Using precision technologies to understand within-field variability

R&D FARM-READY ADOPTION READINESS

Department of Agriculture and Fisheries

Sun City Exports, Woodridge, Western Australia

Jul 2020

Key outcomes

- Crop soil sensing imagery and soil mapping layers showed differences in soil and crop growth.
- Soil variability was due to differences in soil moisture based on topography and subtle differences in soil texture (given the sandy soil type).
- Modelling of water flow and drainage identified an area of water accumulation at the lowest elevation.

Background

Francis Tedesco had not previously implemented any precision agriculture (PA) technologies prior to his involvement in this project.

He had observed variability across individual fields, such as the site of this case study; a pivot quarter of approximately 9 ha. There was some soil texture variability evident at this site, with areas that were wetter and visibly darker in colour.

Francis was involved in work predicting carrot yields from remotely sensed satellite imagery, yield mapping using a yield monitor on the carrot harvester and in quantifying and understanding the variability across this pivot quarter.

Activities

Soil mapping

Electromagnetic (EM38), elevation and radiometric soil mapping was carried out to identify and understand any variability in the soil, based on visible differences across the field.

The soil mapping was carried out at 12 m swaths across the field. After processing the soil sensing data, the resulting maps were used to locate sample points within each zone (based on both ECa, elevation and radiometric data) (Figure 1).

Soil samples were collected at each of these sample points to a depth of 60 cm and analysed for soil texture, electrical conductivity (EC), soil pH, exchangeable cations and nutrients.

Grower: Sun City Exports, Center West

Location: Woodridge, Western Australia

Area: 530 ha

What they grow: carrots

Soils: sands

Topography: undulating sands

Average annual rainfall: 970 mm (winter dominant)

Precision technologies implemented: Yield mapping, EM38 and gamma radiometric soil mapping and yield prediction from high resolution satellite imagery through VG16009

Laboratory analysis of soil samples did not indicate any difference in soil EC, and there were only very subtle differences in soil texture. However, there were obvious visible differences in colour and wetness of the soil in different areas of the field.

"Landscape variability and the soil type is impacting on soil moisture status across the field. Soil mapping and soil moisture sensing has helped quantify this and identified zones that could be used for variable rate irrigation." – Francis Tedesco

