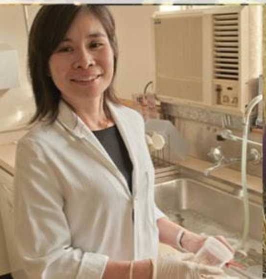
tiar

TASMANIAN INSTITUTE OF AGRICULTURAL RESEARCH

Tasmania
Explore the possibilities

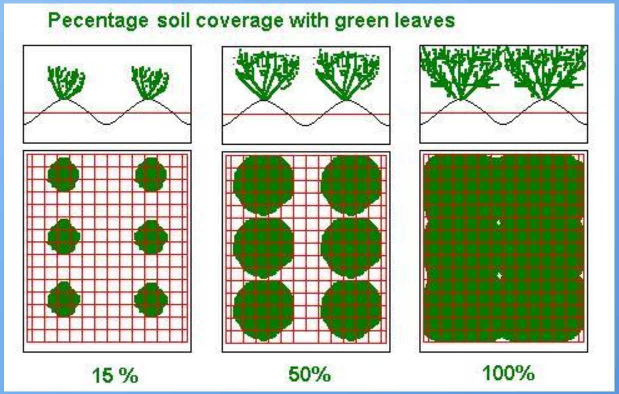
TIAR is a joint venture of the University of Tasmania and the Tasmanian Government

UTAS






Irrigation Efficiency



Outline for today

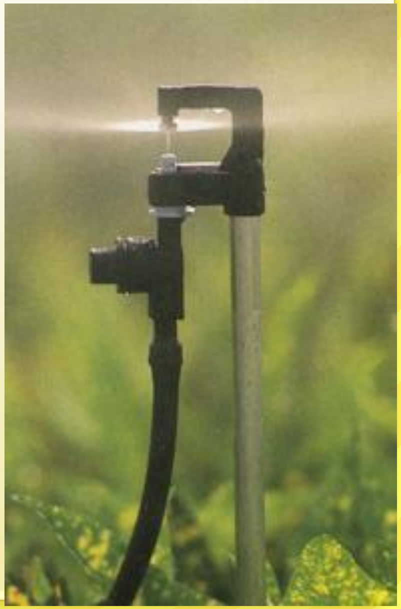
- Irrigation methods
- Water use efficiency – what is it?
- How to improve water use efficiency on your farm
- Crop water use – what are the drivers?
- Evapotranspiration – what is it? How can you use it?
- Monitoring tools / irrigation scheduling
- Crop water requirements
- Soil and water quality
- Variable rate irrigation
- Precision Agriculture

Irrigation Methods

1. Set systems – e.g. portable, solid set
2. Continuous systems
   a. Centre pivot
   b. Lateral / linear
   c. Hard hose / soft hose / boom travellers
3. Subsurface
   a. Tape / drip
   b. Porous tube




4. Micro systems
   a. Drip system
      i. Drip / trickle
      ii. Tape
      iii. Bubbler
   b. Micro sprinkler
      i. Micro sprinkler
      ii. Micro sprayer
      iii. Micro jet
      iv. Pulsator



5. Surface
   a. Flood
   b. Furrow

- Flood and furrow irrigation tend to be less efficient in terms of water use methods
- Increase in the adoption of more efficient water application methods

The type of irrigation system best suited to you depends on:

- Variations in soil types
- Topography of your land
- Availability of power sources
- Availability of water
- Sources of water
- The size of the area being irrigated
- The type of crop and the water demands of the crops that you grow
- On farm water storage capacity
- Availability of labour / financial resources

It is important to consider:

1. Irrigation system capacity
2. Soil water holding capacity
3. Water infiltration rate of the irrigated area
4. Crop water use requirements

Water Use Efficiency

What is it?

- A term commonly used to describe the relationship between water (input) & ag. production (output)
- Another description is tonnes of produce per ML of water
- Water use efficiency is also used to express the effectiveness of irrigation water delivery and use

Efficiency

1. Micro sprinkler and drip systems (most efficient)
2. Centre pivots and linear machines
3. Travelling irrigators
4. Solid set
5. Flood and furrow (least efficient)

How to Improve Water Use Efficiency and Farm Productivity

On farm efficiency can be improved by:

- Know your soil and the amount of water it holds
- Understand the water requirements and growth patterns of the crop you are irrigating
- Water budget
- Irrigation scheduling
- Adopt technology to help match irrigation with crop requirements

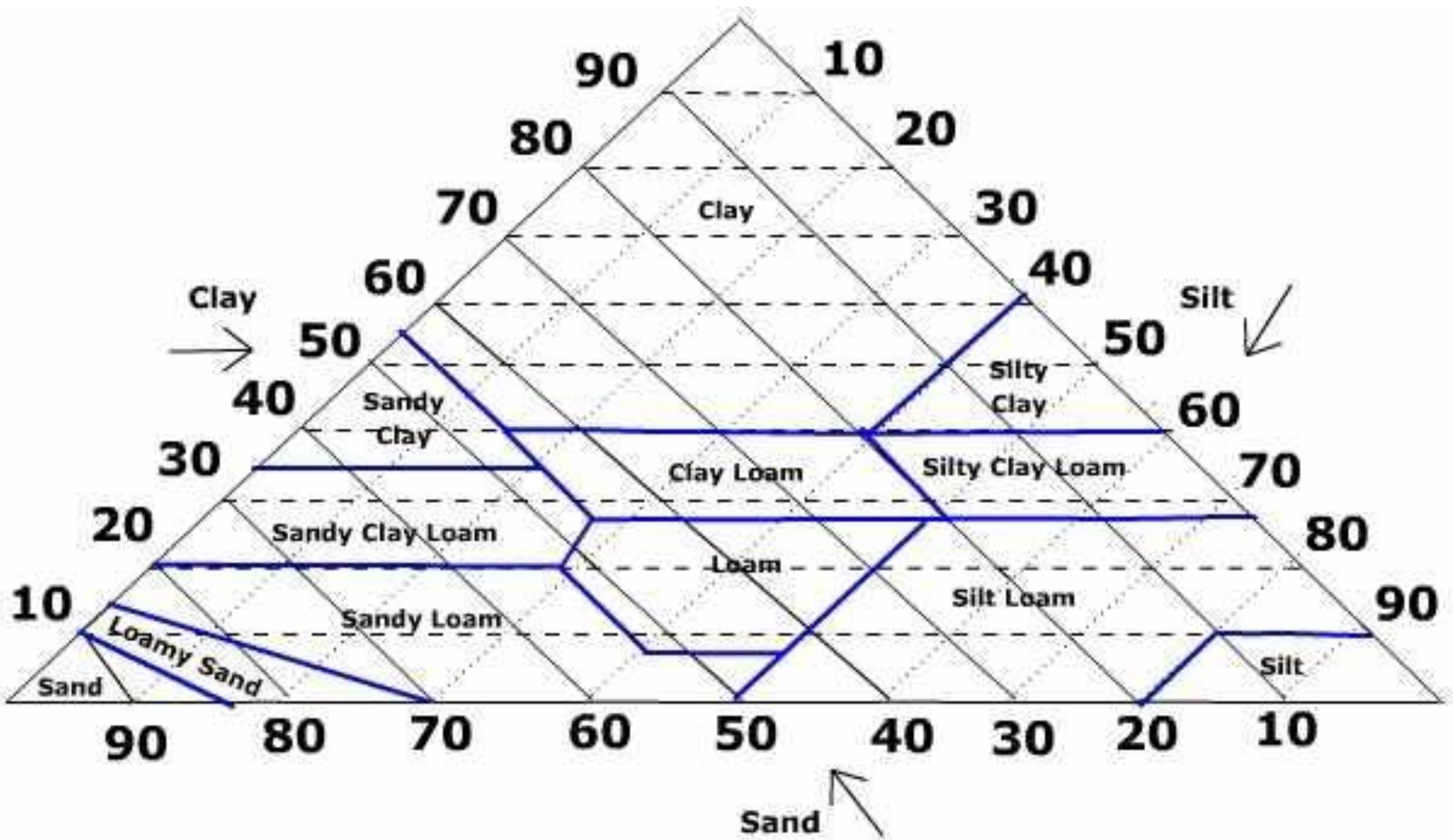
SOILS
and their impact on available soil water & irrigation scheduling

- The amount of water held varies with soil type
- Having a knowledge of the water holding capacity of the soil can help with planning irrigation
- It is useful to know how much water soil types on your farm hold

Soil Texture

- Describes the relative amounts of sand, silt and clay present
- Texture determines how much water is available to the plant
- Plant roots create suction to remove water from the soil pores
- Plant roots use water from the large pores first

The soil texture triangle



http://www.uwsp.edu/geo/faculty/ritter/images/biosphere/soils/texture_triangle_large_2.jpg

- As the amount of soil water decreases it becomes increasingly difficult for plant roots to extract.
- Some plants have a greater ability to extract water from drier soils.
- Soil structure also impacts on the amount of water available to a plant. Good structure holds more water than poor.

