NATIONAL WORKSHOP TO INITIATE ESTABLISHMENT OF NATIONAL STANDARDS FOR IRRIGATED CROP WATER BALANCE AND ETC FIELD METHODOLOGIES

Workshop summary report

June 2002

National Program *for*
Irrigation Research and Development

National Workshop to initiate establishment of national standards for irrigated crop water balance and ETc field methodologies

Workshop summary report

Melbourne, 27 June 2002

Summary

A national workshop was convened by National Program for Irrigation Research and Development (NPIRD) to establish the need for national standards for irrigated crop water balance and crop evapotranspiration (ETc[1]) field methodologies. The workshop was attended by representatives of relevant state agencies and federal organisations. Participants all had a sound understanding of the use of ET in their organization at a technical level and were also able to represent the organization at a policy level.

The findings of the workshop showed that there are sufficient reasons and levels of agreement to pursue national standards that will result in:

- Outputs able to be compared across farm/district/regions/catchments/states so that values have common meaning, particularly for irrigation scheduling and design
- Improved confidence in the estimated water use values of different crops. This information will be critical during water allocation discussions.
- Greater ability to institute continuous improvement in a standardized manner as measurement technology and estimation procedures improve
- Bureau of Meteorology more able to effectively fulfill its role as a national service provider by providing client focused information using a common methodology.

The group recommended that there was a need to develop national standards for ETc methodologies and outlined a process by which to achieve national standards. They believed that there were three tasks required; the first, that of management and coordination of the process nationally aimed at gaining acceptance for the proposal by all relevant State and Federal organizations. The second task is to test the applicability of using FAO56[2] guidelines and identify what technical information was readily available and what was missing. This leads to the third task which is to implement a national research and development program to provide improved agronomic and climatic data in the long term.

To further these tasks, two scoping papers are to be written. The first paper will be a scoping paper about the management of a national project to develop and implement national standards. This is to be drafted by Bernie Prendergast (BRS), Wayne Meyer (CSIRO) and Clive Noble (AgVic) in conjunction with all workshop participants with the support of their organisations. The paper will outline a framework for a standardised approach as agreed to in the workshop and will be submitted to the federal Natural Resource Management Council through the most appropriate route, possibly through National Program for Sustainable Irrigation (NPSI) and the Land and Water Biodiversity Sub-committee. This will ensure that State agencies and the Commonwealth approve of the framework and will support its national implementation.

The second paper will outline the immediate technical issues that need to be addressed to develop a national standard. The technical paper will be drafted by Wayne Meyer (CSIRO) and Alan Kernich (BoM) and then circulated to Geoff Podger (DLWC), Q.J. Wang (AgVic) and Hector Malano (CRC for Catchment Hydrology). It will develop a “proof of concept” to test the applicability of the FAO56 guidelines including:

[1] ETc = crop evapotranspiration (calculated from weather data derived reference ET and a crop development specific crop coefficient, Kc)

[2] FAO56 = “Crop evapotranspiration. Guidelines for computing crop water requirements” FAO Irrigation and Drainage Paper 56. RG Allen et al. 1998. This reference provides guidelines for applying the Penman-Monteith algorithm to obtain ETc values

- Using current data to establish ETo[3] and Kc[4] databases – containing both climatic data and field measurement data to derive ETo and measured validation data
- Producing an operational daily product for national coverage – ETo map and grid file.
- Documenting the methodology.
- Developing a description of what is needed to extend the approach.

Background

At present there is a lack of consistency in methodologies used to calculate crop evapotranspiration (ETc) across Australia. The resulting confusion and challenging of the methods used to estimate crop water use will reduce confidence in the basic data and divert attention from the important major natural resource issues of salinity management and water sharing.

The National Action Plan on Salinity relies on an accurate understanding of groundwater recharge rates in both irrigated and dryland farming systems. For example, these recharge rates can be deduced by subtracting quantifiable and estimated water outputs (losses) from water inputs to the farming system. To be able to do this, and also compare the relative merits of various solutions, we need to use common methodologies across Australia. The National Program for Irrigation Research and Development (NPIRD), a subprogram of Land and Water Australia, conducted a one-day national workshop to initiate the establishment of national standards for irrigated crop water balance and crop evapotranspiration (ETc).

