Hydro Environmental

REVIEW OF GMW REPORT #2078394
"METHODOLOGY FOR WATER SAVINGS AND WATER PRODUCTS"

Draft 2

9 October, 2007

Water For Rivers

State Government Victoria
Department of Sustainability and Environment

GOULBURN-MURRAY WATER

EXECUTIVE SUMMARY

Introduction

Water savings are key to the securing adequate water for the environment and for urban water use both within the River Murray catchment and for Melbourne if the reliability/security of supply for the current irrigators is not to be eroded. To secure this water Goulburn-Murray Water (G-MW) with funding from its customers, Water for Rivers (WFR) and Department of Sustainability and Environment (DSE) have embarked on a number of water savings measures which involve infrastructure and/or operational changes.

The Central Goulburn Channels 1, 2, 3 and 4 modernisation project (CG 1, 2, 3 & 4) is a major water saving initiative in part of the Irrigation District managed by Goulburn-Murray Water (G-MW). As part of this water savings process G-MW has used the experience gained from its CG 1, 2, 3 & 4 project and its Loss Management Reporting Project to produce a paper titled "Methodology for Water Savings and Water Products" (10 January 2007), (G-MW Docs #2078394) (Report 3) and a supporting report titled "Methodology for Water Savings" (G-MW Docs #1876265v2) (Report 3A). Report 3 is to be used as the basis for identifying water savings products and the extent of their respective savings for use throughout G-MW's Irrigation Areas.

Hydro Environmental has been engaged to provide an expert review of particular aspects of these two G-MW documents which relate to the identification of the potential water savings associated with this project. This report by Hydro Environmental does not review every aspect of the two reports and only addresses the issues identified as required by G-MW, DSE and WFR in the Project Brief. This will lead to them determining the certainty regarding the amount of water savings available for transfer to the environmental water reserve and possibly producing an updated guide to water savings calculation methodology.

Advances in the water saving technology and analysis are dynamic with adaptive management leading to many changes in approach and outcome. Report 3 was produced in January 2007 whereas this review was undertaken in September 2007. In the mean time some of the issues raised in this review have been addressed.

Conclusions

The following are the key conclusions from the report. The questions under which the conclusions are grouped are the specific questions that were to be addressed as part of the project brief.

Question 1: What is the validity of the procedure outlined in Report 3 that determines the approximate loss component volumes within an irrigation area?

Conclusion 1

The use of the G-MW Loss Management review data as part of the methodology is reasonable, however;

i) the more years of data that can be used to account for seasonal variation the better, and

ii) all data (including historic data) should be adjusted to ensure consistency of methodology in determining the volume for each loss type in each year.

Conclusion 2

If seasonal loss variations are required, it is reasonable to remove outfall volume and meter losses before applying the fixed apportionment of losses to the each of remaining loss categories. The former two loss categories are measured and are the more accurately known.

Conclusion 3

In priority order, any unknown losses should be allocated by either:

i) allocating unknown losses on an accuracy and volume weighted proportional basis across the losses which are known to be less accurate [i.e. excluding accurately known losses (e.g. outfalls and metering)], or

ii) allocating unknown losses on a volume weighted proportional basis across all losses, or

iii) as a last resort method, the unknown losses should be allocated to leakage which is the least accurately known significant loss.

Conclusion 4

The Hydro Environmental team believes that the use of the loss proportioning adopted in Report 2 maybe correct for the CG 1, 2, 3 & 4 channel system and similar systems at a large scale, but in most cases although the method may provide a first cut estimate, it is not an accurate fit for individual channel scale assessment, or for systems which vary significantly in engineering and geographic character from the CG 1, 2, 3 & 4.

Conclusion 5

The Report 3 procedure used to quantify the approximate loss component in each Irrigation Area is not appropriate in its current form and Section 3.1.2 of this report suggests possible improvements.

Conclusion 6

The G-MW Loss Management Review Methodology should be modified to account for all losses and to distribute the unallocated losses. Suggested improvements to the methodology are included in section 3.1.2.

Conclusion 7

The method used in Report 3 of combining the CG 1, 2, 3 & 4 outcomes with G-MW Irrigation Area specific Loss Management data is not appropriate unless the channel system in the Irrigation Area being analysed is similar in engineering and geographic character to the CG 1, 2, 3 & 4 or the CG 1, 2, 3 & 4 data is appropriately adjusted to take into account the irrigation Area specific characteristics.

Question 2: What are the confidence levels that are associated with the use of measures outlined in Report 3 (average loss/km/season) and (average loss/outlet/season)?

Conclusion 8

In relation to this question it is concluded that:

i) ML/km/season is a reasonable way of articulating channel loss at a system and total loss scale but not at a Pod scale

ii) scaling on basis of channel capacity is a reasonable assumption unless scaling is for dissimilar systems or loss components which are not capacity related

iii) average loss per outlet/season for meter error is considered irrelevant when considering metering error, but may be useful if applied to leakage loss around and through meters.

Question 3: What is the base period that should be adopted to determine the pre intervention water savings potential using CG 1, 2, 3 & 4 and Shepparton areas as examples?

Conclusion 9

The following conclusions in relation to this question are made:

i) the 2004/2005 Irrigation season should be the base year against which any change in supply system configuration and operation should be measured for determining water savings

ii) To facilitate the development of suitable modelling routines and measuring change, G-MW should accurately and comprehensively record the physical and operational procedures and process related to, or affecting, water delivery efficiency as at 30 June 2005 (2004/2005 season).

iii) savings in fixed losses (e.g. seepage) are directly convertible to High or Low Security Water Entitlement but modelling is required to determine the appropriate portions of each

iv) detailed modelling is required to enable the volumes of flow dependent variable water losses to be compared to Water Entitlement

v) an appropriate indication of the losses which are climate dependent (e.g. evaporation), can be determined by using long term average climate data (modelling is required to achieve the best accuracy)

vi) water saved by initiative undertaken prior to 2004/2005 may be exchanged for automation initiatives which improve water savings sustainability or reduce the costs of maintaining water savings.

Question 4: What advice would you give on a suggested better alternative approach that would provide a more accurate approximation of relative losses within specific irrigation areas?

Conclusion 10

Combining detailed system knowledge held by the G-MW Area operators, refining the CG 1, 2, 3 & 4 report results, refining G-MW Loss Management Reporting methodology and developing a better Irrigation Area, and possibly Pod specific, Water Loss assessments will lead to more accurate results than the very generalised approach defined in Report 3. This process will be further assisted by the conduct of pondage tests and more accurate measurement using the new FlumeGateR. regulator gates.

Question 5: What is the validity of determining overall long term water saving associated with each intervention by multiplying the "effectiveness" and "sustainability factors?

Conclusion 11

In relation to this question it is concluded that::

i) determining overall long term water saving associated with each intervention <u>in isolation</u> by multiplying the "effectiveness" and "durability factors" is appropriate provided it is clearly understood what the two factors mean. This approach effectively quantifies the difference between the "baseline (no intervention) loss" and the "deterioration target"

ii) if considering long term water savings on <u>a whole of system</u> basis an approach which will lead to more water savings being claimed, is to add 50 % of the difference between "initial effectiveness" and the "deterioration target" to the difference between the "baseline loss" and the "deterioration target"

iii) in both cases (i) and (ii) above a cost effective intervention target (based on the cost of intervention renewal, asset durability and frequency) must be nominated for each intervention

iv) transferring water savings to investors for claiming water savings between the *Deterioration Target* and the *Initial Effectiveness* in Figure 8 should be done with care because generally any deterioration in water savings in one part of the channel system must be offset by an intervention in another if Water Entitlement security is not to be jeopardised

v) the process outlined in this section provides an indication of the theoretical water savings. Pondage tests undertaken before and after an intervention in each pool would provide a more accurate verification of the theoretical initial saving due to the application of particular interventions.

Conclusion 12

Overall the most accurate result for project water savings is obtained by using actual loss per unit length for those high loss pools to be targeted for intervention and using the length weighted average water savings for only those pools.

Conclusion 13

The process outlined in this report provides an indication of the theoretical water savings. Pondage tests undertaken before and after an intervention in each pool would provide a more accurate verification of the theoretical initial saving due to the application of the intervention.

Conclusion 14

Care should be taken not to confuse the concepts *"delivery efficiency"* and *"water loss reduction efficiency"* when determining the effectiveness and durability of an intervention technique to determine with water savings. The most accurate results are achieved if each effectiveness and durability of each intervention is assessed in relation to each particular form of loss impacted.

Question 5a: What is the validity of the percentage effectiveness measures assigned to each intervention?

Conclusion 15

The **effectiveness** of a water savings intervention is a measure of the degree to which water savings occurs immediately after implementation (i.e. before any deterioration occurs).

The **effectiveness** of each of the water savings measures considered are listed in **Table 8**. The following is a summary of the findings:

i) Asset removal will be 100% effective in achieving water savings provided the water previously delivered by the assets are passed through accurate meters.

ii) Provided the pipelines are well constructed and pressure tested prior to commissioning, it is considered reasonable to increase pressure tested pipeline effectiveness from 90 % to 95 %. A more accurate approach is to consider the impact of piping on individual loss types (e.g. evaporation, seepage, leakage, etc.)

iii) The effectiveness for plastic channel liner could be 90% and 80 % could be used for well placed clay channel lining.

iv) Outfall losses must be considered as being operational losses and rainfall rejection losses. It is considered reasonable that FlumeGates and TCC will be effective in reducing rainfall rejections by 75 % and operational loss rejections by 95 %.

v) If the data is not available to split operational from rainfall rejection outfalls, then it seems reasonable to assume that 50 % of pre-scheme losses apply to each type of loss which will result in an average effectiveness of 85 % (determined by averaging the rainfall rejection and operational loss rejection effectiveness values). .

vi) An effectiveness of 5 % reduction in leakage losses would be achievable by maintaining supply closer to design levels on older type channel designs using TCC and FlumeGates.

vii) A 100% effectiveness is considered acceptable when new meters are installed on the basis that the National Standard compliant meters are being used for the Dethridge meter replacement.

Question 5b: What is the validity of the percentage durability measures assigned to each intervention?

Conclusion 16

The **durability** of the water savings associated with each intervention measure is the deterioration on loss in water savings before renewal of the intervention is proposed / required.

The **durability** of each of the water savings measures considered are listed in **Table 8.** The following is a summary of the key conclusions related to durability.

i) Unless overall meter accuracy on the remainder of the system decreases with time, removal of assets will lead to 100% durability in water savings.

ii) On the basis of a 50 year replacement cycle, it is considered warranted to decrease pipeline durability to 85 % for rubber ring jointed pipelines; however, 90 % would be realistic for welded joint pipelines.

iii) Unless only a very short pipeline replacement interval is used, on an overall basis it is considered warranted to decrease pipeline durability to 85% for rubber ring jointed pipelines; however, 90% would be realistic for HDPE welded joint pipelines.

iv) If a 15 year replacement profile is assumed, a durability of 75% for channel lined with uncovered plastic is reasonable, however, the lining of channels with clay covered plastic would lead to a durability of 90%. If clay lining with a 15 year replacement is used, a durability of 75% would be appropriate. This compares with the 75% used in Report 3 for all lining types.

v) The durability of channel automation should be 95%.

vi) The durability of retail meter standardisation should be 100 % but may be reduced if some of the water saved is to be allocated to increase water entitlement security.

Question 6: What is the validity of the assigned water entitlement reliabilities to water savings volumes as summarised in the Table 5.6 of Report 3?

Conclusion 17

Long term system models should be developed to enable water loss savings to be translated to water entitlements as an appropriate mixture of high and / or low reliability water.

Miscellaneous Issues

Conclusion 18

A water savings and allocation account should be established by G-MW to track and verify water savings and included expected and actual water savings.

Conclusion 19

The water savings calculation methods outlined in the Report 3 are aimed at determining the theoretical water savings. Pre-remediation as well as post remediation measurements at a channel pool level are required to verify actual savings associated with each intervention.

Conclusion 20

Water savings should be monitored and accounted at a system level through the calculation of a standardised delivery and climate dependent water delivery efficiencies which are required to compare the actual overall delivery efficiency performance for a given year.

Conclusion 21

Table E1 shows the effect of multiplying the effectiveness by the durability and how the resultant values compare with those in Report 3. Using the recommended figures in **Table E1** shows the potential volume of water saved as indicated in Report 3 are conservatively stated.

Table E1: Summary of Changes in Combining Effectiveness and Durability

Leakage Remediation Technique	Potential Form of Water Savings	Sustainability times Durability		
		Report 3 (Note i)	HE Report on Report 3	
			Conservative (Note i)	Using System Variations (Note ii)
Asset Removal	Leakage, Seepage, Evaporation, System Filling, Unauthorised Use, (Outfall depending asset removed)	100 %	100 %	100 %
Pipeline - welded	Leakage, Seepage, Evaporation, Unauthorised Use, Outfall	90 %	86 %	90 %
Pipeline – rubber ring		90 %	81 %	88 %
Channel Lining - Plastic uncovered	Leakage, Seepage	68 %	68 %	79 %
Channel Lining - Plastic covered	Leakage, Seepage	68 %	81 %	86 %
Channel Lining - Clay	Leakage, Seepage	60 %	60 %	70 %
Channel Automation	Outfall	85 %	81 %	83 %
Channel Automation	Leakage (Maintaining Supply Level)	2 %	5 %	5 %
Meter Standard	Meter Error	50 %	100 %	100 %
Bank Remodelling- early intervention	Leakage	Not reported	68 %	79 %
Core trenching of banks	Leakage	Not reported	20 %	50 %

Notes

i) *average pre intervention loss per km (ML/km) x effectiveness x durability (%) x length of channel treated*

ii) *average intervention loss per km (ML/km) x [Effectiveness x((1 + Durability) / 2))] (%) x length of channel treated*

Recommendations

As many of these changes and the conclusions in this report will impact on the methodology used by G-MW to analyse, quantify and record water savings it is recommended that:

1. Each of the conclusions in this report be considered and actioned
2. A Water Savings analysis methodology guideline be developed by G-MW possibly by updating Report 3
3. A water savings register be established by G-MW to monitor and record the output and distribution of water entitlements from water savings initiatives.

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Acknowledgements

This report has been prepared by Hydro Environmental and is based on data provided by Goulburn-Murray Water.

The authors thank Derek Poulton, Ross Plunkett and Greg Shannon of Goulburn-Murray Water and Graham Turner of Department of Sustainability and Environment for their assistance in providing data and explanations on the analysis and reports.

1. INTRODUCTION

Water savings are key to the securing adequate water for the environment and for urban water use both within the River Murray catchment and for Melbourne if the reliability/security of supply for the current irrigators is not to be eroded. To secure this water, Goulburn-Murray Water (G-MW), with funding from its customers, Water for Rivers (WFR) and Department of Sustainability and Environment (DSE) has embarked on a number of water savings measures which involve infrastructure and/or operational changes.

As part of this water savings process G-MW has used the experience gained from its Central Goulburn Channels 1, 2, 3 and 4 modernisation project and its Loss Management Reporting Project to produce a paper titled "Methodology for Water Savings and Water Products" (10 January 2007), (G-MW Docs #2078394) (Report 3) and a supporting report titled "Methodology for Water Savings" (G-MW Docs #1876265v2) (Report 3A). Report 3 is to be used as the basis for identifying water savings products and the extent of their respective savings for use throughout G-MW's Irrigation Areas.

Hydro Environmental has been engaged to provide an expert review of particular aspects of these two G-MW documents which relate to the identification of the potential water savings associated with this project. This report by Hydro Environmental does not review every aspect of the two reports and only addresses the issues identified in the Project Brief as required by G-MW, DSE and WFR. This will lead to them determining the certainty regarding the amount of water savings available for transfer to the environmental water reserve.

The Project Brief to which Hydro Environmental was working is included in **Appendix A.**

Advances in the water saving technology and analysis are dynamic with adaptive management leading to many changes in approach and outcome. Report 3 was produced in January 2007 whereas this review was undertaken in September 2007. In the mean time some of the issues raised in this review have been addressed.

2. BACKGROUND

The Central Goulburn Channels 1, 2, 3 and 4 modernisation project is a major water saving initiative in part of the Central Goulburn Irrigation Area of the Goulburn-Murray Irrigation District (GMID) managed by G-MW.

The first stage of the project involved the automation of regulating structures along Central Goulburn (CG) channels numbered 1, 2, 3 and 4, (CG 1, 2, 3 & 4) by replacing the manually operated drop bar regulating structures with FlumeGatesRs operated by Total Channel Control (TCC) software monitored in the G-MW office in Tatura. This project also includes the replacement of Dethridge meters, which measure the volume of water delivered to G-MW customers, with more accurate smaller FlumeGateM measuring devices. The aim of this first stage of the project was to minimise the outfall flows from this section of the water supply system by installing the FlumeGatesRs on all regulators. FlumeGateMs or Magflow meters have replaced the Dethridge meters on all supply points only in the CG Channel 2 system (CG 2). It is proposed that the Dethridge meters on the CG 1, 3 and 4 system will be replaced at a later stage of the project. All four channels operate in TCC mode. The project is being funded by the Victorian Water Trust.

