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Keeping Australian farmers at the cutting edge

Australian Government
Department of Agriculture and Water Resources

Australian Government
Cotton Research and Development Corporation

Dairy Australia

# Automated camera-based crop monitoring and site-specific irrigation control systems

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# NCEA's automation research

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- Machine vision, automation, robotics
- Low cost machine guidance
- Precision monitoring tools

# Site-specific irrigation

- Can be over 200% variation in irrigation requirements: soil water holding capacity, elevation
- Variable-rate irrigation (VRI) hardware and variability mapping can be used

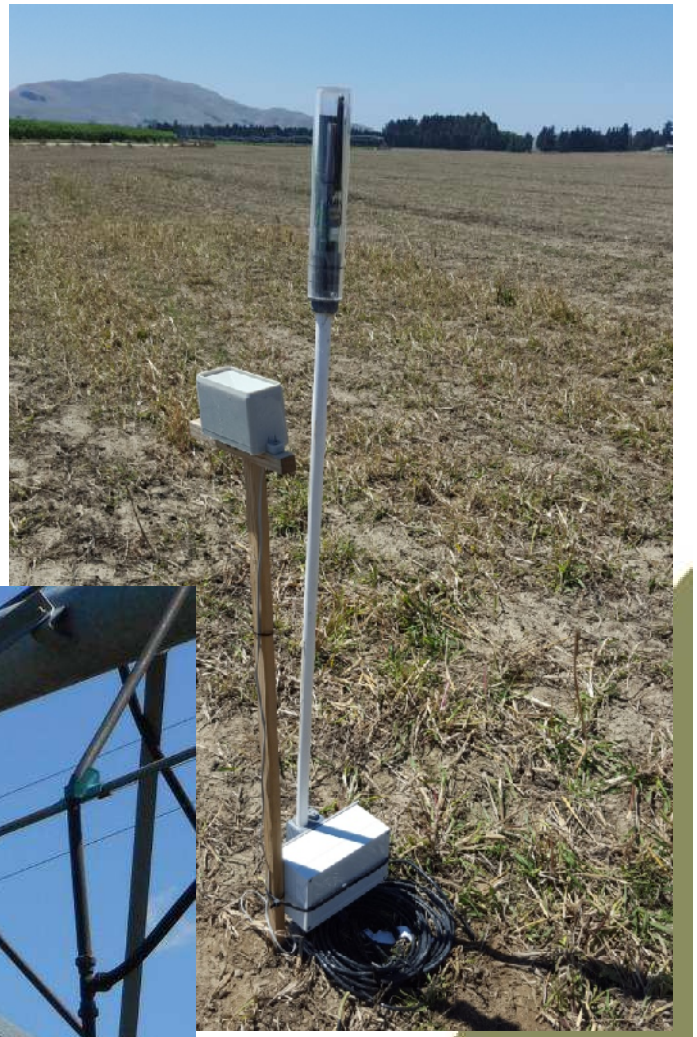
**Dairy pasture in Tasmania:**

**Horticulture field in Kalbar:**

# VRI research

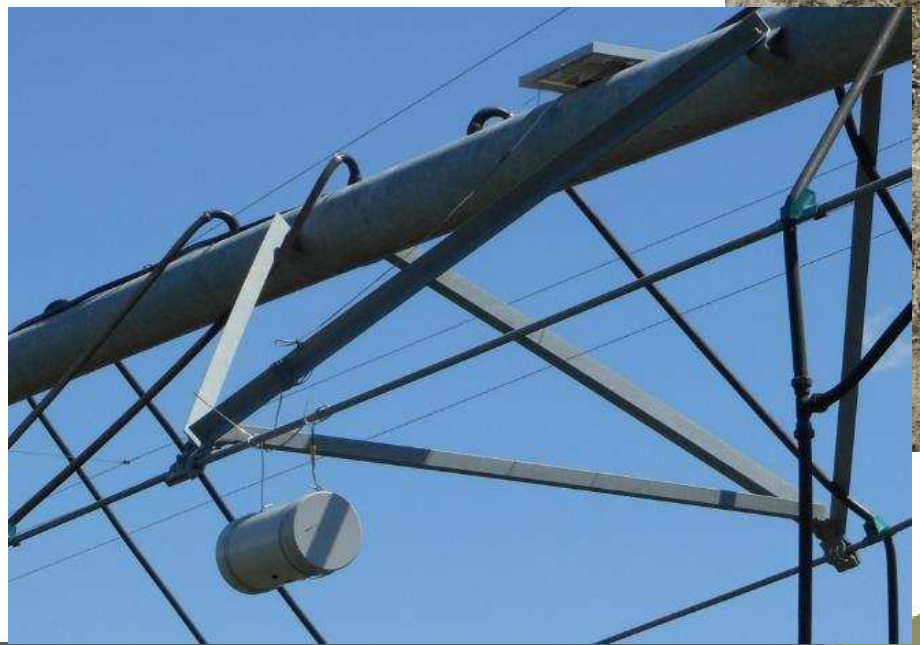
- Research trials in horticulture, corn, pasture and cotton in Australia, New Zealand and USA
- Inputs include soil type, soil moisture, temperature, crop growth

**Soil moisture network in NZ:**



**IRTs in Texas:**

**Cameras in QLD:**



# Commercial VRI use

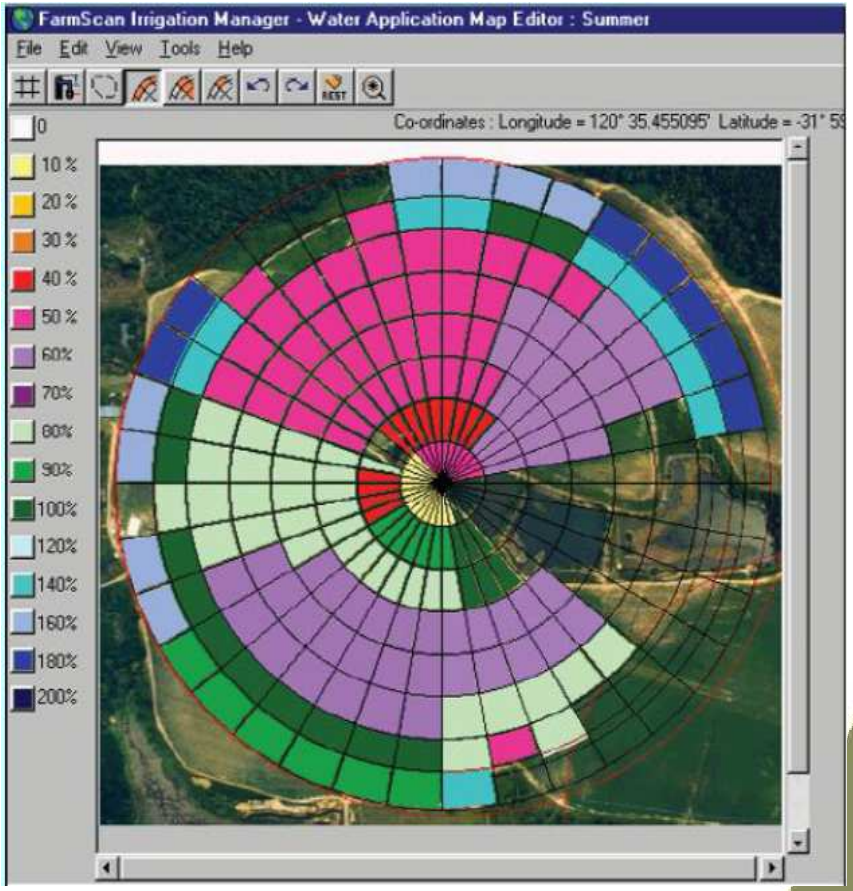
- Cost about $1500/ha – includes VRI hardware, GPS, software, remote access
- Generally 0-20% yield increase or water reduction reported in literature
- Generally used for avoiding roads
- Only 10% of VRI purchased still used