The aims of the workshop were to establish:

1. The need for national standards for irrigated crop water balance and crop evapotranspiration (ETc) field methodologies
2. If there was an agreed need, to identify the steps to be taken to have all agencies agree on and promulgate these methodologies
3. If there was difficulty in reaching agreement, to identify any additional research that needed undertaken to provide more information on the methodologies.

Workshop participants represented Bureau of Rural Sciences, Bureau of Meteorology, CSIRO, Agriculture Victoria, NSW Department Land and Water Conservation, Tasmanian Department of Primary Industry Water and Energy, Queensland Natural Resources Science & Mines, NSW Agriculture, Primary Industry and Resources South Australia, Queensland Department of Primary Industry and CRC for Catchment Hydrology.

Representatives from Agriculture WA and Water and Rivers Commission were kept informed about the workshop and their comments sought on this report. In future, both organisations are willing to be involved where appropriate.

[3] ETo is daily reference evapotranspiration
[4] Kc is a coefficient for the crop type

Workshop process

The workshop began with a presentation by Clive Noble, Director of Agriculture Victoria on the need for national standards from a policy perspective.

The rest of the workshop required participants to work through four questions as follows:

1. Why do we need National Standards?
2. What is the current situation?
3. What do national standards need to look like?
4. What needs to happen to achieve National standards?

1. Why do we need a national standard?

Aim

To seek agreement that it is worth pursuing a national approach.

Process

Participants broke into small groups to identify the three to four key reasons for a national approach.

Findings

The groups identified the following reasons for a national approach:

- Outputs able to be compared across farm/district/regions/catchments/states so that values have common meaning, particularly for irrigation scheduling and design
- Improved confidence in the estimated water use values of different crops. This information will be critical during water allocation discussions.
- Greater ability to institute continuous improvement in a standardized manner as measurement technology and estimation procedures improve
- Bureau of Meteorology more able to effectively fulfill its role as a national service provider by providing client focused information using a common methodology.

The discussion highlighted some of the problems inherent in the current approach. Problems with crop factors relate to:

- The lack of collated sets of data for different crops, regions and practices
- Limited data on stressed crops, growth rates and soils types and affect on Kc factors
- Data doesn't cover all crops
- Often data comes from overseas
- If using Kc for water balance need to look at other standardized measures for other components of water balance

Problems with estimation of evaporation relate to:

- Lack of national consistency in data collection methods and processing equations applied, often with inadequate documentation of what was done
- Uncertainty about the source of data or understanding of how data is derived – ETo can be derived from Epan[5] or daily weather data

[5] Epan is evaporation from an evaporation pan ("Standard Class A pan")

- Epan data is highly site sensitive. Pans are now standardized but there is a sparse network of pans. The variability of data and its known proneness to error has greatly reduced the use of recorded data, instead, interpolated maps are used to provide modeled data
- Confusion about application of appropriate level of aggregation ie sometimes data is needed at paddock, other times catchment level data is needed.

There was an additional request to include standardisation of measurement of evaporation from small and large (shallow) water storages. Where does the boundary get drawn?

2. What is the current situation?

Aim

To clarify their State and/or organisation perspectives covering:

- Current techniques and standards
- Applications and uses
- Limitations with current approach
- Future needs.

Process

Representatives of each State filled in a proforma sheet. Those from Federal agencies combined and provided a "Stateless view". The situation in Murray Darling Basin Commission (MDBC) was covered with SA as the representative for MDBC was from SA.

The results of this activity have been compiled into the table on pages 4 and 5.

Findings

The FAO approach is widely used though there appear to be several versions. Most organisations are moving towards wider use of FAO56. In the USA they have developed 2 sets of coefficients, one for short crops (based on mown grass) and one for tall crops (based on lucerne/alfalfa).

