Deep drainage and soils – practical implications

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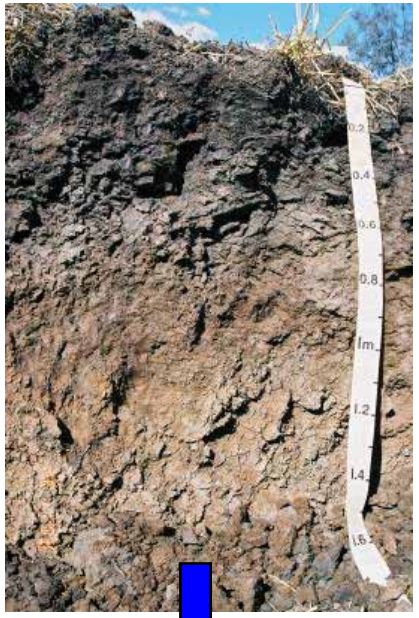
The problem

- 5 years ago, little data in Qld…and a belief that 'clay soils don't drain'
- Scepticism over modelled drainage…and with little data, who would know?
- Confusion over how to measure and model deep drainage

Setting the scene

For salinity to occur, need all these:

- Salt in soil and groundwater
- Soil or groundwater system to hold water
- Change in water balance – more deep drainage



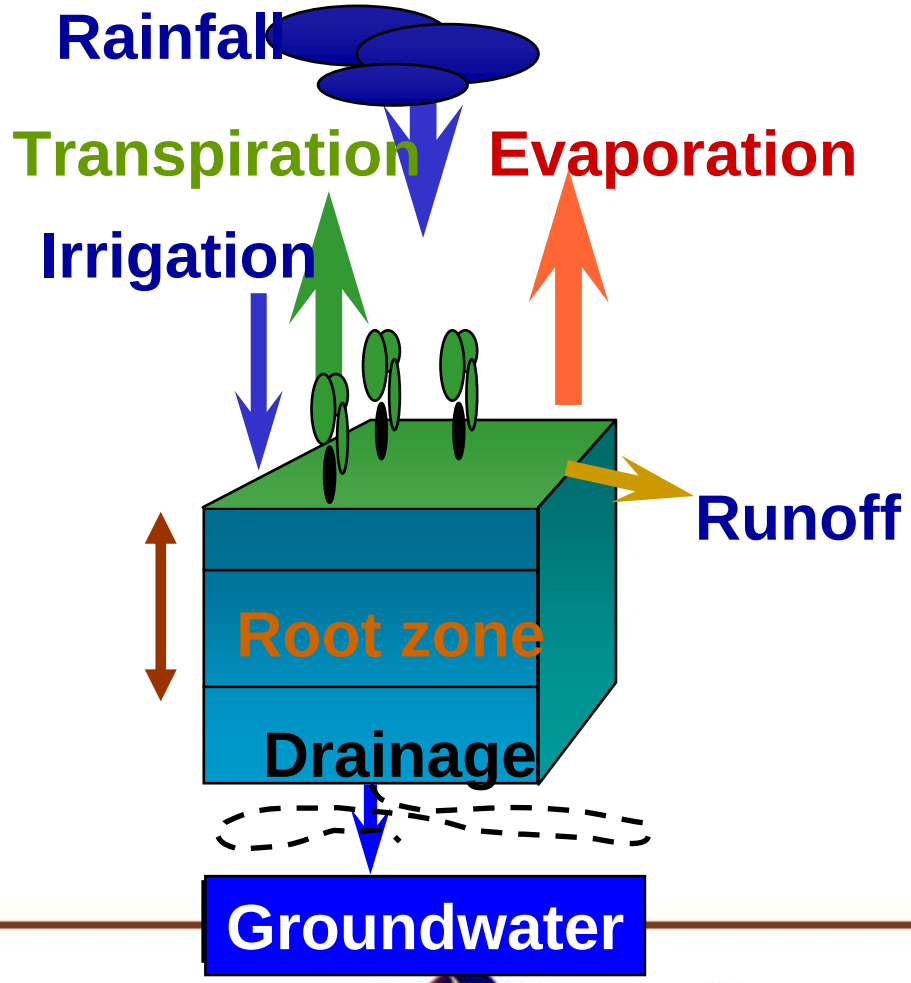
- The 'extra' water moves salt
- The mobilised salt 'discharges' or threatens an asset
- Problems emerge many years later
- Going back is hard!

What is deep drainage?

Definition: water moving below root zone

NOT necessarily equal to groundwater recharge

1-D water balance



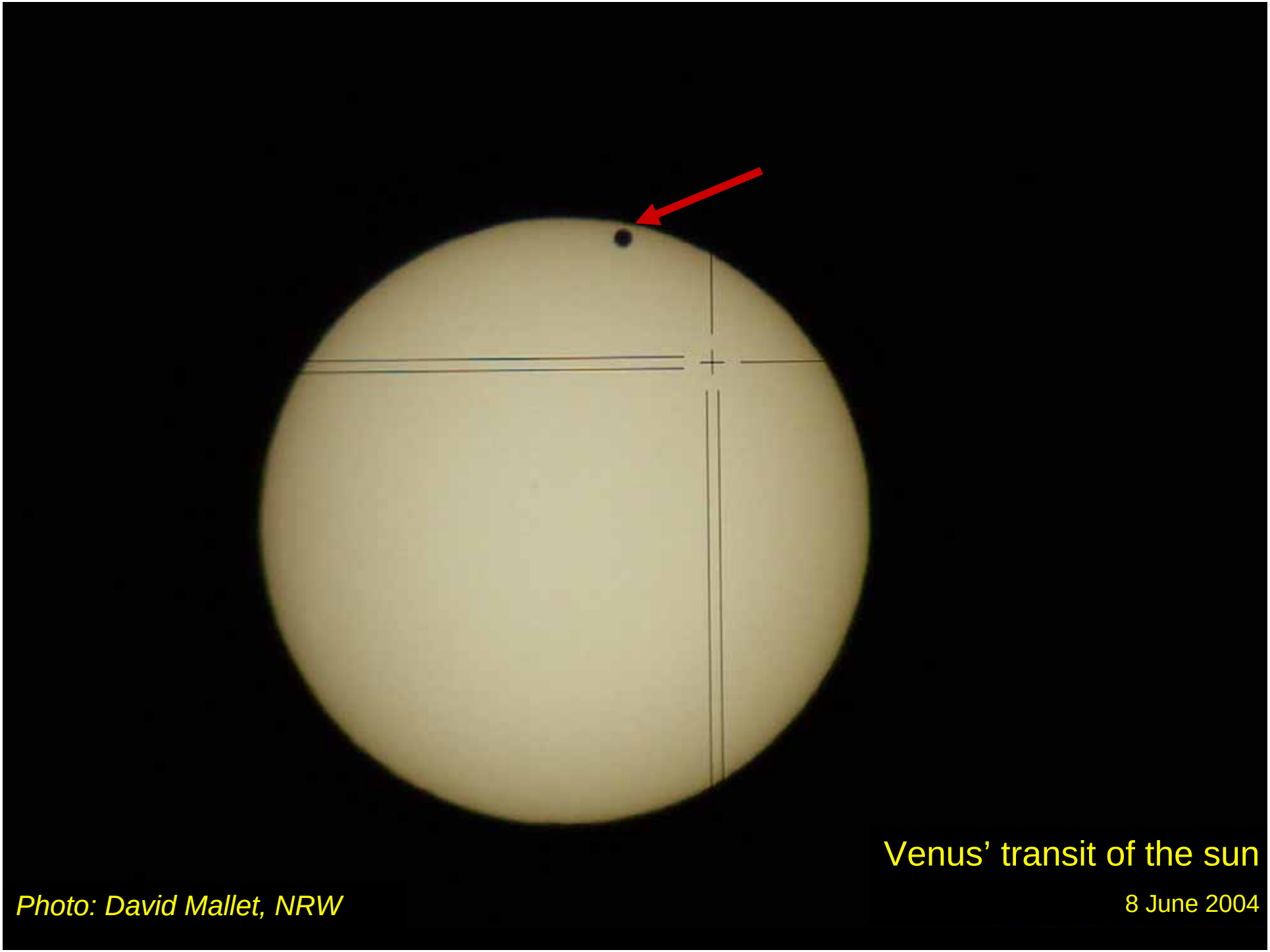
Why measure drainage?