Water savings achieved through this project have been identified by the Department of Sustainability and Environment (DSE) to be allocated to the Snowy River Environmental flow initiative. Water for Rivers (WFR) will therefore purchase the water savings from the Victorian Water Trust at the completion of the various stages of the project with the validation of water savings being a critical part of that transaction.

The work undertaken to January 2007 has produced the following reports:

- Water Balance Analysis 2005/06 (G-MW Docs # 1954588) (Report 1),
- Water Business Case Reconciliation, (G-MW Docs # 2014335) (Report 2),
- Methodology for Water Savings and Water Products (10 January 2007), (G-MW Docs #2078394) (Report 3), and
- a supporting report titled, Methodology for Water Savings (G-MW Docs #1876265v2) (Report 3A).

Report 1 provides an analysis of the water losses that occurred during the 2005/06 irrigation season on G-MW CG Channels 2, 3 & 4. This analysis provides a major improvement on previous loss analyses which underpinned the original business case for the project, through the ability to more accurately measure leakage and seepage within each channel pool using the newly installed FlumeGateRs. In addition the more accurate delivery meters in CG 2 has enabled a better understanding of the water "loss" associated with Dethridge Wheel measurement to be gained.

Report 2 refers to system losses included in the original business case for the CG 1, 2, 3 & 4 project, using five years of data (from 1998/99 to 2002/03). There are a number of assumptions in the apportioning of losses to each of the contributing loss factors, leading to a significant uncertainty in the unaccounted water losses. At the time the best information available regarding apportioning losses to each of the contributing factors was a report prepared in 2000 by Sinclair Knight Merz (SKM).

Report 3 extends the work undertaken on the CG 1, 2, 3 & 4 systems and the standard G-MW irrigation system loss management process to develop a methodology for assessing potential water savings. As well as introducing the concept of the sustainability of water savings, the report examines water savings associated with potential changes in metering standards and provides a case for assigning Low and High Reliability water products to water saved.

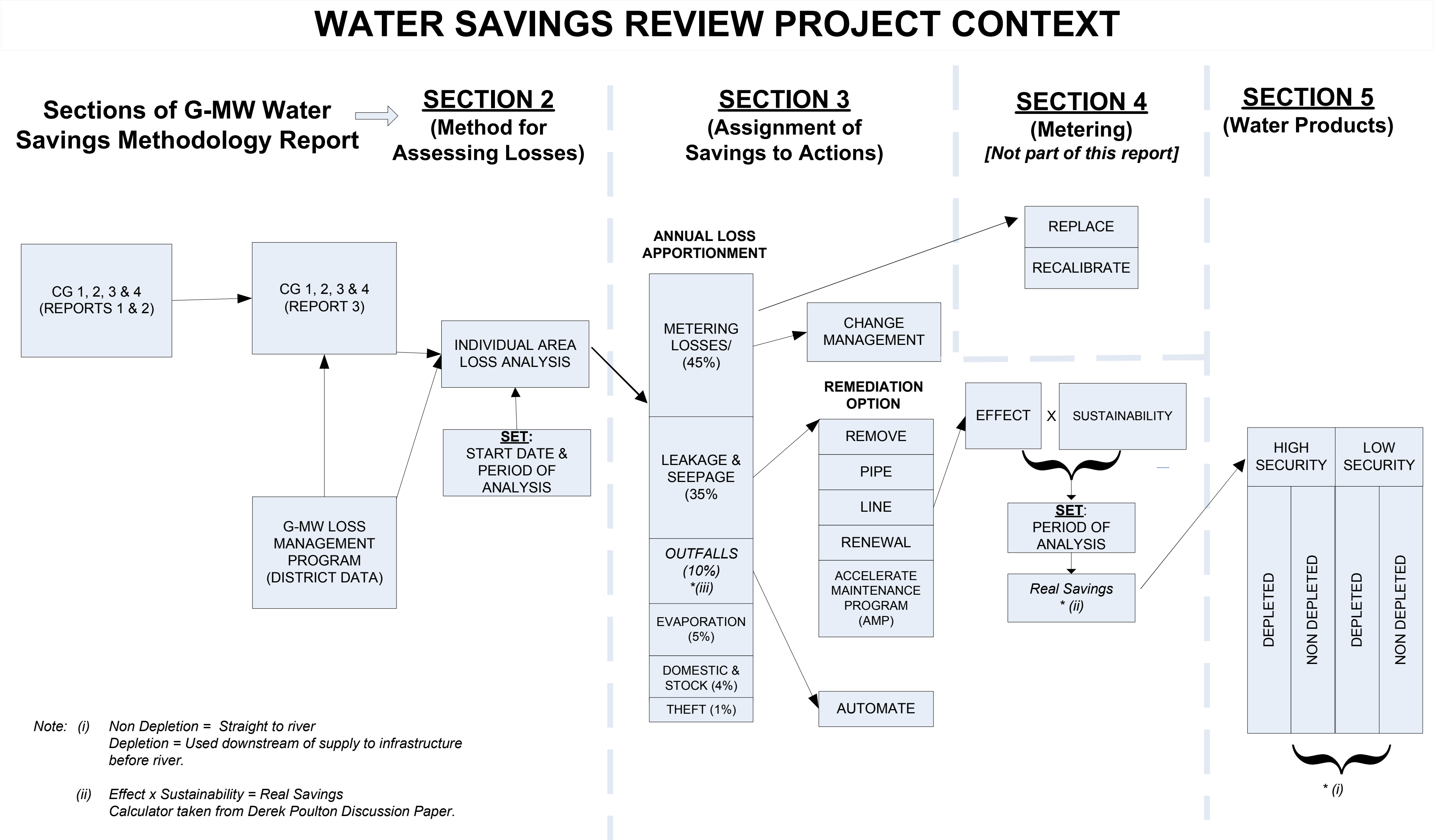
Report 3a presents a methodology for establishing which are high loss pools in any section of channel as well as a theory on how the volume of sustainable water saved should be calculated.

Figure 1 diagrammatically shows the context in which these water savings reports sit. **Figure 1** also shows the water savings components which are included and excluded from this review.

The brief and subsequent discussion with the Steering Committee also requires reference to the other reports and papers which provide valuable, if not always consistent, background information. These documents include:-

- Further Investigation to List the Shepparton Irrigation Are Water Savings Project on the Living Murray Initiative Development Register – 30 October 2006 (URS and SKM)
- Business Case – Shepparton Irrigation Area Modernisation Project Part B – Analysing the Options version 1.1 (G-MW, 2007)
- Proposal for Final Stage Modernisation of the CG 1,2,3,&4 Channel System – Version 7, Section 5.2 – Leakage and Seepage Remediation (G-MW, 2007a)
- Shepparton Irrigation Area Water Savings Project – Water Resources Modelling Project – Draft A – April 2007 (SKM, 2007)
- Water Savings Can they be Accurately Estimated – August 2007 – (ANCID, 2007) (D Poulton, R Plunkett and D Santamaria)
- 2005/06 Loss Management Review – September 2006 (G-MW, 2006).

Figure 1:- Water Savings Review Project Context



Note: (i) Non Depletion = Straight to river
Depletion = Used downstream of supply to infrastructure before river.

(ii) Effect x Sustainability = Real Savings
Calculator taken from Derek Poulton Discussion Paper.

(iii) Detailed in report by SKM and URS titled “Further Investigation to List the Shepparton Irrigation Area Water Saving on the Living Murray Initiative Development Register”.

3. PROJECT METHODOLOGY

The methodology followed by the Hydro Environmental team (the Project Team), addresses all of the requirements of the Brief in Appendix A to the level of detail agreed by the WFR project manager (Denis Santamaria) and the G-MW project manager (Ross Plunkett). An outline of the methodology is as follows;

i) Briefing by WFR, DSE and G-MW Project Managers

ii) Follow-up briefing by DSE concerning the base year implications

iii) Meeting of the Project Team with Derek Poulton and Ross Plunkett in Tatura

iv) Meeting of the Project Team with G-MW Loss Management System Manager Greg Shannon in Tatura

v) Meeting of the Project Team with Ross Davies, Denis Santamaria and Ross Plunkett in Tatura

vi) Additional information and detail sought from G-MW, Southern Rural Water, Rubicon Systems and the interstate water Providers (Harvey Irrigation, Murray Irrigation and SunWater as well as Grampians Wimmera Mallee Water)

vii) Analysis of the information at a high level based on the expertise and knowledge of the Project Team. This involved the Project Team in gaining an understanding of the work and words presented in the reports but did not involve the Project Team in seeking information and undertaking detailed analysis to ensure that the mathematics and arithmetic were formulated and correctly undertaken. In several instances where necessary information for this review was not available within the reports, attempts were made to obtain this information with varying degrees of success. Most of these instances are discussed within the report

viii) Two meetings of the Project Team met with Graham Turner and Racheline Jackson of DSE and others to assist in the formulation of the process involved in the adoption of a base year

ix) Preparation of draft and final reports and presentation of the report to WFR and G-MW project managers and Ross Davies from DSE.

As indicated above, because of limited funding, the need for a cost effective output and the lack of consistent documentation by G-MW regarding the detail behind the approach, this review only provides a high level evaluation. Many of the conclusions made are estimates based on the experience and knowledge of the project team. This review does not provide an in-depth assessment of the technical detail or calculations contained within the reports reviewed.

By progressing through the process above, in broad terms, this report provides an assessment and comment on Report 3 by answering the questions following each of the headings listed below. These questions are as required by the Project Brief.

A. Methodology to assess potential water savings.

1. Procedure

What is the validity of the procedure outlined in Report 3 that determines the approximate loss component volumes within an irrigation area?

2. Method Assessment

What is the assessment method used in Report 3 to combine CG 1, 2, 3 & 4 outcomes with local area data?

3. Confidence Levels

What are the confidence levels that are associated with the use of measures outlined in Report 3 (average loss/km/season) and (average loss/outlet/season)?

4. Base Period
What is the base period that should be adopted to determine the pre intervention water savings potential using CG 1, 2, 3 & 4 and Shepparton areas as examples? In this answer, look at the different periods and conditions.

5. Alternative Approach
What advice would you give on a suggested better alternative approach that would provide a more accurate approximation within an irrigation area?

B. Methodology for Assigning Savings to Various Intervention Project Types
This section identifies a range of project types designed to reduce water loss. An assessment is made on the effectiveness of each intervention in reducing water loss immediately following implementation and then a further assessment of the sustainability of the intervention over time.

6. Percentage Effectiveness Measures
What is the validity of the percentage effectiveness measures assigned to each intervention?

7. Percentage Sustainability Measures
What is the validity of the percentage sustainability measures assigned to each intervention?

8. Long Term Water Saving
What is the validity of determining overall long term water saving associated with each intervention by multiplying the two factors?

9. Other Interventions
How many other known interventions should be considered (including channel remodelling)?

C. Water Saving Products

10. Reliability Ratings
What is the validity of the assigned reliabilities proposed which is summarized in the Table 5.6 of Report 3?

3.1. Methodology to Assess Potential Savings

In addressing this and other sections of Report 3, it is assumed that the CG 1, 2, 3 & 4 losses will be recalculated using the now better known channel dimensions and metering losses to improve the accuracy of the seepage and leakage components in particular. This will provide a better foundation against which to measure these losses in other systems.

This section describes the recommended procedure that draws on recent experience and historic loss analysis to quantify potential water loss in a G-MW Irrigation Area.

3.1.1. Procedure

Q: What is the validity of the procedure outlined in Report 3 that determines the approximate loss component volumes within an Irrigation Area?

A: The procedure adopted by G-MW to determine the water losses on a channel system basis builds on the information published in the CG 1, 2, 3 & 4 Reports 1 and 2 and attempts to incorporate the differences in attributes for the various Irrigation Areas by using the data published in the G-MW Irrigation Area Annual Loss Management Reviews.

On the CG 1, 2, 3 & 4 it was found that both meter error and leakage were higher than originally estimated and were adjusted to accommodate the unallocated loss. The procedure allocates the unallocated loss as follows;

- 2 % Metering Error (Bulk and Outlet)
- 2 % Leakage and Seepage Error
- 1 % D&S Evaporation, System filling and overtopping error.

That is on a 40/40/20 basis. In Section 2.5 of Report 3 the unallocated losses are distributed on a 60/40/0 basis for metering and leakage not the 40/40/20 basis used on the CG 1, 2, 3 & 4.

To account for variations between Irrigation Areas, the Report 3 procedure averages the loss components as assessed by the Loss Management Review for the number of years of available data and then distributes the unallocated loss components (excluding outfalls, to account for seasonal comparison) between metering and leakage on the 60/40 ratio.

A second set of loss figures is then derived by assuming the same relative proportion of losses as were used in Report 2 but with the average deliveries for the years in question. These figures were derived as follows:

i)	Meter Error	50 % of Loss minus outfall volumes
ii)	Seepage	6 % of Loss minus outfall volumes
iii)	Leakage	31 % of Loss minus outfall volumes
iv)	Evaporation	5 % of Loss minus outfall volumes
v)	D&S	3 % of Loss minus outfall volumes
vi)	System Filling	5 % of Loss minus outfall volumes
vii)	Theft	0 % of Loss minus outfall volumes.

The resultant two sets of figures (one from the Loss Management Reviews and one based on CG 1, 2, 3 & 4 proportions) are then averaged.

The following comments are made on each step in the process.

Step 1 – Loss Management Review Data

Step 1 involves taking the average loss from as many delivery seasons as possible. In the example in Section 2.7 of Report 3, the data for two seasons is used. It is understood that the data provided is sourced from G-MW's 2005/06 Loss Management Review Report and covers 2004/2005 and 2005/2006.

It is noted that in Appendix G of the Loss Management Review Reports, the determination methodology used for some of the loss components has varied from year to year. A copy of the Appendix G calculation methodology used for the three years the report has been produced is included in **Attachment 2** of this report.

To ensure consistent results and to enable the best possible comparison between years, the loss breakdown for past years should be adjusted for new knowledge and any change in determination methodology. For example if the channel surface width used in evaporation and seepage loss determination is adjusted to better match actual width rather than using asset life records, or assumed meter losses are changed from say 8% to 10%, then the adjustments should be made to all data years.

Conclusions

The use of the Loss Management Review data as part of the methodology is reasonable, however;

i) **the more years of data that can be used to account for seasonal variation, the better, and**

ii) **all data (including historic data) should be adjusted to ensure consistency of methodology in determining the volume for each loss type in each year.**

Step 2 – Separation of Outfalls

A new value of Total Loss minus Outfall Volume is determined for each Irrigation Area to allow comparison with the Report 2 loss proportions.

The Project Team understands that for seasonal comparison (Section 2.4) to allow for variation in delivery volumes and other seasonal features, the losses after the outfall losses are subtracted, are then apportioned as per Report 2, namely:

i) 50 % Meter Error (Assuming predominantly Dethridge meters)
ii) 31 % Leakage
iii) 6 % Seepage
iv) 5 % Evaporation
v) 5 % System Filling
vi) 3 % D&S
vii) 0 % Unauthorised Use.

37 % leakage / seepage

The Project Team does not believe this method is appropriate because it assumes that all losses are variable and proportional to the volume of water delivered which is not the case.

Conclusion

If seasonal loss variations are required, it is reasonable to remove outfall volume losses and meter losses before applying the fixed apportionment of losses to the each of remaining loss categories. The former two loss categories are measured and are more accurately known.

Step 3 – Distribution of Variable losses

The unallocated loss volume is distributed between meter error and leakage on a 60/40 split.

As is indicated above, it is understood that the 40/40/20 basis used to distribute the unknown losses between metering, leakage and other losses was an educated estimate based on the perceived uncertainty in the determination of each of these components of loss. In this Report 3 methodology, the uncertainties appear to have been combined as explained below to give 60/40 for metering and leakage respectively.

It is assumes this distribution has been based on the assumption that D&S, Evap, Filling, Flooding Error is small and hence adding part of the unknown loss could adversely skew the answer, the seepage loss at a system level is assumed to be relatively well known which leaves the bulk of the unknown being the metering error and leakage. Experience with the CG 1, 2, 3 & 4 would indicate that the leakage losses are by far the biggest unknown. For unknown reasons G-MW has assumed that the metering loss is the biggest unknown. **Table 1** shows the distribution of unknown losses assumed in the Report 3 methodology, together with the logical split which should have been used for Report 3, based on the content of Report 1.