Soil water storage examples

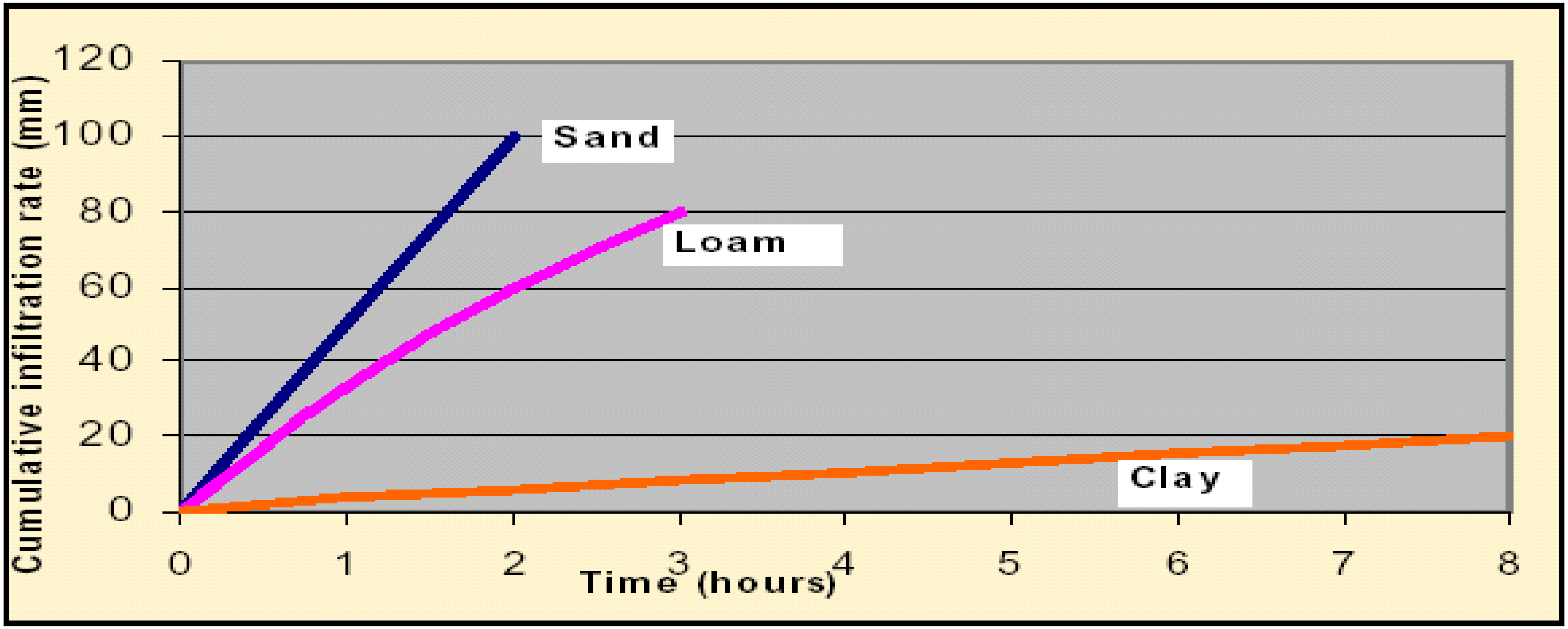
(mm of water per 1 metre depth of soil)

• Sand	30
• Loamy sand	40
• Sandy loam	50
• Sandy loam with OM	80
• Loam	90
• Clay	40
• Well structured clay	70

Water Infiltration Rate

- Is the rate that water can enter the soil.
- The rate of water applied must not exceed the soil's infiltration rate.
- Exceeding the infiltration rate can result in soil damage and run-off.
- It can cause erosion, loss of nutrients and excessive waterlogging in low lying areas.

Figure 12. Cumulative infiltration of water



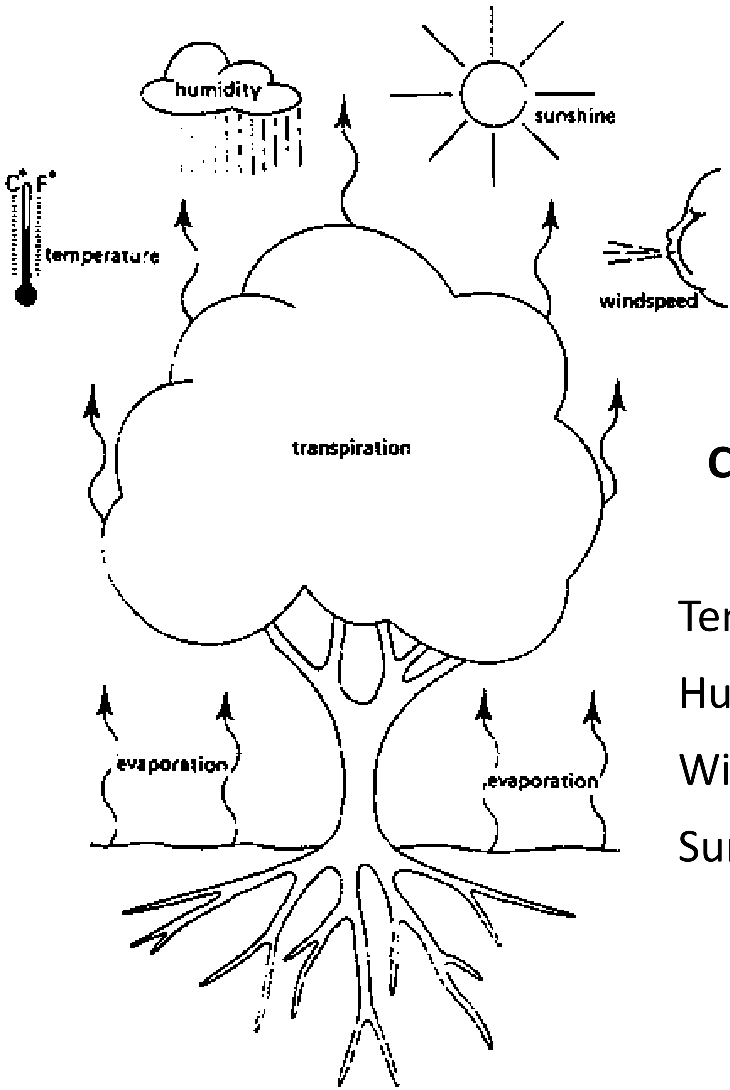
Crop Water Use

- Depends on type of crop
- Crop water use changes with the stage of growth
- Evapotranspiration is the term used to describe the combined losses by evaporation and transpiration (plant water use).
- When a crop is actively growing the majority of water use is transpiration.

What drives crop water use?

1. Solar radiation
2. Humidity
3. Wind speed
4. Temperature

Major climatic factors influencing crop water needs



Climatic Factor	Crop water need	
	High	Low
Temperature	hot	cool
Humidity	low (dry)	high (humid)
Windspeed	windy	little wind
Sunshine	sunny (no clouds)	cloudy (no sun

Crop water use can be estimated from:

1. Weather data
2. Class A pan evaporation
3. By examining the plant
4. By using ET_0
5. By using soil water monitoring tools

Evapotranspiration

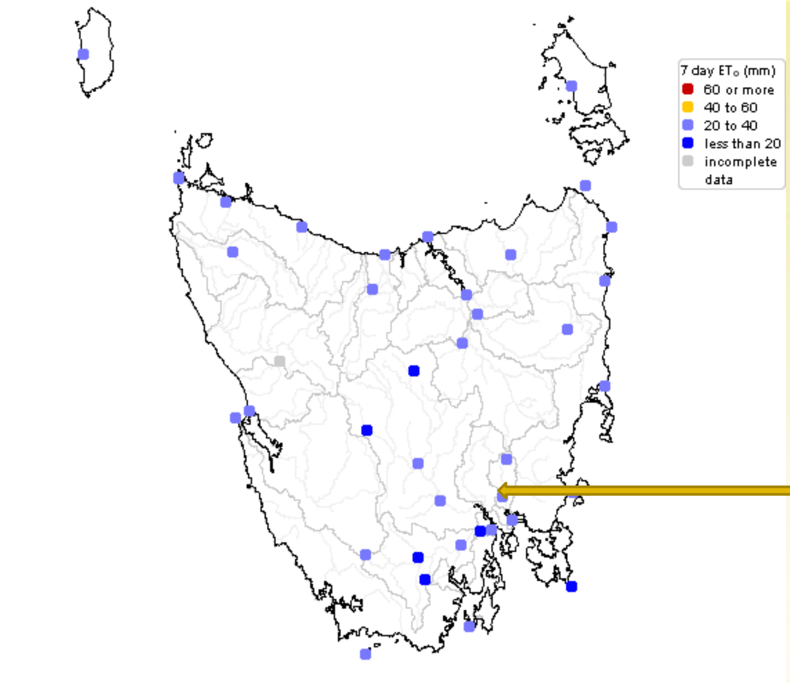
What is it?

How can I use this information?

Evapotranspiration

- Evapotranspiration is a combination of evaporation and transpiration
- Transpiration occurs when water in the plant tissue is lost to the atmosphere – mainly through stomata on plants leaves
- BOM calculates ET_0 using a Penman-Monteith equation as recommended by FAO

- A “reference” crop is used in the calculation – wide area of grass, 12cm high, well watered, actively growing, full ground cover.
- Evapotranspiration varies according to crop height, colour, leaf area, age and condition.
- ET_0 figures are published by BOM for about 400 sites across the country

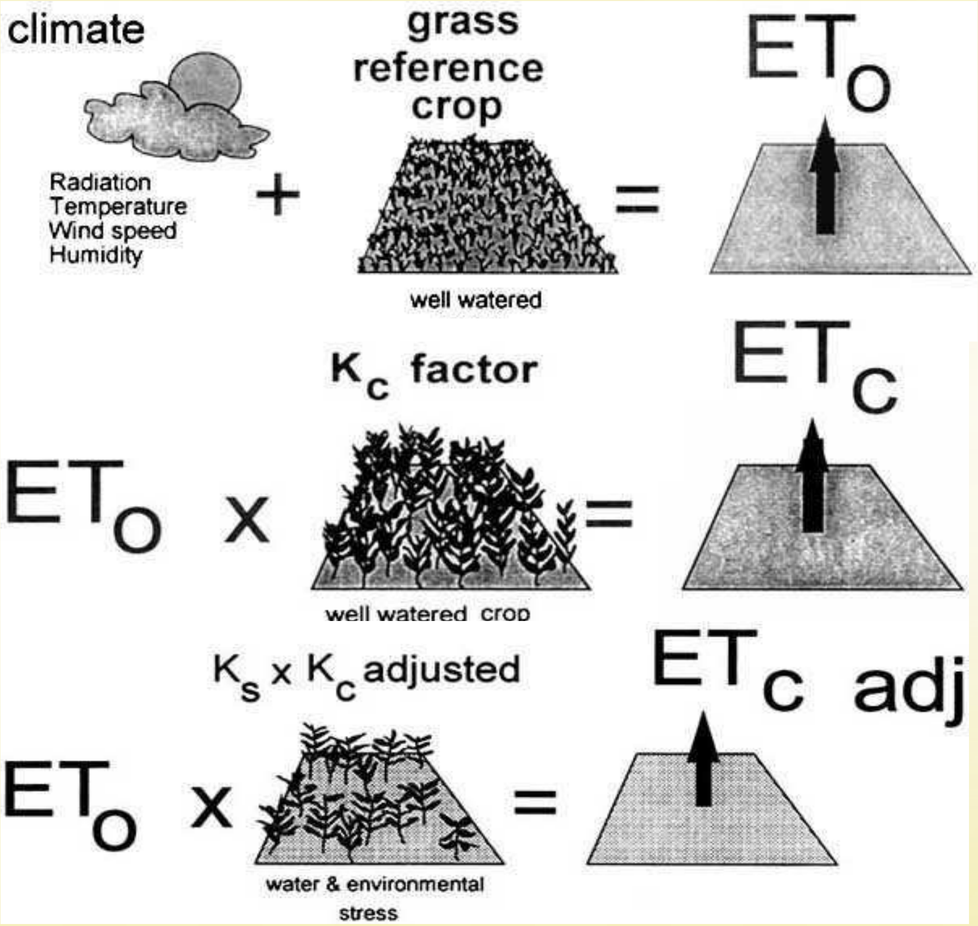


Reference evapotranspiration for Tasmania: 7 days to 18/10/2011 inclusive, issued 19/10/2011.