- Learn more about mechanisms of water transport
- Inform water balance models
- Impact of changing land use on salinity risk and water quality
- Drainage as water use efficiency issue

- "Clay soils don't drain"
- "Queensland is different"

Drainage studies (5 yrs ago)

Where	How	Who	Soil	Drainage (mm/yr)
NATIVE VEG Qld soils	Steady state salt balance (SaLF)	R Shaw	766 soils	**1 – 3 (most)** **12 (max)**
Wycanna	Steady state salt balance	Cook 2002; Jolly 1989	Sodosol Vertosol	**<1**
DRYLAND Chinchilla (Warra) Goondiwindi Wycanna	Peak displacement	Cook 2002; Jolly 1989	Heavy clay Medium clay Grey Vertosol	**4** **6** **<1**
IRRIGATED 22 soil Qld & N.NSW	Steady state salt balance (SaLF)	Gordon & Zischke	Average 7 D Downs 5 Namoi	**210** **266** **27**
D. Downs	Chloride (SODICS)	Gordon & Zischke	Vertosols	**145-350**
D. Downs	Lysimeters	Gordon & Zischke	Grey clay	**160-180**
Gwydir Valley	Water balance	Montgomery Cotton CRC	Grey clay Red alluvial	**158** **53**
Emerald	Watbal Model	Connolly	Vertosol	**246**