This change in distribution of losses would have resulted in about 1 % of the losses being transferred from leakage losses to meter losses for Report 3.

Table 1: Unallocated loss Distribution

Component	Logical Aggregation of Unknown Loss Distribution Assumed in Report 3	Logical Aggregation of Unknown loss Distribution Assumed in Report 1
D&S, Evap, Filling, Flooding Error	0 %	0 %
Seepage Error	0 %	0 %
Leakage	40 %	60 %
Metering error	60 %	40 %

Irrespective of this error, the original division of unaccounted losses to meter error, leakage, etc. respectively was an educated estimate made to close the water balance (per comms RP) and it was not expected that the answer would be accurate. The reason for asserting that the apportionment may not be correct is that it is expected that the other minor loss components will also be in error and may be also be underestimated to varying degrees. For example, it is well known that the evaporation losses, which are based on channel water surface area, are underestimated because design width, rather than actual widths, are used.

If the unallocated losses are to be apportioned across the loss categories in the same proportions as they are to one another, the result would be as shown in the last columns of **Table 2.**

Table 2 also shows the apportionment of the Pyramid Boort Irrigation Area losses;

i) as shown in the Section 2.7 table in Report 3

ii) as proposed in Report 1

iii) in accordance with the correct apportionment of 40 % meter losses and 60 % leaking which is a modified version of the Report 1 distribution.

In the latter case the Report 1 seepage losses have been distributed as leakage losses, which is more likely to be what has happened in reality. This would lead to a 2.2 % reduction in metering and increase in leakage losses compared with those reported in Report 3.

Table 2: Apportionment of Unallocated Losses as Proposed in Reports 1 and 3

	Unallocated Losses Distributed as per Report 3 (60:40) (ML) (i)		Unallocated Losses Distributed as per Report 1 (40:40:20) (ML) (ii)		Unallocated Losses Distributed as per Report 1 (40:60) (ML) (iii)		Unallocated Losses Distributed as per Report 3 (Proportionally) (ML)(iv)	
Unallocated Losses	5,372				5,372		5,372	
System Fill	4,850	9.8%	4,850	9.8%	4,850	9.8%	5,442	11.0%
Evaporation	8,636	17.5%	8,636	17.5%	8,636	17.5%	9,692	19.7%
Seepage	7,814	15.8%	8,888	18.0%	7,814	15.8%	8,769	17.8%
Leakage	6,036	12.2%	6,036	12.2%	7,110	14.4%	4,362	8.8%
Un-metered D&S	293	0.6%	293	0.6%	293	0.6%	329	0.7%
Theft	198	0.4%	198	0.4%	198	0.4%	222	0.4%
Meter Inaccuracy	21,475	43.6%	20,401	41.4%	20,401	41.4%	20,484	41.5%

Notes:

i. Unallocated losses distributed 60:40 Meter losses and Leakage losses

ii. Unallocated losses distributed 40:40:20 Meter losses: Leakage losses: Seepage losses

iii. Unallocated losses distributed 40:60 Meter losses and Leakage losses

iv. Unallocated losses proportionally distributed according to all losses.

The significant difference between the Pyramid Boort Loss Management Review figures and the CG 1, 2, 3 & 4 figures included in the Section 2.7 table of Report 3 is that the Loss Management System identifies leakage losses as being relatively much less than seepage.

In view of the errors identified in the Hydro Environmental review of Reports 1 & 2, the relative apportionment of losses is expected to change when the CG 1, 2, 3 & 4 figures are recalculated.

It is understood that the loss categories identified are all encompassing. Any unallocated losses should fall into one of these categories and should be distributed to one of the identified categories. This will also, from a public point of view and generally, aid understanding and ensure a better understanding of the order of magnitude of each of the losses. Although not recommended, if unallocated losses are seen as being acceptable, the most accurate and not the most informative result is wanted these losses should not be distributed and the unaccounted losses figure retained.

As indicted above, unallocated losses are known to be made up of a number of loss components, however, the relative proportions of each are unknown. Allocating these losses to other loss components on an arbitrary basis only makes the determined loss components more blurred, however, allocating unallocated losses to just two components does not reflect potential uncertainty in other component determination. For example, as we have commented earlier, in the Report 1 and Report 2, the seepage and evaporation losses are likely to be understated.

Comments on each of the loss components are as follows;

i) meter error loss is solely a function of delivery volume, therefore if there are concerns that the current method is understating the error volume, then the 8 % error figure should be revised based on current knowledge. Based on the CG 1, 2, 3 & 4 and the field testing of Dethridge meters, this figure should therefore be between 10 % and 12 % of delivery volumes

ii) it is thought seepage and evaporation losses are being understated. Adjusting the channel surface width and length to be closer to approximating actual channel dimensions should not only improve accuracy but also reduce unallocated losses. Seepage should also be adjusted to better reflect the seepage rates for the actual soil types, and be weighted by channel surface area in the Irrigation Area or channel area being reported

iii) unmetered D&S losses should only be the volume over and above the deemed volumes. The deemed volumes should be included as part of the metered supplies with the deemed value reducing from 20% in 2004/2005 to about 10% in 2006/2007. It should be noted that, although the large D&S users are metered, the number of smaller D&S users is increasing as more outlets are detected.

iv) based on the more precise work undertaken on the CG 1, 2, 3 & 4 and the basis of the estimation technique used in the Loss Management reports, leakage is also thought to be significantly understated in the Loss Management reports.

Conclusions

In priority order, any unknown losses should be allocated by either;

i) allocating unknown losses on an accuracy and volume weighted proportional basis across the losses which are known to be less accurate [i.e. excluding accurately known losses (e.g. outfalls and metering)], or

ii) allocating unknown losses on a volume weighted proportional basis across all losses, or

iii) as a last resort method, the unknown losses should be allocated to leakage which is the least accurately known significant loss.

Step 4 – Distribution of losses in other systems based on CG 1, 2, 3 & 4 Apportionment

This Step involves utilising the "total loss minus outfall volume value" determined in Step 2. The loss component volumes are calculated using the relative proportion of losses adopted in Report 2.

In addressing this and other steps, it is assumed that the CG 1, 2, 3 & 4 losses will be recalculated using the now better known figures for the CG 1, 2, 3 & 4.

The age, size, soil types and engineering and geomechanical characteristics of channels vary significantly across the Goulburn-Murray Irrigation District (GMID) hence the relative proportions of seepage, leakage and other measurable losses will vary relative to one and other.

Conclusion

The Hydro Environmental team believes that the use of the loss proportioning adopted in Report 2 maybe correct for the CG 1, 2, 3 & 4 channel system and similar systems at a large scale, but in most cases, although the method may provide a first cut estimate, it is not an accurate fit for individual channel scale assessment, or for systems which vary significantly in engineering and physical character from the CG 1, 2, 3 & 4.

3.1.2. Loss Management Reviews

As part of the assessment of the water loss determination method, Hydro Environmental referenced the G-MW 2005/06 Loss Management Review. The method used to calculate each component of loss in each of the three years for which the Loss Management Review has been undertaken is outlined in **Attachment 2.** It should be noted that the Review has been through an adaptive management form of continuous improvement with the method used for determining each loss being improved as new information becomes available.

It is understood that the Loss Management Review is intentionally based on simple, easily calculated inputs so that the G-MW Area based field operators understand, and have ownership and empathy with the results and see some reward for their efforts. The methods employed to establish each loss do not necessarily quantify the entirety of that loss but instead provide a means of detecting change. For example leakage is only focused on leaks repaired, losses over bank and losses through Dethridge meters and leaves out diffused leakage which is usually a significant part of the loss on older style channel banks.

As G-MW is now commercially harvesting potential water savings and must not allow this process to adversely impact on water security, there is potential for the Annual Loss Management Review to be used to determine when additional remedial actions are required to ensure that delivery efficiency are above a certain level and hence water savings are maintained. It is therefore important that the Loss Management Review water loss calculation methodology approximates the methodology used in determining the water losses referred to WFR, Food Bowl and DSE for purchase.

The 2004/05 and 2005/06 Loss Management Review report indicates that, on average, delivery efficiency is 72.7 %, with the fixed losses (seepage, evaporation, system filling, unmetered D&S and theft) being 43 % (37 % excluding Torrumbarry which has higher than average seepage and evaporation losses) of the total losses. However, as shown in **Table 3,** the relationship between change in losses and change in water diverted shows that 24.6 % of additional water diverted is lost (75.6 % delivery efficiency). Surprisingly, these results are only marginally better than the average 2004/2005 delivery efficiency of 72.7 %, with the overall average being skewed because of the 10.3 % reduction in outfall losses and 11.3 % reduction in what should be fixed losses (system filling, unmetered D&S error and theft), leaving 46.4 % increase in the other losses. This result does not support the credibility of the chosen fixed and variable losses, but instead supports the notion that significant additional losses occur in the upper part of the channel banks.

Table 3: Change in Losses as a Proportion of Changes in Diversions as provided in the G-MW Annual Loss Management Reviews

Item	Year 04/05		Year 05/06		Difference (ML)	Proportion of Change in Diversions Delivered
Total Diversions (ML)	2,311,606		2,431,238			
Fixed Losses (ML)	287,450		276,260		11,190	
Variable Losses (ML)	375,371		357,108		18,263	
Total Losses (ML)	662,821	100 %	633,368	100 %	29,453	24.6 %

Although not reviewed in detail, the following observations and suggestions concerning possible improvements concerning the methodology used in the Loss Management Reviews are made. The suggested improvements are also included in the last column of **Attachment 2** which was referred to G-MW's loss management team for comment.

i) **The System filling** loss should only be the nett amount of water used to charge the channel system after subtracting the volume of water recovered through deliveries to customers (including D&S deliveries) and through outfalls. It appears that deliveries are often not subtracted from this component. It is therefore proposed that:

Channel fill is assumed to be the unallocated losses during system filling less the volume of any negative unallocated losses during the channel draining period at the end of the season. Unallocated losses during the season should be relatively small and are the losses remaining after subtracting the quantifiable losses and measured outflows from the inflows.

ii) **Evaporation losses** are determined from asset based channel widths and lengths. These dimensions generally do not take into account bank erosion which increases these widths as is schematically shown in **Figure 9**. Evaporation should not vary significantly from year to year.

It is not clear whether evaporation minus rainfall or just evaporation is used. Rainfall accounts for about 400 mm of evaporation annually. The evaporation figure used should be evaporation less rainfall when determining losses.

Rainfall and evaporation vary significantly between the eastern and western boundaries of the GMID. It is therefore important that the closest Class A Evaporation Pan be used to determine seepage. The environment in which the evaporation pan sits relative to the channel water surface conditions is also important because the losses associated with a large expanse of clear water are different to one that is sheltered. The pan factor appropriate to each pan will depend upon the environment in which the pan sits. In the absence of better information, it would be appropriate to use a pan factor of 1.

The preferred and most accurate way of determining the nett evaporation figure is by using weather station data and calculating the theoretical clear water evaporation, however additional research is needed to determine the appropriate analysis and conversion factors to allow for the evaporation environment encountered in G-MW channels. It is understood that this work is already being undertaken by G-MW in conjunction with the CRC for Irrigation.

*Channel width (and possibly length) should be more accurately determined from aerial photography or field inspection or taken to be as per Asset Life **plus** as allowance for bank erosion based on asset condition to allow for bank erosion and using the nearest Class A Pan Evaporation Pan and its relevant pan factor for clear water (Pan factor of 1). Care should also be taken to ensure that the nett evaporation less rainfall is used in calculating losses.*

iii) **Seepage losses** should also be relatively constant and only vary if the amount of time systems are dry varies from year to year. As with evaporation loss, seepage loss is determined from asset based channel widths and lengths and using the average SKM based seepage rates.

Once again channel width (and possibly length) should be more accurately determined from aerial photography or field inspection or taken to be as per Asset Life plus as allowance for bank erosion based on asset condition to allow for bank erosion. Seepage rates should at least be adjusted to reflect the typical soil types in each area and ideally be based on the channel area weighted by the soil type.

iv) **Unmetered Unauthorised Use (Theft)** is estimated and could be underestimated. It is suggested that it *should be based on the sum of prosecuted, detected and suspected thefts plus an allowance of say 20 % to allow for undetected theft.*

v) **Unmetered Domestic and Stock Deeming losses** are provided by Bill Heslop but should be based on 20 % of the deemed unmetered domestic and stock volumes for the 2004/05 season, reducing to 10% in 2006/07 (pers comm. D. Poulton) or the percentage deemed volume as estimated by Bill Heslop during his trials for the “unmetered” deemed values. The deemed volumes of domestic and stock deliveries should be added to the measured volumes of deliveries.

vi) **Customer Metered Delivery losses** are generally calculated as 8 % of all deliveries.

Based on recent work by G-MW this should conservatively be increased to 10 % of actual delivery through Dethridge meters or based on more recent area specific Dethridge meter field testing as it becomes available. Meter error is a function only of deliveries and is generally confined to Dethridge meters which have systematic errors. This loss generally does not apply to MagFlow and FlumeGate meters which do not have a systematic error. The same may apply to Mace meters, however, initial indications are that G-MW has meters which have a 3.8 % error in favour of its customers.

vii) **Outfall Delivery losses** as per volumes submitted by individual Area Managers. Some of these will be metered volumes and others will be based on a daily measurement. The latter could have errors of up to 50 % with the average adopted for the Shepparton Irrigation Area study being a conservative 30 %. Area Managers should make adjustments as required for unmetered outfall sites.

It is suggested that this practice continue, however the number of outfalls should be rationalised and all should be metered with meters which do not have a systematic bias and are accurate to ± 5 %.

viii) **Leakage** is determined by Area Managers collating the total number of leaks and allowing 5 ML for bank leak or leaks around meter outlets plus 1 % of deliveries to allow for leaks through meter outlet structures plus overtopping submitted by Area Managers. This ignores the diffuse non-flow dependent (fixed) leakage losses and the diffuse flow dependent (variable) leakage losses due to leakage through the banks.

The installation of more FlumeGateR regulating structures similar to those on the CG 1, 2, 3 & 4 will make this process simpler by facilitating the conduct of pondage tests.

It is suggested that leakage be the balancing item and comprise:-

1. *Bank point source leaks*
2. *Meter outlet leaks (Dethridge meter)*
3. *Overtopping leaks*
4. *Diffuse bank leakage.*

These losses should be determined by using a combination of the following;

1. *determine the number of leaks detected (excluding leaks around Dethridge meters) and allow an average of 5 ML/year/leak (or the amount determined through measurement) per leak*
2. *through and around Dethridge meters use 1.6 ML/year /Dethridge meter*
3. *over topping losses estimated by the Area Manager for each back over topping event*
4. *determined from the CG 1, 2, 3 & 4 calculations on a per km of channel basis adjusted for the conditions (length of channel with Supply level below ground level) in each Area.*
5. *plus any unallocated losses.*

ix) **Unallocated losses** are losses that remain after the other components are analytically quantified using their respective mathematical relationships. Unallocated losses are often reported in the Loss Management Reports as being negative (particularly at or near the end of irrigation season) in many cases this is not a logical outcome. Some of these negative figures are caused by the channel fill volume being recovered.

The changes indicated in the sections above should lead to the unallocated losses being relatively small and the biggest error being in the area of diffuse leakage which is partly a fixed and partly a variable loss.

It is therefore suggested that the initial leakage loss be quantified as indicted above. It is also suggested that the unallocated losses then be assumed as either all leakage, or alternatively be distributed in accordance with the volume weighted uncertainty of the loss volume in each category of leakage losses except when channel filling is occurring. If unallocated losses are negative it should be deemed that they are part of the channel filling volume and subtracted from the channel filling losses.

Conclusions

In relation to this question it is concluded that::

i) the procedure used in Report 3 to quantify the magnitude of approximate loss component in each Irrigation Area is not appropriate in its current form. Suggested improvements are outlined in this section of this report

ii) the G-MW Loss Management Review Methodology should be modified to account for all losses and the distribution of the unallocated losses. The suggested improvements are outlined in this section of this report.

3.1.3. Method Assessment

Q: What is the method used in Report 3 to combine CG 1, 2, 3 & 4 outcomes with Local Area data?

A: The resultant two sets of figures, one utilising the Loss Management Review data for the G-MW Irrigation Area being analysed (averaged over 2 years) and one based on CG 1, 2, 3 & 4 proportions are averaged.

There is a significant variation in the relative magnitude of the various loss components derived in the Loss Management process and CG 1, 2, 3 & 4 derived process. The Irrigation Area specific Loss Management data has high seepage losses whereas the CG 1, 2, 3 & 4 data has high losses in leakage. Although a difference may still exist, it would be more accurate if the CG 1, 2, 3 & 4 losses were adjusted for the Irrigation Area specific variations (e.g. soil types, channel width, etc.) before being compared with the Loss Management Data. Unless the CG 1, 2, 3 & 4 results are adjusted to take into account the different conditions in each of the Irrigation Areas, the averaging of the results from the two processes is only smoothing the result rather than necessarily making the answer more accurate.