Campania (Kincora)

Date	**13/10/11**	**14/10/11**	**15/10/11**	**16/10/11**	**17/10/11**	**18/10/11**	**19/10/11**	**Total mm**
ET_0	3.3	3.7	4.6	2.9	3.7	4.7	7.1	30
Rain	0.2	0	0	0.2	8.2	0	0	8.6
Net	-3.1	-3.7	-4.6	-2.7	4.5	-4.7	-7.1	-21.4

To estimate ET for different crops – x ET_0 by a crop factor (Kc)



Crop factor Kc examples

- Grapes – months after 1st leaves appear

1	2	3	4	5	6	7	8	9
0.25	0.45	0.65	0.75	0.75	0.7	0.55	0.45	0.35

	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Apricots			0.56	0.68	0.83	0.9	0.9	0.9	0.9	0.83	0.71	
Walnuts			0.5	0.72	1.1	1.1	1.1	1.1	1.06	0.79		

- Perennial pasture – high input 1.05
  - low input 0.7

Soil Water Monitoring Tools

Soil Water Monitoring Tools

Soil Water Monitoring Tools


t-Bug
MEA

TBugs and GBugs

- Each TBug can run 4 Theta probes or 4 SM200 sensors (most commonly installed this year)

- SM200 Sensor

Costs

GBug

- Watermark lite $88
- GBug $605
- MEA Retriever $1155

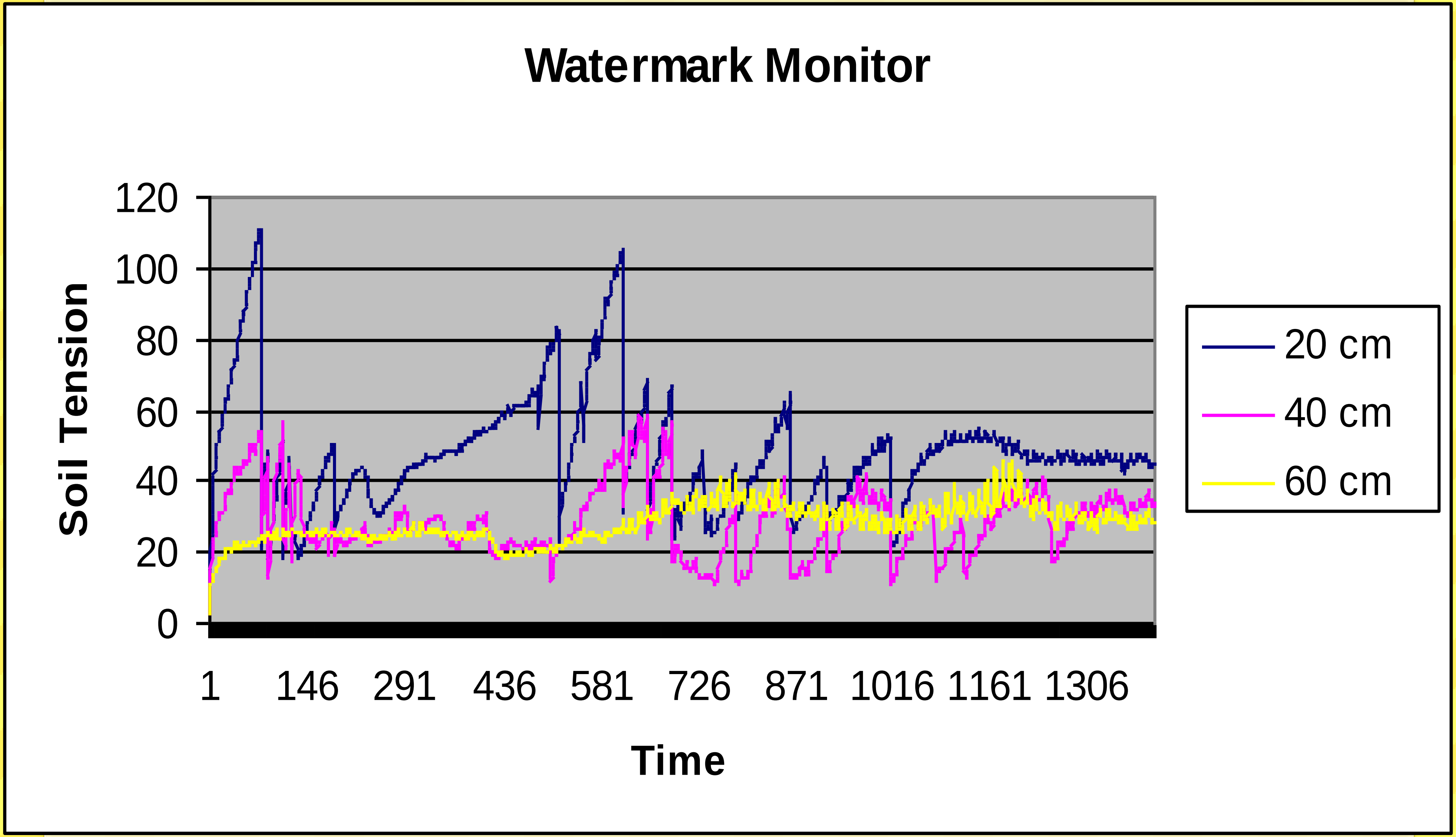
TBug

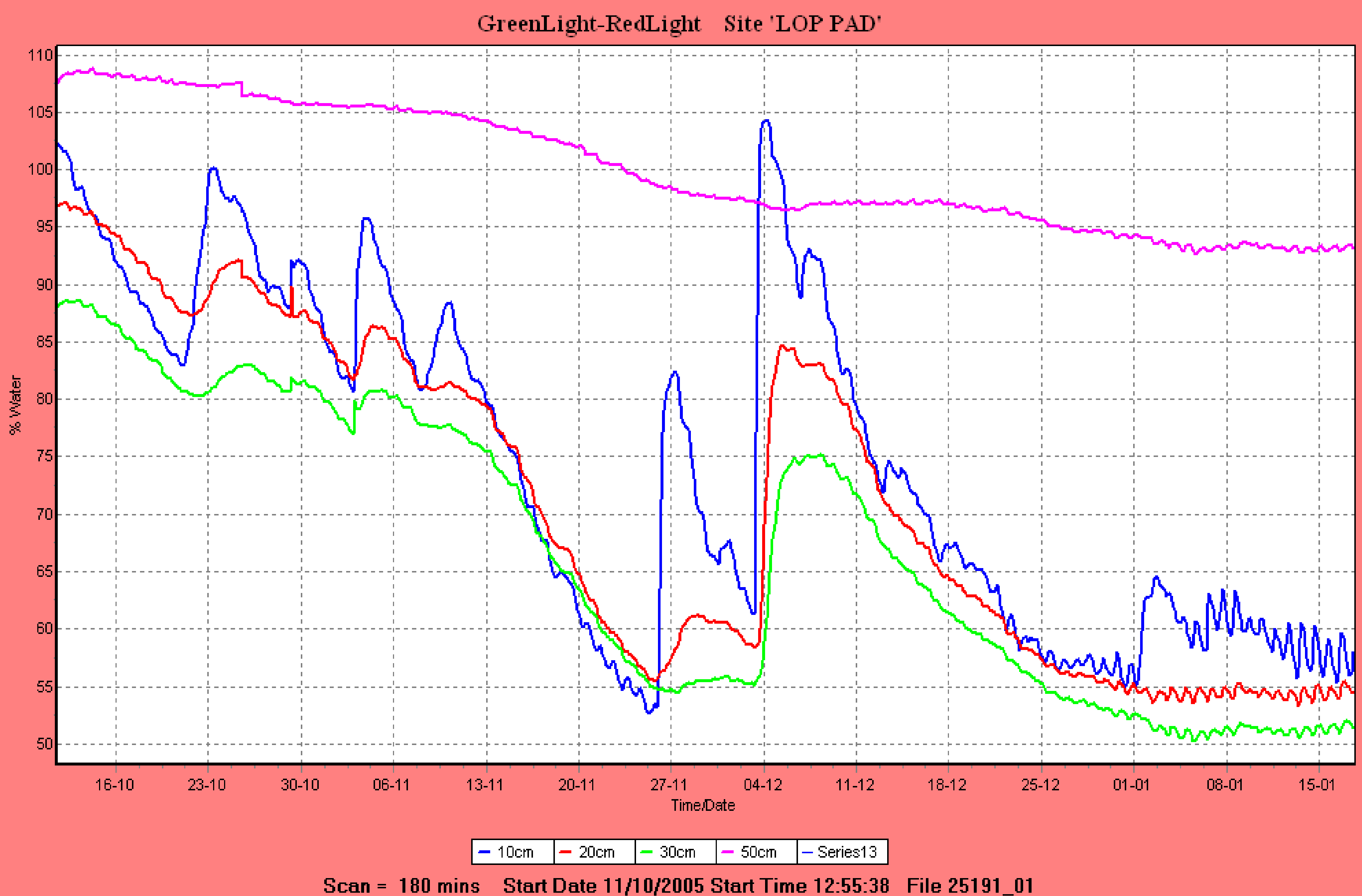
- SM200 $385
- TBug $825
- MEA Retriever $1155

- Over recent years there has been huge growth in the range of equipment available for measuring soil water.
- The main expansion has been in the frequency domain reflectrometry (capacitance) instruments.
- Volumetric and Tension instruments are all indirect measures that reflect soil water content

- Some commonly used instruments are:
  - Hansen loggers
  - G-bugs
  - T-bugs
  - EnviroSCAN
  - GLRL Odyssey
  - Gopher
  - Tensiometers
  - Aquaflex
  - Adcons
- Increased use in telemetry with soil moisture logging equipment.

- Factors influencing your choice will include:
  - What information do you need?
  - How labour intensive is the equipment?
  - How useable is the information from the device?
  - What level of accuracy do I need?
  - Does soil type affect my choice/
  - Does the irrigation system I use limit my choice?
  - Does the crop type limit my choice?
  - What other site factors may affect choice?
  - How durable is the product?
  - How much maintenance will it need?
  - What is the cost? Can I afford it?
  - What are the next steps?