Penman-Monteith (P/M)[6] also varies in how it is used, and the variations usually relate to coping with limitations of data such as:

- Radiation [solar irradiance values at ground level]. (Note: BOM now have confidence in this data as it is now estimated from satellite information.)
- Local wind measurement
- Missing data and limited geographic coverage
- Calibration methodology
- Advection effects
- Other limiting data relates to spatial coverage (uncertainty about how far we extrapolate) and Kc data.

Commercial weather stations vary in terms of measurements they take to calculate ETo and which version of Penman-Monteith they use.

[6] Penman-Monteith is an algorithm used to estimate ETc

2. Current situation (cont)

	Victoria	TAS	NSW	Qld	SA/MDBC	Stateless
	NRE	DPIWE	DLWC, NSW Ag	DPI, NR&M	PIRSA, MDBC	AFFA, BoM, CSIRO, CRC
Current techniques and/or standards you use for estimating Etc	• Research uses FAO56 • Not sure what consultants use • Pan used most often • Penman-Monteith – use BOM data • Crop factors from overseas	• No ETc techniques, scheduling often based on direct soil moistures • planning, gross expected irrigation requirement /ha	• Different regions have different methods • Based on pan • Penman-Monteith • FAO • Field measurement • Morton variation[7] • Climate spline, SILO data	• Water balance by different (both NR&M and DPI) • Soil samples at two times – pre-plant & post-harvest (both NR&M and DPI) • Deep drainage estimate - modeling, EC profile & Chloride profile, lysimeter (weighing) • Eddy correlation, energy balance – doesn't work (NR&M) • QCCA silo interpolated data fed into Penman - Monteith • In APSIM (Priestly-Taylor[8] sometimes) • Bowen ration by CSIRO • In WaterSCHED being redeveloped using P/M (previously Pan and/or modified Penman 1977 (DPI) • MEDLI & PERFECT use Class A Pan • Groundwater group uses Morton variation of Penman-Monteith	• ETpan → ETo (Ks/Kp) FAO[9] • Long Term Average standard pan, district policy • Local actual (SILO) farm/WUE	• BoM not focused on crop ET • General application to water resources and agriculture • Historic Epan → automatic Epan – ET calc demand longer term applications • AFFA – use others ETo input • CSIRO – local met stations ETo from Griffith, Penman - Monteith and heaps of other models • CRC-CG compares methods / Penman - Monteith

[7] The Morton formulation is a variation of the Penman-Monteith algorithm
[8] Priestly-Taylor is a simplified calculation for Eto which requires less data variables
[9] Kp= plant component of the crop coefficient Kc Ks =soil compoment of the crop coefficient Kc. Note: Kc = Ks + Kp

	Victoria	TAS	NSW	Qld	SA/MDBC	Stateless
Where and how is this applied/used in your state or organization?	• Irrigation scheduling • WUE • Water allocation (realm) • New development planning	• On-farm scheduling • Pan evap x general crop factors	• Farm dam modeling • Ground water modeling • River basin modeling • Irrigations scheduling	• Irrigation scheduling (WaterSCHED) • Experiments and modeling at paddock sale • APSIM (at paddock and catchment scale)	• Daily water balance • Estimate drainage • Input into WUE calcs (farm and dictrict) • Input into volume allocation processes	• BoM general supply to ag water resources policy planning • AFFA policy/exceptional circumstances, referring • CSIRO and CRC modeling research irrigation/water balance
Limitations you encounter with your current approach	• Not much local data on crop factors • Inconsistency in applications • Insufficient pan and other climatic data – wind and solar radiation (only 26 sites nationally)	• Limited crop factors – poppies, pyrethrum • Allocation catchment planning limited by much other lacking information ie river groundwater metering	• Spatial and temporal coverage • Non-consistent approaches	• Available weather data to calculate ETo • Reliable and working instrumentation • Soil type variability • Cost of lysimeters • Length of data record for modeling	• Inconsistency between LTA standardized data and local raw pan data • Local site influences in evap • Appropriate Kc for modern scheduling technique (RDI) and limiting conditions • Sparseness of monitoring sites for Epan	• Standard ETo • Standards Kc • Limitation of data • Info transfer – end up perpetuating poor data