# VRI hardware

- Solenoid valve on each dropper
- Zones controlled with pulse width modulation and speed control to adjust flow rate
- Valley, Lindsay Zimmatic, Reinke, Trimble

# Prescription map development

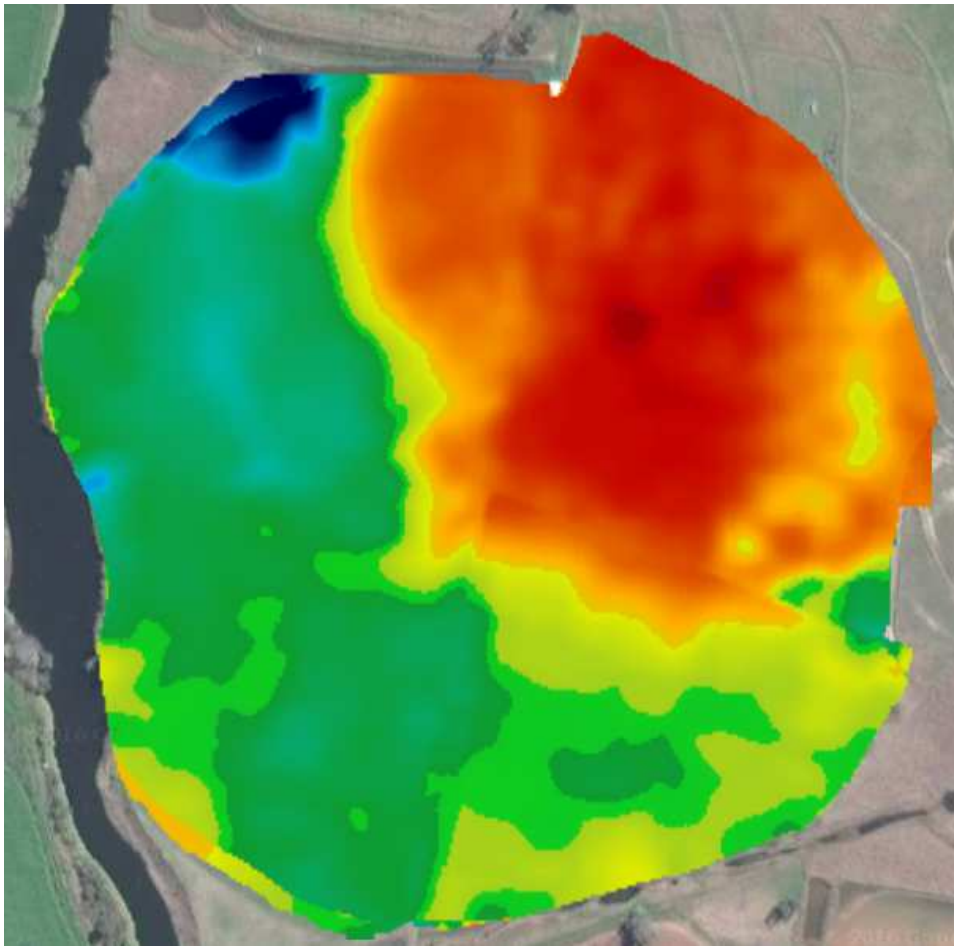
- For centre pivots, field divided into 1° sectors and zones along machine
- Original VRI systems needed manual entry of irrigation volume into individual zones
- Now polygons define zones