If the attributes of the supply system under consideration vary significantly from those of the CG 1, 2, 3 & 4 then the resultant average will be skewed and therefore not be representative of the particular system being examined. This could result in works being wrongly targeted or the incorrect type of works being used to target savings that are not actually available from that particular source of water loss. For example targeting a reported high seepage loss will lead to expenditure on channel sealing, where in fact bank leakage which requires bank reconstruction may be the more dominant loss.

Conclusion

It is concluded that the method of combining the CG 1, 2, 3 & 4 outcomes with Irrigation Area specific Loss Management data is not appropriate unless the channel system in the Irrigation Area being analysed is similar in engineering and geographic character to the CG 1, 2, 3 & 4 or the CG 1, 2, 3 & 4 data is appropriately adjusted to take into account the Irrigation Area specific characteristics.

3.1.4. Scaling

Q: What are the confidence levels that are associated with the use of measures outlined in Report 3 (average loss/km/season) and (average loss/outlet/season)?

A: To determine the potential water savings from a particular section of channel, Report 3 proposes that water loss for an Irrigation Area scale system be expressed as two values, namely:

i) ML/km/season for leakage, seepage and evaporation; and

ii) Average loss per supply point/season for meter error.

The report then proposes that these loss values can be scaled down to a smaller area, or up for larger area or particular channels, on the basis of the average channel capacities.

1. **ML/km/season:** One method used in Report 3 is to use the average water loss per unit length of channel per loss type in ML/km/season for the Irrigation Areas in question and then scale that loss to smaller or larger channels. For example in Pyramid Boort the average loss rate for evaporation is 5 ML/km/year for the average channel size of 107 ML/d. If a 50 ML channel in the Pyramid Area is being assessed the loss rate would be assumed to be (5 * 50/107) = 2.3 ML/km/yr (i.e. a (107-50)/107 = 53 % reduction).

   The use of this technique is a reasonable means of articulating supply channel loss as a whole and on a loss component basis for comparison with other channels/systems to assist in works prioritisation and targeting provided the specific channels being assessed do not deviate significantly in engineering or geographic character from that of the average channels in the Irrigation Area in question. That is, applying this function to smaller areas is reasonable provided the soil types and channel condition and geometry in the geographic area being considered are similar to those in the Irrigation Area as a whole.

Applying the capacity ratio also assumes that channel dimensions and losses are proportional to flow. Assuming proportional channel dimensions would be reasonably true when comparing a large channel in a predominantly flat area with a smaller flat area channel but not when comparing flat area channels against undulating area channels or areas with ridges (i.e. channels with low or no banks) and depressions (i.e. channels with high banks). The latter would have higher leakage for the same soil, channel size and condition).

Some of the loss components, namely theft and unmetered D&S, do not logically directly relate to capacity, hence the error in applying this technique to this component is likely to be high. The elevation of channel water level above ground is more related to the need to command the adjacent land for irrigation purposes rather than the requirements to pass a certain flow in that channel. Unless the average elevation of the channel water level above the adjacent ground level is related to capacity, leakage loss is also unlikely to relate to channel capacity.

This process will be assisted by developing a matrix showing the variables such as soil types, operation differences, climate, configuration, topography, command levels, bank integrity, cross-sectional variability, use of natural systems, offline storages, pool lengths, bank condition and materials, etc., and each Irrigation Area and the likely variation of each compared with the CG 1, 2, 3 & 4.

Conclusion

The overall conclusion is that at a total losses level, the technique proposed can give a guide to the relative total losses provided near average conditions prevail, however, the application of this technique to loss components at Pod scale is likely to lead to significant error.

2. **Average loss per supply point/season:** Another technique proposed in Report 3 is to assume the average loss per metered customer supply point will be constant with the total volume of loss being determined by scaling up or down as the case may be by the number customer supply points.

   This application is not logical because meter error is a function of total deliveries and as such is not reliant on the number of meters in a channel pool or system. The actual water loss on each outlet also depends upon the volume of delivery per outlet and this varies significantly between Irrigation Areas, across each Irrigation Area and within Pods.

   Loss per outlet for leakage around meter emplacements, or through door seals, could however be a relevant measure for determining the meter related part of the leakage loss component. Advice from Derek Poulton indicates that a loss of 1.6 ML/year per outlet could be appropriate.

   Conclusions

   Overall for this and the previous section it is concluded that:

   i) ML/km/season is a reasonable way of articulating channel loss at a system and total loss scale

   ii) scaling on basis of channel capacity is a reasonable assumption unless scaling is for dissimilar systems or loss components which are not capacity related

   iii) average loss per outlet/season for meter error is considered irrelevant when considering metering error, but may be useful if applied to leakage loss around and through meters.

3.1.5. Base Period for Measuring Savings

Q: **What is the base period that should be adopted to determine the pre intervention water savings potential using CG 1, 2, 3 & 4 and Shepparton areas as examples?**

A: The base year to be used for water savings analysis is required for two reasons, namely:

1. to determine the base asset and operational conditions against which each of the water savings changes should be measured (i.e. to determine the beneficiary of each water saving action)
2. because delivery and outfall volumes are weather dependent, the potential savings for the same action will vary from year to year. Selection of a common base year is therefore essential.

To date G-MW has used the 2004/2005 season as the base year for both the CG 1, 2, 3 & 4 and the Shepparton loss savings reports. As can be seen in **Figure 2,** annual rainfall in the GMID varies significantly from year to year with the average rainfall at Tocumwal being 447 mm annually. As shown in **Table 4,** even over the drier than usual period of 2000 to 2006, there is a significant variation in rainfall from one year to another**.**

Figure 2: Rainfall for the Period 1891 to 2007

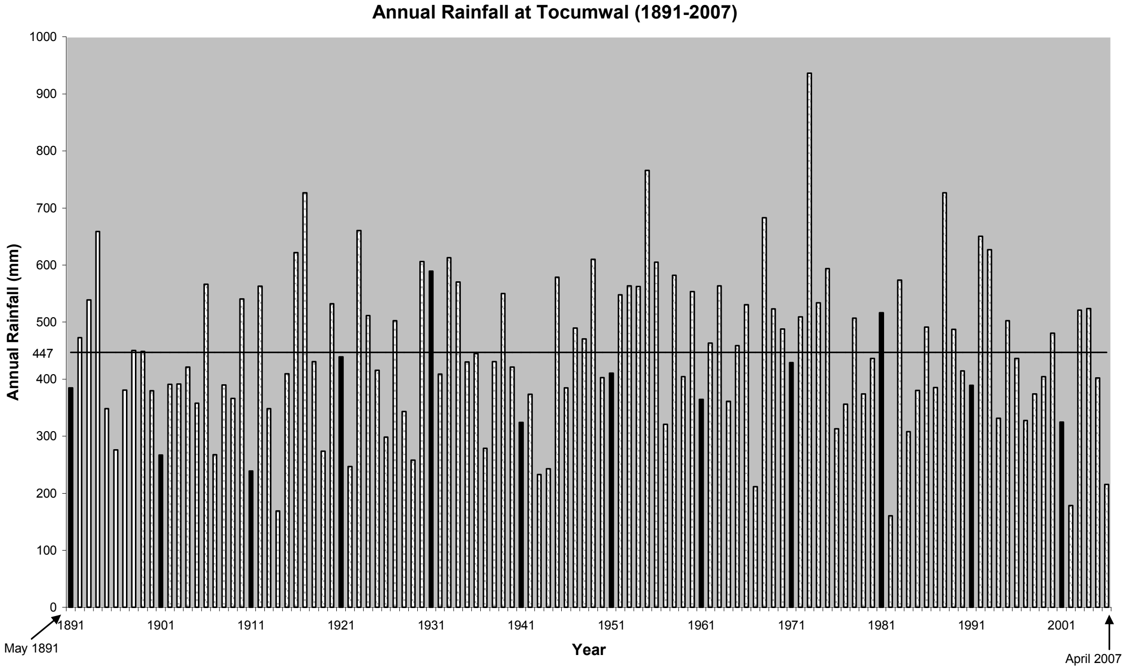


Figure 3 shows how a simulation of the water allocation announced for the Goulburn System in February each year would have varied between 1892 and 2005.

Figure 3: Annual Water Allocations in the Goulburn System (From SKM - Shepparton outfall modelling report)

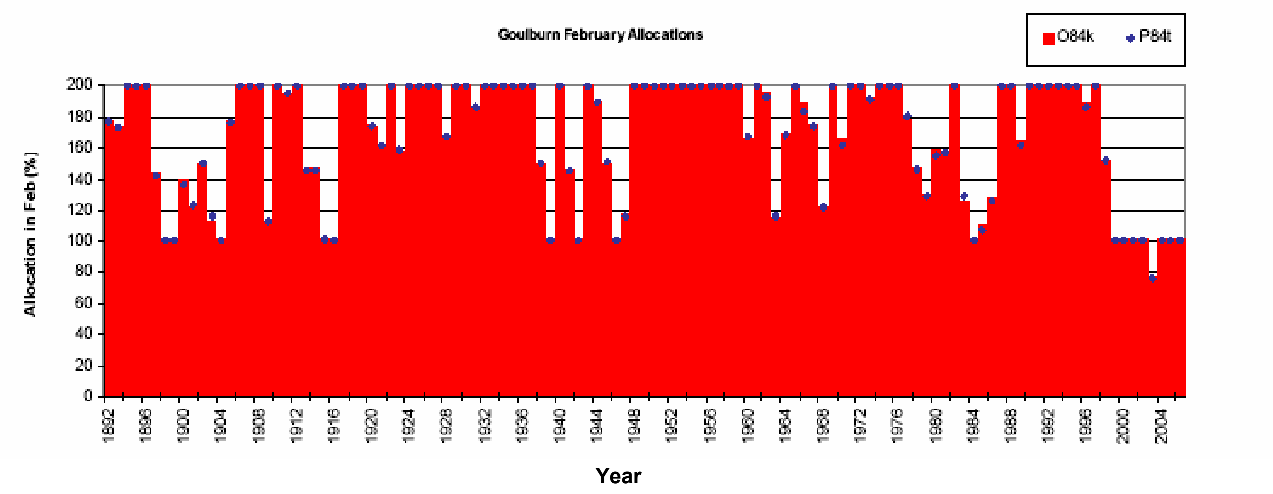


Table 4 includes the announced end of season water allocations on each of the Murray and Goulburn Rivers for the years 2000 to 2007. Also shown in **Table 4** are the actual water deliveries for the Shepparton Irrigation Area, the Central Goulburn Irrigation Area and the GMID. Total Water Entitlements for the Central Goulburn Irrigation Area, Shepparton Irrigation Area and GMID are around 180,000 ML, 380,000 ML and 1,610,000 ML respectively.

Table 4: Rainfall, Water Allocations and Water Deliveries 2000-2007

Calendar Year		2000	2001	2002	2003	2004	2005	2006
Annual Rainfall (mm/yr)		527	365	198	482	368	488	229
Financial Year		2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07
Maximum Water Allocation (%)	- Murray	200%	200%	129%	100%	100%	144%	95%
	- Goulburn	100%	100%	57%	100%	100%	100%	29%
Total Water Deliveries (ML)	- Shepparton	159,615	177,219	113,323	155,403	156,835	156,335	69,019
	- Central Goulburn	402,339	439,225	270,038	406,660	381,911	383,714	152,276
	- Total (excl. diversions)	1,943,374	2,106,958	1,485,782	1,615,584	1,654,371	988,565	354,049

*Annual Rainfall data was recorded at Kyabram

As expected, the **Table 4** figures show that the actual water deliveries do not have a constant relationship/correlation with water allocations, Water Entitlement or annual rainfall.

As most of the fixed water loss classes are related to weather conditions (evaporation and rainfall) and the variable losses are related to water deliveries, the perceived savings from particular actions will vary depending upon the year chosen as the base year for the analysis.

Significant water savings have been generated by virtue of the additional focus placed on improving supply system efficiency by G-MW introducing its loss management process and publishing its Annual Loss Management Review. The first annual review was produced in 2003/04. Amongst other things, this process led to changes in operating procedures such that channel outfall losses were significantly reduced and hence water delivery efficiencies were improved.

3.1.5.1. Year from which Interventions should be Measured

Selection of the base year against which to measure actions taken to generate water savings is almost arbitrary. From the selected date forward, on an action by action basis, the funders of all aspects of the water savings action (additional capital, replacement, maintenance and operating costs) should be entitled to the water savings from that action. It is however important to remember that any actions to which water savings are assigned must be maintained such that the water savings are durable in the longer term.

As can be seen by comparing **Figure 4** and **Figure 5,** which were produced from modelling undertaken by SKM for the Shepparton Irrigation Area outfalls, there is expected to be a significant reduction in channel outfall volumes following the introduction of the Loss Management Process.

Figure 4: Modelled pre Loss Management Process outfalls (pre 2002/2003) (From SKM)

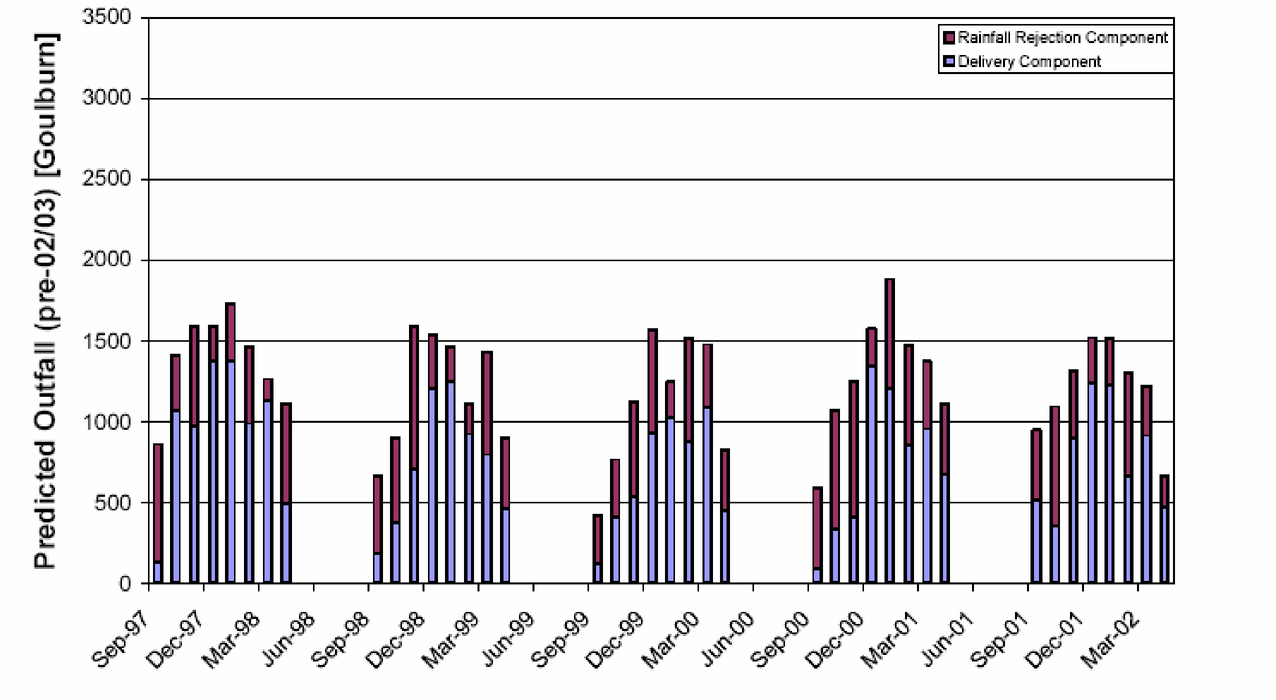
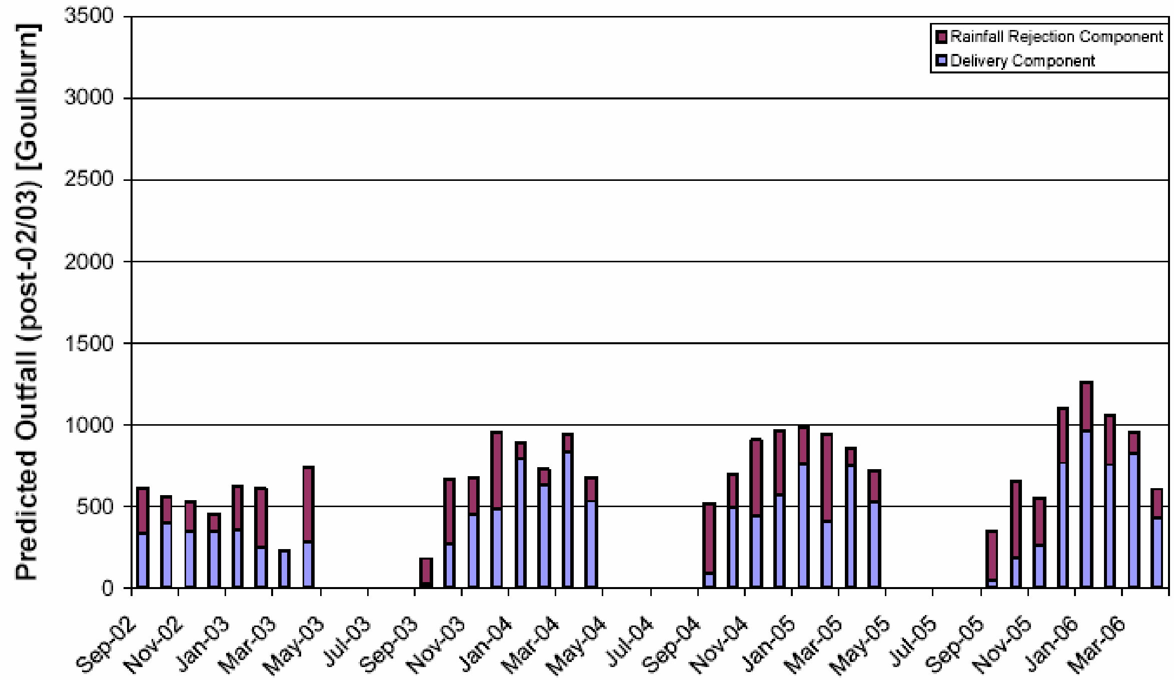


Figure 5: Expected Loss Management Process outfalls (post 2002/2003) (From SKM)



This change is further accentuated on the CG 1, 2, 3 & 4 where the outfall volumes before intervention by undertaking regulator upgrades and the introduction of the Water Loss Management system by G-MW were an average of 3,390 ML annually over 5 years. After the upgrades occurred the 2005/2006 outfalls were 490 ML. Over this same period inflows changed from 123,090 ML to 142,163 ML. Outfalls have therefore effectively reduced by 85% which is consistent with other findings.