Watermark Monitor
Soil Tension
120
100
80
60
40
20
0
1
146
291
436
581
726
871
1016
1161
1306
Time
20 cm
40 cm
60 cm


GreenLight-RedLight Site 'LOP PAD'
% Water
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105
100
95
90
85
80
75
70
65
60
55
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16-10
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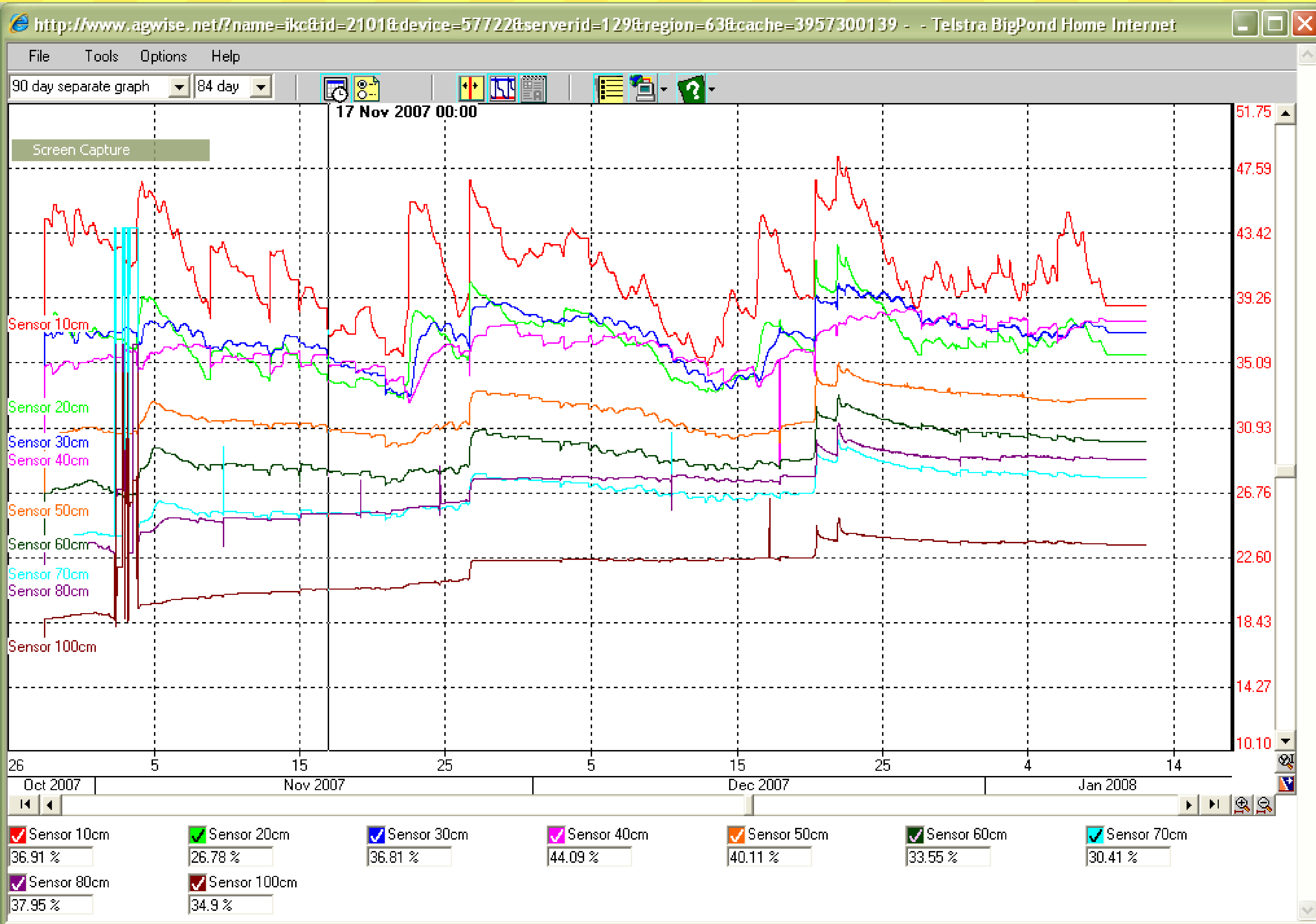
http://www.agwise.net/?name=ikc&id=2101&device=57722&serverid=129&region=63&cache=3957300139 - - Telstra BigPond Home Internet
File
Tools
Options
Help
90 day separate graph
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Screen Capture
Sensor 10cm
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51.75
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5
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14
Oct 2007
Nov 2007
Dec 2007
Jan 2008
Sensor 10cm
36.91 %
Sensor 20cm
26.78 %
Sensor 30cm
36.81 %
Sensor 40cm
44.09 %
Sensor 50cm
40.11 %
Sensor 60cm
33.55 %
Sensor 70cm
30.41 %
Sensor 80cm
37.95 %
Sensor 100cm
34.9 %

MEA Bug software - Towong Council - Irrigation Project
File Connect Retriever View Options Help
Graph
Table
Last 48 Hours
Site
Irrig - Mint Pivot2 (GBug 2013)
Show
1 month
Symbols
Middle of day
Print
Irrigation/Rainfall Events
Soil Tension kPa
5/01/2008 8 am
Irrig - Mint Pivot2 10cm 60 kPa
Irrig - Mint Pivot2 20cm 61 kPa
Irrig - Mint Pivot2 30cm 56 kPa
Irrig - Mint Pivot2 50cm 44 kPa
Rain Gauge: Rain 10
Irrigation Shift: Irrig - Mint: Pivot2
Show Irrigation data
Water (mm)
Wet
Dry
0
20
40
60
80
100
120
140
160
180
200
50
45
40
35
30
25
20
15
10
5
0
Top
200
Bottom
0
Full Scale
Scale
50
mm
29 30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
Dec 2007 Jan 2008
Calendar
Refill / Full points
Refill point 35 kPa
Full point 5 kPa
Site : Irrig - Mint Pivot2 (GBug 2013)
Site has data from 25 October 2006 to 30 April 2008
start
MEA Bug software
5:25 PM

Irrigation Scheduling

Soil Water Monitoring

Irrigation Scheduling

- Is a decision making tool
- Helps determine when and how much water to apply
- It brings together your soils information and the crop water requirements

Irrigation Scheduling

- Aim to monitor soil water status and manage it at an optimal level for the crop
- Traditionally irrigation scheduling focused on irrigating to achieve maximum production
- The focus is possibly shifting to maximizing farm profits or water use efficiency ($/ ML)

Irrigation Scheduling

- With micro-irrigation systems irrigation schedules are often less complicated
- Depend primarily on crop water use
- Localised wetting patterns limit accurate measurements of soil moisture depletions
- May find that using evapotranspiration information is useful

The amount of water applied depends on:

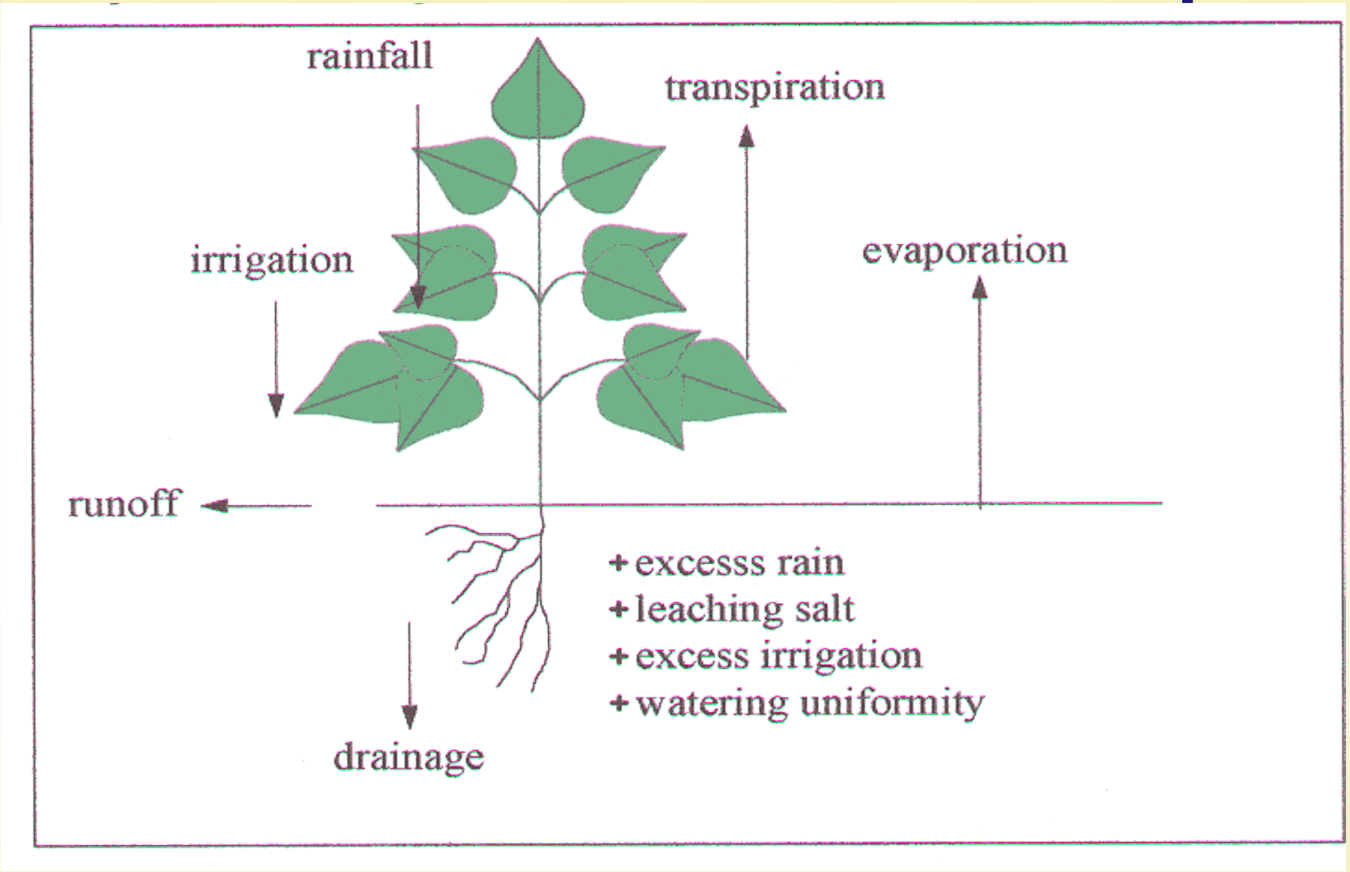
1. The stage of growth of the crop
2. The depth of the plant/ crop root system
3. The field capacity of the soil

- Note: the amount of water applied should fill the rooting zone and no more.

