Applying PA Techniques for Better Decisions

Michael Wells, Precision Cropping Technologies

INTRODUCTION

The successful incorporation of Precision Agriculture techniques into the farm management system has some fundamental requirements. It is very much dependant on the degree of within-field variability that exists and also our ability to accurately measure and map this. The challenge then is to build an understanding of the nature of this variability and the consequences it has on management and productivity. If this can be achieved then the likelihood of generating successful outcomes from differential management over a uniform whole field approach will be greatly enhanced.

Today an increasing range of sensors are being combined with high accuracy GPS to collect large amounts of geo referenced information of how a particular attribute varies over a given field area. Information can be gathered on variations in elevation, soil conditions, yield, and crop health amongst others. With the addition of GPS assistance to many farming management operations the farmer now has the ability to collect some of these important datasets. The challenge he/she then faces is how this and other information can be managed in such a way that it realises its potential benefits.

This paper aims to demonstrate, by way of a case study, how a farmer planning to manage water-logging issues has used Precision Agriculture techniques to build his knowledge about within field variability and use this to make a more informed decision on soil amelioration and designing of surface drains.

CASE STUDY : PADDOCK 290A

Overview

This project was conducted on a field in the Esperance District of WA. The paddock is centred at a converging point of a larger catchment area that feeds naturally into the Neridup Creek. It is characterised by gentle undulations and slight ridges which trap sheets of water that combine with heavy clay subsoil to cause chronic water-logging in wet seasons. This was quite evident in winter 2005 when field work could be carried out on the adjacent paddocks but the problem paddock was clearly un-trafficable with uneven canola emergence.

Due to the farmer's experiences with raised beds on this type of country he believed much of the gain they produce in improved drainage could be delivered to this paddock through strategically located surface drains. Though beds may deliver a little extra overall benefit across all soil types this would not compensate for the complications he had encountered at harvest with chaser bin entry and when wind-rowing barley for grass control.

The farmer chose to use Precision Agriculture techniques in his planning of remedial activities for water-logging. Firstly he wanted to identify where the main issues were in the paddock and then focus his investment in those areas as opposed to a whole field broad-brushed approach. He was concerned that the whole field approach would result in money being spent where it was not needed and not enough work being done where it was actually required. Secondly he planned to construct the surface drains on his own and felt that designing a complex system of drains using lasers alone, on-the-go in the field, would be almost impossible as well as placing his investment at risk. With the information and maps generated through PA techniques he believed he would be able to see more clearly where drains should go and the area of catchment that would feed each drain.

There were also plans to apply gypsum, especially to the worst of the areas, to work in combination with the drains to reduce the water-logging risk. The farmer was aware that there were different soil types but the actual surface soil similar. Therefore it was not an option to visually patch out the problem areas with gypsum.

COLLECTING THE REQUIRED INFORMATION

The first stage of the process was to collect the relevant data from the field. Given that the issues with water-logging had in part been both topography and soil type related it was necessary to measure the changes in elevation and apparent soil profile conditions over the paddock. To do this, three sets of information were required.

An EM38 survey was conducted in vertical dipole mode coupled with a Starfire RTK GPS system. The survey, completed at 20m swaths, allowed the collection of high accuracy elevation and measurements of apparent soil profile change simultaneously. From here the sets of information were initially managed independently before being integrated at a later stage to assist with decision making. The third set of information required were the soil cores with laboratory analysis.

MANAGING THE INFORMATION

Soil

The EM38 data was processed in AGIS software to create a map showing apparent variation in the soil profile conditions through the changes in bulk electrical conductivity detected by the EM38. To interpret the nature of the variability and to better understand more specifically the actual soil properties that are varying, soil cores were collected at selected and known locations.

The soil cores were subject to laboratory tests and defining of texture through analysis of particle size distribution which determines the proportions of sand, silt and clay. The subsequent analysis of these soil-test results with the EM38 data revealed some significant and useful correlations.

Electrical Conductivity dS/m	$r^2 = 0.82$
Chloride ppm	$r^2 = 0.79$
Clay %	$r^2 = 0.66$
ESP	$r^2 = 0.63$
Cation Exchange Capacity meq/100gm	$r^2 = 0.62$
Boron ppm	$r^2 = 0.94$
Ca:Mg ratio	$r^2 = -0.82$

With the exception of Ca:Mg ratio, as the EM38 measurement increases over the field it is inferring an increase in the above properties. The Ca:Mg ratio is decreasing as the EM increases. Of particular importance for the farmers plans to apply gypsum are the correlations between Clay % and Exchangeable Sodium % (sometimes referred to as sodicity) with EM data. This has allowed the building of a map that infers where the sodicity condition varies over the field even though not visible on the surface. This provided the basis for a VRT gypsum plan that was implemented by a local contractor with higher rates applied to the problem areas.