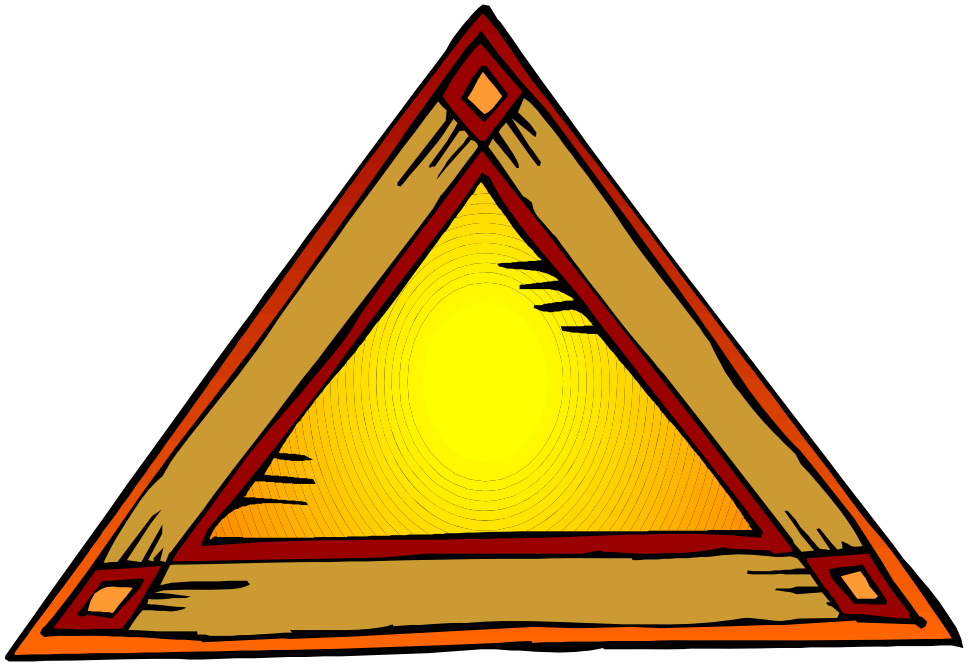
Venus' transit of the sun

8 June 2004

Photo: David Mallet, NRW

The solution

Lysimetry, soil physics

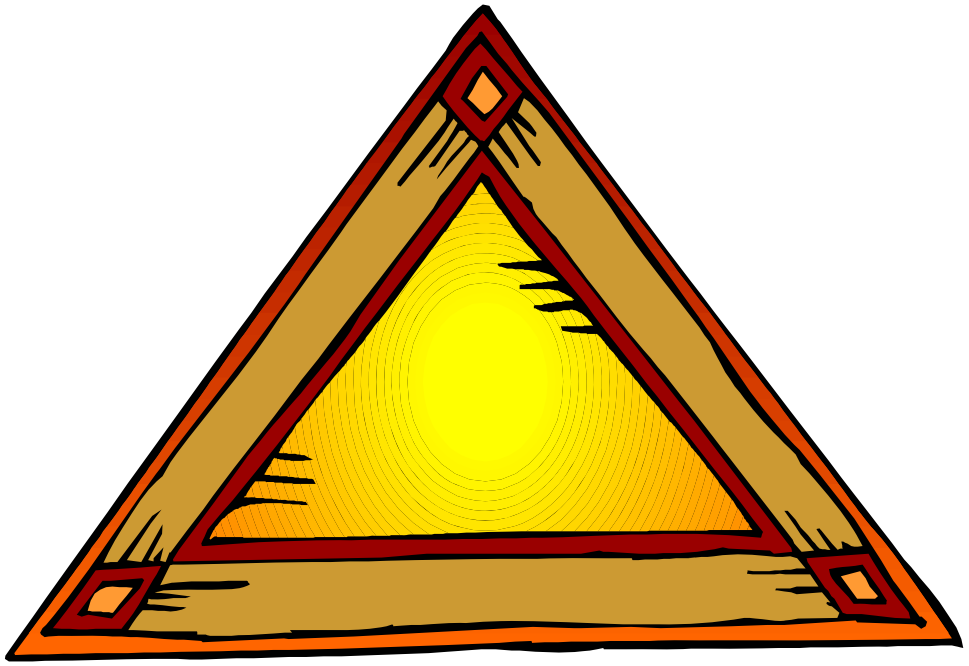


Chloride

Modelling

The trilogy

Lysimetry, soil physics



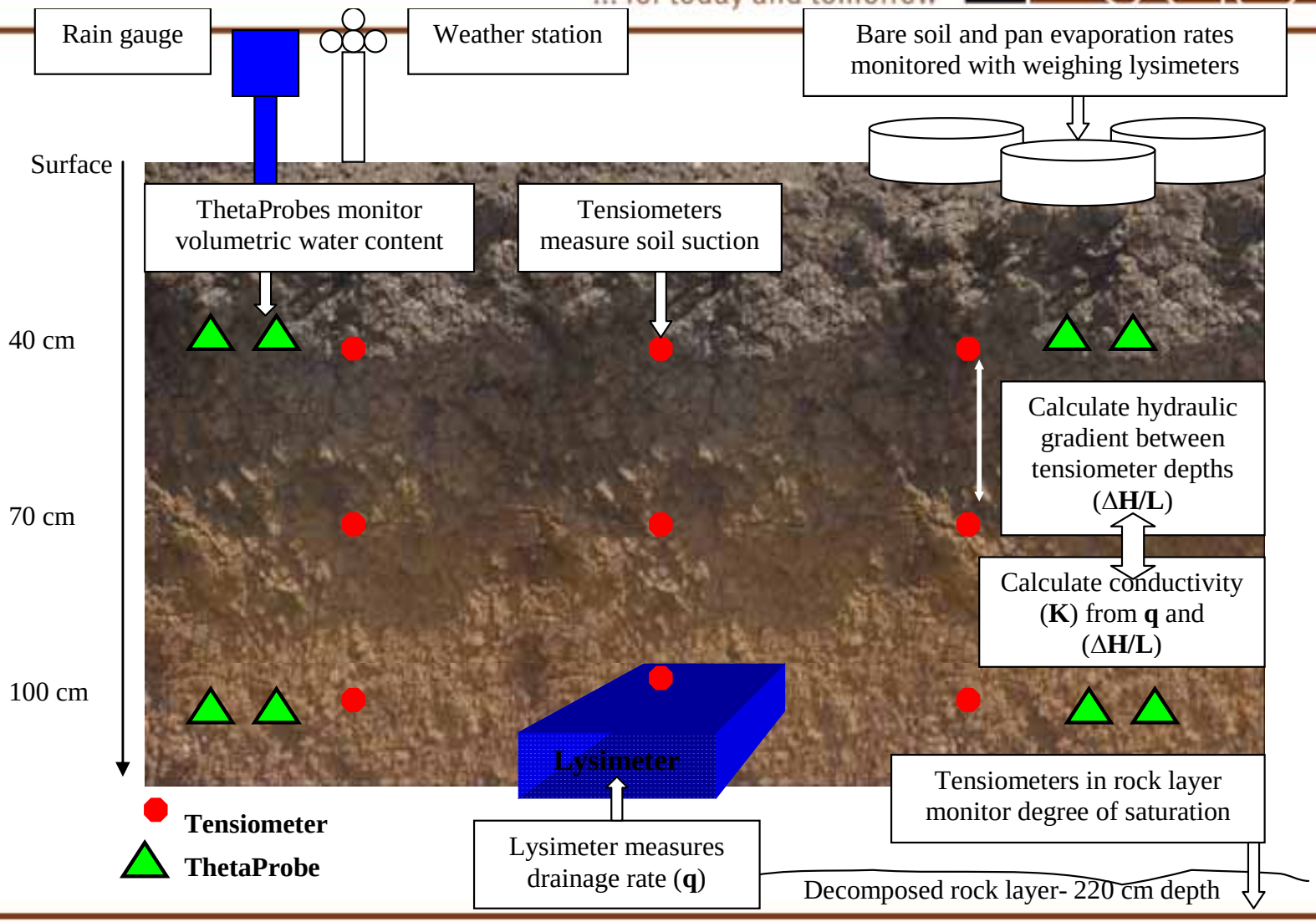
Chloride

Modelling

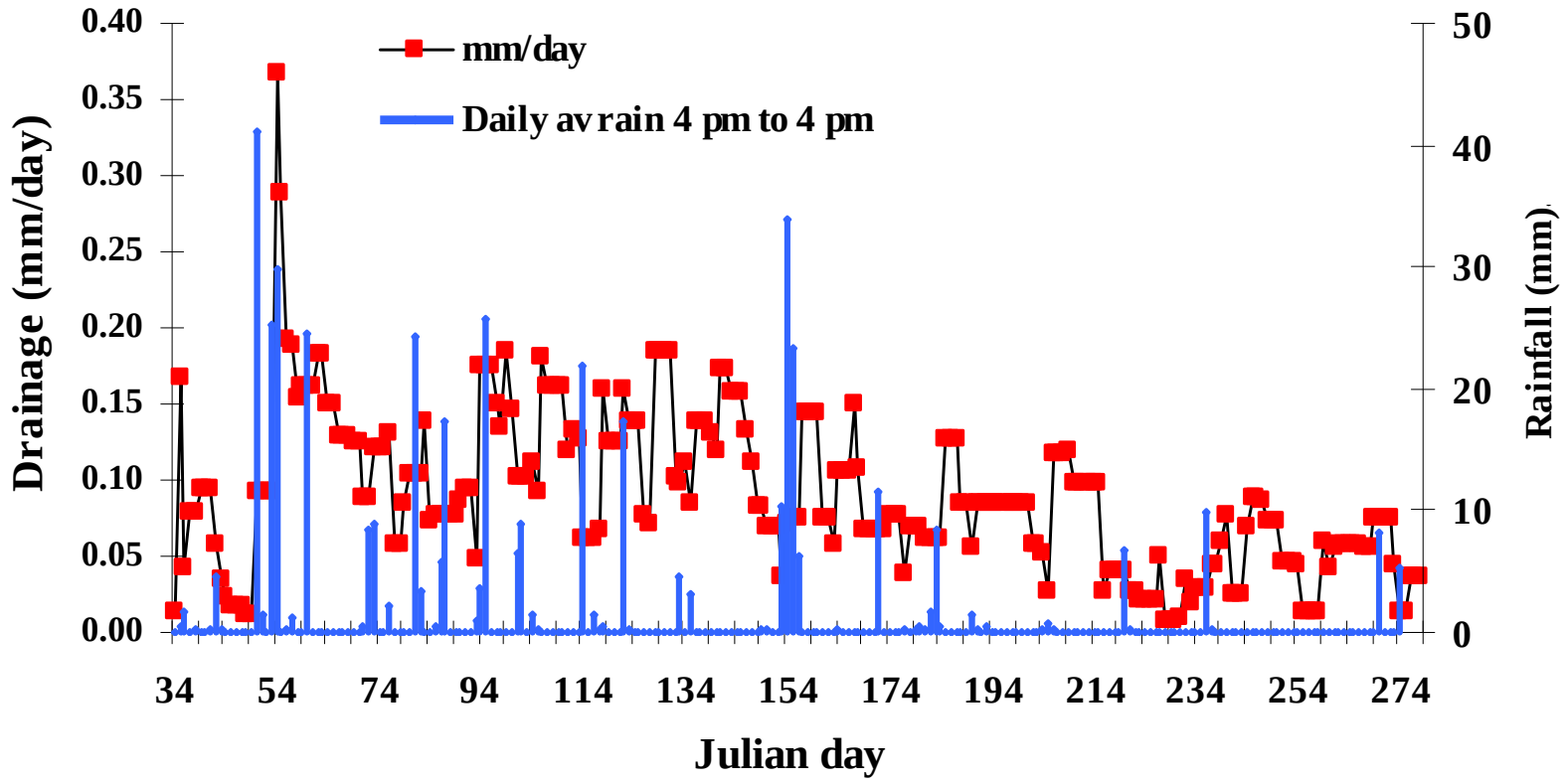
Lysimeter – measures the volume flow of water in soil

- To quantify deep drainage, need to measure drainage rates
- To obtain accurate rates, need to avoid affecting natural flows
- In soil profile, highly active suction forces pulling water in all directions (dynamic system)
- Most accurate are 'hydraulically invisible' variable tension lysimeters

→ Key tool to improving our understanding of physical **processes** of water movement


Rain gauge
Weather station
Bare soil and pan evaporation rates monitored with weighing lysimeters
Surface
ThetaProbes monitor volumetric water content
Tensiometers measure soil suction
40 cm
70 cm
100 cm
Calculate hydraulic gradient between tensiometer depths (ΔH/L)
Calculate conductivity (K) from q and (ΔH/L)
Lysimeter
Tensiometers in rock layer monitor degree of saturation
Tensiometer
ThetaProbe
Lysimeter measures drainage rate (q)
Decomposed rock layer- 220 cm depth