As G-MW has initiated and funded the introduction of the risk management process and associated operational initiatives, the savings associated with the initiatives should be credited to G-MW customers to provide for improved security. These saving should be partly reflected in the 2003/2004 loss management figures but will be better reflected in the 2004/2005 (i.e. after 2 years of the reporting system and its associated changed management focus being applied).

The adoption of a particular base year does not preclude G-MW introducing further changes as part of its Loss Management Reporting system to save more water and receive credit for that initiative. Nor does it preclude G-MW claiming credits for additional post 2004/05 loss Management System generated savings which may be deemed as a legacy of history from pre 2004/05 initiatives.

Setting the base year effectively sets the channel physical, operating procedures and operational processes against which changes should be measured.

Hydro Environmental recommends that:

1. 2004/2005 be selected as the base year against which any changes in operational or physical conditions should be measured for the purpose of measuring changes in water savings/losses.
2. To facilitate the development of suitable modeling routines and measuring change G-MW should accurately and comprehensively record the physical and operational procedures and process related to, or affecting, water delivery efficiency as at 30 June 2005.

3.1.5.2. Quantification of Savings

As can be seen in **Figure 2, Figure 4, Figure 5** and **Table 4**, water deliveries and climatic conditions vary significantly from year to year. Any loss savings must be expressed in terms of megalitres of Water Entitlement if they are to be transferred to a third party or considered to be used as Water Entitlement. The same need does not arise if savings are to be applied to increased security.

The quantification of the Water Entitlements available at a given level of security (high security 97 % and low security 44 %) is determined using hydrological modelling over the last 100 years. It is therefore not appropriate to use only one or two years of flow and weather data from which to quantify savings such as outfall, leakage or evaporation savings. To date, the calculations for Shepparton have been based on only the 2004/2005 and 2005/2006 irrigation seasons.

To enable savings to be converted to water entitlements it is therefore proposed that;

i) Savings of fixed (non flow, delivery, or climate dependent) losses can be directly compared however the assignment of reliabilities to the savings will required detailed modelling over the same period as used for the setting of the original Water Entitlements and their reliabilities

ii) Savings of variable losses (losses which vary with flow, delivery or climate) will required detailed modelling over the same period as used for the setting of the original Water Entitlements and their reliabilities.

This approach is summarised in **The modelling** will involve having a set of benchmark modelling parameters to reflect any implemented and proposed water savings actions. These parameters will be based on the physical and operational details related to the 2004/05 season.

This modelling will require the existing REALM models of the GMID irrigation system to be enhanced to include more detail relevant to the water loss mechanics in each of the GMID channel systems.

Table 5.

The modelling will involve having a set of benchmark modelling parameters to reflect any implemented and proposed water savings actions. These parameters will be based on the physical and operational details related to the 2004/05 season.

This modelling will require the existing REALM models of the GMID irrigation system to be enhanced to include more detail relevant to the water loss mechanics in each of the GMID channel systems.

Table 5: How to Convert Water Savings to Water Entitlements

Water Loss Type	Water Loss Component	Requirements to Achieve Water Entitlement Compatibility
Fixed	• Seepage • Lower bank leakage • Metered outlet leakage • Theft • Channel filling • D&S deeming	Directly comparable with modelling required to define the volume of each product generated from a particular intervention
Variable	• Outfalls • Upper bank leakage • Meter error	Requires modelling
Semi-Variable	• Evaporation	Use Modelling or good approximating can be gained by use long term average evaporation and rainfall

The modelling needed to determine the relationship between meter savings at a regional scale and water entitlement will be relatively easy with initial modelling showing that 79 % of water used is High security water and 21 % of water used is Low security water (per comm Seca). There is some uncertainty as to whether these proportions are pre or post the 80:20 creation of environmental allocations. Assuming these figures are current and based on long term modelling of water entitlement use over the same climatic conditions as used to determine water entitlements, for each 10 ML of water savings due to improved metering accuracy, 7.9 ML of High Reliability water entitlement and 2.1 ML of Low Reliability water entitlement would be created.

3.1.5.3. Improved Sustainability or Effectiveness of pre 2004-2005 Interventions

As indicated in the previous section of this report, G-MW introduced its Loss Management System in 2002/2003. Since then the reporting system and its associated initiatives has generated a number of significant water savings across the GMID. The introduction of channel automation and/ or modernisation may lead to either an improvement in the effectiveness or sustainability or a reduction in the cost of the initiatives that have lead to the water savings. It may be argued that the funders of these upgrades may be entitled to a part of the pre 2004/2005 generated water savings.

Whether part of the pre 2004/2005 water savings should be given up in exchange for part of the benefits associated with automation etc. could be a point of negotiation between G-MW and the funder of the initiative providing the benefit. Care must however be taken in negotiating these tradeoffs to ensure that more pre 2004-2005 water is not given up than was generated by the original initiative.

If water is to be exchanged for reduced costs, the capitalised present value of the saved operating cost should exceed the market value of the water exchanged at the time of the automation being implemented.

Conclusions

In relation to this question it is concluded that::

i) **the 2004/2005 Irrigation year should be the base year against which any change in supply system configuration and operation should be measured for determining water savings**

ii) **To facilitate the development of suitable modeling routines and measuring change, G-MW should accurately and comprehensively record the physical and operational procedures and process related to, or affecting, water delivery efficiency as at 30 June 2005 (2004/2005 season).**

iii) **savings in fixed losses (e.g. seepage) are directly convertible to High or Low Security Water Entitlement but modelling is required to determine the appropriate portions of each**

iv) **detailed modelling is required to enable the volumes of flow dependent variable water losses to be compared to Water Entitlement**

v) **an appropriate indication of the losses which are climate dependent (e.g. evaporation), can be determined by using long term average climate data (modelling is required to achieve the best accuracy)**

vi) **water saved by initiatives undertaken prior to 2004/2005 may be exchanged for automation initiatives which improve the sustainability or reduce the costs of maintaining water savings.**

3.1.6. Alternative Approach

Q: What advice would you give on a suggested better alternative approach that would provide a more accurate approximation of relative losses within specific irrigation areas?

A: The Irrigation Areas have too many different variables (soil types, operation differences, climate, configuration, topography, command levels, bank integrity, cross-sectional variability, use of natural systems, offline storages, pool lengths, bank condition and materials, etc.) to try and utilise the fixed known loss proportions of one system to better model another. The current benchmark is the results of the loss assessment on the CG 1, 2, 3 & 4 resulting from the installation of the FlumeGate regulator gates in 2003/2004.
At best it may be possible to benchmark against each component of loss in each Irrigation Area taking into account the known differences between the CG 1, 2, 3 & 4 system and other systems.

There are only 10 G-MW systems, six of which are within the GMID and generally comprise open channel. Each of these six systems has significant differences across their respective Irrigation Areas. It may however be possible to determine a range of factors that best describe the variability between, and across, each Irrigation Area, for example:

- use a different seepage rate that better approximates the average seepage rate for the soil types in the area (i.e. system area weighted soil type using GIS to overlay the waterway width and length on soil maps)
- acknowledge that some systems have proportionately wider water ways and others include natural carriers, online storage or weir pools which are incorporated into the supply system and are likely to have a higher proportion of evaporation losses (i.e. use the GIS system to determine the are occupied by the supply system)
- channel banks in some areas are generally older and/or built with substandard materials or construction techniques, therefore bank leakage rates are likely to be higher (categorise sections of channel by their likely leakage potential based on soil types, construction history and elevation above adjacent land). Reports of the location and extent of bank leakage repairs in some areas may assist in this process. All leakage repairs should be GPS located and recorded to facilitate this process
- if possible, future analysis should differentiate between the non flow dependent diffuse leakage, flow dependent diffuse leakage and point source leakage
- point source leakage rates and period of leakage (hence the volume of water lost) are likely to vary from leak to leak depending on the size of channels. A 5 ML/d leak on a large channel may go unnoticed for significant period whereas a 5 ML/d on a 20 ML/d channel would be more apparent. Although the 5 ML/leak figure may be a reasonable average, record keeping and analysis should be enhanced to modify this figure to better suit the channel capacities and characteristics of each Irrigation Area. The location and an estimate of the duration and volume of water lost should be made for each leak. Perhaps an average factored by the average channel capacity may be appropriate for scaling.

Rather than using the average of the current loss management process results and the unadjusted CG 1, 2, 3 & 4 loss assessment results (i.e. Reports 1 & 2) as presented in Report 3, and noting the comments above and in section 3.1.4 of this report, it is suggested that:

i) the CG 1,2,3& 4 results be re-analysed based on the best available data for waterway area, deliveries and metering errors

ii) the Loss Management Reporting process be amended to better reflect the nature of each of the loss components and each of the total losses in each Irrigation Area and to logically distribute the unallocated losses based on specific system knowledge

iii) based on the new results from i) and ii) above, a better estimate of the split and nature of each of the losses in each of the Irrigation Areas be made (where differing results occur averaging should be avoided instead an accuracy weighting approach should be taken whereby the relative uncertainty of each figure should be used to determine the impact each has on the adopted result).

Conclusion

The Hydro Environmental team believes that combining detailed system knowledge held by the G-MW Area operators, refining the CG 1, 2, 3 & 4 report results, refining G-MW Loss Management Reporting methodology and developing a better Irrigation Area; and possibly Pod specific, Water Loss assessments will lead to more accurate results than the very generalised approach defined in Report 3. This process will be further assisted by the conduct of pondage tests and more accurate measurement using the new FlumeGateR. regulator gates.

3.2. Methodology for Assigning Savings to Various Intervention Project Types

This section assesses the validity of the proposed Report 3 methodology used to determine water savings as a result of implementing an intervention and identifies a range of intervention action types designed to reduce water loss. The Report 3 methodology is understood by Hydro Environmental to be underpinned by Report 3a which was written prior to Report 3 (pers comm. D Poulton).

Report 3 adopts two principles as the basis for determining water savings, namely:

Principle 1 – Transfer of Bulk Entitlement for environmental purposes, should not reduce the reliability associated with existing water entitlements.

Principle 2 – The average volume of water saving can be determined as the difference in average loss rate (ML/year) of the improved system compared with 'business as usual'. The average volume of water saving should be determined 'in perpetuity' that is several replacement cycles – for ease of calculation will assume 50 years.

In that report an assessment is made on the effectiveness of each intervention type in reducing water loss immediately following implementation and then a further assessment of the sustainability (durability) of the intervention over time. Report 3 then multiplies the "effectiveness" and "sustainability" factors to obtain the proportion of the loss component being addressed that would be water savings.

This Hydro Environmental report then goes on to discuss the quantification of the effectiveness and sustainability of the various intervention techniques presented in Report 3.

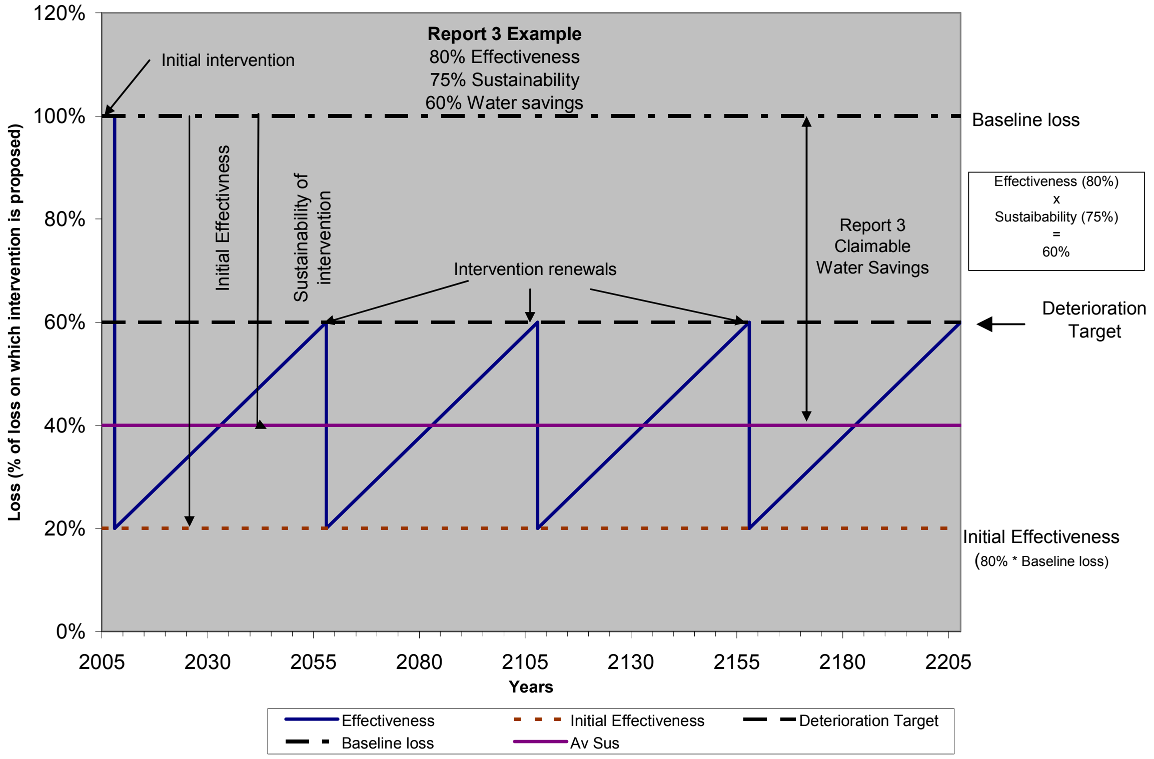
3.2.1. Long Term Water Saving

Q: What is the validity of determining overall long term water saving associated with each intervention by multiplying the "effectiveness" and "sustainability" factors?

A: Report 3a proposes that the water savings generated by a particular intervention technique will be determined by considering both the "effectiveness" and "sustainability" of each particular technique by multiplying the two factors together. "Effectiveness" is defined as the reduction in losses when the intervention is first implemented and "Sustainability" is defined by G-MW as the average measure of the deterioration in the effectiveness of that measure allowed before the intervention is replaced/repeated. This is referred to as the "average water savings" in Report 3a and "average loss rate" in Report 3.

The multiplication of these two factors aims to obtain the proportion of the loss component being addressed by the intervention to produce water savings as shown diagrammatically as 60 % in **Figure 6.** In practice, for the savings generated by any intervention to be sustainable, the intervention must be periodically revitalised to restore the initial effectiveness. The line labelled the *"deterioration target"* in **Figure 6** is the intervention target defined by G-MW to ensure that, on average and considering the whole system, the longer term savings are maintained.