Hort Innovation Strategic levy investment
VEGETABLE FUND
Queensland Government

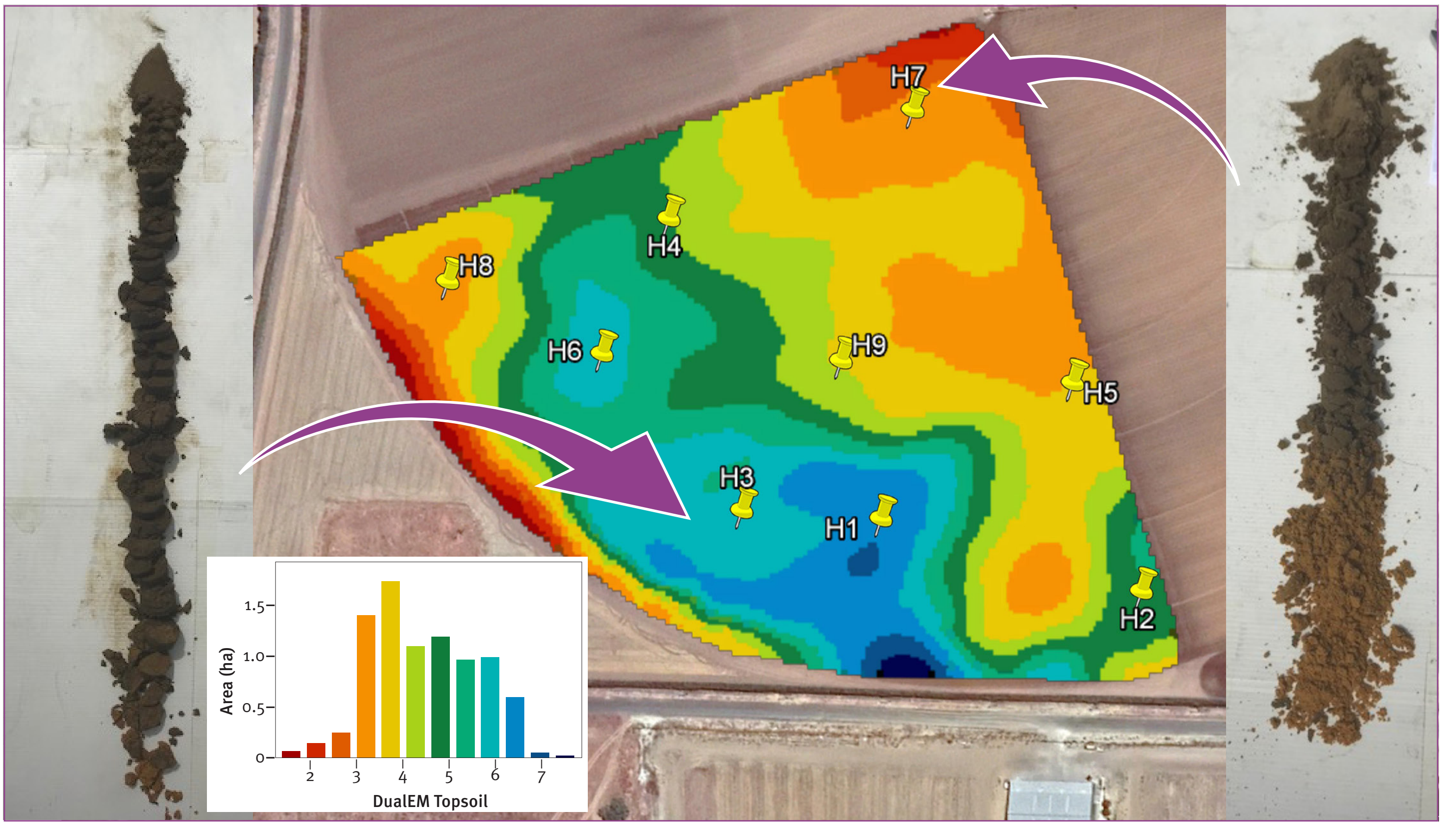

Figure 1. Soil sampling points located across different EM38 zones (centre) and soil sample cores from high EM zone (left) and low EM zone (right). EM38 detects apparent differences in electrical conductivity (ECa) which is influenced by clay content, soil moisture and soil salt content. Blue areas indicate higher ECa. Differences were even more evident in the subsoil.

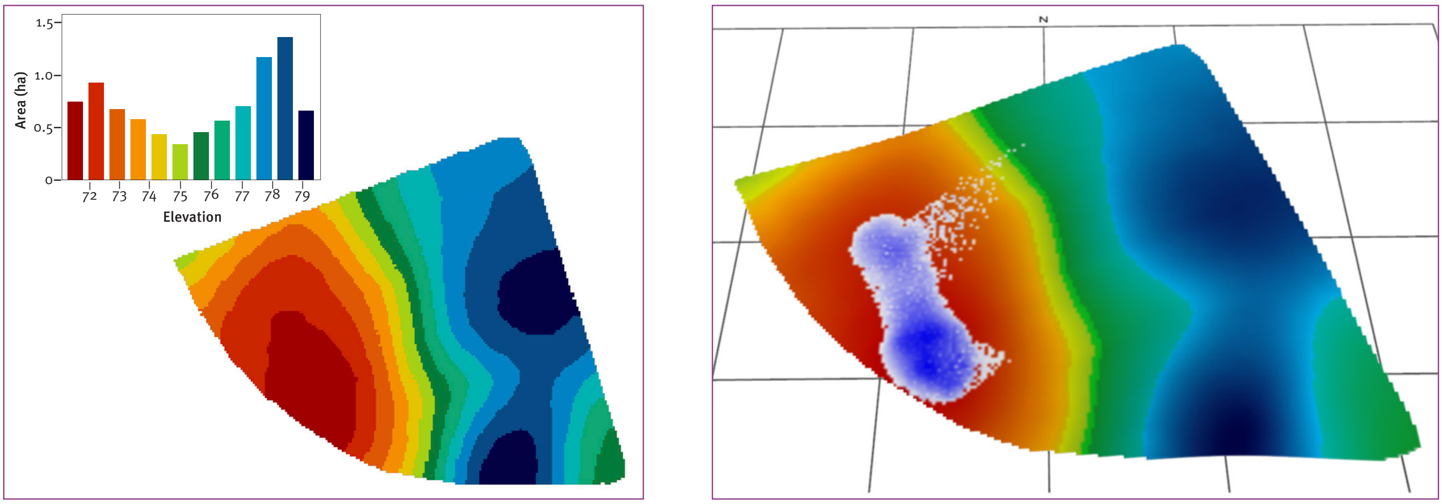

Figure 2. Elevation (left) and water flow model (right) based on the elevation data for this pivot quarter.

Drainage modelling

Given the topography of the field and the spatial pattern in EM38 data, the high resolution elevation data collected as part of the soil mapping exercise was used to model drainage across this pivot quarter. This model indicates an area of water accumulation at the lowest part of the field (Figure 2).