	Victoria	TAS	NSW	Qld	SA/MDBC	Stateless
Future needs	• Standardization establish crop factors • Improve climatic data availability	• More crop factors	• Farm dam modeling • Ground water modeling • River basin modeling • Irrigation scheduling	• Irrigation scheduling • Crop water requirements and allocations • Getting good Kcb[10] and Ke[11] figures (for dual coefficient approach)	• Standardized data sets, data collection protocols, algorithm (FAO P/M) • Kc's for agronomic purposes/limiting conditions • Robust allocation process • Robust methodology for assessing/reporting • WUE – farm/district	• Overcome/have processes to improve and adapt • Water allocation and distribution equitable and fair water use

[10] Kcb = basal crop, just crop not soil
[11] Ke = soil evaporation

3. What do national standards need to look like?

Aim
To identify the desired outcomes of National standards both in terms of measurement and application

Process
Participants worked in three small groups to scope out what National Standards will need to look like. Which algorithm to accept then availability and quality of data? The findings are summarized below:

Findings
In the USA the ASCE accepted FAO56 and then a technical working group produced a prescribed way of applying it.

Agreement to use FAO56 though recognizing the limitations of using the model such as:

- There are no indications of the sensitivity or uncertainty in the final number therefore research on sensitivity of FAO P/M is required
- Caveats need to be strictly adhered to
- Lack of documentation of the FAO hierarchical process such as what parts require real data and where extrapolated and/or interpolated data can be used without reducing sensitivity
- Need for greater understanding of bias (size, nature and source/s).

Need to decide on data collection and computation methods. Requires a three dimensional framework – application, scale and time. Establish preferred methods for particular application and data (retrospective and real time)

Need to establish formal process for reviewing new methodology against accepted standards.

<u>Data level</u>
Data is required to calculate ETc at both:

- Paddock level
- Regional level.

<u>Data type</u>
Paddock level calculations require both real time and retrospective data for some applications, in daily and weekly intervals progressing to even more timely and intense data.

Regional level calculations require retrospective data at weekly/monthly/annual intervals. Historic data is essential, for some applications.

Data reliability

Need a high degree of accuracy & consistency. Some historical meteorological data is of dubious quality (in some instances RS12 from the old surface network, pre 1993, could be up to 10% in error but the accuracy is generally unknown). Wet bulb data from some sites can be of dubious quality due to inadequate maintenance.

Need to establish maintenance and accuracy protocols for weather station sensors. Bureau of Meteorology Automatic Weather Stations (AWS) are well maintained and supporting documentation is available. Tier 2 AWS (less expensive) can be used in the field but should be referenced to an appropriate AWS of acceptable reliability eg. a nearby Bureau of Meteorology site.

Documenting of changes of data and calculations – there is an important need for consistency over time between public and commercial estimates

Need more exposure of levels of uncertainty: eg ETo = 7.5 $\pm$ 0.4 mm/day

What is needed

- Need nationwide availability of ETo on a daily basis available by WWW, rural media
- Need to aggregate/collate Australian data and their origins
- Need to revisit/recalibrate Australian data
- Need to develop method for interpolation of sparse data
- Need data augmentation to make best use of all historical data including long pan series (Statistical and stochastic approach)
- Need to lobby BoM for public access to:
  - solar radiation for any location
  - calculated ETo estimates for any location – by whatever method we agree on
- Reinterpret the Kc values and Ks values derived in Australia to suit new crop management regimes with respect to FAO hierarchical process - new reference ETo
- If standard ETo is available then all past research can be reused to calculate Kc
- Redevelop Kc values for new crops
- Need Kcb, Kc and Ks (basal crop, crop and soil)
- ETactual = Etc = ETo x Kc
- Convert Epan to ETo using FAO56 guidelines
- Standard approach to developing local Kp[12] values
- Greater need to have understanding of data extension (long time sequences) capturing extent of climate variability and sequences.