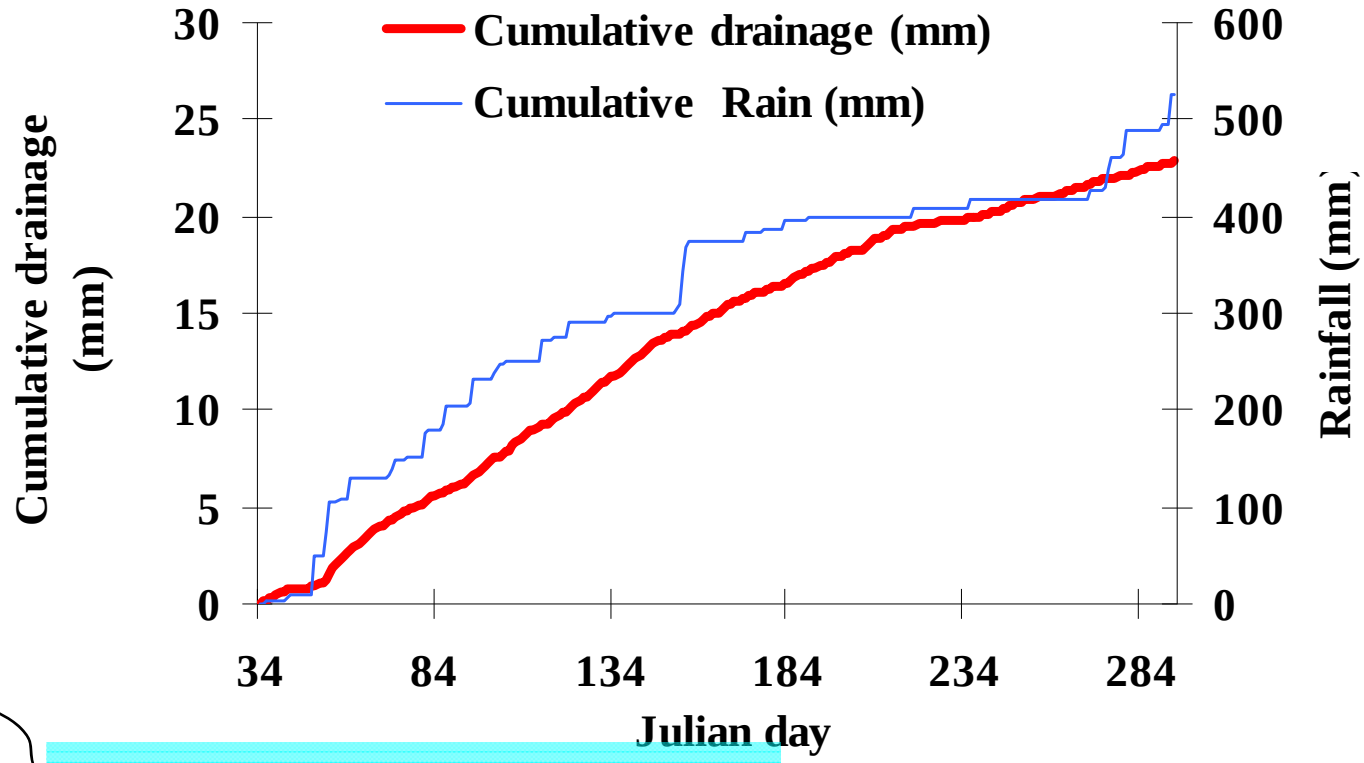
Kingsthorpe Drainage Lysimeter - 2003

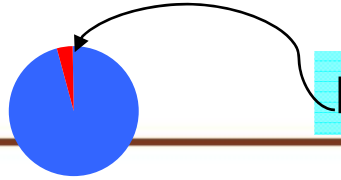


Kingsthorpe drainage lysimeter 250 days in 2003

CRACKING CLAY SOILS DO LEAK!!
...at this site ...

