Estimating Delivery Efficiency of Irrigation Schemes

then improving efficiency

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Step 1: Top down (beer coaster) approach

- Written many water balance models for irrigation and dryland farming in eastern Australia (e.g. Watertrack – www.waterack.com.au)
- My experience is that if the complicated model comes up with a different answer to the beer coaster model, its generally best to believe the beer coaster model and check the complicated one.
- Second rule is that if most common response when discussing an issue is that *it's too complicated,* then it's really important to first develop a robust beer coaster model

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Data set

- 11 Schemes
- From Goulburn River to Macquarie River
- Length 35 km to 3800 km
- Nominal Allocation 26,000 to 1,800,000 ML
- Time period about 1980 to 2007
- Lucky that it included drought (to get some variation)
- 195 data points

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Chuck it in, stir it up, see what comes out

Looked at:

- Delivery Channel length
- Volume diverted
- Volume delivered

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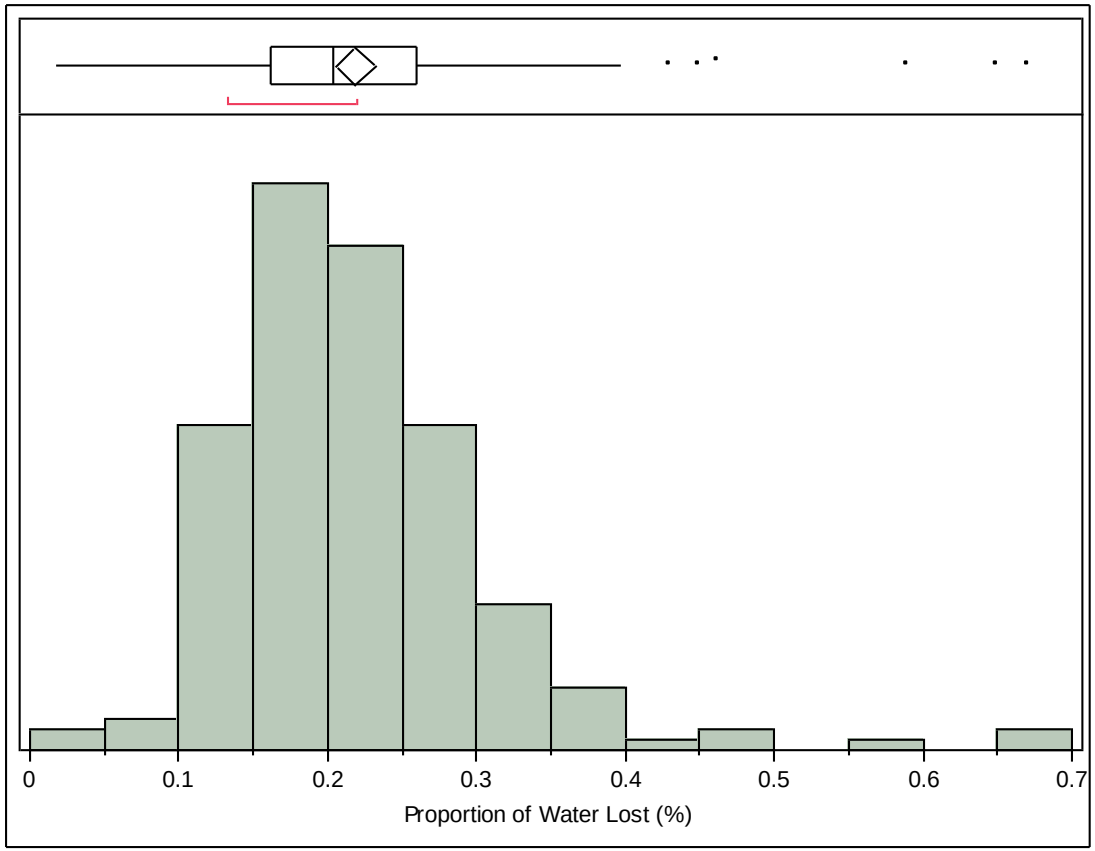
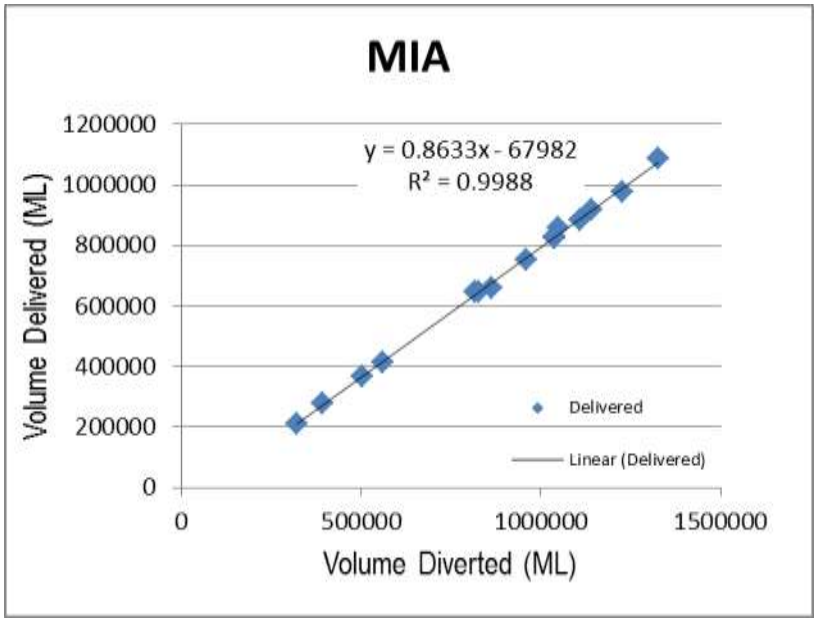
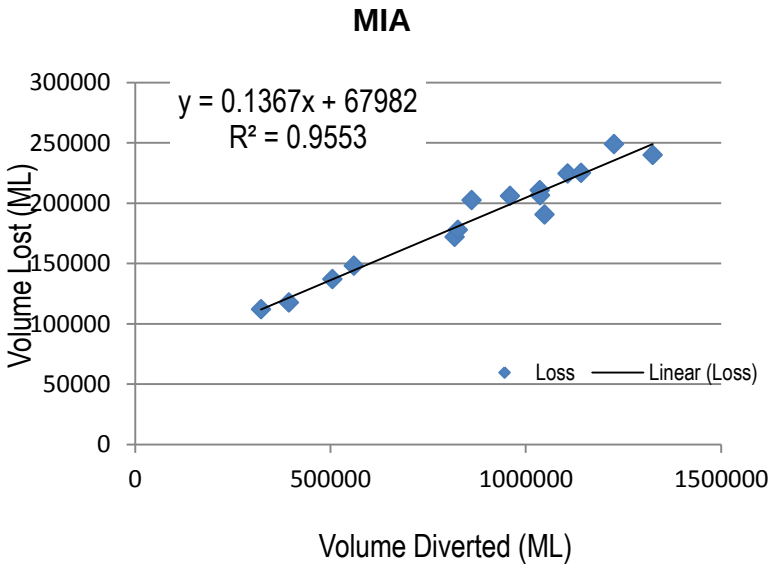
Plenty of variation so there's hope