[12] Kp = Plant component of the crop coefficient

4. What needs to happen to achieve National standards?

Aim

Develop a project brief including who needs to be involved, focus of any research, process for ratification, timeline.

Process

Participants broke into three groups according to their area of expertise and/or interest to work on three project briefs of management, technical and R&D.

Findings

Project brief 1. Management of the whole project

Aims:

1. To put in place an approval process with a suitable timeline to achieve a phase-in and national agreement
2. To assign responsibility to ensure the momentum is maintained.

Action:

Bernie Prendergast (AFFA), Wayne Meyer (CSIRO) and Clive Noble (AgVic), with the support of workshop participants and their organizations, will develop a scoping paper outlining the agreed standardized approach for endorsement by state and commonwealth jurisdictions. Care will be taken to include WA as this State was not represented at the workshop.

Return paper to NPSI for management of next steps.

Paper to be submitted to the NRM Council through the most appropriate route, possibly the Land and Water Biodiversity Sub-committee. Then it will have State agency sign on and Commonwealth NRM approval.

Those organizations that will need to be informed and asked for endorsement include:

- ANCID, IAA, consultants (SKM, URS etc), IE Aust, AIAST, water lobby groups, national irrigators council, CRC's
- State agencies, AFFA, EA, MDBC
- Instrument manufacturers (Agrilink, Sentek, ServeAg, Agrisearch, etc)

Who has carriage? State Agencies plus AFFA/EA

Funding to be sought from NPSI and LWA, AFFA and EA

This task will need some resources.

Project brief 2. Technical process

Action 1
Wayne Meyer (CSIRO) and Alan Kernich (BoM) to draft and circulate paper to Geoff Podger (DLWC) , Q.J. Wang (AgVic) and Hector Malano (CRC for Catchment Hydrology) to develop a "proof of concept" including:

- Use current data to establish a measured ETo and Kc database – containing both raw material and validation data, also climatic data and field measurement data
- Produce an operational daily product – ETo map and grid file.
- Develop a description of what is needed to extend the approach
- Report on methodology.

This could be a 3-5 months pilot project on national basis for 1 person, possibly post-grad. Requires BoM approval and some resources and input from CSIRO. Use paper as basis for a funding proposal to NPSI.

Estimated cost for this is $50,000.

Action 2
Longer term process is to develop a trial product based on existing "best" data derived from the following: (*note – this leads into the R&D brief*)

Solar radiation • Satellite data – global - net (1990-94, 1997 → • Corrections to existing ground global (1970 →, 26 – 10 sites) • Sunshine hours correction 1900?→ • Cloud observations 1900?→ • Solar data generation/gap filling • Stochastic solar data • Other solar data (weather models)	Wind • Representative wind run (average during evap) • Ht adjustment to 2m • Spatial coverage techniques • Gap filling methods • Stochastic generation • Predictions
Temperature • Av temp for day (seasonal and spatial variations) • Gap filling methods • Temperature generation/extension • Stochastic generation • Predictions	Humidity • Recent data OK • Data review of historic data • Gap filling methods • generation/extension methods • Stochastic generation • Predictions

Carriage: BoM and agencies

Timeframe : 12 months
Cost estimate: $200K

Action 3

Penman/Monteith ETo

- Site basis and selection
- Spline sites on daily basis
- Spline solar radiation/temperature/humidity/wind and determine P/M
- Uncertainty splines both point area
- Cross validation (lysimeter, water balance etc)

Carriage: ANU, BoM etc

Kc

- Identify predominant representative crop species
- For water bodies, irrigation crops, dry land, native vegetation, fallow, bare soil, cracking soil, forestry, grass & pasture
- Field experiments - lysimeter, water balance
- Satellite, LAI, Etc correlations
- Existing data sources (irrigation diversions, soil moisture)
- Estimate of Kc for limiting growth conditions

Carriage: This would be a cross-agency task (including forestry), activity will rely on state interest.
Timeframe: 2-3 years and ongoing
Cost estimate: initial estimate of approximately $300K

Project brief 3. R&D requirements

Action: the R&D plan is expected to come out of the findings of the technical group. Research areas will most likely be similar to the following:

1. Uncertainty/sensitivity and bias in algorithms

2. Kc
   - Review available
   - Recalibrate
   - Gap filling
   - Local values
   - Non-standard conditions

3. DATA augmentation
   - Missing data (use historical data)
   - Transfer of data/information
   - Capture climate variability

4. Validation of ETc and Kc
    - Methods
    - Inputs eg. net radiation, wind
    - Local adjustor factor, and other methods of data presentation

Relevant publications

Allen, RG, Pereira, LS, Raes, D and Smith M (1998), Crop evapotranspiration. Guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper 56, FAO Rome

Meyer, Wayne, 1999. *Standard reference evapotranspiration calculation for inland, south eastern Australia*. CSIRO.

Meyer, Wayne et al, 1999. *Estimating reference evaporation and evapotranspiration from weather data and crop coefficients*. CSIRO.

ICMS, 2002. *Annual irrigation requirements for horticultural crops – a guide for estimating annual irrigation requirements for perennial horticultural crops in South Australia*, PIRSA.

Bart, C.M., Mutziger, A., Howes, D.J. and Solomon, K.H., 2002, *Evaporation from irrigated agricultural land in California*, ITRC Report 02-001, www.itrc.org/Evaporation CA/EvapoationCA.html

ASCE, 2001, *The ASCE Standardised Reference Equation,* Environmental and Water Resources Institute of the American Society of Civil Engineers Standardisation and Reference Evapotranspiration Task Committee, Draft for Review only, available from www.asce.org

ETc workshop participant list

Name	Organisation	Address	Town	State	Pcode	Phone	Email
Bernie Prendergast	Bureau of Rural Sciences	PO Box 858	Canberra	ACT	2601	02 6272 5716	bernard.prendergast@brs.gov.au
Clive Noble	Agriculture Victoria	475-485 Mickleham Rd	Attwood	VIC	3049	03 9217 4283	clive.noble@nre.vic.gov.au
QJ Wang	Agriculture Victoria	ISIA	Tatura	VIC	3616	03 5833 5348	qj.wang@nre.vic.gov.au
Alan Kernich	Bureau of Meteorology	PO Box 421	Kent Town	SA	5071	08 8366 2600	a.kernich@bom.gov.au
Wayne Meyer	CSIRO	Private Bag No 2	Glen Osmond	SA	5064	08 8303 8439	wayne.meyer@adl.clw.csiro.au
Geoff Podger	DLWC	GPO Box 39	Sydney	NSW	2001	02 9228 6111	gpodger@dlwc.nsw.gov.au
David O'Donnell	DPIWE	PO Box 303	Devonport	Tas	3130	03 6421 7617	david.o'donnell@dpiwe.tas.gov.au
Alison Vieritz	Natural Resources, Science & Mines	Block B, 80 Meiers Rd	Indooroopilly	QLD	4068	07 3896 9635	alison.vieritz@nrm.qld.gov.au
Helen Fairweather	NSW Agriculture	PO Box 865	Dubbo	NSW	2830	02 6881 1211	helen.fairweather@agric.nsw.gov.au
Tony Adams	PIRSA	PO Box 411	Loxton	SA	5333	08 8595 9138	adams.tony@saugov.sa.gov.au
Mark Skewes	PIRSA	PO Box 411	Loxton	SA	5333	08	skewes.mark@saugov.sa.gov.au

						8595 9138	
						07 4688	
Graham Harris	QDPI	PO Box 102	Toowoomba	QLD	4350	1559	graham.harris@dpi.qld.gov.au
Hector Malano	CRC for Catchment Hydrology	University of Melbourne	Parkville	VIC	3052	03 8344 6645	hmm@devtech.unimelb.edu.au

Facilitator

Peter Box	Group Strategies	22 Statesman Drive	Benalla	Vic	3672	03 57626309	boxy@netc.net.au

Workshop coordinator

Alison Carmichael	Naturally Resourceful	PO Box 355	Alstonville	NSW	2477	02 6628 7079	alison@naturallyresourceful.com.au