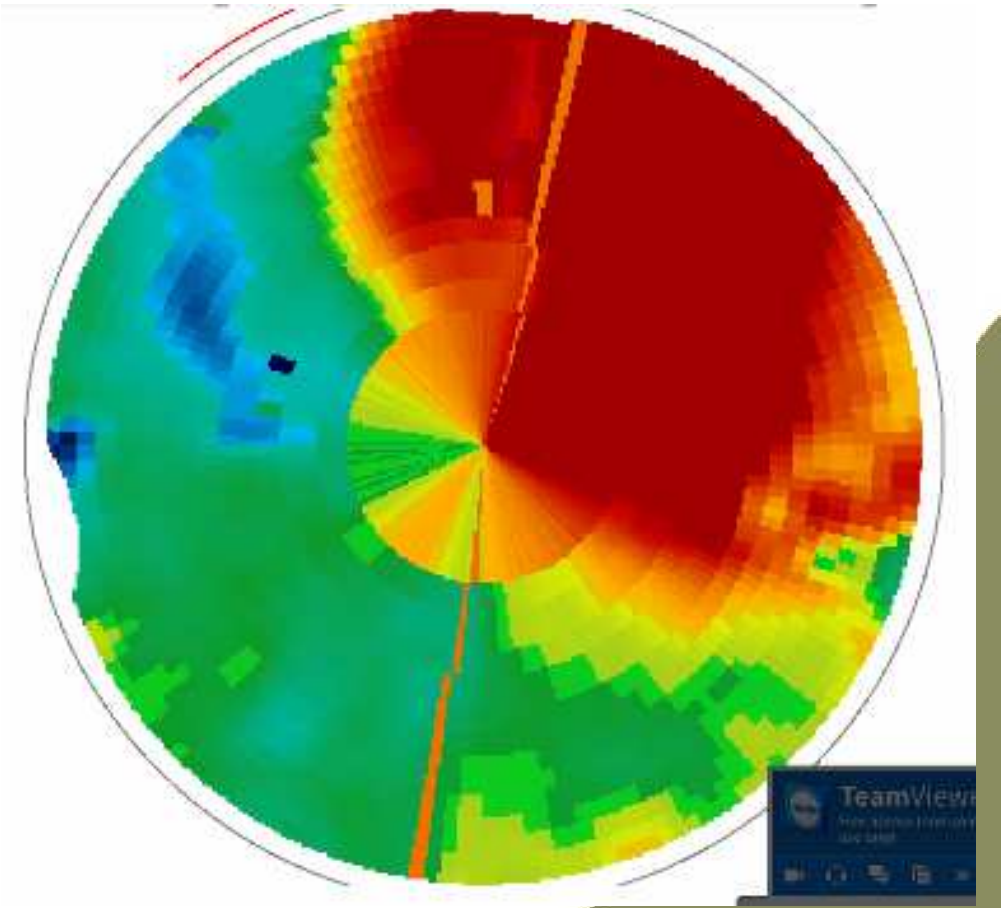
# Prescription map development

- Field map imported into data management software e.g. PCT, SST

**Original map:**



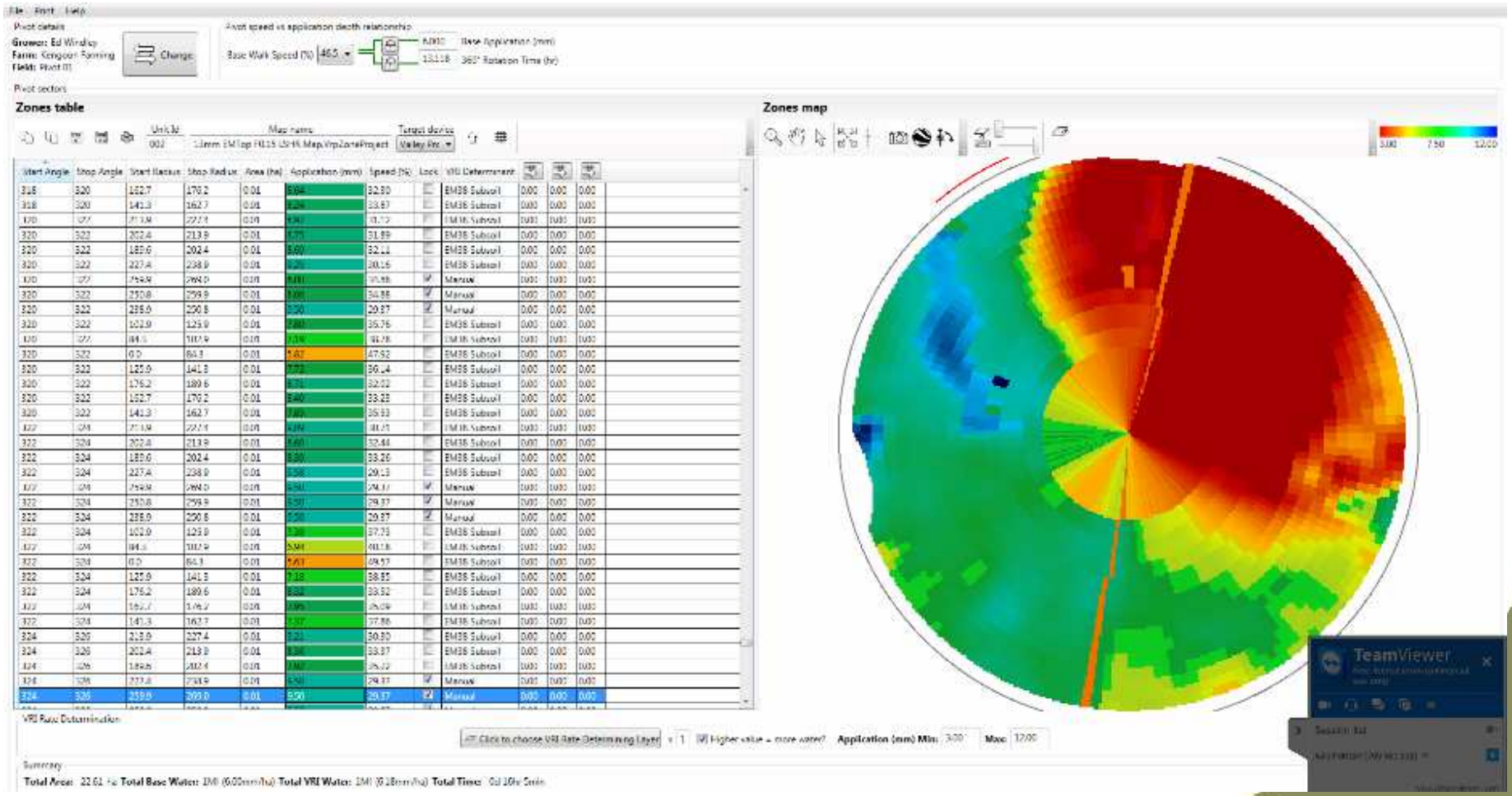
**VRI map:**



# Prescription map development

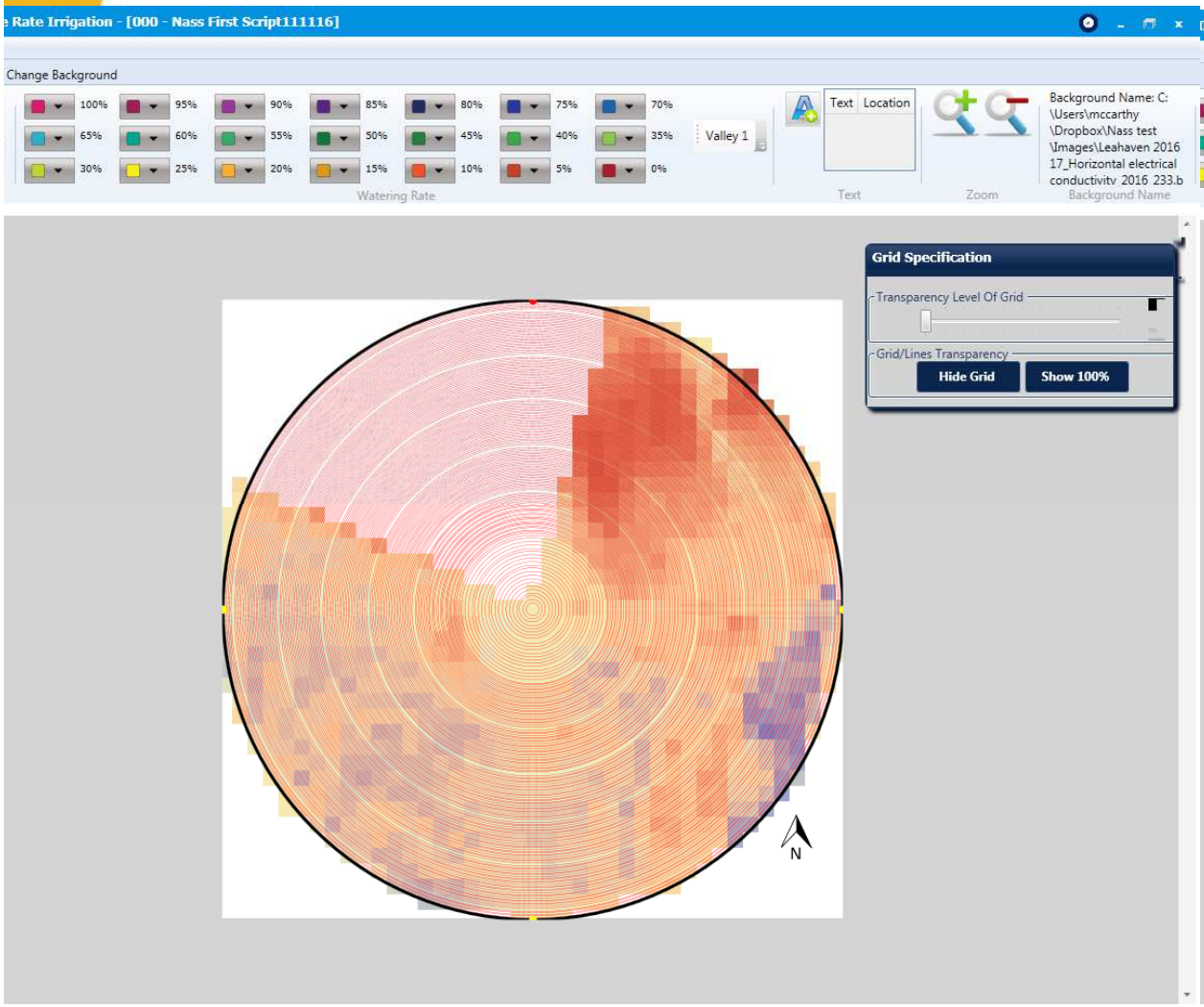
- Zone-by-zone editing of prescription map