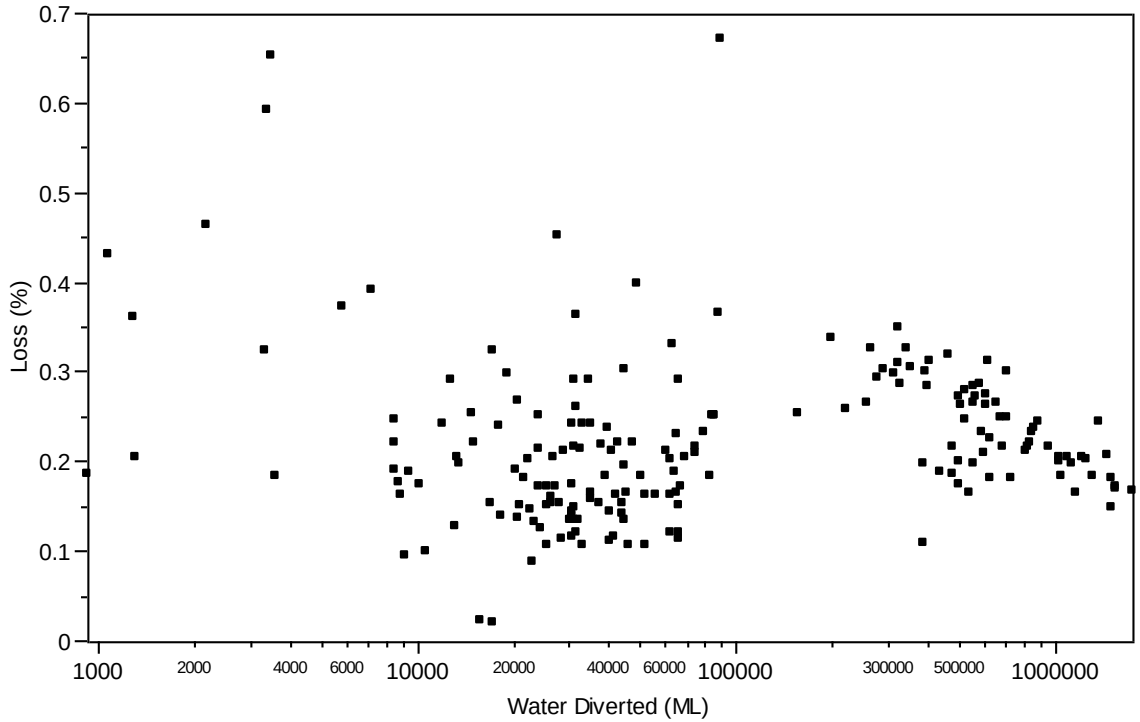


Individual Schemes Followed a pattern of a fixed and variable loss





But they're all different right?



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Maybe

Graph removed for privacy reasons

There's a pattern of greater losses with smaller deliveries. Coleambally was different – I believe that scheme had little incentive to have losses smaller than their loss account, so ran system with large escapes. Dropped Coleambally from analysis

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Or maybe not

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Appears that schemes work best when delivering more than 400 ML/km

They are inefficient when delivering less than 200 ML/km

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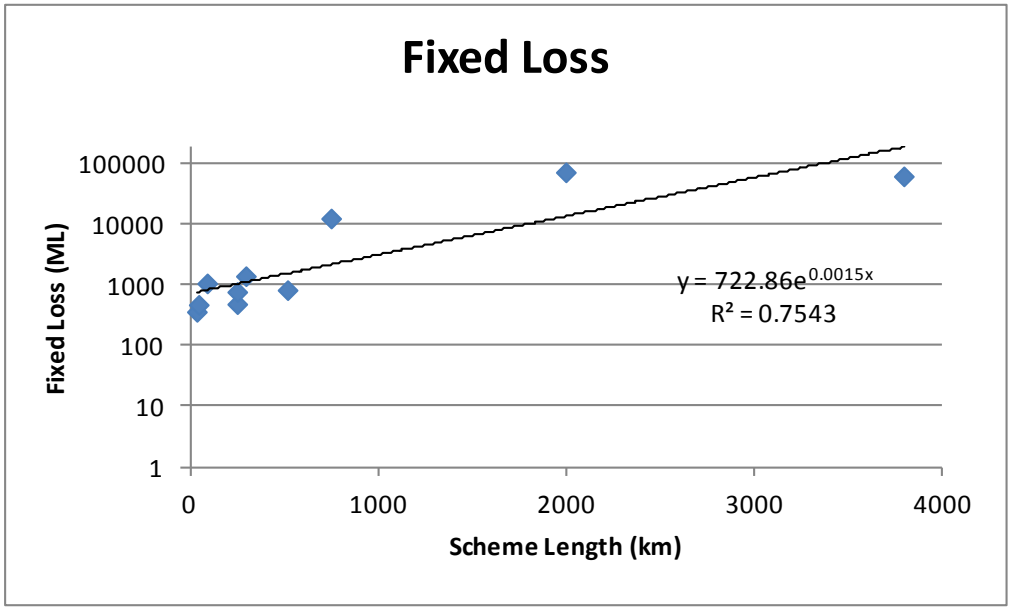
Looking a little bit deeper



