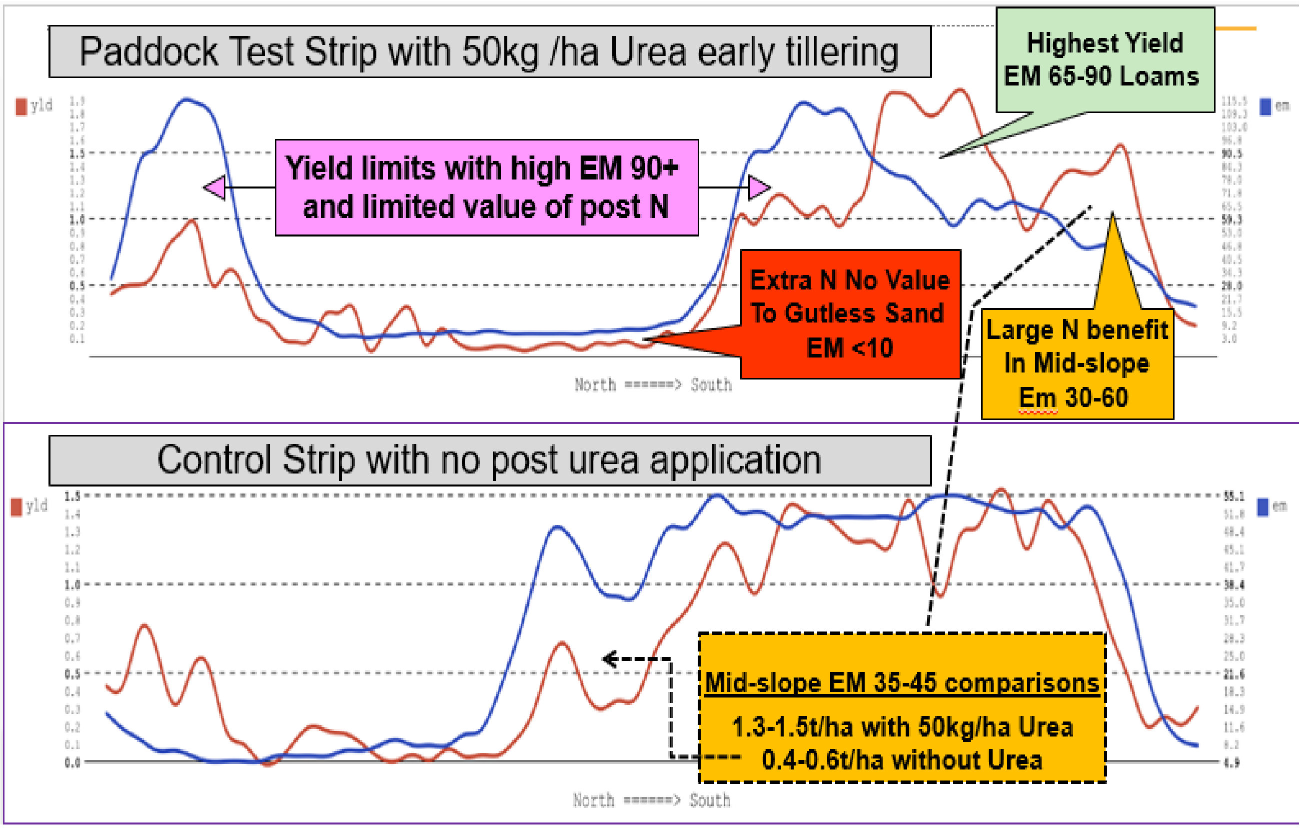
Fertiliser N sources, costs and N contents		Cost ($/ton) (include transport)	N content (%)	N cost ($/kg)
	Urea	500	46	1.09
	Amm Sulphate	500	21	2.44
	Amm Nitrate	500	35	1.45
	Other	500	48	1.04
Type of N fertiliser to be used		Urea		

Cost of grain transport to silo/port ($/t	10
Total variable cost ($/ha) (includes costs of fertiliser applied at sowing)	150