Black Vertosol



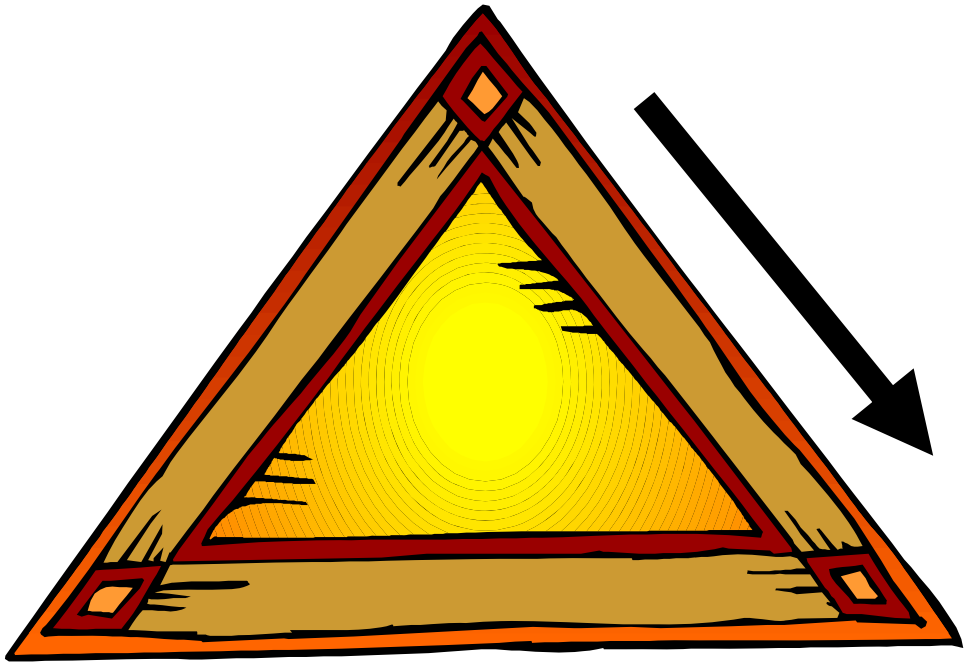


Drainage = approx 4% of rain

rain

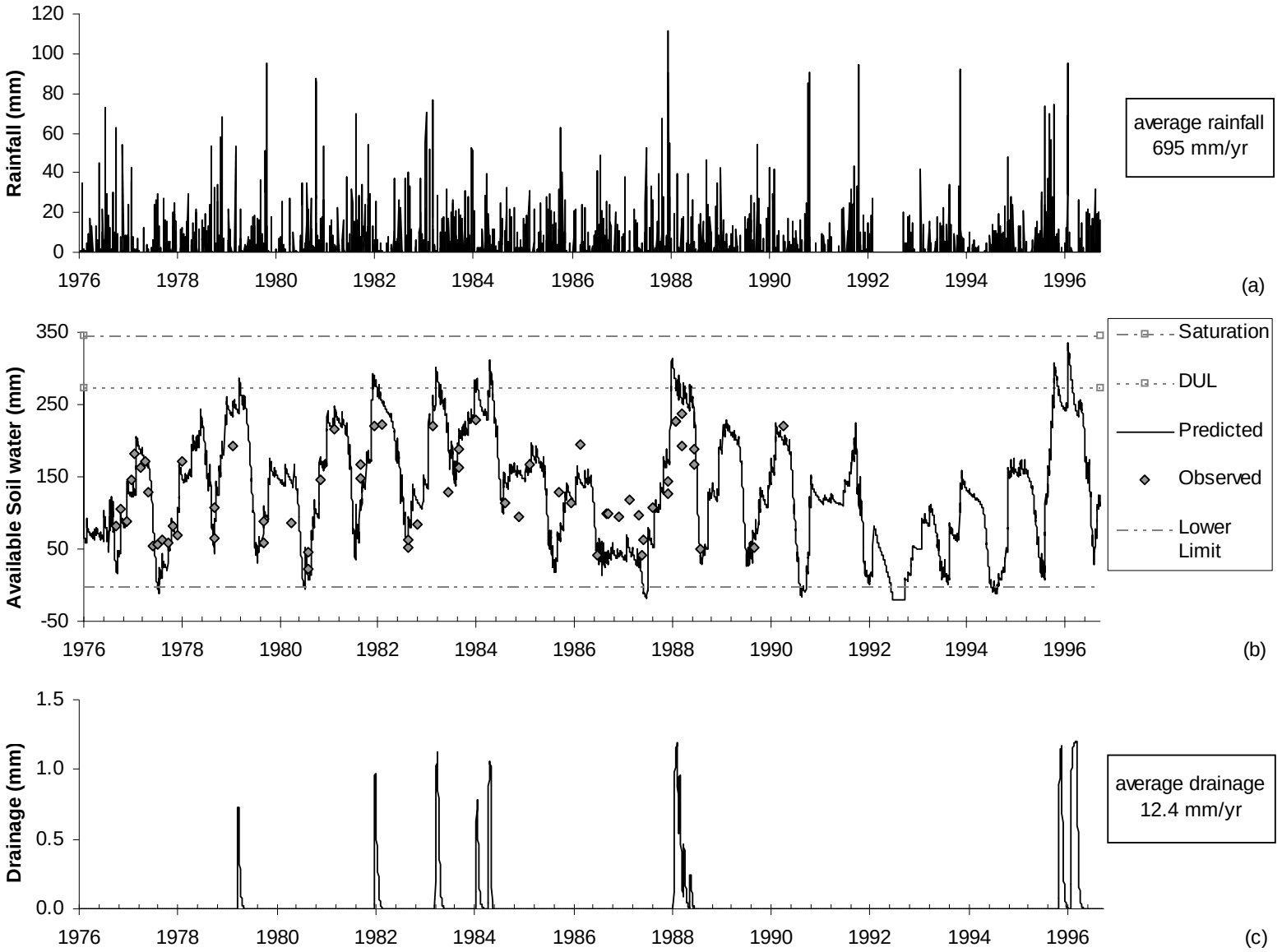
The trilogy

Lysimetry, soil physics



Chloride → Modelling

Drainage very episodic

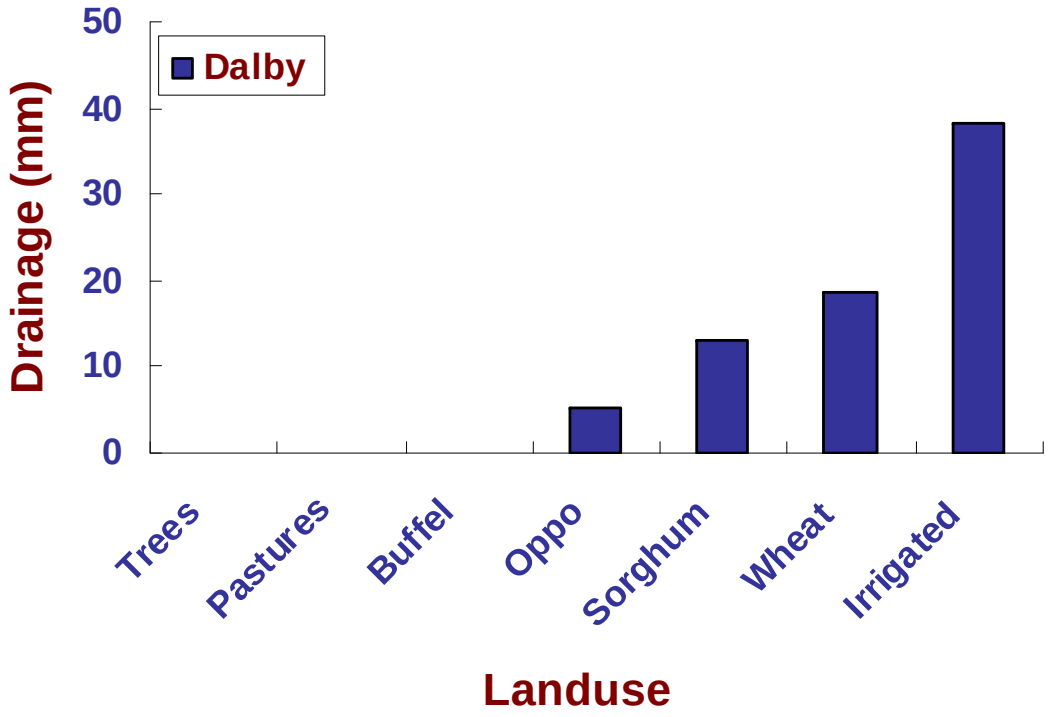


Data source: J Owens

Cl: 14 mm/yr

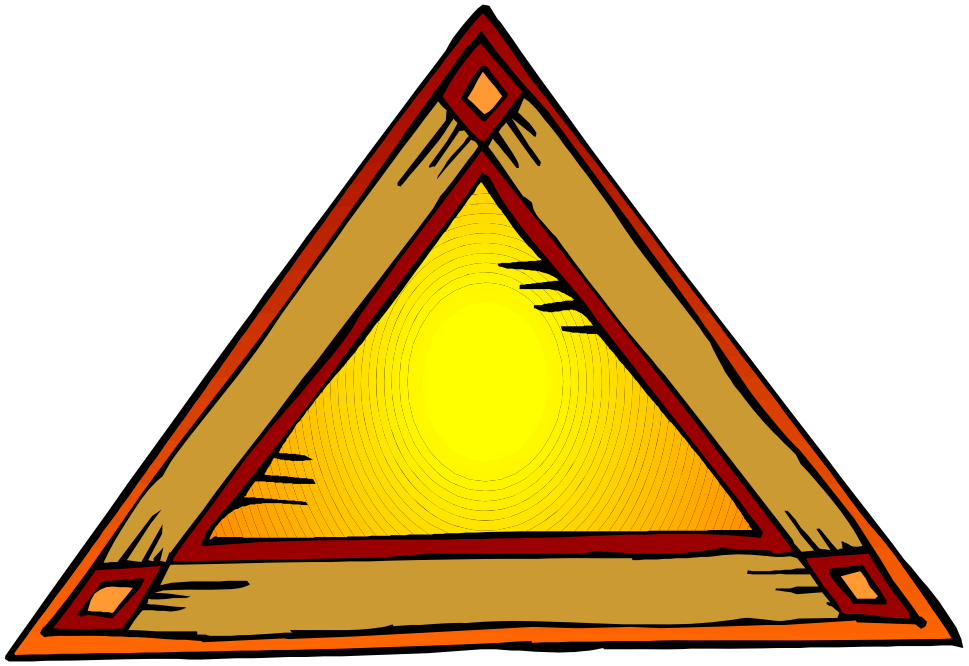
Drainage Calculator or Matrix

Location	Trees	Pastures	Buffel	Oppo	Sorghum	Wheat	Irrigated
Augathella	0	1	0	3	9	7	28
Bollon	0	0	0	3	5	4	26
Brigalow	0	2	4	9	23	24	44
Charleville	0	0	0	4	7	5	23
Chinchilla	0	1	2	6	17	20	43
Condamine	0	0	0	5			
Cunnamulla	0	1	0	2			
Dalby	0	0					
Dirranbandi	0	0	0	3			
Goondiwindi	0	0	1	5			
Greenmount	0	1	1	11			
Hungerford	0	0	0	1			
Inglewood	0	2	2	6			
Injune	0	1	1	5			
Killarney	0	1	1	21			
Meandarra	0	0	0	4			
Miles	0	1	2	5			
Mitchell	0	1	1	5			
Moonie	0	0	0	3			
Morven	0	0	0	4			
Mungindi	0	0	0	4			
Narayen	0	0	1	10			
Nindigully	0	0	0	4			
Oakey	0	0	0	4			
Quilpie	0	0	0	1			
Roma	0	1	0	5			
St.George	0	0	0	3			
Surat	0	0	0	6			
Talwood	0	1	1	4			
Tambo	0	0	0	3			
Tara	0	0	0	5			
Taroom	0	1	1	8			
Texas	0	1	1	8			
Thargomindah	0	0	0	1	0	2	8
Toowoomba	0	11	10	48	62	96	165
Wandoan	0	0	1	5	18	19	41
Warwick	0	0	0	9	13	26	117
Wyandra	0	1	0	1	4	1	19
average	**0**	**1**	**1**	**6**	**13**	**15**	**43**