(Similar relationship for variable loss failed the beer coaster test)

Hulme, P.J., 2008. Suggested method to estimate proportion of licence needed to compensate irrigators for water transferred of irrigation schemes. Public Submission on the Draft Water Market Rules to the ACCC.
http://www.accc.gov.au/content/item.phtml?itemId=849646&nodeId=d0781ee613010949943d214891958f52&fn=Submission%2014%E2%80%94Dr%20Pat%20Hulme.pdf

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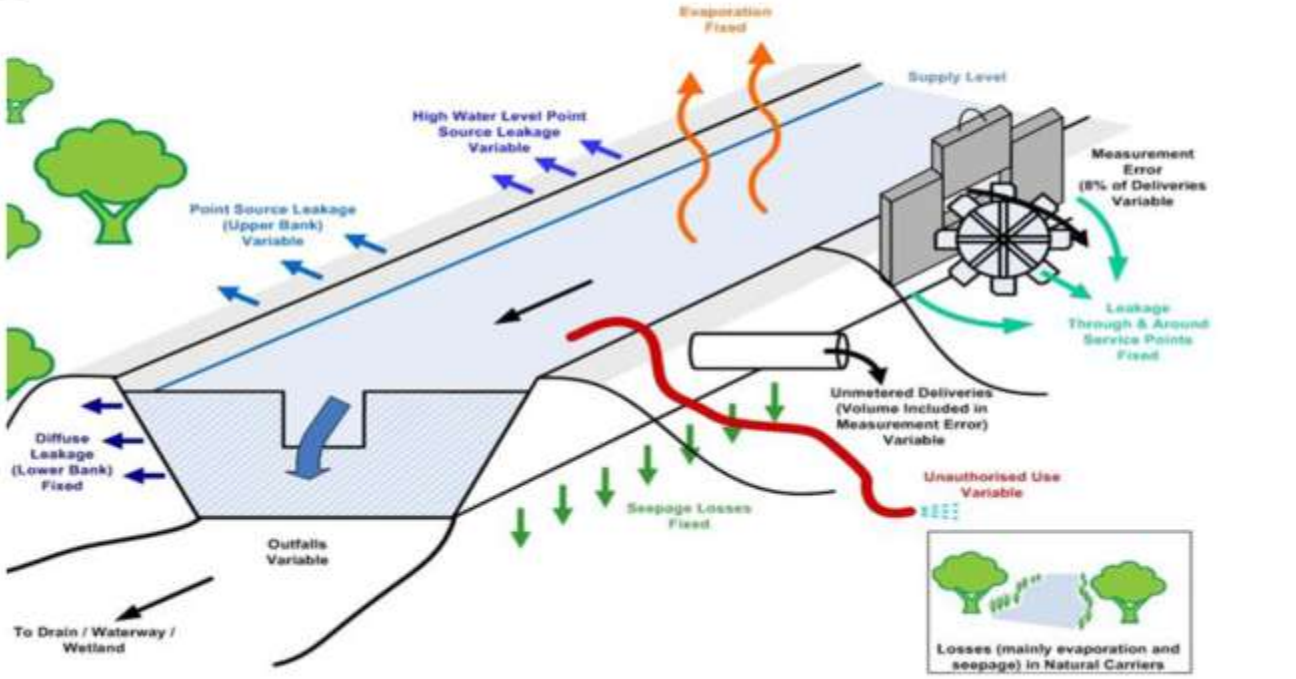
Where does the water go?
Goulburn Murray Water analysis



GMW allocation of losses (Roberts, Schulz and Alexander, 2013)

- Inaccurate metering 20 to 25%
- Outfalls 8 to 12%

Subtotal around 30%

- Evaporation 10 to 15%
- Leakage 25 to 30%
- Seepage 10 to 15%

Subtotal around 70%

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How can Schemes Reduce Losses?

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Beer coaster approach

- Increase water volume delivered per kilometre of channel.

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How?