Elevation

The elevation data collected in the survey was processed using AGIS to create a Digital Elevation Model (DEM). On its own this has limited application for the farmers planning. Given that surface drains were the chosen option over a raised bed system the elevation map was processed further with a focus on generating information about potential surface water movement.

The first of these layers were the elevation contours at 10cm increments. The field was then segregated into natural Watershed areas. These are like mini water catchment zones which are best described in that water would have to move uphill at some point to cross the line into the next watershed area. These can be used as a guide for assessing the size of the area from where water would shed into a prospective drain.

For each Watershed area in the paddock there will be a final culmination point for the flow of water for which a mark was located that can be over-layed on any other maps of the paddock to highlight the low points of where water flow will terminate. These points can be linked together with a surface drain.

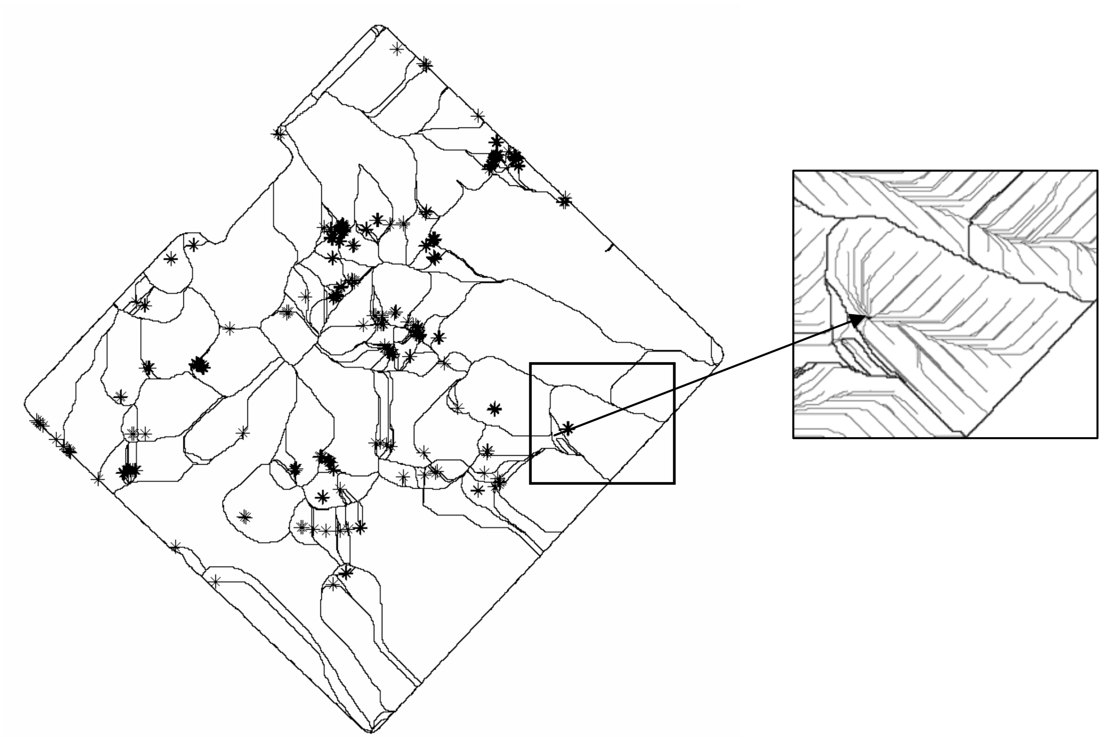

Figure 1: Drain Points over-layed on Watershed Boundaries. The exploded section shows the Water Grid layer which identifies the natural water flow lines of laterals into a main within each Watershed Boundary area. The farmer found this useful in choosing pathways for drains.

BUILDING NEW KNOWLEDGE

To this point we had identified the areas most requiring gypsum and this had been implemented in a variable rate application fulfilling the first of the farmer's objectives. However water-logging risk was also influenced by changes in the surface topography.