Figure 6: Report 3 Calculation of Claimable Water Savings



The actual calculation of water savings generated by the application of an intervention is not indicated in Report 3**,** however, it is implied that the intervention effectiveness (Section 3.2) is multiplied by the intervention sustainability in Section 3.3 to give the combined water savings in Section 3.4.

Report 3a also indicates that "the determined water savings is multiplied by the length of intervention". It is presumed that this means that the determined water savings for the component being targeted is multiplied by the length of channel to which that intervention is applied.

The ***Business Case*** *– Shepparton Irrigation Area Modernisation Project – Part B* (G-MW Docs #2138076) indicates the method is:

Water Savings generated by an Intervention

= average loss per km (ML/km) ***x effectiveness*** *(%) x length of channel equipped with the intervention.*

That is the Shepparton Irrigation Area Modernisation Project report indicates that only intervention effectiveness is considered and omits intervention sustainability which, if taken as written, would indicate that the water savings available from the Shepparton Irrigation Area Modernisation Project has been overestimated. Hydro Environmental was however subsequently advised (per comm Ross Plunkett) that there was a typographic error in the Shepparton Business Case and the formulae should have been:-

Water Savings generated by an Intervention

= *average loss per km (ML/km)* ***x effectiveness (%) x sustainability*** *(%) x length of channel equipped with the intervention.*

For the purpose of analysing Report 3, it is therefore assumed that the latter version of the formula applies and that the average loss per km is scaled for the channel/pool length in question as per Section 2.7 of Report 3.

This technique can be applied to any length of channel where the intervention is proposed. However care must be taken if only part of a pool is to be lined and loss rates have been determined by measuring losses on a whole of pool basis. The length to be lined will only generate the savings associated with losses in the particular section of the pool being treated. The same caution applies when considering only one pool in a multi-pool channel system.

To further illustrate this point, the whole channel length can be used and the potential savings determined by multiplying the average loss per km. Unless the total length of channel in the system is treated, which is unlikely to be economic, this approach could provide a misleading result. The error will result from the inclusion of the savings from many sections of channel where the losses are below the level where intervention is warranted and has occurred. If the average loss is used and multiplied by the total length of the system the savings assumed will be overstated.

If the average loss is used and multiplied by length of channel treated, the actual savings will be more than calculated (i.e. the calculation will be an understatement of the savings). It is understood that the for the CG 1, 2, 3 & 4 the average loss in the high loss pools is being used and it is assumed that the intervention will be effective on a pro-rata bases. This will lead to the actual savings being greater than estimated with the degree of over estimation being proportional to the inverse of ratio of the length of pool being treated relative to the total length of the pool.

Because it is not cost effective to determine the losses on individual sections within channel pools, it is concluded that overall the most accurate result is therefore obtained by conduction pondage tests before and after the remediation treatment. However, if only an estimate of savings is required the following approached could be used:-

i) by multiplying the actual average loss per unit length in the high loss pools and the length to be treated by remediation. This would result in the most conservative result.

ii) by multiplying the actual average loss per unit length in the high loss pools and the length to be treated by remediation weighted by the relative permeability of the soil types underlying the channel pool as a whole and the section of pool to be treated.

Hydro Environmental is unsure how G-MW proposes the Report 3 technique is to be applied if an intervention is applied to losses for two or more loss components or interventions. Section 2.7 of Report 3 shows the calculation of loss rate per km for each loss component. If it is assumed that channel lining is the intervention used, and seepage and leakage are targeted, the losses for those components would presumably be added and divided by total channel length, scaled and, sustainability ***x*** effectiveness factors applied to determine the water saving. In applying this technique care must be taken to ensure that double counting of water savings does not occur.

What is effectively being determined using the proposed Report 3 technique is the risk that the proposed intervention will/will not sustain the determined water savings in perpetuity? Multiplication of these factors is similar to the generally accepted risk based analysis (namely consequence x likelihood), in this case, the terms effectiveness (consequence) x sustainability (likelihood). It could therefore be considered a valid procedure for applying to water savings analysis.

3.2.1.1. Terminology

In the water savings context meaning of the word used by G-MW for sustainability is the average measure of what water saving is being achieved. It is suggested a better concept is to define the ratio of the initial effectiveness and the targeted minimum effectiveness (i.e. the effectiveness at which the intervention renewal is proposed) as the "*Durability*". It is therefore proposed that the durability of savings be defined as the measure of the *Deterioration Target* which is defined as the "***Effectiveness x Durability"*** as shown in **Figure 7**.

The nominated durability of any intervention depends upon the targeted allowable deterioration level of the particular remediation technique in question before intervention is proposed.

The concept of durability is further discussed in Section 3.2.4.

3.2.1.2. Implication of Approach

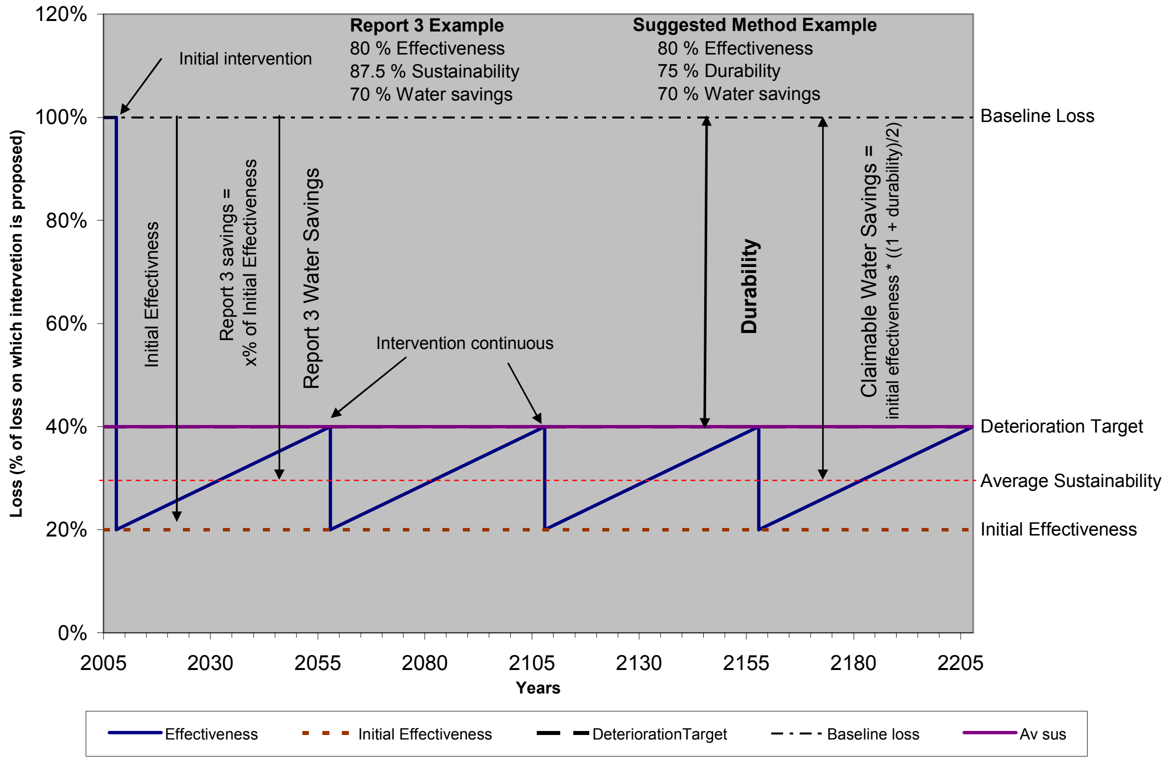
If, in the first instance, a short section of channel is considered when the intervention is first undertaken the savings is measured by the *initial effectiveness* and over time the water savings deteriorates until the intervention is renewed at the time the minimum water savings is achieved, that is, the *deterioration target*. The minimum water savings that can be claimed without jeopardising water entitlement reliability is therefore the difference between the *baseline loss* and the *deterioration target*.

If, however, a whole of system approach is taken and a linear rate of deterioration in one section of channel is offset by a corresponding water savings intervention restoration in another section of channel, on a whole of system basis half the difference between the "*initial effectiveness*" and the "*deterioration target*" can be included as water savings. This concept is diagrammatically shown in **Figure 7**.

As shown in **Figure 7** the water losses that can be claimed are conceptually the same using the methodology proposed by Hydro Environmental and as proposed in the Report 3 methodology, however, the concept proposed by Hydro Environmental is more transparent and can more easily be transferred to different short and isolated sections of channel as well as different intervention measures.

As indicated later in this report, and shown in **Figure 7**, the measure of durability (x%) does not correspond to the value referred to as sustainability (x%) in Report 3. In the example shown in **Figure 7**, 87.5 % sustainability in Report 3 would correspond to a durability of 75%.

Figure 7: Comparison of Intervention Durability with Report 3 Approach



3.2.1.3. Alternative Water Savings Calculation Methodology

When water savings are considered on a whole of channel basis, the calculation indicated earlier in this report,

Water Savings generated by an Intervention

$$= \text{average pre intervention loss per km (ML/km)} \times \text{effectiveness (\%)} \times \text{durability (\%)} \times \text{length of channel treated by the intervention.}$$

is a <u>conservative</u> approach to the water savings.

A more accurate water savings quantification takes into account not only the water savings between the “*baseline loss*” and the “*deterioration target*”, but also includes the water savings that could be gained as the intervention deteriorates over time as shown in **Figure 7.** An assumption underlying this approach is that the savings are considered on a whole of system basis and that on average the rate of remediation off sets the rate of deterioration in water savings associated with that measure elsewhere in the system.

Provided there is an exact match between deterioration and remediation and the deterioration rate is approximately linear, mathematically the loss component being addressed by the intervention will equate to the difference between the “*baseline loss*” and the “*deterioration target*”, plus half the difference between the “*initial effectiveness*” and the “*deterioration target*”.

For this scenario the water saving can be derived using following formula:

$$\text{Water Savings generated by an Intervention} = \text{pre intervention loss per km (ML/km)} \times [\text{effectiveness} \times (1 + \text{durability}) / 2)]\ (\%) \times \text{length of channel treated by the intervention (km).}$$

The difference in the use of these formulae is shown in **Table 9.** The average change in water savings between the conservative approach and the approach which considers the average deterioration allowed varies but for the interventions shown in **Table 9** is 7 % points, or 10 % of the savings calculated using the conservative approach.

On a whole of system basis it is unlikely that the deterioration- intervention relationship will be that precise. In the case of the current proposals for the GMID interventions, where an accelerated program is proposed, it is likely that the initial savings will on average greatly exceed the average of the “*initial effectiveness*” and the “*deterioration target*” and the subsequent renewals of the intervention will be more scattered over time. Because it will be some time before increases in water losses due to deterioration of the interventions will warrant remediation works being undertaken, it is not expected that there will be a constant intervention renewal action commencing at the time interventions are first completed.

If the savings between the “*baseline loss”,* the average of the “*initial effectiveness*” and the “*deterioration target*” (70 % in **Figure 7**) is the target savings, this should be converted to a volumetric water savings. This volume of savings will then be the benchmark against which to measure year to year delivery efficiencies and which will in turn be converted into a change in the target system delivery efficiency.

To avoid the oscillations in delivery efficiency caused by delivery variations and climate and to have a benchmark which is independent of delivery volumes and climate, a standardisation set of target delivery efficiencies must be developed using a modelling process. This process would develop a series of standard delivery dependent efficiencies against which performances can be measured The movement actual efficiency relative to the benchmark for that particular delivery volume, will then in turn be used to determine when intervention renewals are required.

If deterioration and remediation interventions are equal across a whole system, the resultant water savings can be considered sustainable as long as, the overall rate of deterioration is monitored and the timing of the renewal of the interventions is balanced and well planned. The replacement trigger would be when the stated deterioration target is reached.

In the case shown in **Figure 7**, the effective savings is 70%. However in practice, after the initial intervention, when the "*initial effectiveness*" water savings will be achieved, because intervention will not be undertaken on a continuous basis, intervention will only be triggered when the overall system deterioration has lead to an overall deterioration which equates to 50% of the difference between "*initial effectiveness*" and the "*deterioration target*" (i.e. 10% increase in losses as shown in **Figure 7**). By this time individual sections of channel may have deteriorated to the "*deterioration target*" (i.e. 20% increase in losses as shown in **Figure 7**).

Where this approach is adopted and, if Water Entitlement Security is not to be diminished, a suitable system of monitoring channel performance and targeting interventions for replacement would need to be established and the overall increase in losses offset by a corresponding intervention renewal. Overall an adaptive micro level and macro level monitoring system is required to ensure agreed system efficiencies are met and hence committed water savings are maintained.

The CG 1, 2, 3 & 4 proposal to DSE (G-MW document #2266708) indicates that intervention renewal will occur when the overall channel system loss rate returns to the nominated proportion of the initial effectiveness of the intervention identified by monitoring through TCC technology and regular pondage testing.

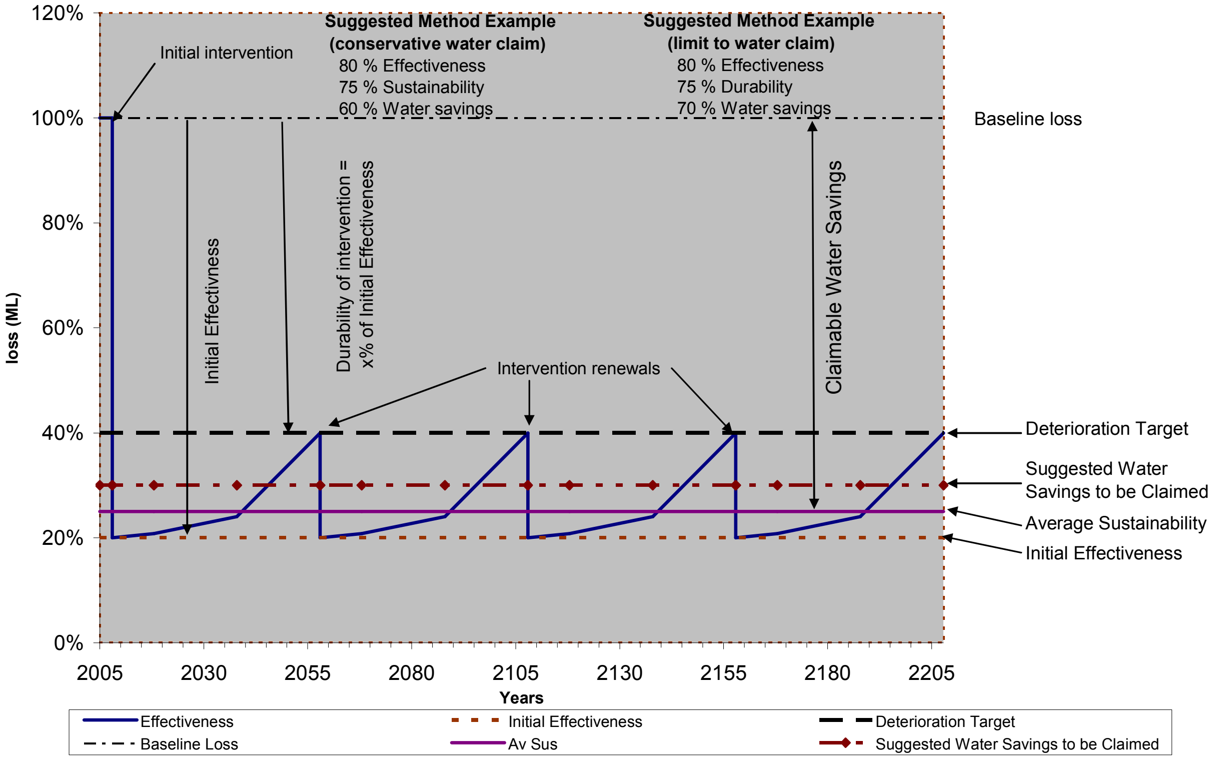
Hydro Environmental believes that working to a target is appropriate, however it is unclear what the CG 1, 2, 3 & 4 target of 75 % physically means, nor is the level of rigour used in its establishment known. If **Figure 7** is used as a reference, the greater the difference between "*initial effectiveness*" and the "*deterioration target"* the greater the time between interventions and the lesser the present value cost. The "*deterioration target"* should therefore only be set after the present value of cyclic cost of restoration of the intervention is known. That is, renewing interventions after a shorter life based on a tighter duration target may lead to greater water savings but it may also render the intervention uneconomic.

3.2.1.4. Intervention Decay Curve

The effectiveness deterioration curve of any particular intervention is unlikely to be linear. Most interventions are expected to be near their maximum effectiveness for a number of years, producing a flat savings change curve and as they start to deteriorate, the curve slope increases. The curve being its steepest near the end of its life. With this form of deterioration curve, the resultant time weighted water savings would be greater than where the application of a linear curve is used to determine water savings. This effect can be seen by reference to the linear deterioration curves in **Figure 7** and the non linear deterioration curve in **Figure 8**.