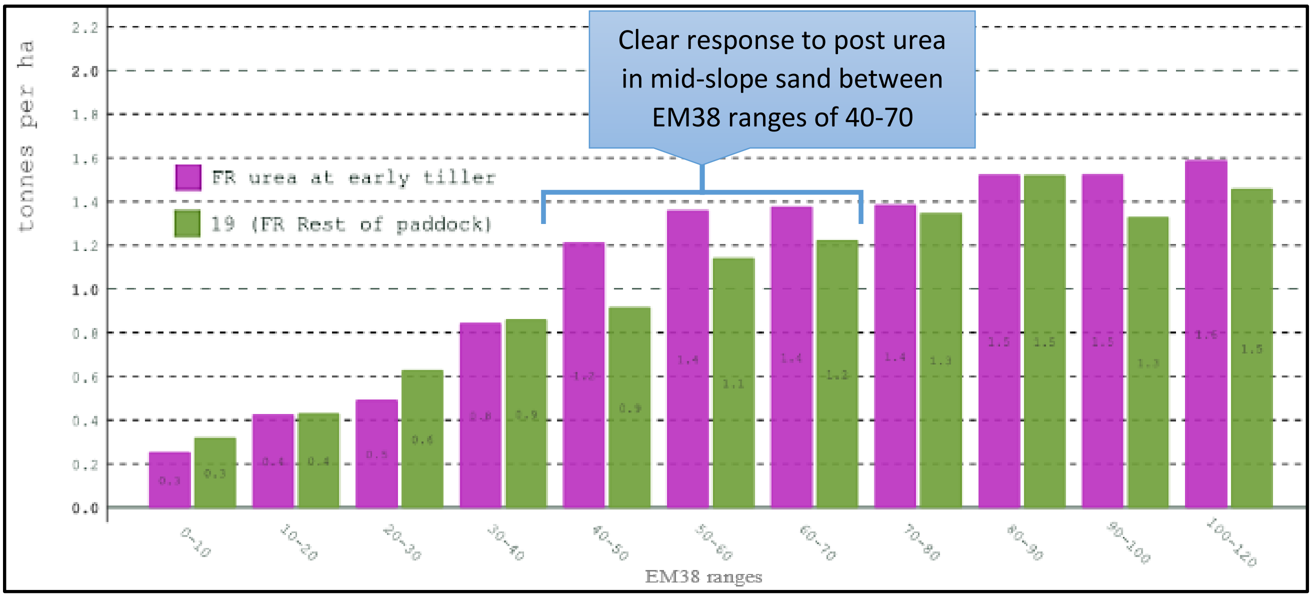
8. **Yield maps are analysed against zones, EM38 ranges, trial strips and input costs to determine the economic benefit of the rates applied, as well as which soil types and zones are most responsive to higher or lower inputs. This forms the basis for further adjustment to VRT plans in the future.**

Examples of test strip response assessment of fertiliser treatments across EM38 ranges.



Although initial paddock zones may be defined by EM38 ranges of 30-50 units or more, the comparisons of yield results can be analysed at intervals of every 10 EM38 units, allowing for a clear assessment of soil type responses allowing for a more objective adjustment of zones and management strategies.

Example of refining optimal zone contours through analysis of test strips across 10 unit intervals of EM38



Economic responses to treatments are then made to establish the comparitive benefits of applying VRT strategies paddock zones. Paddock plans and processes are refined with each farmer to improve their strategies and confidence to continue with successful VRT application into the future. (NB. Within the years comparitive analysis is important to account for specific seasonal conditions or events that may have influenced results. Decisions to change approaches based on limited results may be premature, if seasonal conditions are significantly different next year. This is where local experience and an objective understanding of influencing factors is important, as well as the value of assessing comparitive data over a number seasons.

Example of yield and financial comparisons after using variable rate in a drought year at Loxton. Note that much of the financial benefit came from reducing inputs on heavier ground. With low rainfall, post N application was not applied in this season.

Table 1 Zone	Ave P (ppm)	Org C Ave (%)	Farmer Flat Rate		Variable Rate	
			DAP	Yield	DAP	Yield
1. Sand	14	0.6	40	.51	80	.76
2. Midslope	19	0.8	40	.82	50	.85
3. Flats	23	1	40	.73	30	.77
4. Flats with Constraints	30	1.2	40	.69	20	.71

If the VR was applied across the whole paddock, would have used 3.71t more DAP, but reapt another 24.4t of Wheat or $25.23/ha return ($300t-grain & $550t-Fert)

Another example of yield and financial analysis presentation, detailing Gross Margin comparisons within each zone.

Zone	Ha	Fixed Rate			Variable Rate		
		Yield t/ha	Cost $/ha	GM $/ha	Yield t/ha	Cost $/ha	GM $/ha
1 Sand	9	0.6	110	40	0.9	120	105
2 Mid-slope	60	1.4	110	240	1.6	130	270
3 Loam	25	2	110	390	2.1	100	425
4 Heavy Flat	18	2	110	390	2	90	410

The GM benefit of applying variable rate over whole 112ha was $3620 or $32/ha at a wheat price of $250/t

Farmers individual report folders will be updated with final paddock result analysis and individual recommendations for the future application of VRT.

9. Project farmers will meet together with project consultants and facilitators to discuss and evaluate the success of the project methodologies, information presentation and support, as well as recommendations for improving VRT processes in the future that will enable more farmers to adopt and benefit from it.

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This information has been compiled by Chris McDonough, Insight Extension for Agriculture, consulting to Rural Solution SA.