The topographic information layers described so far provide a useful insight of the potential behavior of surface water movement and will prove to be very useful for the farmer when it comes to design the drains and importantly implement them in the field. They do not though fully satisfy the objective to direct the design of surface drains to the most problematic regions. This could mean the areas that through water-logging suffer nutrient loss, harbor weeds or cause trafficability problems. They could also be defined as those areas that suffer significant yield loss in wet years. Yield loss areas can be identified beyond a simple visual appraisal through comparative analysis.

Yield maps were created from data collected in drier seasons (2002, 2004) and a wetter year (2003). AGIS was used to build an Elevation Error Surface. This is used as a guide of where water is more likely to pond or shed according to the subtle, localised variations in elevation. In the graphs using Elevation Error below, positive values refer to likely water-ponding areas and negatives values indicate potential water shedding areas. The yield maps with the EM38 and Elevation Error surfaces were analysed in AGIS to generate following information about the major causes to yield variation in different seasons.

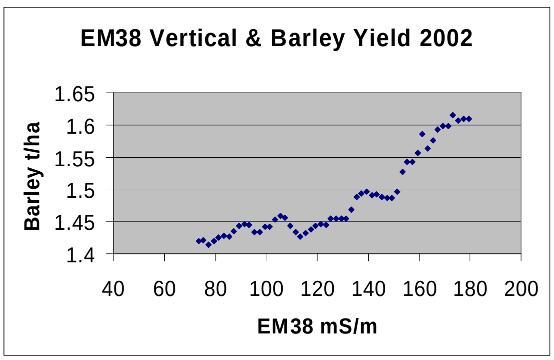

Figure 2

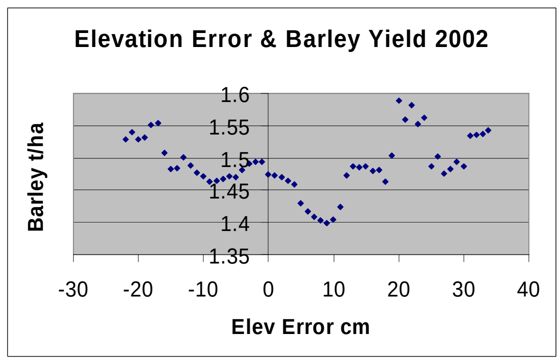

Figure 3

In AGIS we have asked "as the EM38 value increases over the paddock what happens to the barley yield". Season 2002 was dryer with barley averaging 1.46t/ha. Figure 2 indicates a steady trend of yield increasing as the EM38 value increases over the field. Soil-test information indicated higher clay content as the EM value increased. Apparent improved water holding capacity is supporting more yield. Figure 3 suggests no meaningful trend between yield and the paddocks surface ability to pond or shed water. The graphs suggest that in 2002 the changes in soil had more of an influence on yield than did potential water-logging.

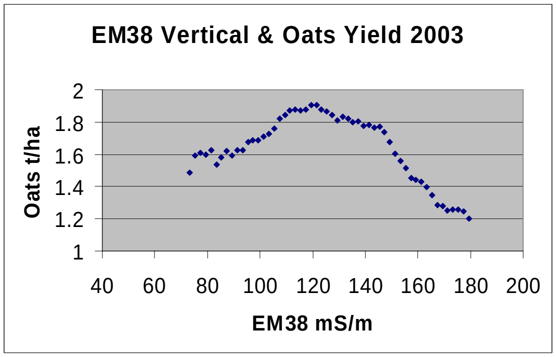

Figure 4

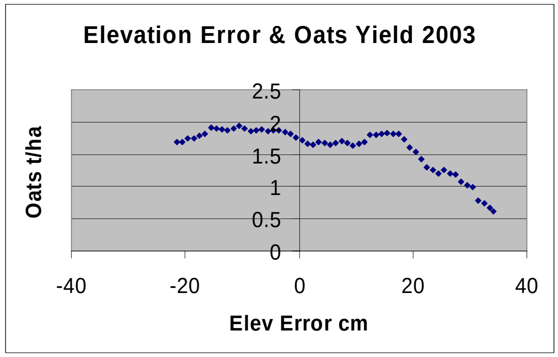

Figure 5

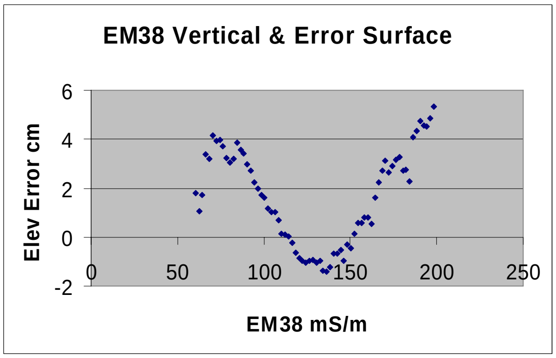

Figure 6.