The time interval between applications depends on:

1. The area of transpiring surface (crop leaf area)
2. The rate of transpiration
3. The rate of evaporation from the soil
4. The field capacity of the soil

Soil - Plant - Water Relationship



Describing Soil Water Content

- Saturation or Full Point

  - is when all the pore spaces are full of water
  - this is after rainfall or irrigation, before drainage occurs
  - at this point there is no benefit in applying more water
  - excess water causes plant stress, waterlogging, run-off, leaching, drainage below plants root zone

Field Capacity

- this is when the gravitational water has drained away
- depending on soil type this takes 12 hrs to 4 days
- this is the maximum amount of water the soil can store for crop use.
- it is easy for plants to extract water at or near field capacity.

- Permanent Wilting Point

  - is when plants are unable to extract soil water.

  - plants wilt but do not recover when water is applied.

  - If soil dries to this point, plant growth and yield will be severely reduced.

- Refill Point

  - this is when the soil water becomes more difficult for the plant to extract.

  - Refill point is when you should irrigate.

  - Refill points will vary with the crop type and the stage of growth of the crop.

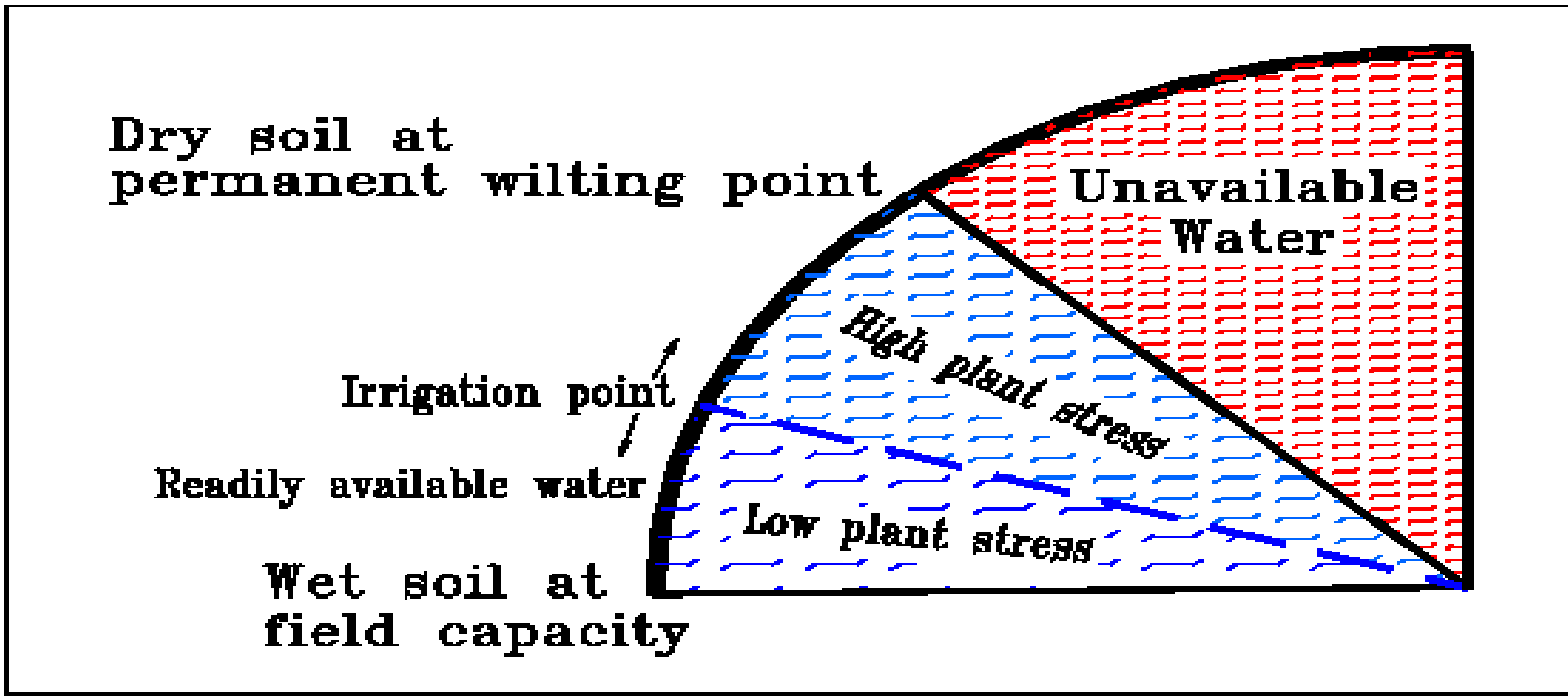
- Readily Available Water (RAW)

  - this is the amount of water stored in the soil that can be easily extracted and used by plants

  - it is usually calculated down to the depth of the plants effective root zone

Water availability

Figure 8. The availability of water in the soil



Effective rootzone

- is the part of the rootzone where the main mass of the plants roots are found
- there may be roots below the effective rootzone but the water they extract is not significant
- the effective rootzone is typically 2/3 of the depth of the deepest roots
- When calculating RAW use only the effective rootzone
- For annual crops the effective rootzone changes as the crop grows during the season.

SUMMARY - Why is it important to manage irrigation?

- There is increasing competition for water
- Less water is available
- Increasing cost of water and growing crops
- Changes in regulations for water allocation and water use

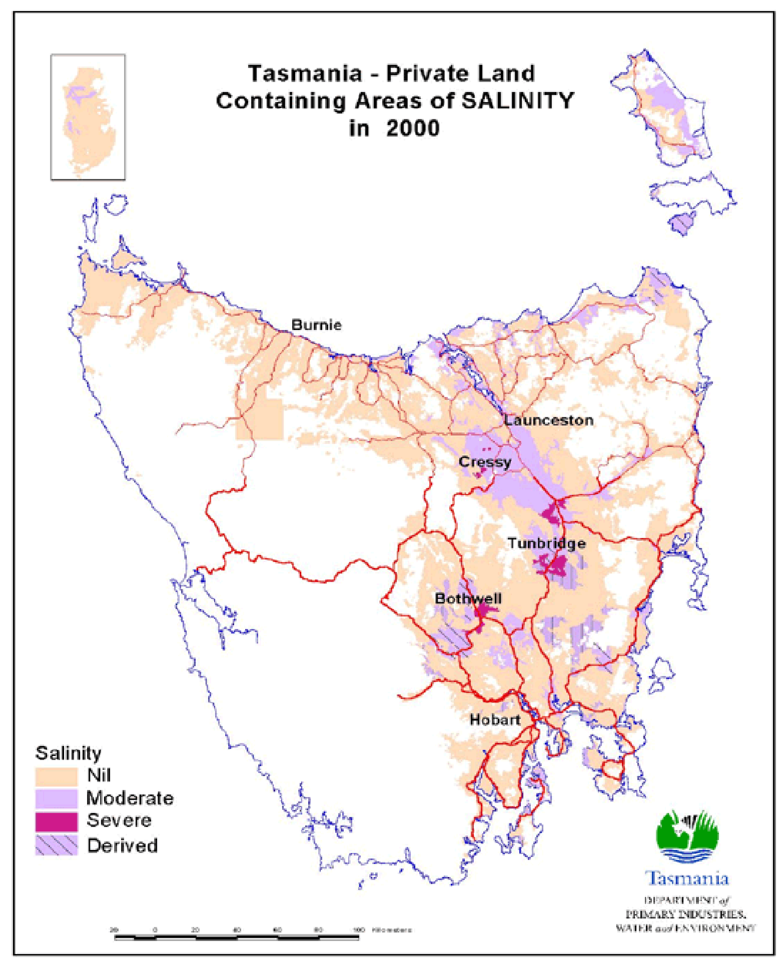
- Improved production – avoid waterlogging and drought
- Improved crop health - less pests and diseases, better quality
- Economic benefits – more efficient use of water and energy
- Reduced environmental impacts

Crop Water Requirements

Average water requirements

Crop	Irrigation depth	Irrigation Quantity
Potatoes	300 – 400 mm	4 – 7 ML
Poppies	200 – 300 mm	2 – 3 ML
Peas	150 – 200 mm	1.5 – 2 ML
Green Beans	200 – 250 mm	2 – 2.5 ML
Pyrethrum	100 – 200 mm	1.5 – 2 ML
Carrots	300 – 400 mm	3 – 5 ML
Onions	300 – 400 mm	3.5 – 4.0 ML
Broccoli	200 – 250 mm	2 – 3 ML
Squash	150 – 200 mm	1.5 – 2 ML
Lucerne	350 – 550 mm	3.5 - 6.5 ML
Pasture	350 – 450 mm	3.5 – 5.5 ML
Wheat	200 – 350 mm	0.75 – 1.0 ML
Grapes		2.5 - 8 ML (av5)
Walnuts		6 ML

Soil and Water Quality



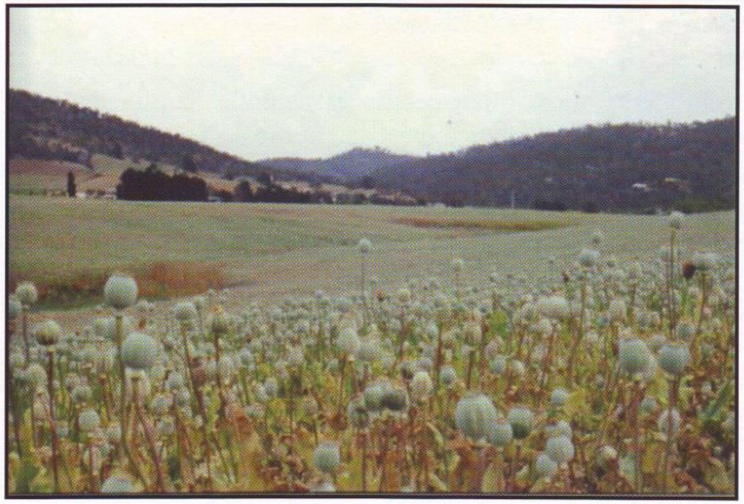


Plate 6.2: *Poor poppy growth and yield evident in a salt affected drainage line, southern Tasmania.*

Plate 6.3: *Sea Barley Grass,* Hordeum marinum.