The trilogy

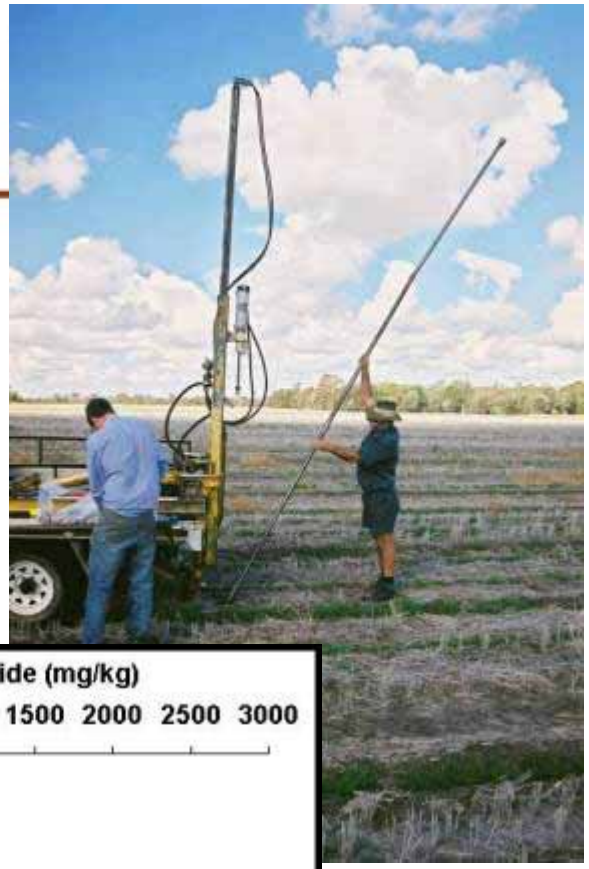
Lysimetry, soil physics



Chloride

Modelling

Chloride mass balance



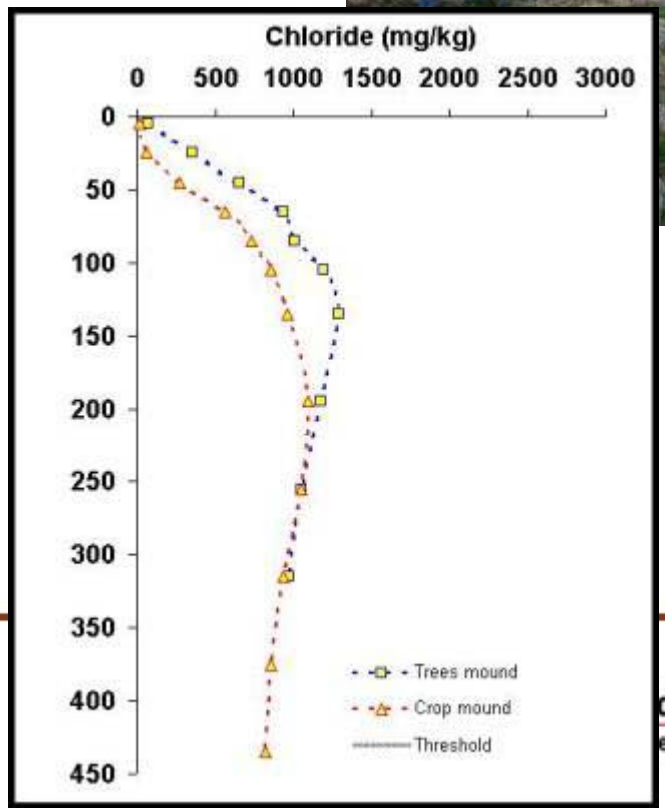
- Based on conservation of chloride mass within the root zone
- Soil sampling
- Compare native vegetation with current land uses
- Rainfall, site history

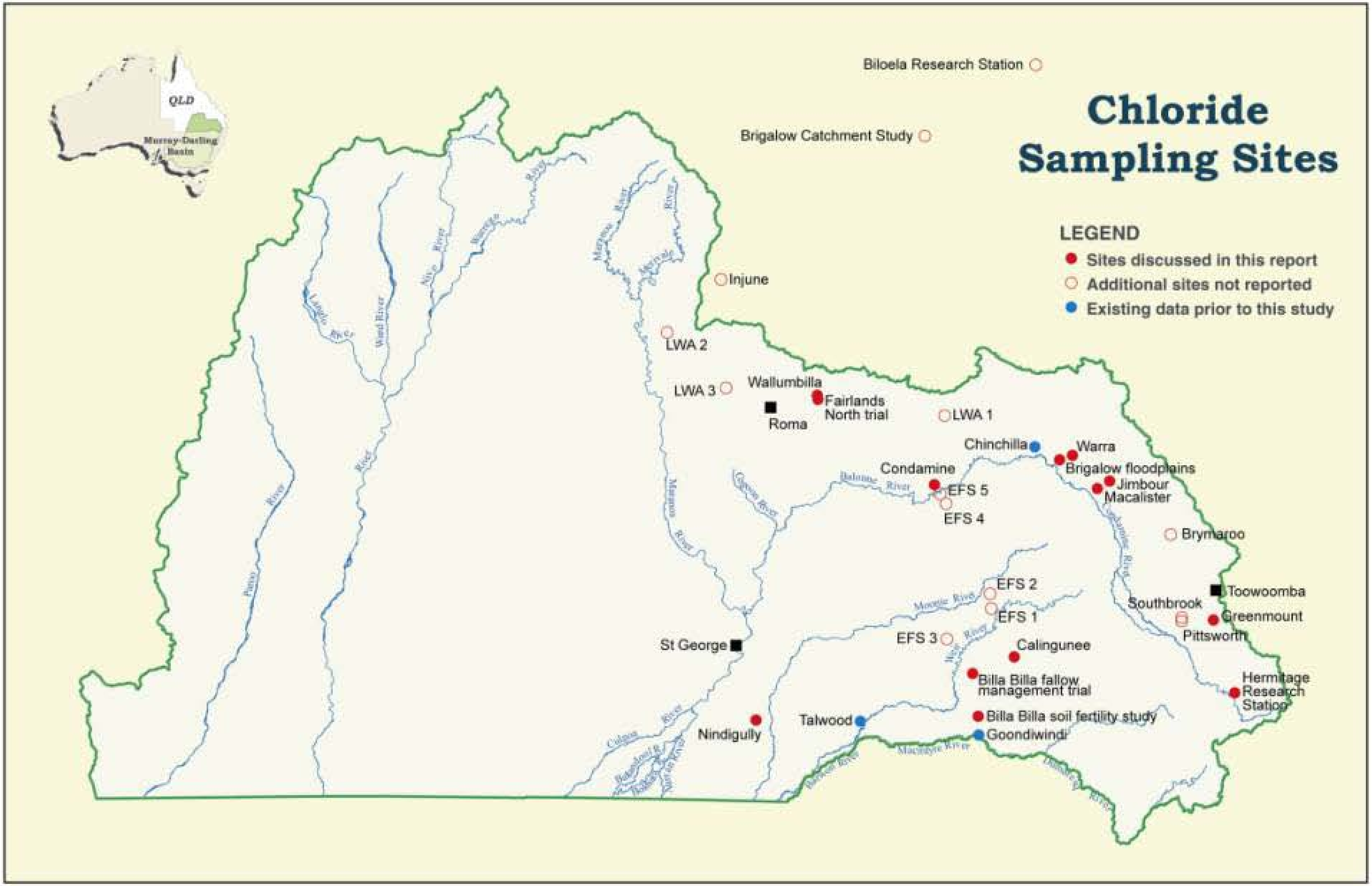
→ Salt store (t/ha)