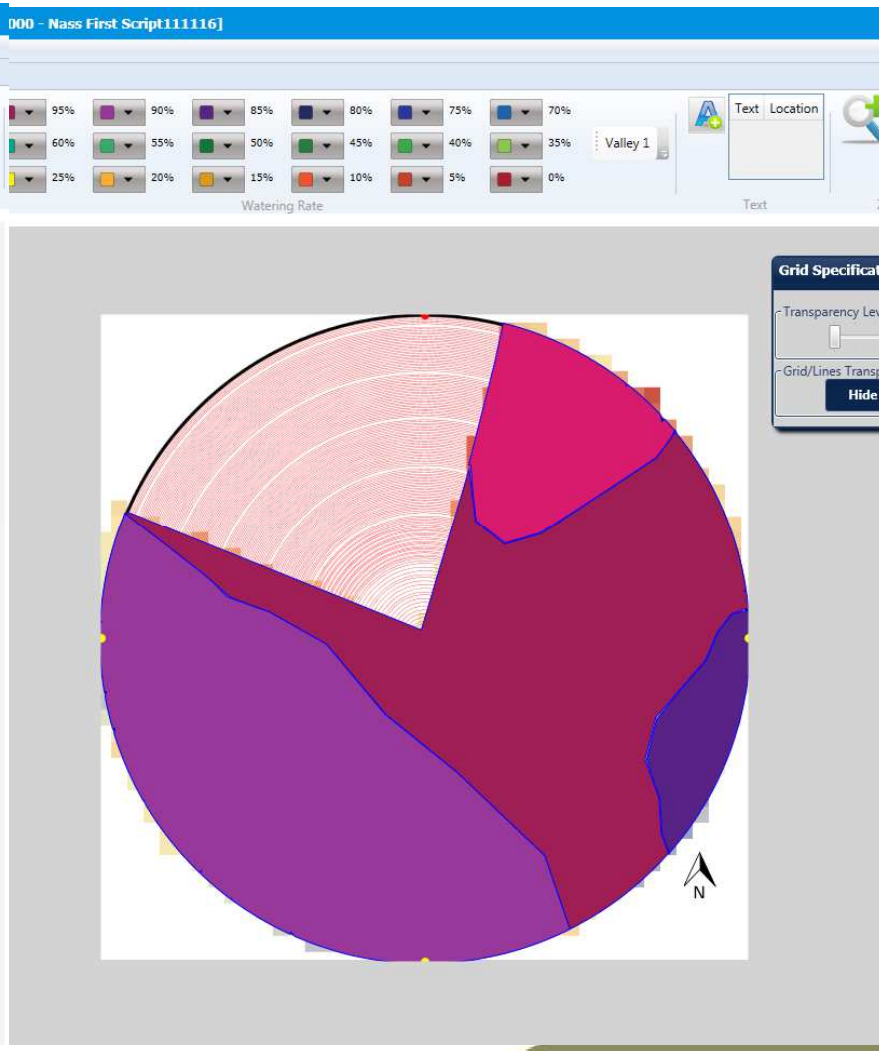
**Zone prescription input:** **VRI map:**