Plate 6.4: *Buck's Horn Plantain,* Plantago coronopus.

Plate 6.5: *Yellow Water Buttons,* Cotula coronopifolia.

Irrigation Water Quality

Sue Hinton

TIAR

Know how much salt is in your irrigation water

Table 6.1: *Irrigation water quality classes*[7].

Water Quality Class	Conductivity Range (dS/m)	Salinity Class
Class 1	0.0 - 0.28	Low
Class 2	0.28 - 0.8	Medium
Class 3	0.8 - 2.3	High
Class 4	2.3 - 5.5	Very High
Class 5	>5.5	Extreme

Salinity

- Salinity affects crop performance through
  - Decreasing water availability
  - Decreasing shoot growth and yield
  - Toxicity of certain elements such as chloride, sodium and boron
- Measured as dS/m
  - < 0.8 OK for most crops if soil is moderately to well drained
  - > 2.3 not suitable for continuous use for most crops and pastures

pH

- Measure on a scale of 0 – 14
  - Less than 7 is acid
  - 7 is neutral
  - More than 7 is alkaline
- Highly alkaline water with high carbonate and bicarbonate levels can affect uptake of calcium, magnesium and some trace elements
- pH <6.0 or >8.5 can decrease the effectiveness of some pesticides

Sodicity

- Sodium Adsorption Ratio – SAR
- High SAR levels will affect soil structure and cause poor penetration, poor drainage and low aeration levels
  - SAR < 3 is OK for all soil types
  - SAR 3-12 can be used on sands and loams
  - SAR >12 generally unsatisfactory
- Gypsum is usually applied to combat high sodium levels

Chloride

- High chloride may cause poor growth and death – esp if sprayed on leaves
- < 140mg/L (ppm)
  - generally acceptable
- 140 – 350 mg/L
  - treat with caution
- >350 mg/L
  - Should not be used

Iron

- Generally only a problem with bore water
- Causes blockages to irrigation components and “rust” discolouration when soluble iron oxidises and precipitates
- Aeration and settlement may be OK, but filtration sometimes required

Turbidity - cloudiness

- Indicator of suspended solids in the water
  - Usually high in large rivers, low in headwaters
- Major cause is soil erosion
- Can block micro irrigation systems through slime build-up

Nutrients

- Main nutrients of concern are phosphates and nitrates
- Encourage algal blooms and aquatic weeds
  - Some blue-green algae can be toxic to stock and people through contact or ingestion

Pesticides

- Can contaminate water through:
  - Direct application
  - Drift
  - Spillage
  - Careless disposal
  - Run-off

Variable Rate Irrigation

How do we manage irrigation in such variable soil types?


What are the challenges
you face when irrigating?


Non wetting soils

Unplanted areas

Variable Application Pivot

- The aim is to vary the quantity of water applied by the pivot relative to the water holding capacity of the soil
- Will reduce wasted water
- Will help to maximise yield across a paddock
- Should see an improvement in the quality of the crop

- Uses Farmscan software to program the pivot (quantities applied can vary between 0% and 100% in 10% increments)
- Zones are roughly 10 m x 10 m
- You prepare your maps and application rates on your computer, then save to a memory stick which then goes into the pivot


T·L

Costs

- The controller is approximately $10,000

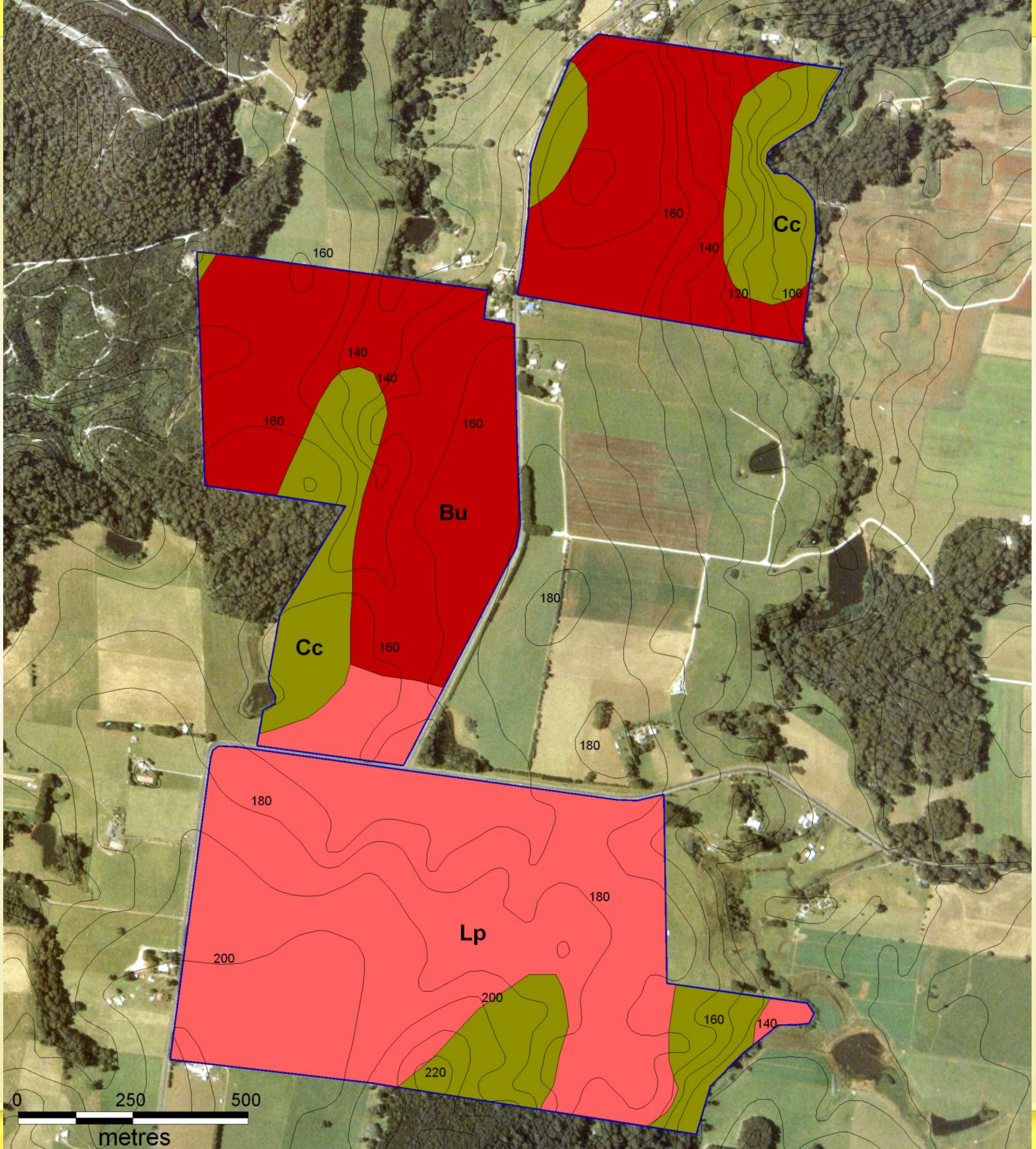
- To set up each span is approximately $4,000

Benefits

- More efficient use of water
- Improved quality of yield
- Maximising yield

How do you determine the water holding capacity of your cropped area?

- There are a number of methods
- Your knowledge of the areas of your farm
- Soil maps
- Land capability maps may provide a guide
- Soil surveys
  - Traditional methods
  - EM surveys



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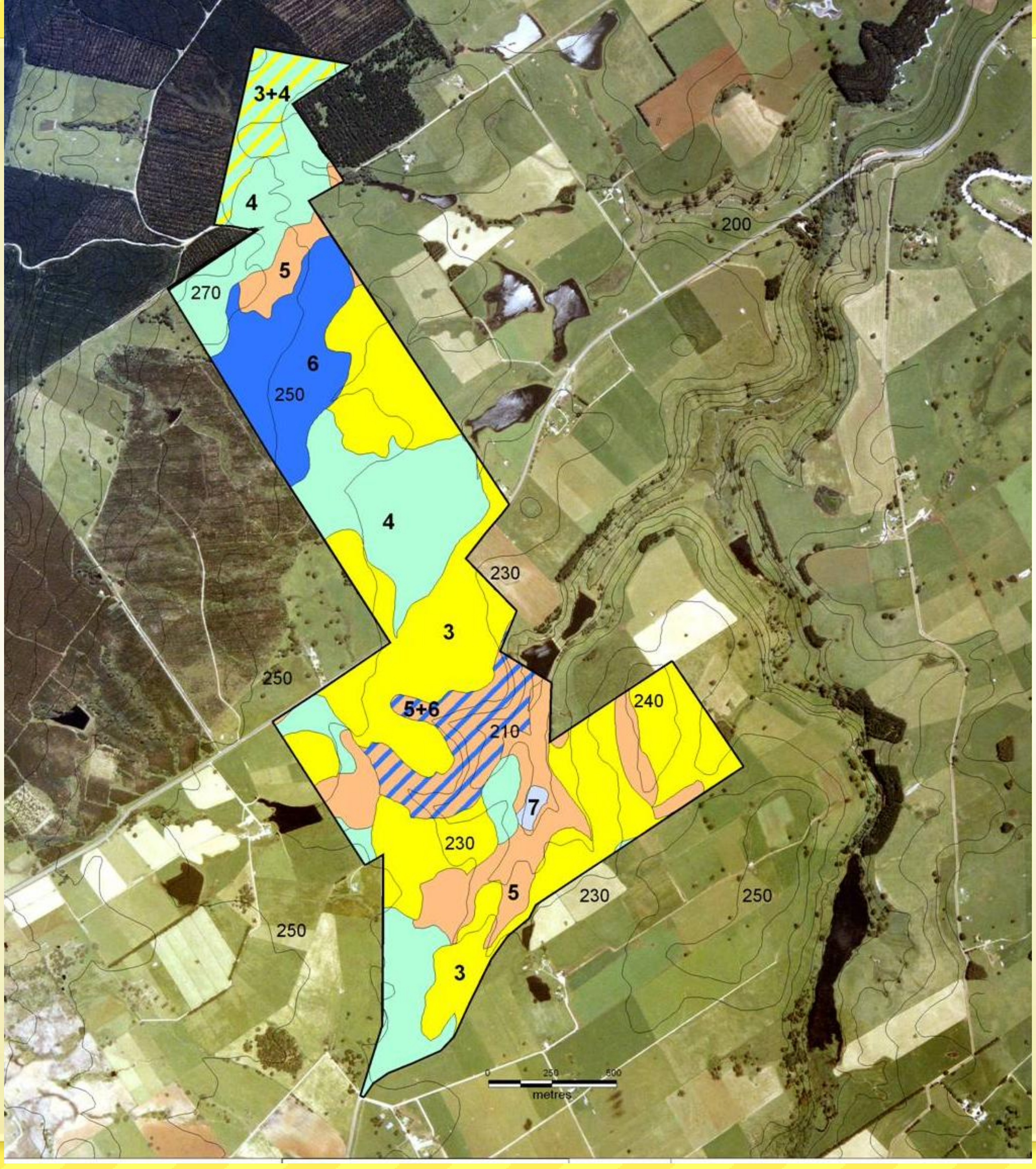