Given the predominantly sandy soil type, this is likely to reflect subsurface water movement to this point in the field. This is the likely cause of variability and the visible differences evident in the soil.

Figure 3. Location of Wildeye soil moisture sensors (left) and Wildeye soil moisture sensor in the field (right).

Soil moisture monitoring

Wildeye soil moisture monitors were installed to observe how soil moisture might vary across this pivot quarter, given the area of water accumulation at the lowest elevation. This information will help with understanding irrigation requirements across the pivot quarter. The location of these sensors are shown in Figure 3. Both the elevation and EM38 soil mapping data were used to locate the Wildeye soil moisture sensors.

The Wildeye data did indicate differences in soil moisture across the field (Figure 5):

- Wildeye-1 consistently monitored as significantly wetter than the other monitoring sites at three depths (15, 30 and 45 cm), and remained wet for more than half of the growing period. This supports the drainage model, which indicates that soil water would be accumulating in this area of the field.
- Both Wildeye-3 (medium-high elevation) and Wildeye-4 (high elevation) exhibited good soil moisture at each depth. Although the Wildeye-4 data indicated lower soil moisture at 30 cm throughout the crop.
- Wildeye-2 did have periods of low soil moisture throughout the crop, suggesting some crop stress may have occurred. The radiometric data and the EM38 subsurface data does indicate that this area of the field has differences in soil type characteristics, which could be impacting on soil:water interactions and water movement in this area (Figure 4). Infiltration of water from the sand would be slowed when it reached the heavier texture. Water then drains in a horizontal direction, based on the elevation, to the lower area of the field. This would explain the lower soil moisture level at Wildeye-2, and the higher soil moisture levels at Wildeye-1.

This information needs to be considered in the context of the soil type and landscape at this site, which, given the sand and elevation changes, would suggest significant subsurface soil water movement. The wetness at Wildeye-1 likely reflects subsurface movement of water from the higher elevations within the field. The true impact of this observed elevation and soil moisture variability can only be measured with yield.

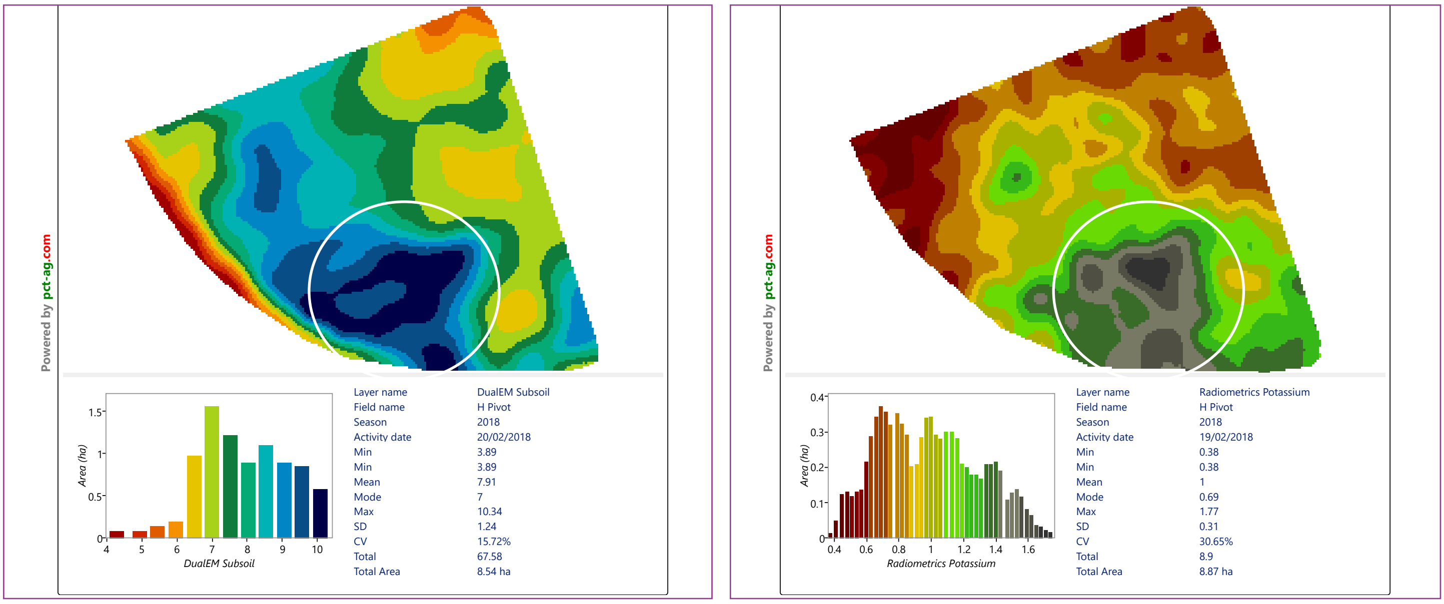

Figure 4. Subsurface EM38 and radiometric data showing differences in the area around Wildeye 2.