# Prescription map development

- User draws on polygon to define zones

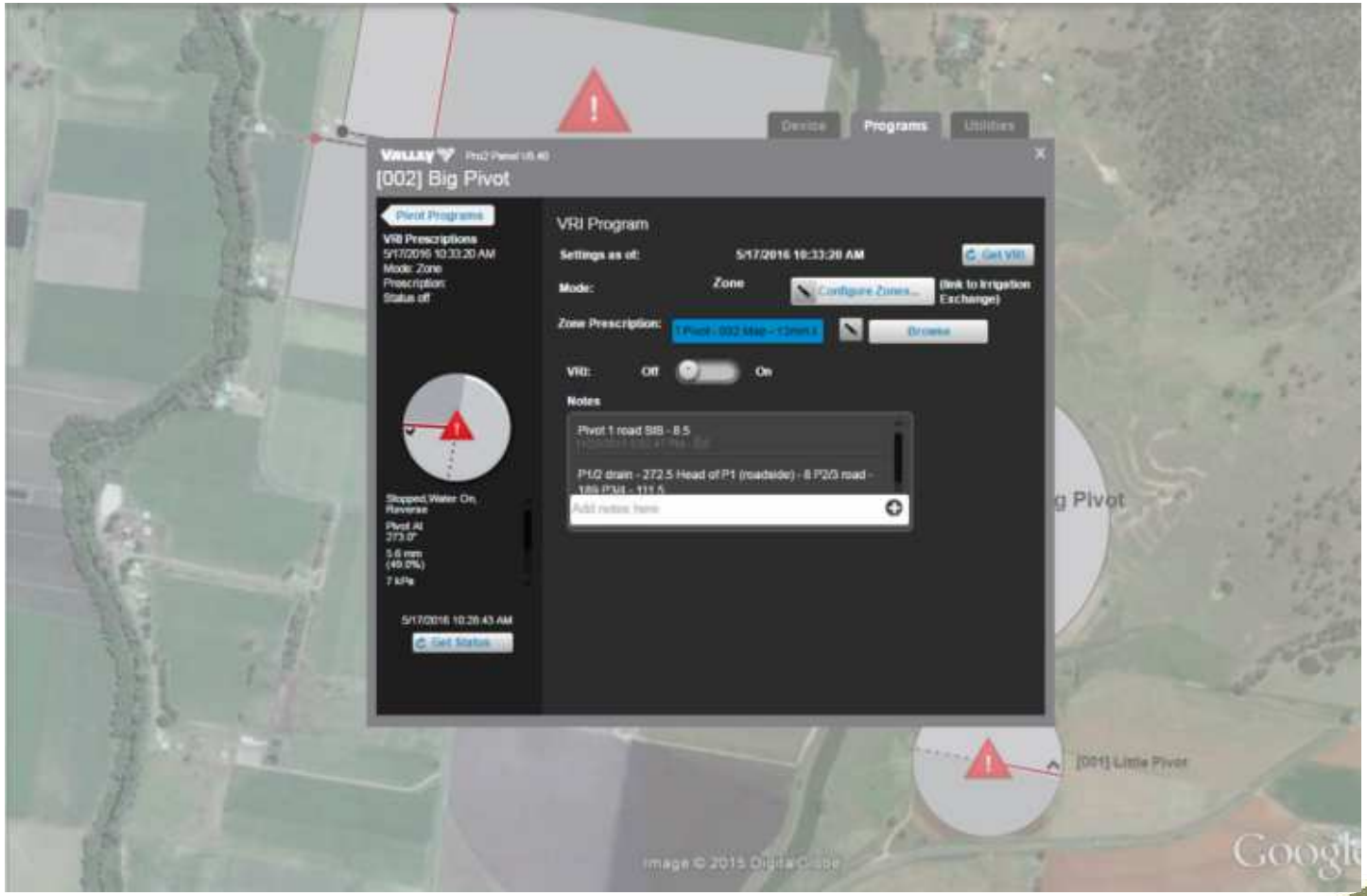


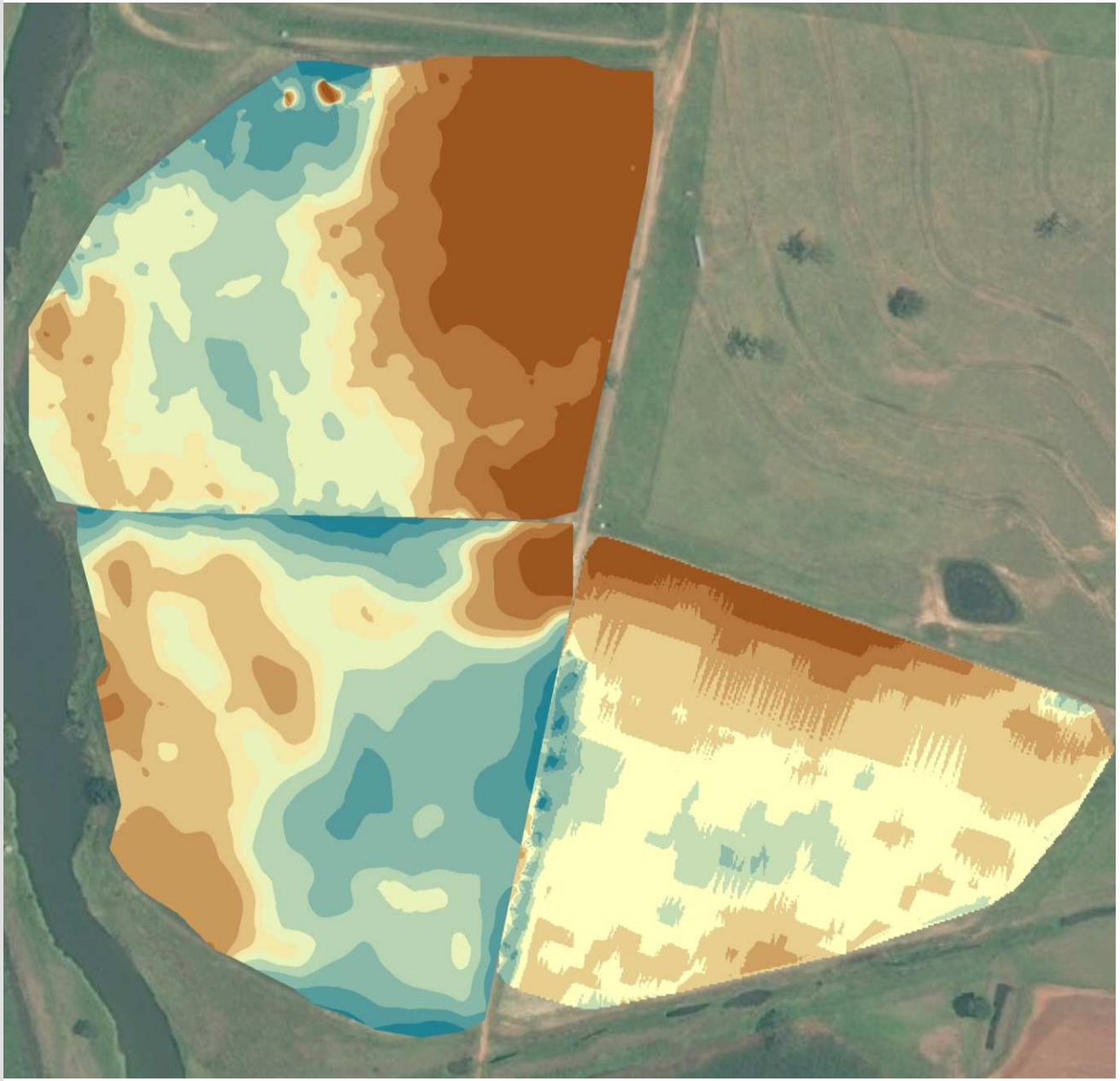
# Upload map to VRI system

- Remote access, radio or manual upload

**Valley VRI map upload:**



# Monitoring - soil



# Monitoring – machine imagery

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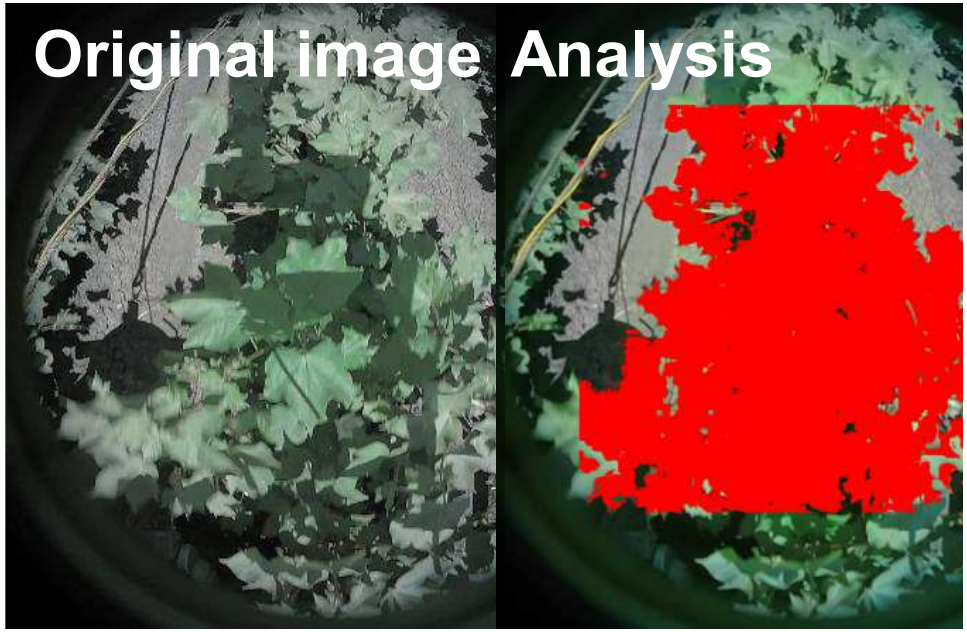
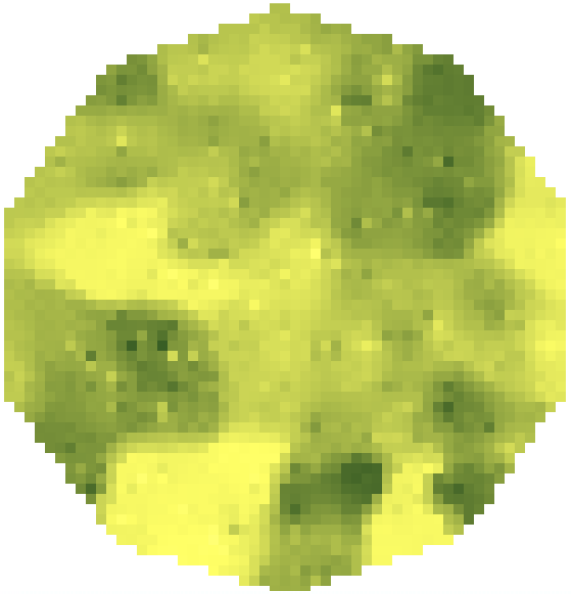
## Smartphone camera

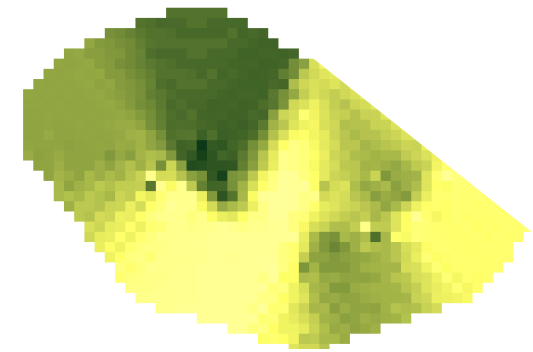