If the deterioration curve is steeper than the linear curve in its earlier years, the intervention is unlikely to be appropriate, nor economical to use, because of the early deterioration and hence higher cost, loss of water savings and the greater risk of early and more frequent intervention.

Figure 8: Water Savings – Non-linear effectiveness curve



Conclusions

In relation to this question it is concluded that::

i) determining overall long term water saving associated with each intervention in isolation by multiplying the “effectiveness” and “durability factors” is appropriate provided it is clearly understood what the two factors mean. This approach effectively quantifies the difference between the “baseline (no intervention) loss” and the “deterioration target”

ii) if considering long term water savings on a whole of system basis an approach which will lead to more water savings being claimed, is to add 50 % of the difference between “initial effectiveness” and the “deterioration target” to the difference between the “baseline loss” and the “deterioration target”

iii) in both cases (i) and (ii) above a cost effective intervention target (based on the cost of intervention renewal, asset durability and frequency) must be nominated for each intervention

iv) transferring water savings to investors for claiming water savings between the *Deterioration Target* and the *Initial Effectiveness* in Figure 8 should be done with care because generally any deterioration in water savings in one part of the channel system must be offset by an intervention in another if Water Entitlement security is not to be jeopardised

v) the process outlined in this section provides an indication of the theoretical water savings. Pondage tests undertaken before and after an intervention in each pool would provide a more accurate verification of the theoretical initial saving due to the application of particular interventions.

3.2.2. Effectiveness / Sustainability v Efficiency

In accounting for water savings from each intervention the effectiveness is measured in terms of the reduction in losses. However, the performance of water supply systems is more commonly measured in terms of delivery efficiency (i.e. the proportion of measured deliveries divided by system inflow).

Conceptually the difference in the use of the two figures is due to the base measure to which they relate. Efficiency is a proportion of total inflow whereas effectiveness is a proportion of only the water loss (i.e. inflow less delivery).

Care must be taken not to think of the effectiveness of each intervention type in reducing water loss and the assessment of the durability (sustainability) of the intervention in terms of system efficiency, particularly for pipelines. To avoid confusion it is better to assess the effectiveness of each intervention for each loss type affected by that particular intervention. This approach also reduces the possibility of double counting water savings.

For example, utilising the average loss management data from the example in Report 3 and assuming the whole system is pipelined, a pipeline that is initially 98 % efficient in delivering water is only 92 % effective in reducing losses. The point at which the economic cost of replacing the pipeline is less than continuing leak repair would be around 90 % efficiency in delivering water. This delivery efficiency equates to a durability of 58 % (i.e. 53 % of the initial loss will be saved if the pipeline is replaced at 85 % efficiency assuming the conservative approach is taken).

The comparison of Efficiency v Effectiveness and Durability for a Pipeline in **Table 6** shows a significant difference when comparing efficiency against effectiveness and durability to a pipeline.

Table 6: Comparison of Efficiency v Effectiveness and Durability for a Pipeline

Initial Delivery Pipeline Efficiency (%)	Corresponding Water Savings Effectiveness (%)	Assumed Water Savings Durability (%)	Resultant Minimum Water Savings (conservative approach) (%)	Resultant Final Pipeline Delivery Efficiency (%)
98	92	58	53	90

Conclusion

Care should be taken not to confuse the concepts *"delivery efficiency"* and *"water loss reduction efficiency"* when determining the effectiveness and durability of an intervention technique to determine with water savings. The most accurate results are achieved if each effectiveness and durability of each intervention is assessed in relation to each particular form of loss impacted.

3.2.3. Percentage Effectiveness Measures

Q: What is the validity of the percentage effectiveness measures assigned to each intervention?

A: The effectiveness of each intervention measure is a quantification of the difference in the water losses before and after each intervention measure is applied. This effectiveness is usually quantified as the percentage reduction in losses due to the introduction of a measure. This effectiveness is calculated as the reduction in water loss as a proportion of the water loss before the measure is applied.

The following comments are passed on the effectiveness of each of the intervention measures mentioned in Report 3.

3.2.3.1. Asset Removal

Report 3 = 100 % effective.

It is agreed that where channels, pipelines or storages are completely removed and not replaced with an alternate conveyance system, either on or off-farm, or passed through an inaccurate meter, 100 % effectiveness in loss reduction will be achieved.

Conclusion

Asset removal will be 100% effective in achieving water savings provided the water previously delivered by the assets are passed through accurate meters.

3.2.3.2. Pipeline

Report 3 = 90 % effective

The effectiveness of a pipeline depends on material used to manufacture the pipe and the connection technique used between each length of pipe. The typical weakness in pipelines is usually the jointing system.

Most rubber ring jointed pipes of various materials would all be considered to have an initial effectiveness of a least 95 %, a life of at least 70 years and a final effectiveness at end of life in the range of 80 - 90 %.

Report 3 identifies the effectiveness of pipelines as 90 %, however it is noted that G-MW has identified the pipeline effectiveness as 95 % in the CG 1, 2, 3 & 4 proposal to DSE (G-MW Docs #2266708). The Shepparton Irrigation Area modernisation Business Case (G-MW, 2007a) uses 90 % effectiveness.

Harvey Water has reported that the extensive system of welded joint HDPE pipes recently installed has an initial delivery efficiency of 98 % (per comm G. Calder) which is equivalent to an effectiveness of 95 %.

As nearly all of G-MW pipelines are low pressure pipelines, loss could be expected to be less than high pressure pipelines and therefore perform better than in terms of water delivery efficiency. Hence an effectiveness of 90 – 95% would be appropriate.

However, when pipelining is used as an intervention its effectiveness varies depending on the loss type being considered. For evaporation, seepage, outfall losses, filling losses are removed and pipelines are therefore 100 % effective in saving those losses. Leakage losses are changed in nature with pipelining, with diffuse channel type leakage losses becoming point source losses. Near the end of a pipeline life, pipeline leakage losses may exceed channel leakage losses in the effectiveness-durability relationship. This deterioration is related to the durability of the pipe system but it is assumed that overall effectiveness is much higher.

Conclusion

Provided the pipelines are well constructed and pressure tested prior to commissioning, it is considered reasonable to increase pressure tested pipeline effectiveness from 90 % to 95 %. A more accurate approach is to consider the impact of piping on individual loss types (e.g. evaporation, seepage, leakage, etc.)

3.2.3.3. Channel Lining

Report 3 = 90 % effective

Plastic Lining may be applied to the whole of the channel cross-section and be terminated in the top or the outside back of the channel bank. Current practice is to use approximately 2-3 mm HDPE with welded joints for best effectiveness and longevity. This technique however still results in losses at structures and through holes in the untested sheets of HDPE. It is understood that current G-MW practice is to not cover the lining, thus leaving it exposed to animals, radiation, and operator and public intervention and other damaging elements. An average effectiveness of 90 % under these circumstances seems reasonable.

The references identified in **Table 7** tend to indicate 85 % effectiveness for uncovered and up to 95 % effectiveness for a liner covered with clay, however, Hydro Environmental has been unable to confirm whether a measure of sustainability has be built into these figures.

Table 7: Effectiveness of Lining in Reducing Seepage and Leakage

Channel Lining Technique		Expected Life (yrs)		Seepage Reduction (%)	
		LWRRDC (i)	ANCID (ii)	LWRRDC (i)	ANCID (ii)
HDPE Liner	covered	50 +	40 +	85-95	95
HDPE Liner	uncovered	20 +	20-40	85-95	85
Clay Lining		30-40	30	70-90	70-90

i) LWRRDC 2001 - A Guide to Construction and Refurbishment of Earthen Channel Banks
ii) ANCID 2004 - Guidelines to Channel Seepage Remediation

If the liner is covered with clay it is well protected but will still ultimately be exposed at the water line due to the continual wave action. This erosion can be prevented by installing a layer of beaching extending 0.6 m above and 0.4 m below water level to the upper part of the channel bank batter. This action will affect the durability but not the effectiveness of the plastic lining.

A clay lining effectiveness of 80 % is considered reasonable, but will depend on lining thickness and the compaction and moisture content at compaction. A layer thickness of at least 0.5 m is recommended. Deterioration of the layer is caused by cracking when the channel is drained, lining leaching, animal pugging, fish feeding, yabbies burrowing and erosion at the waterline and on filling, however these impacts will affect the durability but not the effectiveness of the clay lining.

Conclusion

It is suggested that reasonable effectiveness figures could be 90 % for plastic channel liner and 80 % for well placed clay channel lining.

3.2.3.4. Channel Automation to reduce outfalls

Report 3 = 85 % effective

Channel outfall events can be classified as either operational escapes or rainfall rejection. Operational escapes are caused by miss ordering or the operator setting the inflows to the channel such that they exceed demand. Whereas rainfall rejections are caused by customers ceasing to take ordered supplies before the headworks can be shut down.

Channel automation can reduce outfalls, by better maintaining the water balance within the system and eliminating operational escapes and being able to retain most of the operation-induced wedge of water within each channel pool nearly instantaneous when a shutdown due to rainfall occurs.

An effectiveness of 85 % has been assumed for managing a system to minimise operational outfalls on the basis of the outcomes of the CG 1, 2, 3 & 4 project to date (G-MW Docs #2266708). The CG 1, 2, 3 & 4 project has operated over two years of 100 % water allocation in the Goulburn system, but with little rainfall. The outcomes related to rainfall rejections cannot be predicted until better data form a more normal delivery and rainfall year is available.

The CG 1, 2, 3 & 4 results indicate that 2,900 ML has been saved against an initial reported loss of 3,390 ML (Report 2). That is an effectiveness of 85 %.

It is unclear why, although the overall effectiveness for outfall reduction is 85 %, different effectiveness ratios have been applied for outfalls to river and outfalls to drains.

- Outfalls to river (2,640 ML saved / 2,950 ML lost = 90 %)
- Outfalls to drains (260 ML saved / 490 ML lost = 57 %).

G-MW advised this was done to overcome the fact that a large proportion of drainage water was used by diverters. However, although the water product resulting from the savings may differ with the downstream usage of the saved water, whether outfall losses are depletion or non depletion flows is irrelevant when assessing the effectiveness of the intervention. The 85% effectiveness should therefore be applied to all outfall loss.

Marsden Jacobs Associates (MJA) adopted 98 % effectiveness for operational escapes and 75 % for rainfall rejection in the Shepparton Irrigation Area Modernisation Business Case (MJA, 2005). MJA also assumed that the proportion of operation escapes and rainfall rejection is 50/50 based on conclusions drawn from data collected between 1996/97 to 2003/04. As shown in **Figure 2**, this period had predominantly below average rainfall years and is unlikely to correctly represent (ignoring potential climate change) the long term proportion of the rainfall rejection. MJA has not provided their basis for adopting the 75 % effectiveness for rainfall rejections in the report, but it assumed to be on the basis that minimal storage is available in the channel system.

It is noted that the average of the MJA effectiveness figures is approximately the 85 % adopted by G-MW. The subsequent modelling undertaken by SKM for the Shepparton Irrigation Area (SKM, 2006) also assumed 85 % effectiveness.

A number of other Irrigation Water Providers have noted a high effectiveness for reducing outfalls by installing FlumeGate regulators and Total Channel Control (TCC). Southern Rural Water has estimated automation can reduce outfalls by up to 90% in the Macalister Irrigation District (MID 2030 Discussion Paper, 2007) with most of this reduction being due to operational improvements offered by FlumeGate regulators and TCC. Coleambally Irrigation Corporation indicated outfall volumes have dropped significantly since implementing TCC (CICL Environmental Reports 2004, 2005 & 2006). Coleambally Irrigation now claims a 90 % delivery efficiency for open channels (ANCID 2005/2006 Benchmarking Report).

Reduction of rainfall rejection is dependent on in-system storage capacity which will vary from channel to channel depending on the difference between the channel supply level and the hydraulic grade line (wedge), as well as number of pipe structures and the length of each pool, however a significant portion of rainfall rejections will be eliminated due to the instantaneous nature of a shutdown utilising TCC.

By logically assessing the level of control and certainty, it is concluded that different effectiveness values should be adopted for operational escapes compared to rainfall rejection. This conclusion is drawn because, on average rainfall rejection is less predictable, less controllable, likely to be a greater proportion of the volume of outfall water, and is less likely to be totally containable in the system during major system shutdowns. The 2006/2007 outfall from the CG 1, 2, 3 & 4 system shows a 98 % reduction in outfall on the basis of little, if any, rainfall rejection (pers comm D. Poulton).

Conclusions

i) **Outfall losses must be considered as being a combination of operational losses and rainfall rejection losses. It is considered reasonable that FlumeGates and TCC will generally be effective in reducing rainfall rejections by 75 % and operational loss rejections by 95 %.**

ii) **However, if the data is not available to split operational from rainfall rejection outfalls, then it seems reasonable to assume that 50 % of pre-scheme losses apply to each type of loss which will result in an average effectiveness of 85 % (determined by averaging the rainfall rejection and operational loss rejection effectiveness values).**

3.2.3.5. Channel Automation to reduce leakage

Report 3 = 20 % effective.

In Report 3, channel automation is stated as having 2 % effectiveness in reducing channel leakage. This is achieved by utilising channel automation to maintain water levels within channels closer to design levels than was able to be achieved with the manually operated systems which were able to be interfered with by landowners, run high by channel operators to keep customers happy and to reduce the number of regulator visits and manual regulator adjustments.

As indicated in the Hydro Environmental review of Report 1, the loss adopted by G-MW due to running channel at levels higher than design supply level is somewhat higher than the 2 % allowed and that, based on the CG 1, 2, 3 & 4 data, a 4 % increase would be reasonable. It should be noted that because this loss depends upon the flow rate, it is assumed that it is a variable loss and is thus dependent on the flow rate in the channel. This notion is also supported by the higher than expected variable losses in the year to year comparison of the loss management system outputs discussed in **Section 3.1.2** of this report.

The Hydro Environmental team believes that, although G-MW has stated a 2 % effectiveness in reducing leakage, that this 2% is sourced from Report 1 where 2 % of the unallocated loss has been added to the total leakage loss (8% of total loss) to allow for flow dependent leakage. The Report 3 effectiveness figure should therefore be equivalent to a 20 % reduction of total leakage loss which is 10 % of the total loss (i.e. 20 %. effectiveness).

Channel systems are now designed with a fully compacted bank and a granula cover to reduce cracking. Additional leakage losses due to running the channels above supply level should therefore be small. Even with automation, channels will still occasionally run above supply level, but they should run at or near supply level more often and seldom exceed Design Discharge Level.

Although not based on quantitative data, based on experience, the Hydro Environmental team believes the effectiveness of automation should conservatively be about a 5 % reduction in leakage losses and that this change should only apply to older type channel designs (i.e. total leakage would be reduced from say 10 % of total losses to 9.5 %).

Conclusions

It is reasonable to assume that an effectiveness of at least a 5 % reduction in leakage losses would be achievable by maintaining supply closer to design levels on older type channel designs.

3.2.3.6. Meter Standard

Report 3 = 100 % effective

Replacement of the Dethridge meters with FlumeGates, MagFlow meters or other meters with non systematic errors [i.e. are within the required standard (± 5 %) and have a neutral bias with on average there being 0 % error] will reduce the errors by an amount equivalent to the average Dethridge meter measurement error which is currently assumed to be 10 % - 12 %.

Conclusion

A 100 % effectiveness is considered acceptable on the basis that the National Standard compliant meters are being used for the Dethridge meter replacement.

3.2.4. Percentage Durability Measures

Q: **What is the validity of the percentage durability measures assigned to each intervention?**

A: In section 3.2.1.1, durability of water savings is defined as the measure of the *Deterioration Target* which is defined as the "***Effectiveness x Durability***" as shown in **Figure 7**.

In other words, the durability of each channel water loss remediation measure is a quantification of the proportion by which the initial change in water losses are allowed to reduce before the renewal of each intervention technique is applied. This durability is quantified in percentage terms (e.g. water loss difference between the without intervention and just prior to renewal of the intervention is divided by the initial reduction in loss when the measure was introduced).

The nominated durability of any intervention depends upon the targeted allowable deterioration level of the intervention which depends upon:

i) the rate at which the water tightness deteriorates

ii) the cost of replacing/refurbishing the intervention such that it continues to generate water savings

iii) the time interval at which replacing/refurbishing takes place relative to the expected life of that intervention (i.e. the traditional time interval at which interventions would be replaced because replacement was less than the ongoing additional maintenance costs to be incurred if replacement does not take place.

As an example, if a plastic liner has an effectiveness of 90% and is replaced every 15 years, the value of the durability will be different to the value of the durability used if the lining is replaced every 20 years when the average industry expected life is 30 years.

