



Cooperative Research Centre for
IRRIGATION FUTURES



New monolayer and associated dam evaporation control systems

Report – May 2008

1. Executive Summary

The project has made significant progress in researching improved monolayer products and associated application systems. A range of new generation monolayer materials have been developed and tested. Some show far superior evaporation and volatilization resistance compared to current commercial products. Initial small scale field trials of one product E10 show promising results. Provisional patents have been lodged to protect the design philosophy for new generation monolayers. Potential sensors for mapping monolayers have been researched. Technical scoping and preliminary design of monolayer monitoring application and control systems has been completed. Funds to progress this work are being sought from Queensland Government and National Program for Sustainable Irrigation.

2. Objective

This one year project was initiated jointly by the CRC Irrigation Futures, CRC Polymers and the Cotton Catchment Communities CRC. The key objective of the project was to develop new technologies for reducing evaporation losses from large storages focussing on improved monolayer products and associated systems. The project has been run as a sub-project of Project 3.51 Storage Dam Evaporation Mitigation with a distinct focus on new monolayer product development.

Irrigation industries have indicated that evaporation loss is a high priority area in need of new innovative science and commercialisation. The alliance of the three CRC's sought to deliver improved monolayer evaporation control technologies that would consistently deliver a 30% reduction in evaporation on large storage dams, where existing evaporation control products are not feasible, and at a price the market is prepared to pay.

Year 1 of the project was initiated to validate the approach for new monolayer product development with an aim to attract funding for a second phase. The second phase would focus on finalising the development and commercialisation of the technologies to deliver significant water saving benefits to Australia.

3. Background

Annual evaporation losses from on-farm storages can potentially exceed 40% of storage volume. A range of structural evaporation mitigation technologies (eg floating covers and modules and suspended shade cloth) are available for small storages (<10ha). Many storage dams have surface areas >10ha and existing structural products are less applicable and require large capital outlay (typically \$50,000 to \$100,000 per hectare). For such large storages chemical monolayers either on their own or in combination with other systems provide a compelling option.

Chemical monolayers have been trialled and shown to have wide variability in evaporation reduction (0%-40%). The monolayer is a special chemical that is applied to the stored water only during periods when the evaporation rates are high. The biodegradable chemical spreads out across the surface to provide a thin (single molecule thick) layer that is not visible and reduces evaporation by restricting the transfer of water into the air.

It has been recognised that the currently available products for forming monolayers on water are less than ideal at preventing water evaporation.

This project initiated an alliance between three Cooperative Research Centres (Irrigation Futures, Polymers, and Cotton Catchment Communities) with the objective of improving this technology so that it can consistently deliver a 30% reduction in evaporation. The alliance brought together all the skills required to develop a technology breakthrough, with the Polymer CRC developing improved monolayer materials, the Irrigation Futures CRC optimizing the methods for applying the monolayers and monitoring their performance, and both the Cotton Catchment Communities CRC and the Irrigation Futures CRCs involving end users of the technology in evaluation trials.

4. Outputs

The project targeted and has achieved the following key outputs:

4.1 Knowledge Based Outputs:

- Analysis and understanding of monolayer evaporation control products.

A review paper has been published by G Barnes (2008) "The potential for monolayers to reduce the evaporation of water from large storages" Agricultural Water Management Vol 95(4) April 2008,

- Confirmation of national market potential for monolayer products, potential water savings and cost-benefit.

A draft technical report has been prepared by C Baillie (2007) "Assessment of evaporation losses and potential of evaporation mitigation technologies for on farm water storages across Australia". This report highlights that national water savings through adoption of monolayers for evaporation suppression could range between 130,000ML and 350,000ML per year. Monolayer solutions are more appropriate than floating covers or shade cloth structures for storages greater than 10ha and have the potential for use on 66% of storage areas.

4.2 Technology Based Outputs:

- Initial screening and specification for potential new low-cost formulations of commercially available degradable chemicals and polymers,

A summary of research undertaken in the development of improved monolayer materials, which has formed the major component of this project has been prepared by the CRC Polymers (Appendix 1).

- Preliminary engineering assessment of effective methods for monolayer deployment and management

A technical scoping document of monitoring application and control systems for monolayers has been prepared by G Brink and T Symes (2007) and a draft project report “Detection of water evaporation suppressing films” has been prepared by P Coop, D Lamb, C Fellows and R Bradbury (2007).