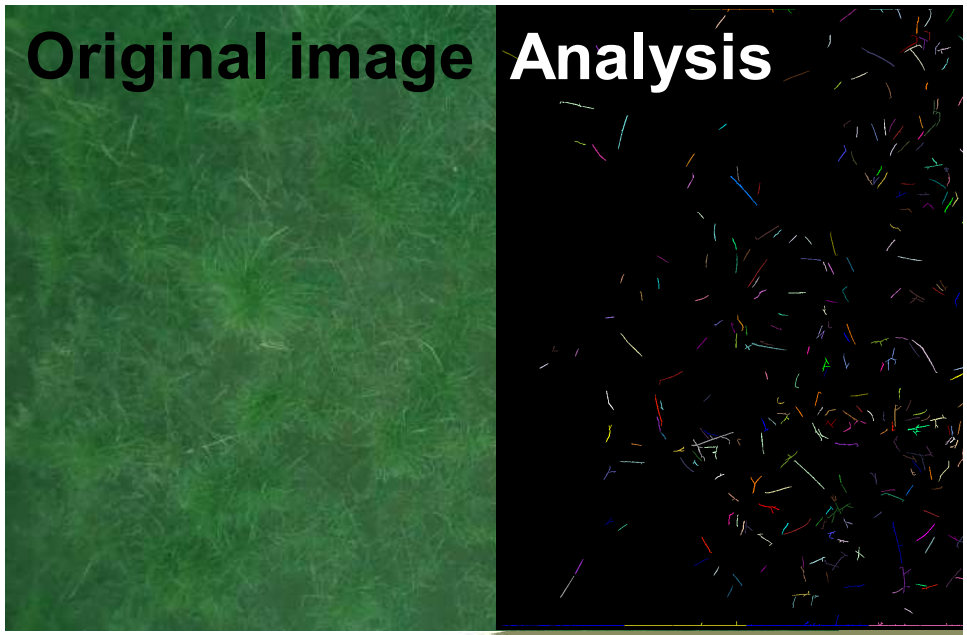

## Height from quad bike sensor



## Canopy cover from cameras

0 Height (mm) 250





# VRI research

- CPLM VRI is historical map based
- Developing automated control strategies for timing and volume

Surface irrigation system

Overhead irrigation system

1. Sensors

- fixed sensors
- historical maps
- on-the-go sensors

2. Control strategy

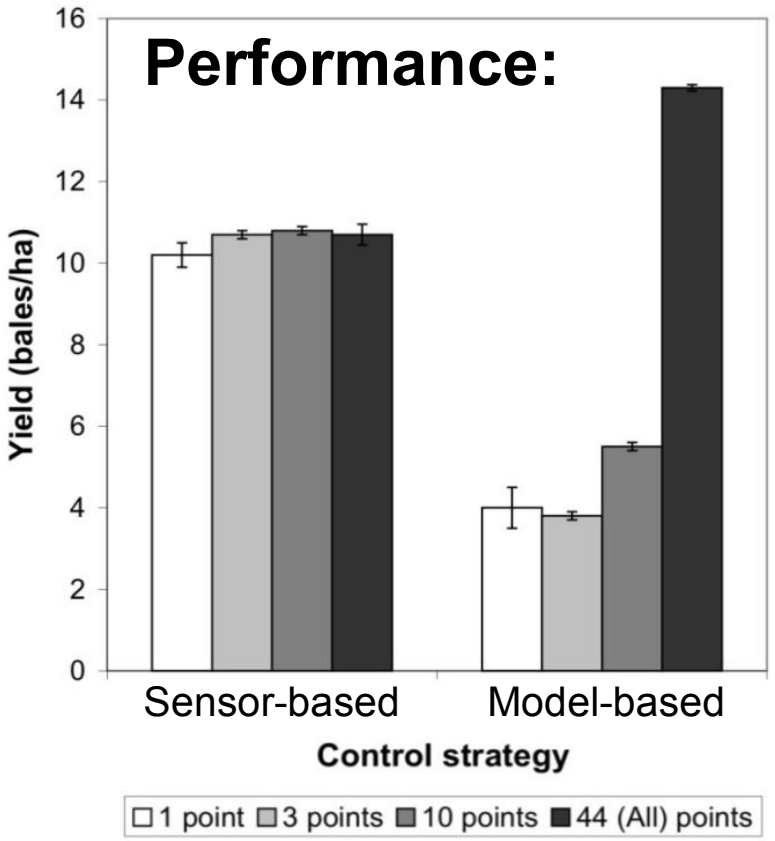
- convert data to irrigation application
- model-based control needs calibration with infield data