- Pipe stock and domestic water where channel run solely for this purpose
- Attract more water to scheme

Or be prepared to lose friends and

- Decommission channels that deliver less than say 200 ML/km
- Limit socialisation of losses and get users on channels that deliver less than say 200 ML/km to pay for additional loss on their spur

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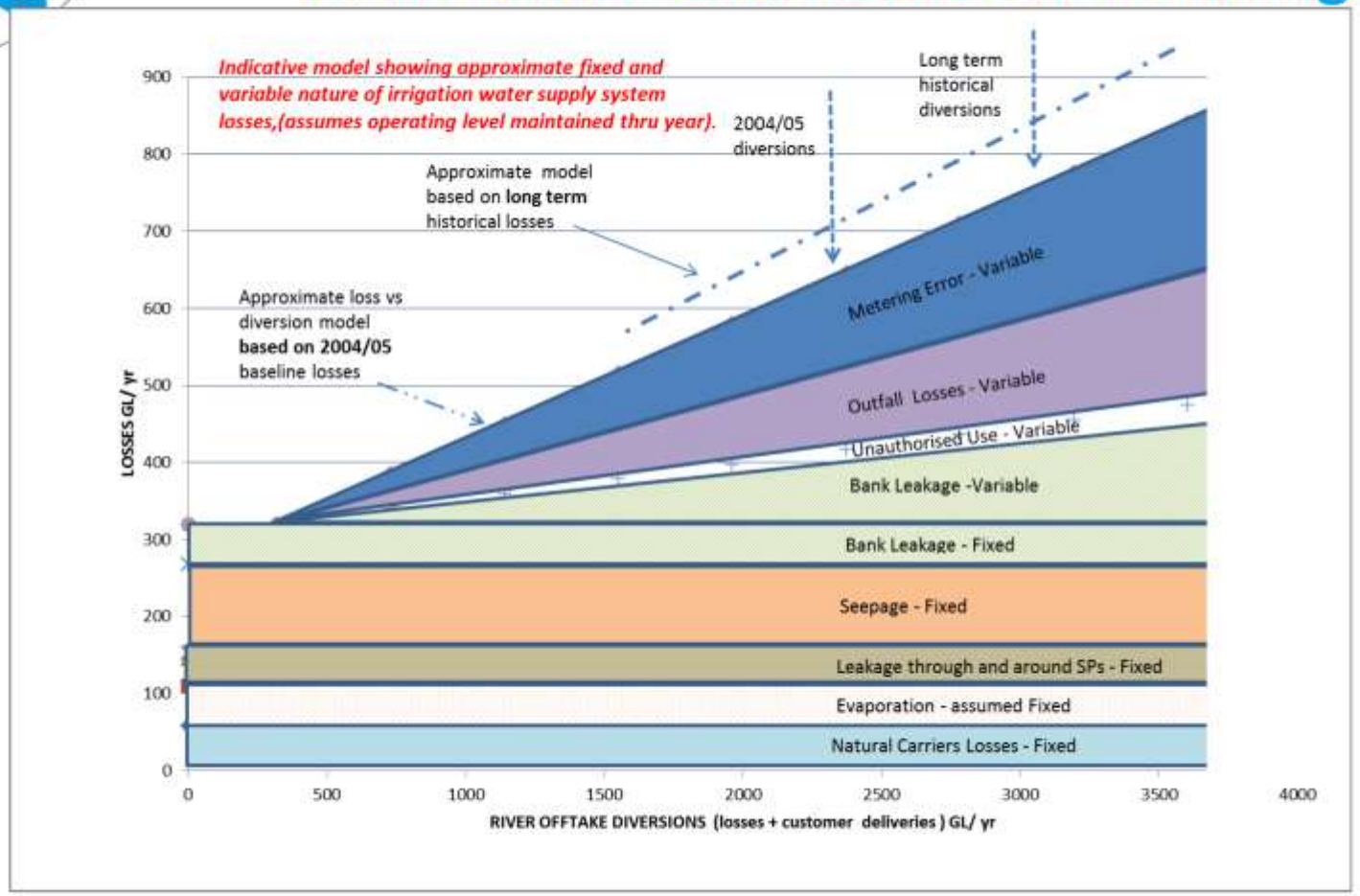
More detailed approach (Roberts et al., 2013)



Detailed Channel Loss Investigation (How do we improve what we've got?)