→ Salt lost (t/ha) from root zone

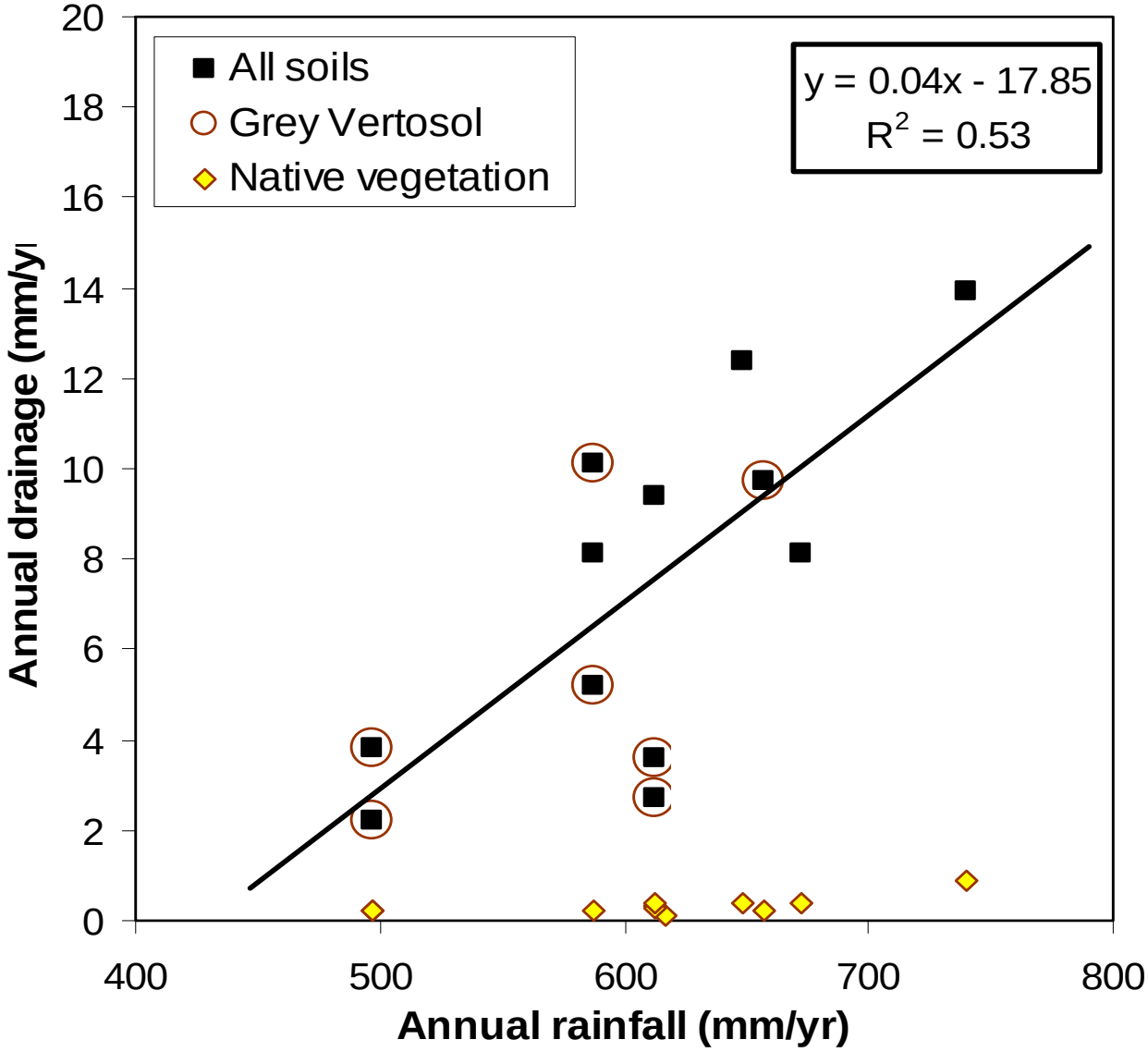
→ Inferred deep drainage (mm/yr)