3. Real-time irrigation adjustment

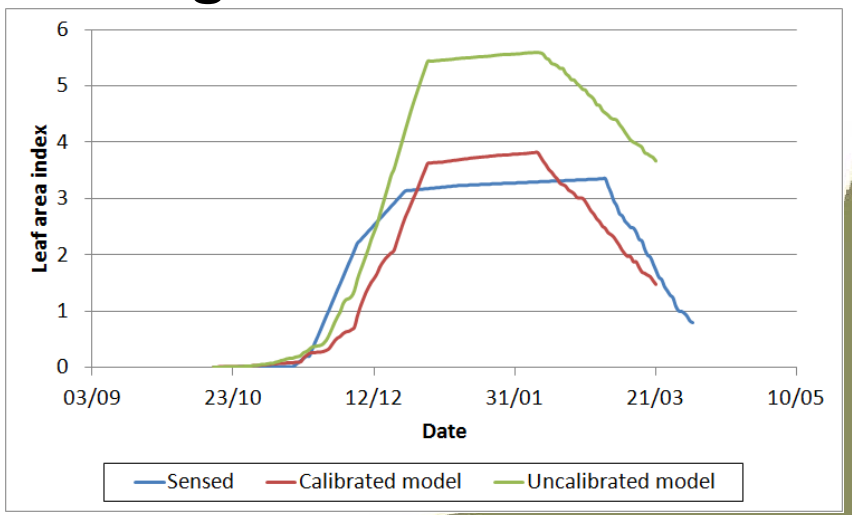
- actuators to apply irrigation

# Irrigation control strategies

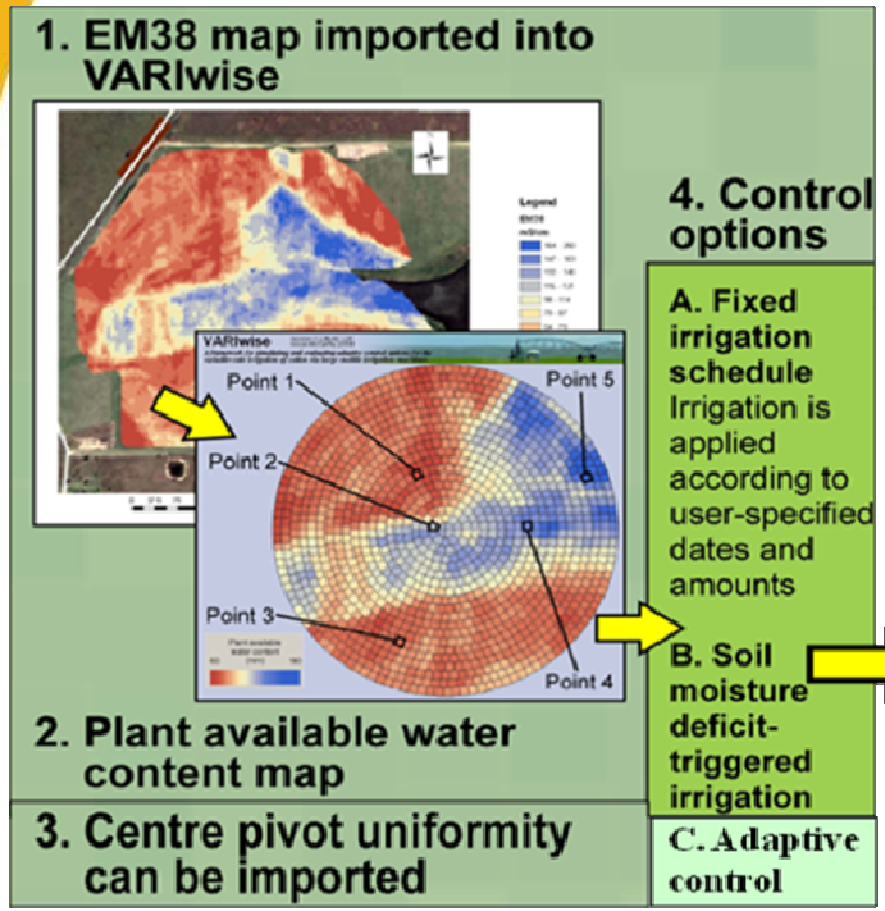
- Sensor-based control
  - Soil moisture status estimation using soil, temperature and/or reflectance sensors
- Model-based control:
  - A calibrated crop model simulates and *predicts* the next required irrigation, i.e. volumes and timings
    - according to evolving crop/soil/weather input
    - separately for all cells/zones
    - can *choose* alternative end-of-season predicted targets
  - Potentially higher yields than sensor-based control

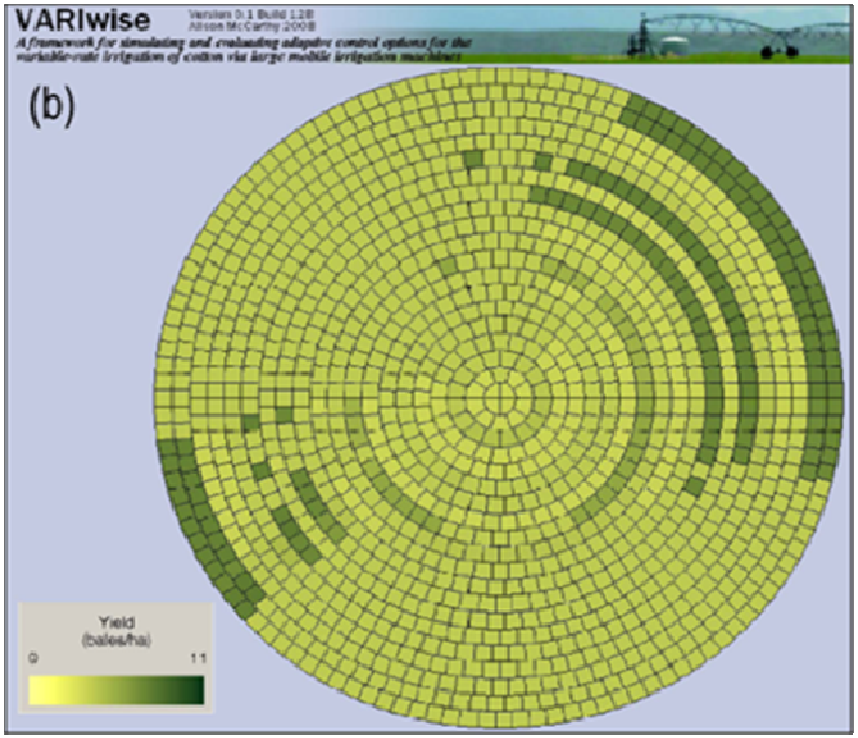



## Plant growth calibration:



# Simulation of sensor-based control




| Sensor location | Variability in machine uniformity | Yield (bales/ha) | Irrigation water use efficiency (bales/ML) |
|---|---|---|---|
| Point 1 | Low | 7.0 | 0.7 |
| | High | 7.0 | 1.0 |
| Point 2 | Low | 7.1 | 0.7 |
| | High | 7.0 | 1.0 |
| Point 3 | Low | 7.1 | 0.8 |
| | High | 4.6 | 0.4 |
| Point 4 | Low | 6.8 | 0.7 |
| | High | 7.0 | 1.0 |
| Point 5 | Low | 7.4 | 0.9 |
| | High | 7.0 | 0.9 |