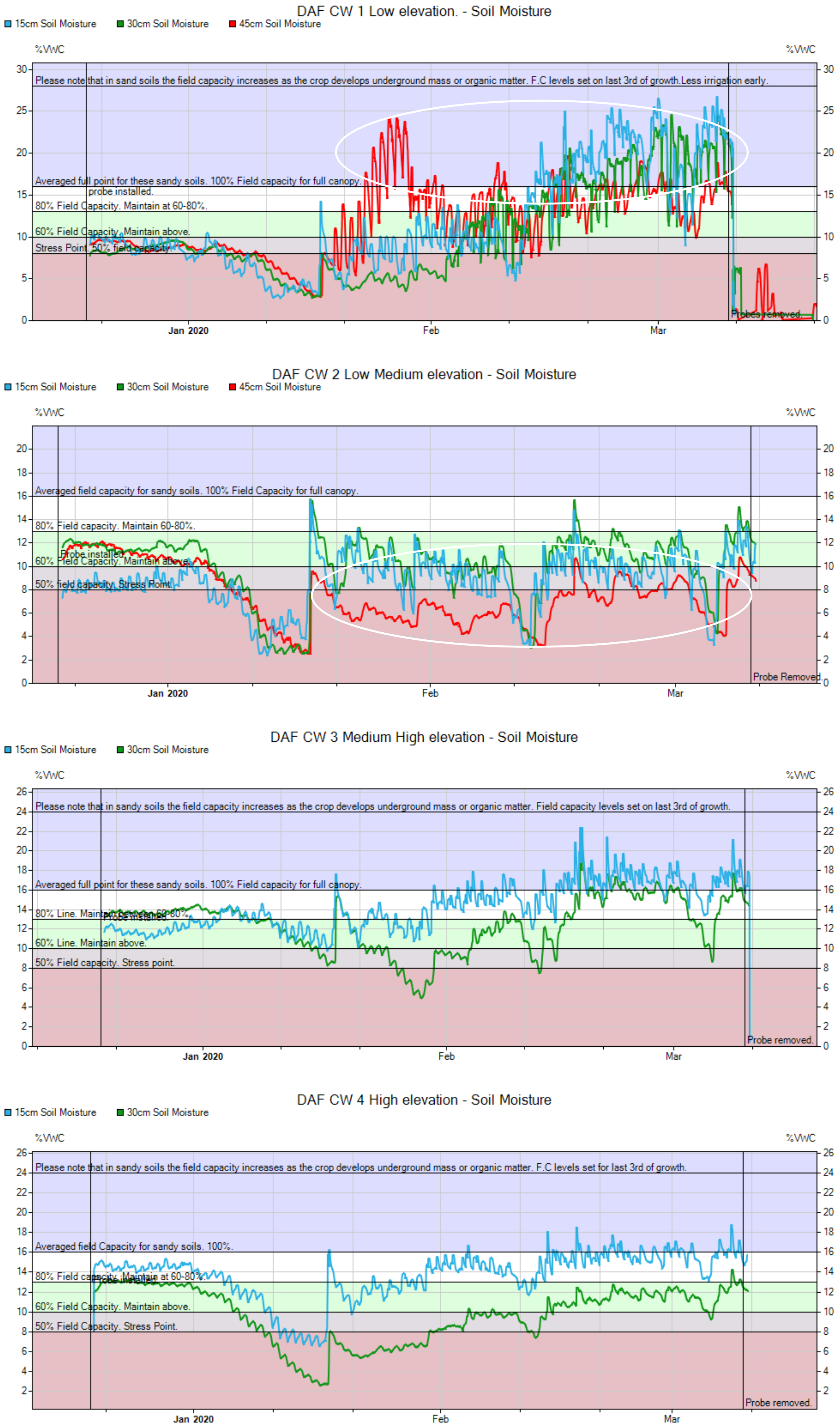

Figure 5. Wildeye soil moisture data for Wildeye sensors W1-W4. Note: Two of the Wildeye sensors had a third sensor at 45 cm due to availability of equipment. Circles indicate the level of wetness for Wildeye-1, and possible periods of moisture stress around Wildeye-2.

Yield assessment

Hand harvested yield assessments were completed at maturity (2 weeks prior to harvest). In total, there were 12 yield samples collected across the field, with three points from each of the four zones based on the elevation, EM38 and high resolution crop NDVI imagery (Figure 6).