2003 was a wetter year with oats averaging 1.75 t/ha. The trend between EM and yield starts the same as in 2002 but when the EM exceeds approx 120mS/m the yield declines as the EM increases. Poorest yields are in the heavy soil regions with some low yields in the lowest EM areas. Figure 5 indicates the areas with greater water ponding yielded the least. Figure 6 Indicates the low EM areas (dense gravelly profile) and high EM areas (heavy clay) have the greatest water-ponding potential which may explain the trend between EM and yield in 2003. The topography and soil change appear to be combining to create different growing environments which reduce yield in wet seasons.

To visually assess for the most problems areas, the Drain Points were over-layed on the yield map for 2003. It was evident they were mostly located in the lowest yielding areas. Gross margin affects of this could also be assessed to build confidence further of which areas to prioritise for drains.

Using the outcomes of soil analysis and the farmer’s observations, the EM38 data was used to divide the paddock into 4 major soil zones. Each soil zone can be assessed for how potential water logging had affected yield and therefore gross margin.

Concerned only with assessing the productivity loss in the low lying areas of each soil class, the yield in Elevation Error zone of -15cm was used as the benchmark to compare with yield performance in the water-ponding areas. This was chosen as the benchmark as areas with an Elevation Error value higher than this were considered likely to suffer some degree of water-logging in extended wet periods or heavy rainfall events. In Figure 7 the Soil Zones are in sequence from the lowest to the highest EM38 survey values.

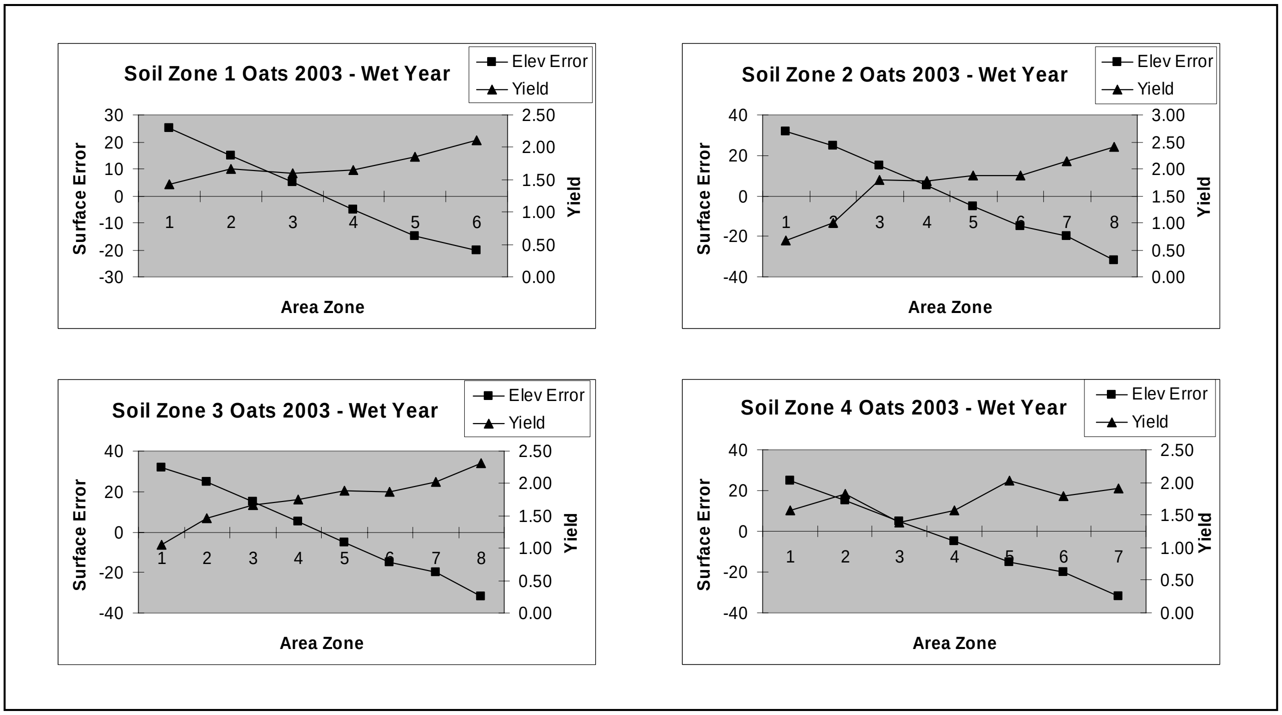

Figure 7: shows that in each soil zone there is a trend of yield increasing as the surface changes from water-ponding to shedding.