# Control system implementation on centre pivot

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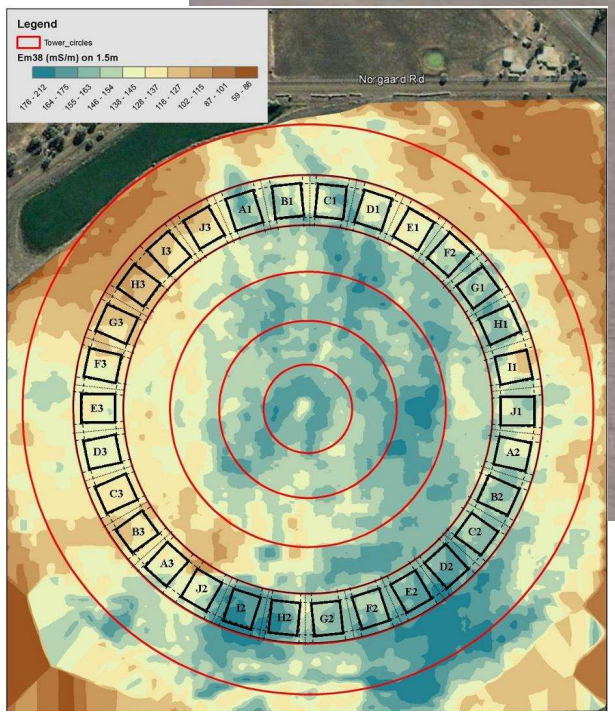
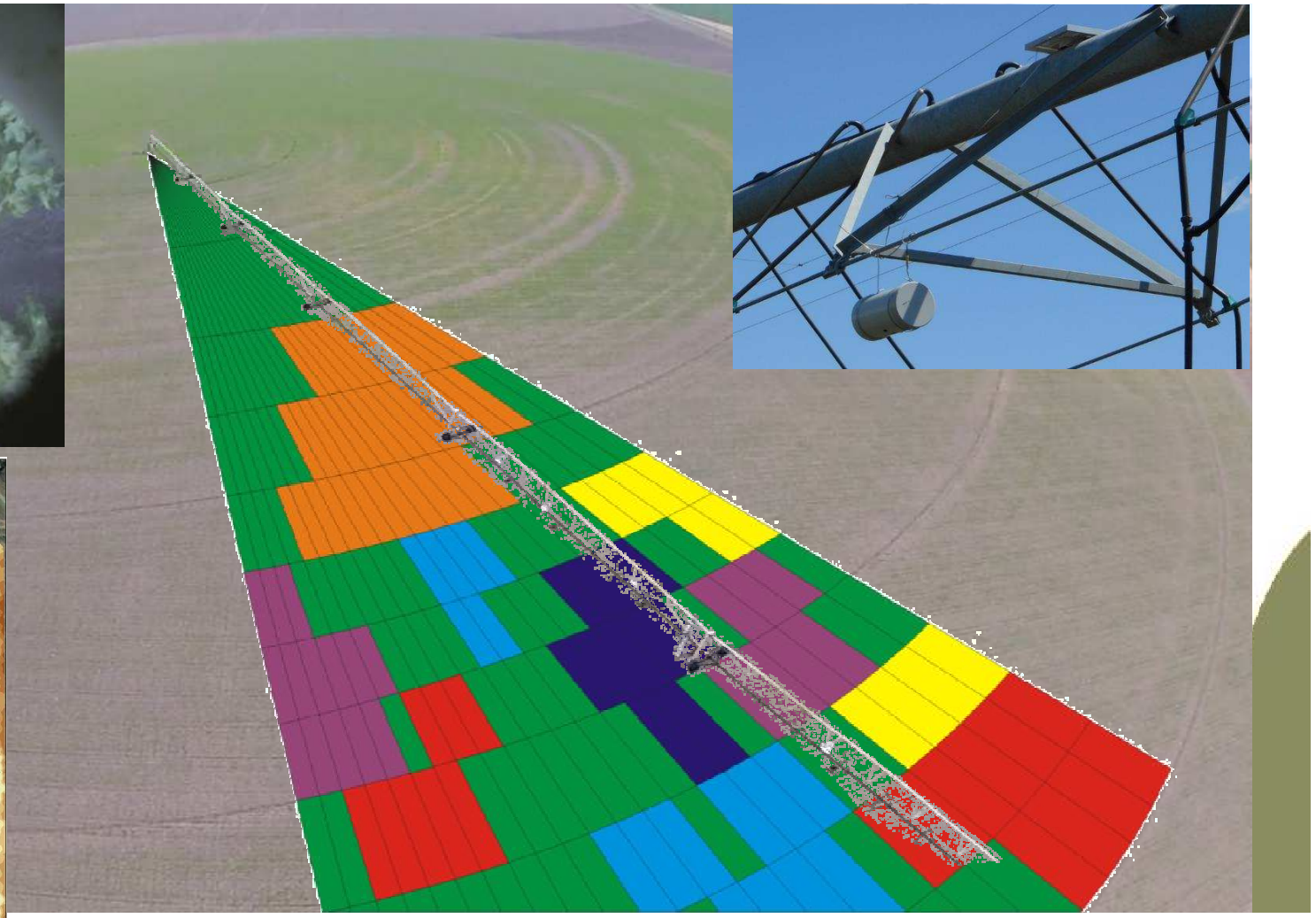
## Real-time camera-based plant sensing to update irrigation:



# Conclusions

- Framework developed for data processing at a range of spatial resolutions
- Next steps:
  - Link control strategy output with commercial VRI system for cotton and dairy irrigation sites
  - Online data management and processing for cotton and dairy data and control
  - Evaluation of control strategies at all sites over next two years

# Acknowledgements


- Cotton Research and Development Corporation, Federal Government Rural R&D for Profit Program, Queensland Government, TIA, Dairy Australia for funding support
- Growers Ed Windley, and Neil and Lachlan Nass for providing field trial sites