3+4
4
5
270
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250
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230
3
250
5+6
210
240
7
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5
230
250
250
3
200
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250
500
metres

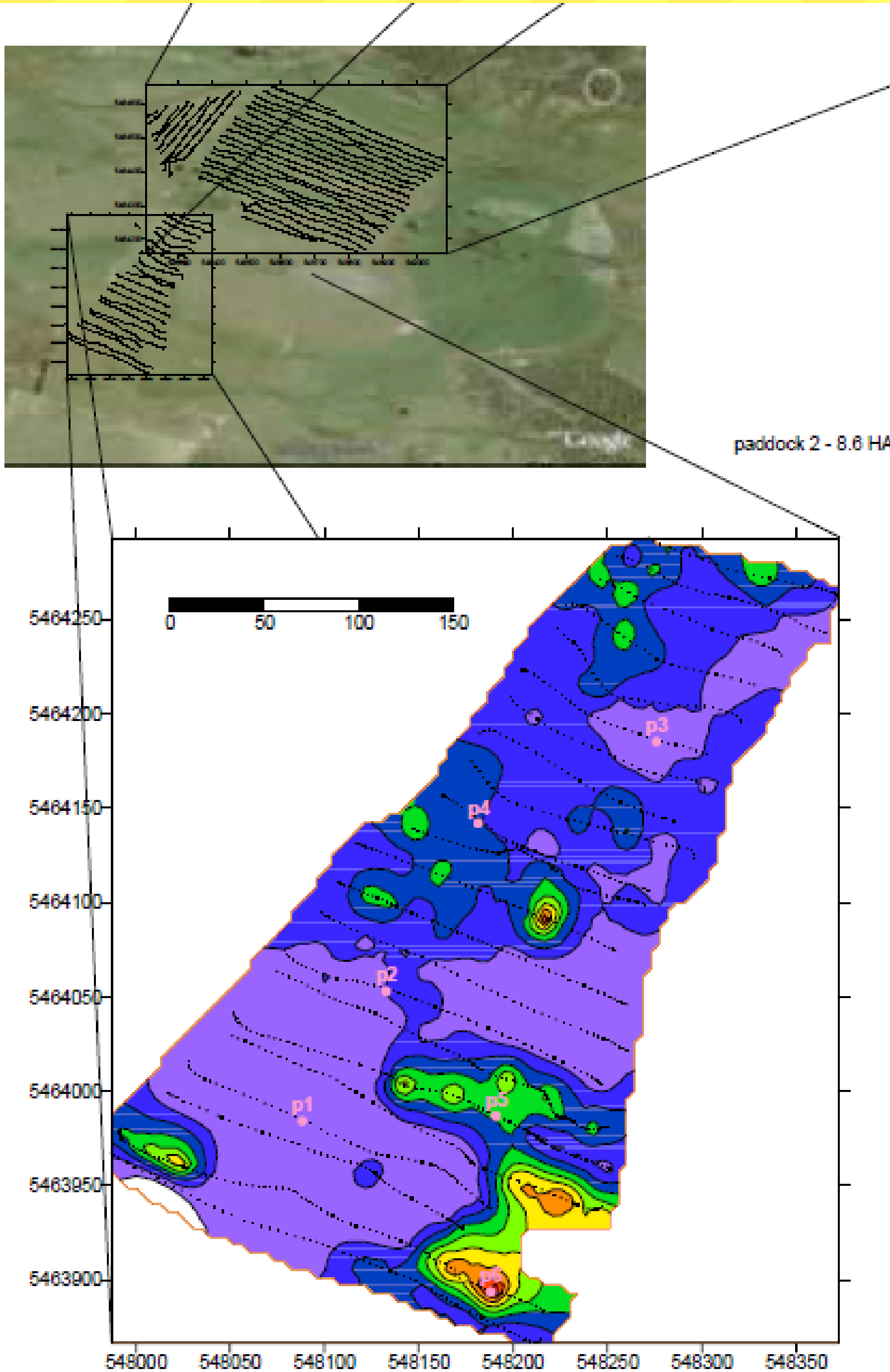
EM38 SOIL SURVEY

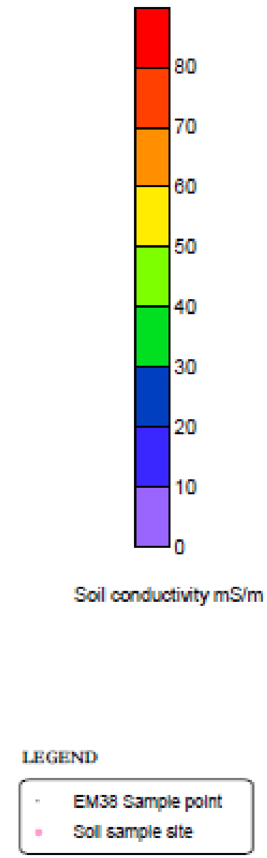
- Using Automated Electromagnetic Induction Techniques

- EM meters can be used to map and characterise the spatial variability of soil qualities related to soil electrical conductivity. Incorporated with a differential Global Positioning System (dGPS)

Aim of the survey

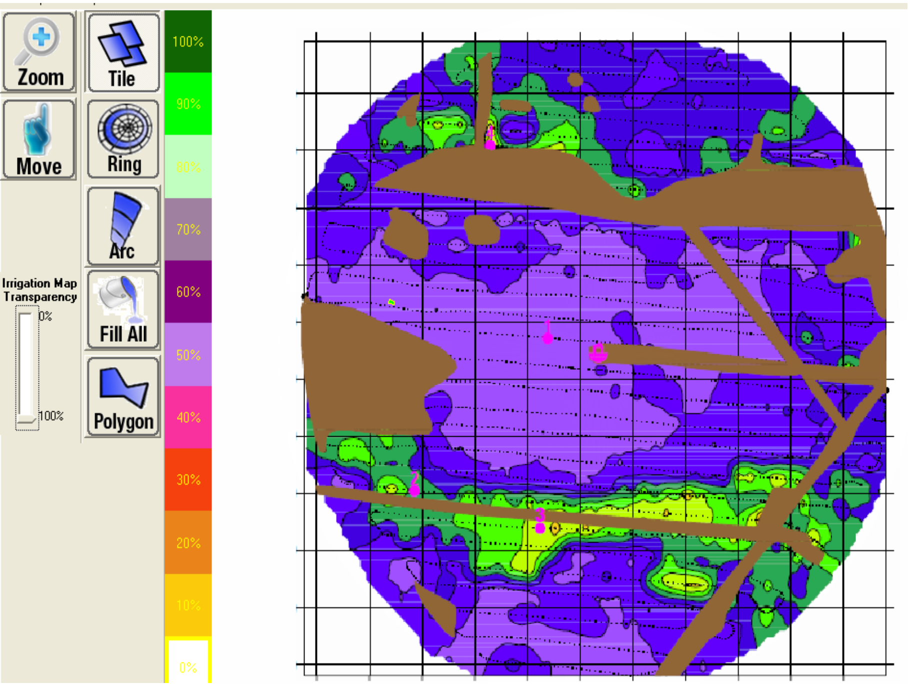
- To assess soil textural differences
- Use this information to work out the water holding capacity of the soil
- Program this into the software for the pivot to allow variable application rates of water