Table 1: Zone 1 dense gravel profile and Zone 4 heavy clay had the highest loss attributable to water ponding

Elev'n Error cm	Loss Zone 1	Loss Zone 2	Loss Zone 3	Loss Zone 4	Total Loss
-32		-$13.67	-$3.07		-$16.74
-25	-$5.17	-$19.12	-$10.59	-$2.59	-$37.47
-15	-$50.18	-$42.57	-$67.42	-$40.11	-$200.28
-5	-$547.29	-$387.57	-$391.90	-$1,290.29	-$2,617.06
5	-$160.55	-$13.42	$39.85	-$475.10	-$609.22
15	$0.00	$0.00	$0.00	$0.00	$0.00
20	$11.94	$22.49	$14.18	-$0.75	$47.87
32		$1.43	$3.56	$0.83	$5.82
	-$751.25	**-$452.43**	**-$415.39**	**-$1,808.01**	**-$3,427.08**

DESIGNING AND BUILDING THE DRAINS

Using both visual and GIS analysis the farmer was confident of which areas he should prioritise when designing the surface drains. In the Viewpoint software all the layers generated for this project were displayed and geo-referenced. This allowed the farmer to trial different drain pathways and then finalise the location of the main drains which supported a series of laterals. Having been created in Viewpoint the drains had their own geo-referencing. This meant they could be transferred to the field using Mobile DLog software allowing navigation to their exact location. Other layers like the Drain Points, Water Grid and Elevation Contours could be taken to the field in the same manner and would prove useful for making on-the-go alterations. Similarly any changes that were made in the field can be recorded and loaded back to the office computer in Viewpoint. He also used printed maps.

The farmer also had the option to have the drain design built to a more advanced level before transferring to the field. Each drain could be designed with controlled slope, direction and depth and this information also being geo referenced allows it to be taken the paddock for ease and precision of drain construction.

Farmer comments

> "The fact that I was doing it myself meant it would be a lot easier to work out where to do them from the PA maps than to try to master the fine art of in the field drainage planning. Wherever possible I set the drains either parallel or square to the working direction, so that machinery such as the sprayer didn't have to negotiate a lean one way then the other to get through the drains. Sometimes that was not practical so an angled drain was cut. This is not so important with the shallower drains. The auto steer on the tractor was good as I could preset the parallel and square angles, and placed the parallel ones at the edge of the boom spray swaths. That way both the sprayer and seeder tractor stay on good ground. Cutting the drains square or parallel also gives me the option of installing beds later if needed, as it is difficult to put beds through angled drains".

> "To design the drains so that the tractor would not be running along them I set the first A_B line at the fence. It was a simple case of finding the nearest track to the "valley" and then locking on. In some cases a "staircase" drain was cut (to avoid angles) with each parallel segment matching in with the tramlines".

> "Using the surface maps as well as my yield maps from a wet year helped me work out which low areas had to be drained, and which ones cope OK without drains".

SUMMARY

With specific objectives in mind the farmer has used information from different sources and his own accumulated of the project area to help with his planning. Yield data from his own yield monitor and high accuracy field data from the EM38 and elevation survey have been combined with soil analysis to provide him with intimate knowledge about the variation in the physical environment of the project area.

The Geographic Information System, AGIS, had a significant role in bringing together the various types of information, processing it properly and presenting it on a single platform so that it could be used to its best potential. The subsequent analysis of the information guided the farmer to where the problems areas existed and gave him confidence that the gypsum applications and surface drains were being directed where they would provide the best effect. With the aid of Precision Agriculture techniques he has been able to design a management plan that satisfies his goals and then implement this in the field on his own.

ACKNOWLEDGEMENTS

Mick and Marnie Fels 'Melaleuca', Esperance, WA – for their kind permission for use of information.

Precision Agronomics Australia, Esperance, WA - for collection of field information including EM38 Survey, Elevation and soil coring.