- Preliminary IP protection of commercial products

Two provisional patents have been lodged for chemical monolayer compounds

- *Patent application number: 2008901439 Title: Method for controlling evaporation (about monomeric compounds)*
- *Patent application number: 2008901440 Title: Method and composition for controlling evaporation (about polymeric compounds)*

5. Progress and Achievements

Key areas of progress and achievements are discussed below:

5.1 Development of New Monolayer Product

An analysis of previous research into using monolayers for water evaporation, as well as the results from field trials, led to the conclusion that the two main problems with the old generation of monolayers were their rapid loss due to volatilization of the actual monolayer material, and their low wind resistance. The problem of volatilization is one that had not been highlighted and addressed by previous researchers, however solving it is of crucial importance in order to produce a new generation of monolayer materials with improved properties. It was also recognised that polymers used for the old generation of monolayers were not ideally chosen to overcome the wind resistance issue. Therefore theories have been develop for a new generation of improved monolayer materials and related IP has been protected by filing two provisional patent applications.

A range of small, new generation monolayer materials have been developed and tested. Some of these have shown far superior evaporation and volatilization resistance compared to the old generation products in laboratory scale trials. E10 has already progressed to further small scale field trials where it is also showing promising results. Ongoing development will be required to further improve the properties.

New generation polymeric monolayer materials have also been developed. These have been tested alone, and as part of a blend with smaller molecules. These blends show promising results to-date and further work is currently continuing on optimising their monolayer properties.

In conclusion the CRC Polymer project team have developed a philosophy to produce a new generation of monolayer materials, with considerably improved properties over the old generation. This philosophy has been verified by results obtained to-date for both the small molecule compounds and the polymeric compounds. Ongoing development of new generation monolayer materials with improved properties is currently underway but will require further funding support.

5.2 Engineering development of Sensors and Control Systems

Various systems for sensing and detecting monolayers have been researched and bench test units developed. These methods include :

- Optical reflectance spectroscopy
- Polarimetry
- Fluorescence spectroscopy
- Thermal imagery (emissivity & reflectance modes)
- Laser ripple
- Horizontal transducer
- Indicator oils
- Surface temperature profiling

Surface temperature profiling is showing greatest promise and future plans are to develop prototype units for integration into monolayer application and control systems.

Systems for optimally applying monolayers have been reviewed and key performance guidelines have been developed for smart autonomous application systems that will achieve 70% coverage of the water surface 90% of the time. A range of liquid and powder based application systems have been scoped and management options (including shoreline barriers and a containment grid system) assessed. A demonstration liquid based application system is being developed and an economic evaluation of various options is currently being prepared under Project 3.51.

5.3 Laboratory and Small Scale Trials

An assessment of factors affecting spreading and performance, degradation rates and influencing factors and seasonal and weather related changes in performance of commercial monolayers is being conducted under Project 3.51. The new product E10, synthesised by CRC Polymers has also had preliminary evaluations under this project. Preliminary trials in tank and trough experiments have shown the product to be highly effective as an evaporation suppressant with savings of between 31% and 69% of evaporation loss. Further testing and development of the product E10 is envisaged based on the approaches captured in the current provisional patents, specifically to improve resistance to wind drag.

5.4 Commercialisation

Provisional patents have been lodged to protect the IP related to new monolayer products. Reports related to monolayer application, sensing and control systems remain Commercial in Confidence, while patent options are reviewed. At this stage it is not envisaged that patents could be registered against these technologies, however IP would be protected in copyright software which would be the basis for system performance optimisation.

6. Communication

There has been extensive communication of the project across a range of forums. These have included Media releases by the CRC Polymers (August and on behalf of the Alliance) and a Media Release by the CRC IF (October on behalf of the Alliance). Conference presentations have been made to the 2007 CRC IF Annual Research Forum (2 Papers and 5 Poster Papers) as well as the National Symposium on Agricultural Engineering (Adelaide, October 2007) and the CCC CRC Science Forum.

A conference presentation was given at the 12th International COMS conference on the commercialization of micro- and nano-technologies in Melbourne on 4th September. The presentation is to be published in the conference proceedings: Solomon, D. and Prime, E., 2007 "Minimizing Water Evaporation by Monolayers" .

Regular project team meetings of the 30 strong research team have been held in Melbourne (February 2008) and Armidale (March 2007).

7. Further Funding

The Boards of all three CRCs individually committed \$50,000 in cash to commence Stage 1 of the alliance (December 06 to December 07). The project team are currently sourcing funding for further development and commercialisation of the proposed monolayer technologies.

A range of proposals for further funding to support development of new monolayer and associated dam evaporation control systems have been submitted. Currently we are awaiting confirmation that NPSI have approved two year funding of \$225,000 per year. This requires matching in-kind contributions of \$50,000 per year from each CRC.

Furthermore it is proposed to submit an application to the Queensland Government Partnership Alliance Facilitation Program for funding to develop a comprehensive business case that would allow the Alliance to attract partners and submit proposals for substantial funding (\$2million over 3 years) for further development and commercialisation of the proposed monolayer technologies.