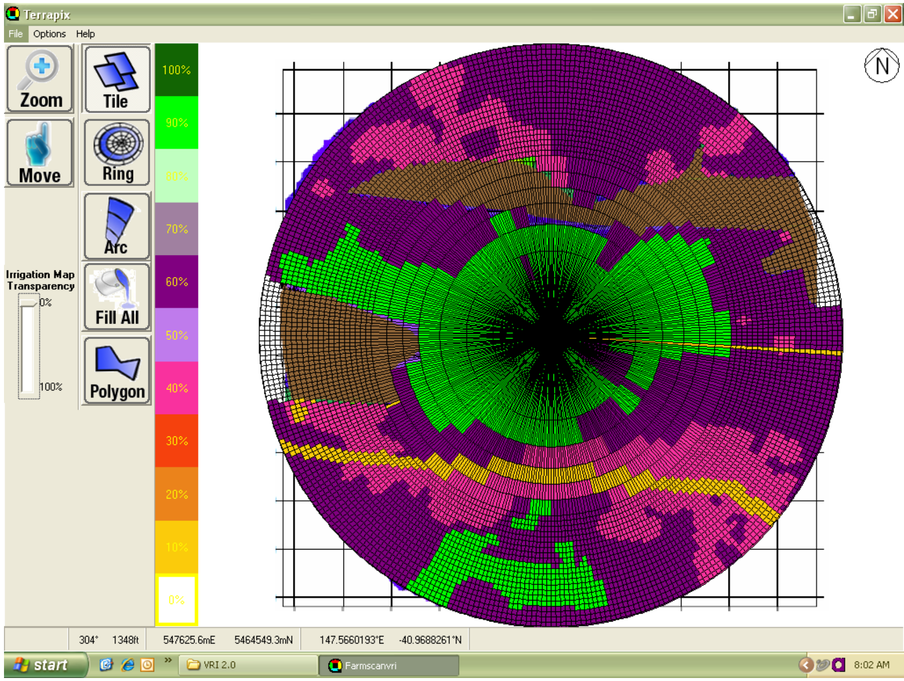


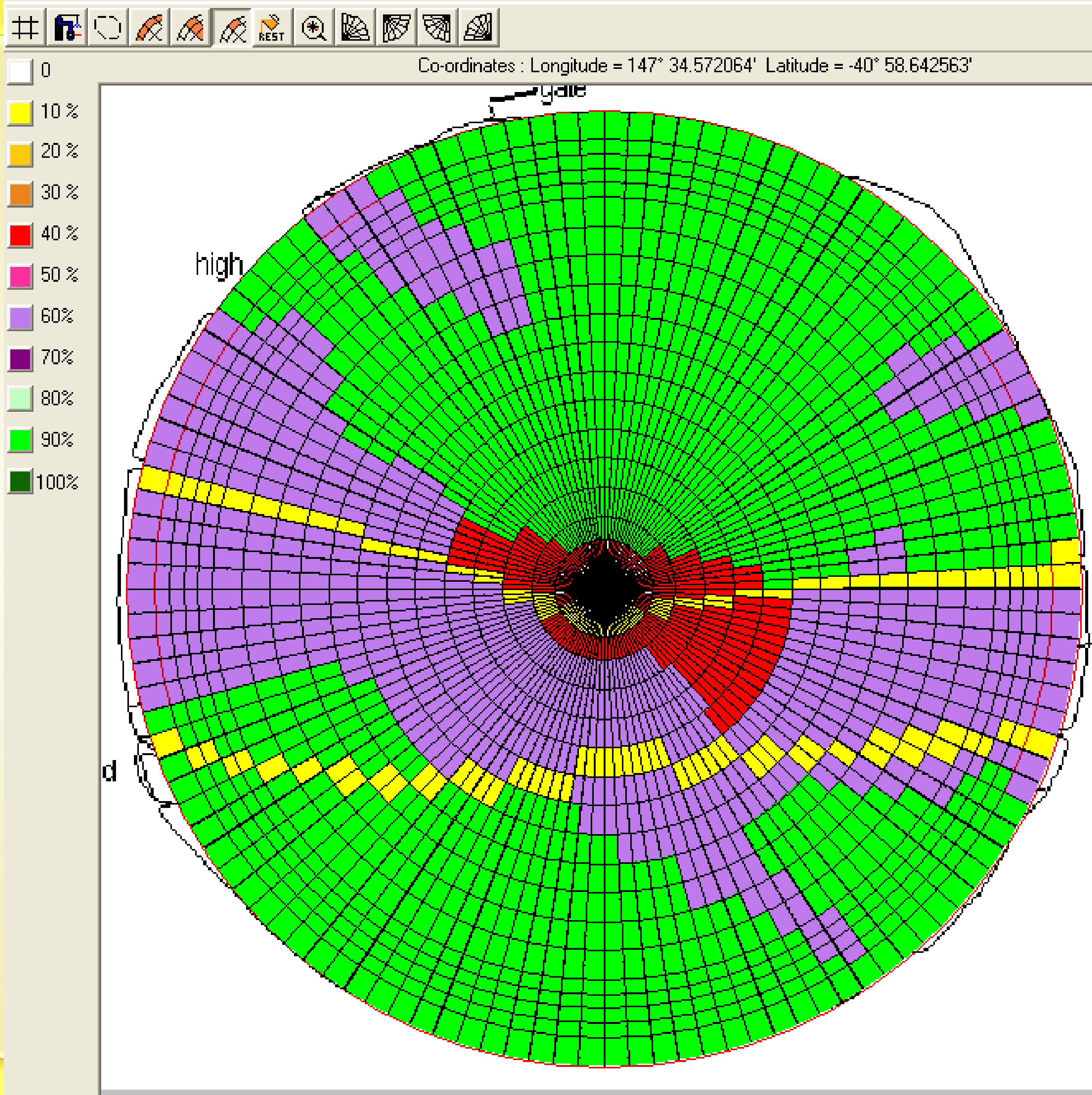


Spatial interpolation of the captured soil apparent conductivity data was undertaken to yield estimates at are not directly assessed. In this map thi was modelled using block kriging wit a universal linear semi-variogram.

EM38 Map and Watering Map

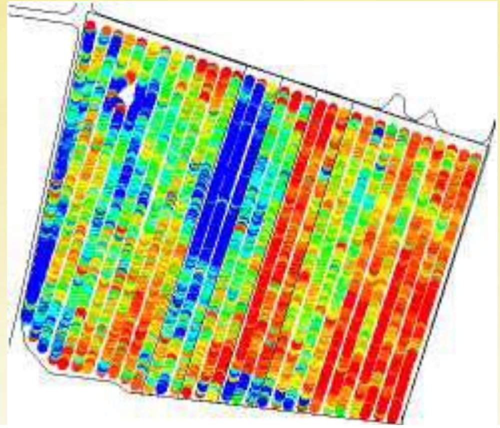


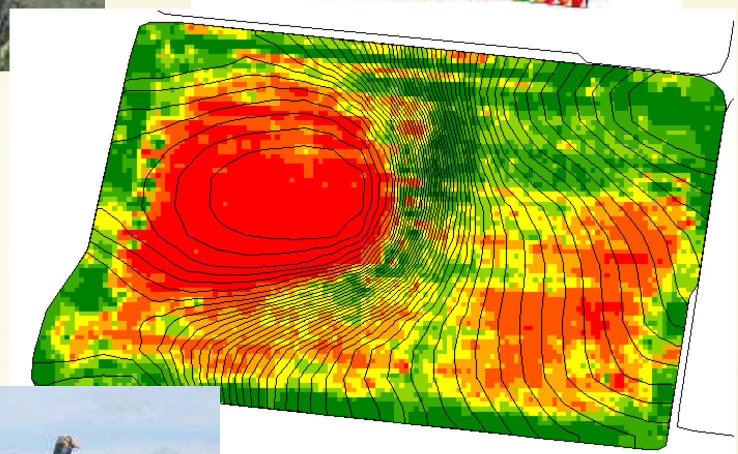


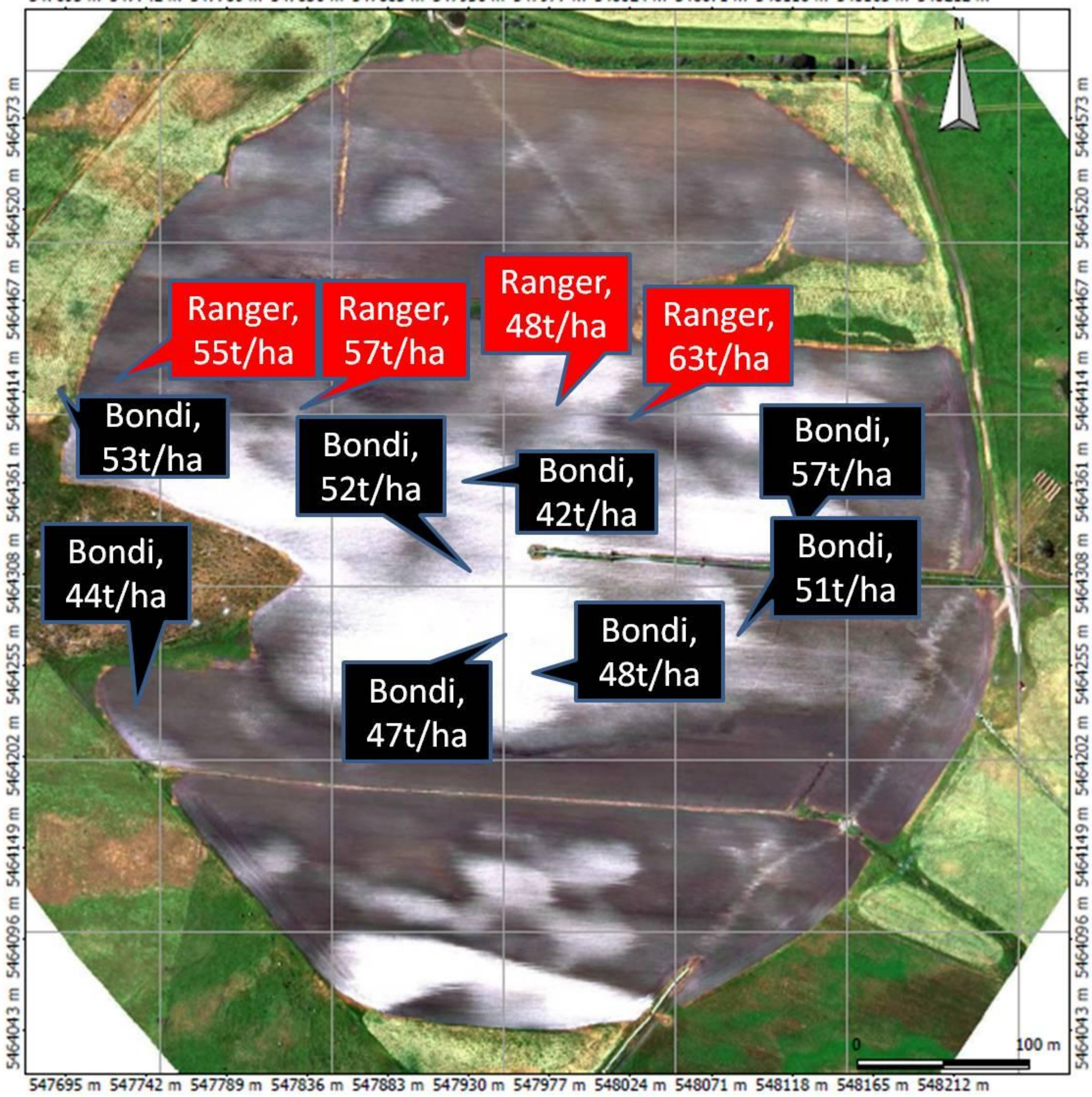

Co-ordinates : Longitude = 147° 34.572064' Latitude = -40° 58.642563'
0
10 %
20 %
30 %
40 %
50 %
60%
70%
80%
90%
100%
gale
high
d

Precision Agriculture

Where does precision irrigation fit?







Ranger, 55t/ha
Ranger, 57t/ha
Ranger, 48t/ha
Ranger, 63t/ha
Bondi, 53t/ha
Bondi, 52t/ha
Bondi, 42t/ha
Bondi, 57t/ha
Bondi, 51t/ha
Bondi, 44t/ha
Bondi, 48t/ha
Bondi, 47t/ha
N
0
100 m
547695 m 547742 m 547789 m 547836 m 547883 m 547930 m 547977 m 548024 m 548071 m 548118 m 548165 m 548212 m
5464573 m
5464520 m
5464467 m
5464414 m
5464361 m
5464308 m
5464255 m
5464202 m
5464149 m
5464096 m
5464043 m