Destination	Improvement methods	Likely gains
Metering	More accurate meters	Literature claims 10 to 20%, but this assumes extractions measured accurately
Outfalls	Run current system tighter Automation	Depends on current outfalls. Was more than 10% in Coleambally
Evaporation	Reduce surface area	Proportional to change in surface area (not sure of efficiency)
Bank Seepage	Compaction, rebuilding, lining	Loss similar to evaporation
Deep drainage	Compaction, rebuilding, rerouting, lining	Can be more than 10% in a few locations. Requires leaky bed, and essentially infinite reservoir

Locating areas of large bank seepage

- Seek information from the channel managers
- Drive along the channel system. Dry Autumn is best, but not only time.
- Look for greener vegetation near toe of bank, water near toe of bank.
- Dominant causes appear to be where bank was laid on top of a loamy A horizon, or built from stable, well structured soil.

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Reducing rapid seepage

- Impact roller – has worked in some situations, not in others. Not so good where water moving through loamy topsoil.
- Clay curtain
- Rebuild bank
- Line
- Operate channel at lower level, especially when not required.

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Locating areas of rapid deep drainage

Requires 2 factors to coincide:

- Very leaky soil (of the order of 10% or less of most alluvial landscapes in the Murray Darling Basin)
- An infinitely large reservoir such as:
  creek bed
  groundwater recharge zone

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Indicators of rapid deep drainage

- Channel manager observations

- Trees that grow in fresh groundwater such as yellow box, carbeen
- Can pick up by measuring groundwater recharge (slow & expensive)
- Understand geomorphology

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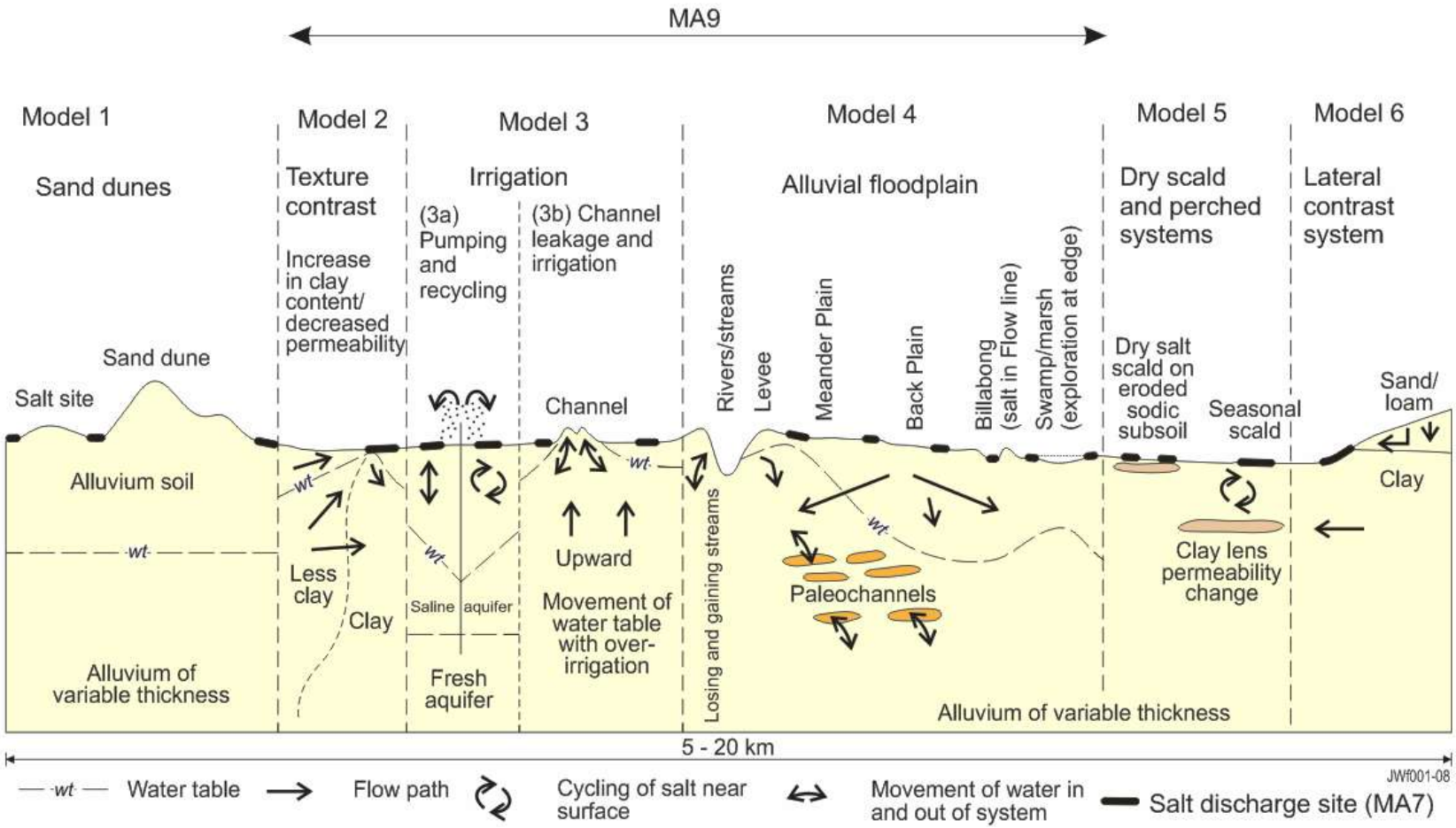
Geomorphology