These zones could be classified as:

- low EM38, high elevation
- high EM38, low elevation
- high EM38, med elevation
- med EM38, med elevation.

The yield assessments indicated that there was up to 37 per cent variability in yield across the field. The red/orange areas in the NDVI imagery had the lowest yields by up to 20 per cent on average (Figure 7). Grading data for the hand harvested yield samples did highlight that there were differences in marketable specifications (based on Woolworths specifications for pre-packed carrots) (Table 1).

The lower yielding areas had almost double the waste percentage. This may be partly due to the fact that the yield samples were collected two weeks before harvest, and some of this waste were small carrots outside size specifications. However, this data highlights that there were differences in crop growth and maturity across the field.

Figure 6. Location of yield sampling points in the field relative to both the elevation (left) and EM38 (right) maps. Circles indicate the approximate zones with three yield samples from each of these areas.

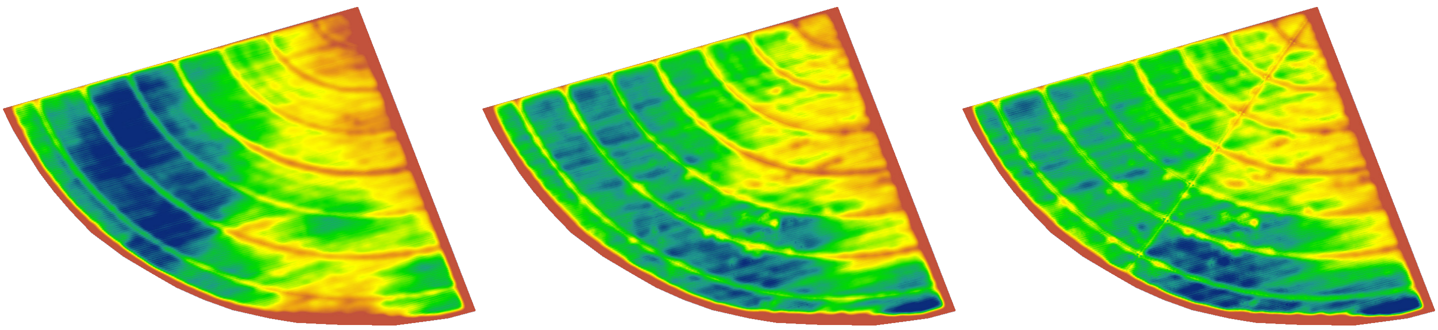

Figure 7. High resolution NDVI imagery in carrots capture approximately 8 weeks after planting (left), 13 weeks after planting (centre) and 15 weeks after planting (right). Blue areas indicate higher biomass and vigour, the orange and red areas indicate lower biomass and vigour.

Table 1. Average yield and grading data from each of the sampling zones.

	Biomass yield (t/ha)	Carrot yield (t/ha)	Class 1 %	Class 2 %	Waste %
low EM38, high elevation (W3)	7.4	42.7	68.7	22.1	8.2
high EM38, low elevation (W1)	9.3	48.5	46	38.1	13.6
high EM38, med elevation (W2)	9.4	39.6	51.3	32.8	15.9
med EM38, med elevation (W4)	7.7	48.4	61.2	28.0	9.1

Key learnings

- Yield variability up to 37 per cent measured across the field. This yield variability matches crop NDVI imagery from early in the growing period.
- Grading data indicates that there are differences in maturity across the field, which is also indicated in the early season NDVI imagery.
- EM38 and radiometric data indicated differences in soil moisture arising from topography, as well as subtle differences in soil texture. There is evidence of a possible heavier texture layer at depth.
- This field has elevation differences that are impacting on soil water movement, particularly given the sandy soil type. Drainage modelling highlights an area of water accumulation at the low end of the field. This was also evident in Wildeye-1 data, which indicated this area was consistently wet throughout the cropping period. While this might have had a detrimental impact on yield in a heavier soil, there did not seem to have any impact on yield in this field. However, other areas of the field still yielded comparatively well, but were not consistent at high soil moisture. There is an opportunity to reduce irrigation across this area with variable rate irrigation for more efficient water inputs.
- In contrast, Wildeye-2 data indicated that this area of the field suffered some low moisture stress over several periods of the crop, which may have resulted in the lower yields from this area.

Service providers: Advanced Technology Viticulture; Precision Agronomics; Precision Soil Tech; Wildeye Soil Moisture sensors; Precision Agriculture

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Costs presented in this document were accurate as of October 2019. These will change over time and between data processing service providers.

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