→ *Salinity risk*

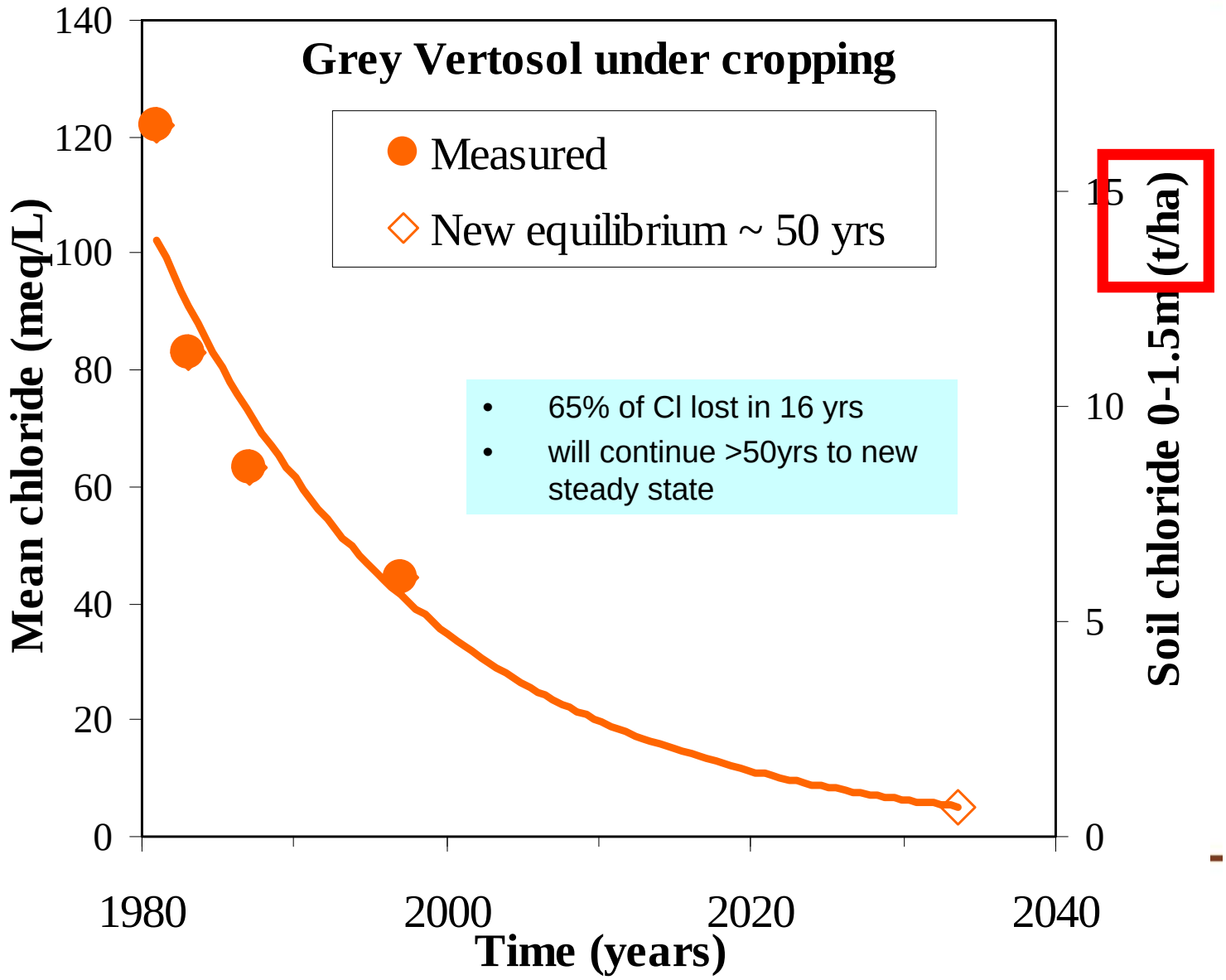



Chloride
Sampling Sites
LEGEND
Sites discussed in this report
Additional sites not reported
Existing data prior to this study
QLD
Murray-Darling Basin
Biloela Research Station
Brigalow Catchment Study
Injune
LWA 2
LWA 3
Wallumbilla
Fairlands North trial
Roma
LWA 1
Chinchilla
Warra
Brigalow floodplains
Condamine
EFS 5
EFS 4
Jimbour
Macalister
Brymaroo
EFS 2
EFS 1
EFS 3
Toowoomba
Southbrook
Greenmount
Pittsworth
Calingunee
St George
Billa Billa fallow management trial
Hermitage Research Station
Billa Billa soil fertility study
Nindigully
Talwood
Goondiwindi

Winter cropping vs. native veg



Salt store soil – Cl since clearing



Management effects

Native veg <1 mm/yr (steady state, USSL)

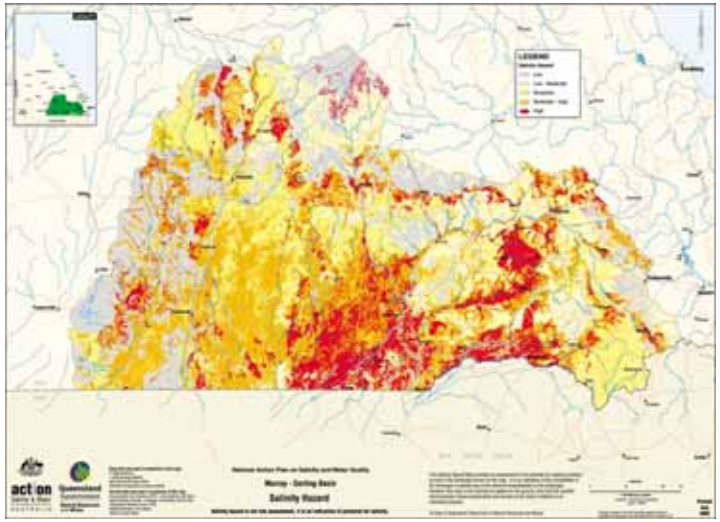
- More options and flexibility for farming systems management in Qld environment

→ opportunity cropping, perennial pastures, crop/pasture phases, winter or summer cropping

Site	Description	Avg drainage at ~1.5 m (mm/yr)			
		ZT	TT	Pasture	OC
Nindigully 497 mm	Farming systems trial 1996-2002	11	8	-	0
Moonie 600 mm	On farm (gilgai mound)	-	8	3	-
Biloela 665 mm	Tillage trial 1984-1993	44	6	-	-

Case study

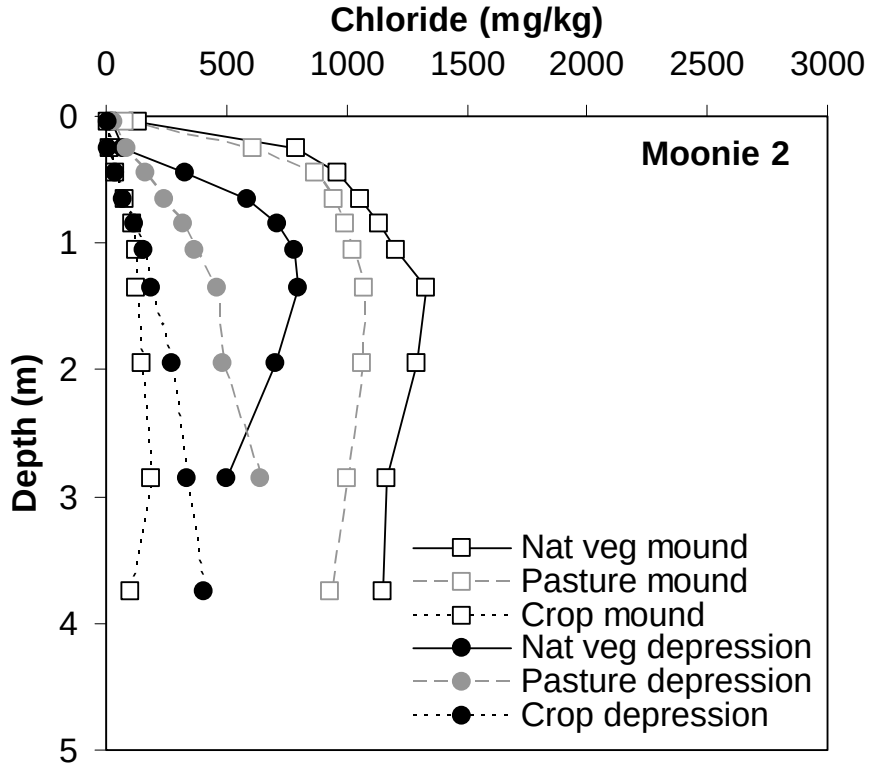
- salinity hazard map QMDB July 2002
- inherent salinity hazard, → salt, recharge potential and discharge potential.
- large part of the Tara Shire in southern Qld was indicated as high hazard
- → pro-active farmer groups sought more information about salinity in their area
- comfortable with modelling, sceptical about DD estimates
- this area typically has high salinity and Cl concentrations in the subsoil; ideal for Cl studies



Case study

- Cracking clay soils
- Gilgai - developed sampling protocol
- Land uses – native veg, pasture, cropping

- Drainage rates:
  - native veg <1 mm/yr
  - pasture 4 mm/yr
  - crop 10 mm/yr



Case study

- Very visual → excellent discussion starter
- 'simple' measured data

- "I believe!!!!!!"

Summary

Lysimeter

- can do a few of
- resource intensive
- real time deep drainage data
- useful hydraulic properties
- precise instrumentation and control

→ PROCESS UNDERSTANDING

Chloride balance

- can do lots of
- straightforward soil sampling
- backward-looking
- deep drainage history since clearing
- salt loads

→ RISK MANAGEMENT strategy

Modelling

- extend existing data sets from these two methods over larger areas and longer time scales
- validate our existing models
- look at 'what if' scenarios, decision support etc

→ one of the TOOLS IN THE BOX

Implications for the future

- Qld has in many places all the precursors for salinity → salt and change in recharge after clearing
  - Evaporation exceeding rain does not prevent salinity ... 'lumpy' rainfall drives drainage events
  - Clay soils do drain ...just more slowly

- We are starting to work out *where*
  - Salinity Audits in Qld Murray-Darling Basin
  - Salinity Risk Assessments in Condamine, Fitzroy Basin

Finally…

- much progress in 5 years
- understand main 'drivers' of deep drainage
- salinity complex - no single simple tool
- measurements vital for modelling
- consequences depend on geology/groundwater
- large time-lags can be involved (or not)
- tools developed and data obtained useful!
- grey-ware matters! multi-disciplinary effort