(couldn't track down source of this diagram)



Geomorphology implications example

	Attribute				
Meander Plain	Sediment	Fine sand, silt, clay (non reactive and reactive clays) and Aeolian material	Fine sand, silt and non reactive clays.	Medium to coarse sand, some gravel, some clay and silt.	Clay and silt
	Width	300 to 400 m	200 to 300 m	100 to 200 m	50 to 100 m
	Soil Type	Variable – Red brown loamy sand to clay loam, Duplex clay loam over red to yellow clay.	Silty loams and silty clay loams over yellow brown clay. Grey heavy clay at around 5 m.	Loamy sand and sandy clay loams	Grey to brown silty clay
	Landscape Features	Source Bordering Dunes, Closed Depressions and In Filled Channels	Levees, Channels and Meander Plain.	Meander Plain, Scrolls and Floodplains.	Levees, Channels, Near Meander Plain and Flood plains.
	Vegetation	Cypress Pine, Yellow Box and Bimble Box	Cypress Pine, Yellow Box and Bimble Box	Yellow Box and Red River Gum	Yellow Box and Red River Gum
Backplain	Sediment	Reactive and non reactive clay	Clay and silt		
	Soil Type	Light to medium clay and clay loam over red clay and medium clay over grey clay	Red to yellow brown silty clay loams and light clay over red to yellow brown clay.		
	Vegetation	Myall and Belah	Myall, Belah and BimbleBox		
	Management Implications	Leaks slowly and very slowly transmissive	Leaks and creates a perched water table. High potential for secondary salinity.	Leaks, large capacity to transmit water	Leaks, large capacity to transmit water

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Deep drainage measurement and modelling

- Ground conductivity survey
  Ground based EM (time domain or frequency domain), resistivity, airborne EM
- **THEN GROUND TRUTH**
- Start with assumption that the EM survey is lying. If you can't prove that then it's probably OK

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Deep drainage measurements

- 100 mm diameter infiltrometers have been good for point measurements
- Ponding tests are the only real measurement, but expensive and need to be located on uniform material.
- Test holes or test pits give an indication of the destination of the water that drains from the channel
- Can model variation in deep drainage if have robust data set
- Model unreliable if water table shallow

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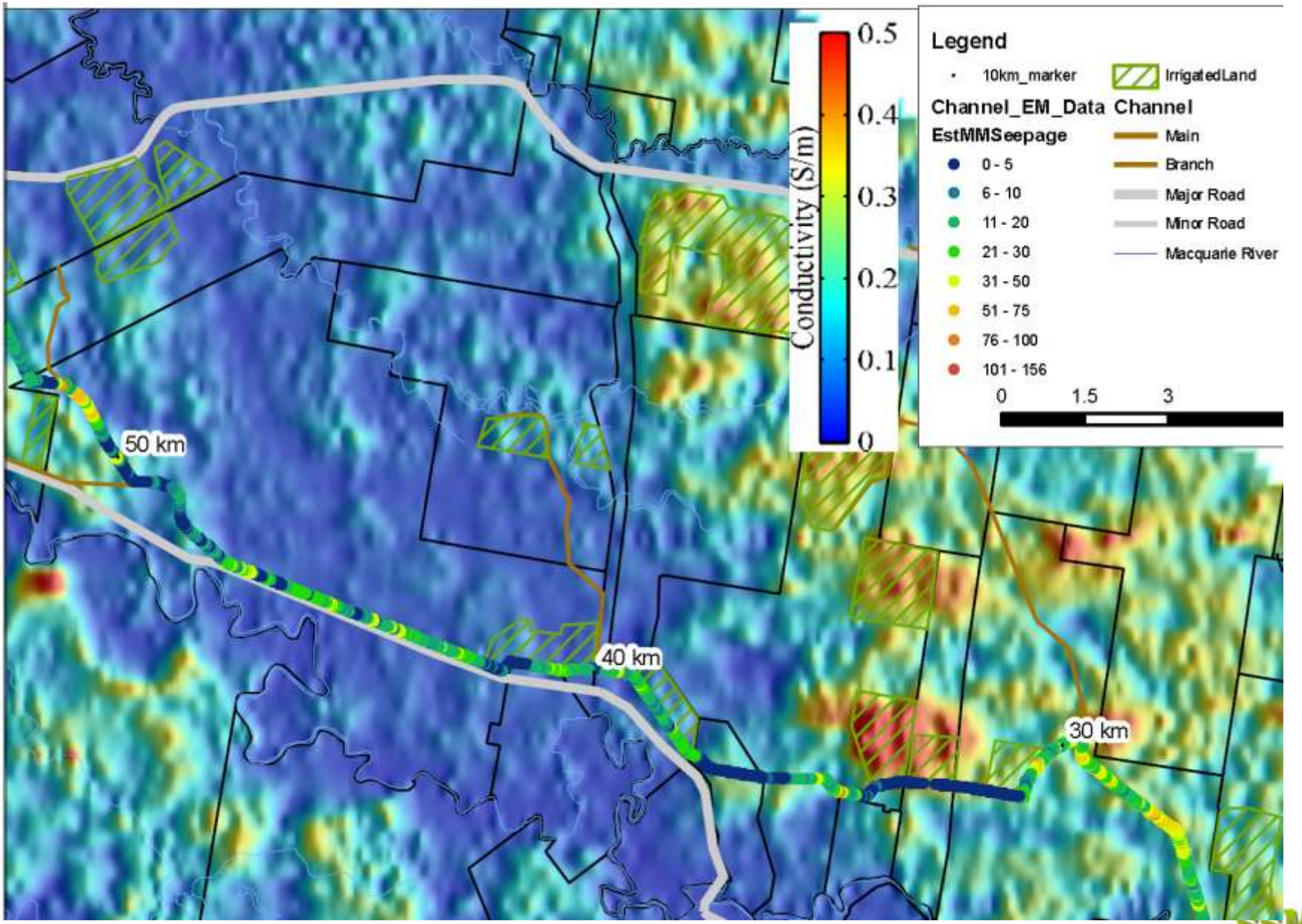

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Use data to drive a model of the channel performance

- Can model effect of lining, shortening channel, changing operating procedures

- Nearly at stage of having some data to check the accuracy of the model for one scheme in the Macquarie (cost millions to reconfigure and line)

- Can apportion losses around scheme

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SUMMARY

Irrigation scheme delivery efficiency is a function of:

- MegaLitres delivered per kilometre of channel

This is because there are substantial fixed losses such as

- Evaporation
- Deep drainage
- Bank seepage

There are also variable losses that include

- Metering error (not sure that this is always in favour of organisation delivering water)
- Escapes

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