The assessment of the most cost effective durability requires a considerable amount of detailed analysis and research information which is beyond the scope of this project. To aid understanding on these issues Hydro Environmental has therefore provides the following comments based on its interpretation of the information provided in Report 3.

3.2.4.1. Interpretation

Hydro Environmental understands that in the case of channel lining (and bank remodelling) in Report 3 the durability percentage is being incorrectly interrupted. Discussions with G-MW personnel have implied that the loss will increase over time due to the deterioration of the liner to a loss figure approaching the baseline loss unless the intervention is renewed earlier. If a renewal is undertaken when the loss has increased to say 75 % of the initial gain, then the durability percentage would be 25 %, not 75 % as listed in Report 3.

The durability percentages in Report 3 for Asset Removal (100 %), pipelines (100 %) and channel automation (100 %) are considered to be correct interpretations however Hydro Environmental may have a different view on what is the correct value for these durabilities which are each addressed later in this report.

3.2.4.2. Principles

The two principles adopted in Report 3 (refer Section 3.2 of this report) as the basis for determining water savings seem sound. Hydro Environmental understands there is no need to qualify the term “perpetuity”, as the qualification in terms of a time interval is irrelevant to the durability of water savings as long interventions are renewed before the target minimum loss reduction (durability percentage) is reached.

The life of an intervention will become irrelevant as future intervention renewals or alternatives will have to be undertaken when the durability target or a adopted target for system efficiency is reached. That is loss reduction reduces to 25 % of initial loss reduction (i.e. an increase of 75 % in losses) as suggested in Report 3a and Derek Poulton’s ANCID Paper.

3.2.4.3. Asset Removal

It is agreed that where channels are completely removed, meters on the remainder of the channel are National Standards compliant, accuracy of new meters is maintained and the channel system is not replaced with an alternate conveyance system, 100 % durability of water savings will be achieved.

Conclusion

Unless overall meter accuracy on the remainder of the system decreases with time, removal of assets will lead to 100% durability in water savings.

3.2.4.4. Pipeline

G-MW has proposed a 100 % durability based on replacing pipelines within 50 years. That is well short of the expected economic replacement life of pipelines, estimated to be at least 70 years.

Whilst it is considered unlikely that pipeline effectiveness will remain constant over its full life cycle, to replace pipelines earlier so as to maintain 100 % sustainability could be financially unattractive and impractical.

As discussed above the effectiveness and durability of a pipeline savings depends on type (material) of pipe and the connection technique use. Most rubber ring jointed pipes of various materials would all be considered to have durability in the range of 80 - 90 %.

HDPE is relatively inert material and does not deteriorate at the same rate as concrete. With the added advantage of being able to weld pipes together, the use of HDPE welded joint pipelines is thought to improve the sustainability of water savings. Overall durabilities in the range 90 %-95 % are expected.

Report 3 identifies the durability of pipelines as 100 %, however, it is noted that G-MW has identified the pipeline durability as 85 % in the CG 1, 2, 3 & 4 Proposal to DSE (G-MW Docs #2266708).

As indicated in the effectiveness section of the report, the effectiveness and durability of pipelines is best expressed for each loss impacted. Using this approach all losses except leakage will generally have a durability of 100 %.

Conclusion

On the basis of a 50 year replacement, it is considered warranted to decrease pipeline durability to 85 % for rubber ring jointed pipelines; however, a 90 % durability would be realistic for welded joint pipelines.

3.2.4.5. Channel Lining

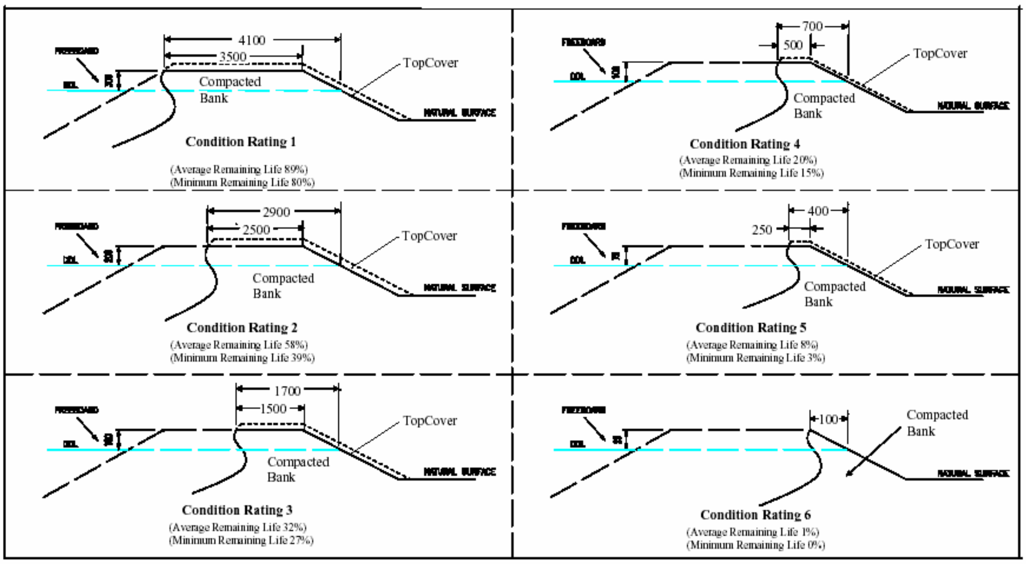
Discussions concerning the asset and water loss intervention proposals assume no intervention from the G-MW Accelerated Maintenance Program (AMP). The use of AMP will increase the durability of most interventions.

It is understood that current G-MW practice is to not cover the lining, thus leaving it exposed to animals, radiation, and operator and public intervention and other damaging elements. The Report 3 Plastic Lining durability is therefore based on limiting life to 15 years which is considerably less than the indicative 30 years shown in **Table 7**. The adoption of this short life means that there should be little if any deterioration in the water tightness of the liner.

Adoption of a 75 % durability would therefore seem reasonable but conservative for uncovered plastic lined channels. For covered plastic lined channels, which have an expected life of 45 + years, if a 15 year replacement life is also assumed, this figure would seem to be very conservative with a durability of 90 % being more appropriate.

These lives assume that the batters are not lined and that the banks deteriorate in the same way as unlined channels. **Figure 9** shows the G-MW assumed channel bank profile for various asset lives with a new channel having an assumed life of 85 years.

Figure 9: Earthen Channel bank deterioration and Condition Rating



Based on the content of Report 3, the lining of channels with clay would have a durability of only about 25 %. It is understood that this 25 % is based on the expected savings to be gained from reducing the channel bank replacement condition from Rating 5 or 6 to Rating 3. These condition ratings are illustrated in **Figure 9**.

Conclusion

If a 15 year replacement profile is assumed, a durability of 75% for channel lined with uncovered plastic is reasonable, however, the lining of channels with clay covered plastic would lead to a durability of 90%. If clay lining with a 15 year replacement is used a durability of 75 % would be appropriate. This compares with the 75 % used in Report 3 for all lining types.

3.2.4.6. Channel Automation to reduce outfalls and reduce leakage

A durability of 100 % has been assumed for operating and managing a channel system to minimise overall outfalls. This figure is based on the outcomes of the CG 1, 2, 3 & 4 project to date, however these results are based the use of new equipment and delivery of water over two years of 100 % water allocation with little rainfall. The channels are therefore not running as hard and there are fewer rainfall shutdowns, meaning that the assumption is yet to be tested under all likely conditions.

It is also reasonable to assume that a high level of durability would be achievable for operational escapes if the channel automation operates correctly and maintains supply at design levels at all times, however Hydro Environmental understands that the durability should be reduced to say 95 % to allow for wetter years and potential equipment malfunctions.

If the channel automation operates correctly and maintains water in the channels at design levels at all times, it is reasonable to assume that a high level of durability would be achievable for reduction of high level diffuse leakage, however, Hydro Environmental believes the durability of automation should be reduced to, say 95 %, to allow for wetter years and potential equipment malfunctions.

Conclusion

The durability of channel automation should be 95 %.

3.2.4.7. Meter Standard

Hydro Environmental is not required to comment on the metering standard as part of this review, however, the durability of metering should be 100 % because new meters which comply with the new Australian standard should, on average, have no bias and must retain their calibration. It is understood that G-MW has adopted a 50 % durability assumption to cover the uncertainty regarding the measurement error which will actually be recovered when new meters are installed. The G-MW approach is conservative and allows an additional conservative margin for error in the other loss recoveries. Although the FlumeGates have a durable sealing system and should not leak in the longer term, the design and durability of the seals on other meters, such as the MagFlow meters, is unknown and cannot be commented on further.

If the durability of meters is assumed to be 100 %, as expected, the additional 50 % durability above that allocated by G-MW will effectively be applied to increasing customer water entitlement security.

Conclusion

The durability of retail meter standardisation should be 100 % but may be reduced if some of the water saved is to be allocated to increased water entitlement security.

3.2.5. Other Interventions

Q: **Are their other known interventions that should be considered (including channel remodelling)?**

A: There are a number of other known interventions. Most are discussed in some detail in the documents titled *A Guide to Construction and Refurbishment of Earthen Channel Banks* (LWRRDC 2001) and *Guidelines to Channel Seepage Remediation* (ANCID 2004). Interventions that may be worth pursuing are:

i) **Bank Remodelling** would be useful where leakage through banks only is to be rectified (LWRRDC, 2001). It has been adopted as an intervention in the CG 1, 2, 3 & 4 proposal with an effectiveness of 90 % as indicted in the CG 1, 2, 3 & 4 proposal is considered reasonable. Unless the channel remodelling intervention is brought forward from condition rating 5 to say condition rating 3, the durability will be 0 % (i.e. the savings able to be claimed will be zero ML as this is the business as usual case). As can be seen in **Figure 9** if condition rating 3 is adopted for bank replacement there is still at least 1.5 m of compacted bank remaining to retain water. A durability of 75 % would therefore seem reasonable.

ii) **Core Trenching** where a plastic membrane is installed in the centre of leaking channel banks is likely to be less than 80 % effectiveness because of the uncertainty in keying into solid material and the unknown foundation materials. The technique also only targets leakage and lateral seepage. Life expectancy is 25 years, and depends on the effectiveness of the key into base material (ANCID 2004) which is where failure usually occurs. Vertical membrane (HDPE) has been successfully used by Murray Irrigation Limited with a 20yr + life (per comm Evangel), for leaks through banks. Core Trenching has a potential for use in banks that leak due to poor materials or compaction with a profile of condition rating of 3 or better. Because of the action of yabbies and deterioration in the seal at the key point on the membrane durability is considered to be low at 25 %.

iii) **Chemical lining** of channels to bind the granular material is not used extensively in Australia other than in a few trials (LWRRDC, 2001). This process is seldom cost effective and often has a short life due to leaching or deterioration of the binding material. It is therefore not considered further.

iv) **Bentonite (clay) slurry wall** in channel banks is a less expensive but less effective form of core trenching. Experience has shown that the durability, hence cost effectiveness, reduces in a relative short time (LWRRDC, 2001). This intervention is therefore not considered further.

3.2.6. Summary of Effectiveness and Durability

Table 8 shows a summary of the Report 3 and the Hydro Environmental suggested effectiveness and durabilities for each of the leakage loss remediation measures proposed.

Table 8: Summary of Sustainability and Durability Changes

Remediation Technique	Potential Form of Water Savings	Effectiveness		Sustainability*	Durability*
		Report 3	HE Report on Report 3	Report 3	HE Report on Report 3
Asset Removal	Leakage, Seepage, Evaporation, System Filling, Unauthorised Use, (Outfall if removed)	100 %	100 %	100 %	100 %
Pipeline –welded (50 year replacement, 70 year life)	Leakage, Seepage, Evaporation, Unauthorised Use, Outfall	90 %	95 %	100 %	90 %
Pipeline – rubber rings (50 year replacement, 70 year life)		90 %	95 %	100 %	85 %
Channel Lining - Plastic uncovered (15 year replacement, 30 year life)	Leakage, Seepage	90 %	90 %	75 %	75 %
Channel Lining - Plastic covered (30 year replacement, 45 year life)	Leakage, Seepage	90 %	90 %	75 %	90 %
Channel Lining - Clay Lining (15 year replacement, 30 year life)	Leakage, Seepage	80 %	80 %	75 % (Actually 25 %)	75 %
Channel Automation	Outfall	85 %	85 %	100 %	95 %
Channel Automation	Leakage (Maintaining Supply Level)	2 %	5 %	100 %	95 %

Remediation Technique	Potential Form of Water Savings	Effectiveness		Sustainability*	Durability*
		Report 3	HE Report on Report 3	Report 3	HE Report on Report 3
Meter Standard	Meter Error	100 %	100 %	50 %	100%
Bank Remodelling- early intervention	Leakage,	Not reported	90 %	-	75 %
Core trenching of banks	Leakage,	Not reported	80 %	-	25 %

* Refer to **Figure 7** for definitions

As indicated above these effectiveness factors and durability factors can be combined to estimate the overall level of water savings to be generated from each intervention. **Table 9** shows the measure of water savings using the figures for effectiveness and durability as detailed in **Table 8** as calculated by:

i) Report 3 which may be considered conservative depending upon how G-MW established its effectiveness and sustainability factors (G-MW (pers comm. D Poulton) indicated that the factors used in Report 3 were meant to target the average of the initial effectiveness and deterioration target as shown in **Figure 7**,

ii) the equivalent of the Report 3 formula with the updated effectiveness and durability factors

iii) using the variable part of the effectiveness which can be used if remediation matches deterioration at a system scale.

As can be seen in **Table 9** the less conservative formula increases the loss recovery by different amounts for different remediations but on average the increase is an additional 7 percentage points on average or 10 % of the conservative figure. The water loss remediations for which there are significant changes in the potential water to be saved are should bolded in red in **Table 9.**

Table 9: Summary of Changes in Combining Effectiveness and Durability

Leakage Remediation Technique	Potential Form of Water Savings	Sustainability times Durability		
		Report 3 Using System Variations (Note i)	HE Report on Report 3	
			Conservative (Note ii)	Using System Variations (Note iii)
Asset Removal	Leakage, Seepage, Evaporation, System Filling, Unauthorised Use, (Outfall depending asset removed)	100 %	100 %	100 %
Pipeline - welded	Leakage, Seepage, Evaporation, Unauthorised Use, Outfall	90 %	86 %	90 %
Pipeline – rubber ring		90 %	81 %	88 %
Channel Lining - Plastic uncovered	Leakage, Seepage	**68 %**	68 %	**79 %**
Channel Lining - Plastic covered	Leakage, Seepage	**68 %**	81 %	**86 %**
Channel Lining - Clay	Leakage, Seepage	**60 %**	60 %	**70 %**
Channel Automation	Outfall	85 %	81 %	83 %
Channel Automation	Leakage (Maintaining Supply Level)	**2 %**	5 %	**5 %**
Meter Standard	Meter Error	**50 %**	100 %	**100 %**

Leakage Remediation Technique	Potential Form of Water Savings	Sustainability times Durability		
		Report 3 Using System Variations (Note i)	HE Report on Report 3	
			Conservative (Note ii)	Using System Variations (Note iii)
Bank Remodelling- early intervention	Leakage	Not reported	68 %	79 %
Core trenching of banks	Leakage	Not reported	20 %	50 %

Notes

i) average pre intervention loss per km (ML/km) x effectiveness x durability (%) x length of channel treated where the durability values are taken as the sustainability values in Report 3 and the effectiveness values are as in Report 3

ii) average pre intervention loss per km (ML/km) x effectiveness x durability (%) x length of channel treated where the durability and effectiveness values are the new values derived by Hydro Environmental

ii) average intervention loss per km (ML/km) x [Effectiveness x((1 + Durability) / 2))] (%) x length of channel treated where the durability and effectiveness values are the new values derived by Hydro Environmental.

Conclusions

i) **the potential volume of water saved as indicated in Report 3 are conservative**

ii) **Table 9 shows the differences between the Report 3 combined water loss reduction factors and those recommended by Hydro Environmental.**

3.2.7. Monitoring Actual and Sustainability of Water Savings

Under the proposed Bulk Entitlement accounting system the volume of water available is finite and any changes must be justified if reliability of supply is to remain fixed. As part of the water savings management process it is therefore important that a local G-MW water savings accounting system is established which includes:

i) the expected savings and to whom they are allocated

ii) a post implementation record of the savings generated

iii) a record of how the volumes of under or over savings are to be managed including any impact on water security.

The detail in this paper outlines the processes involved in theoretically determining the water savings in each water loss component for each intervention. It is important to note that for each remediation action the pre and post action water losses are assessed on a standardised basis (i.e. taking into account changes in climatic conditions and deliveries where appropriate). In the case of seepage and leakage losses this will involve undertaking a pre and post remediation pondage test and adjusting the expected water savings account accordingly.

If water security/reliability is not to deteriorate over time (i.e. as intervention measures deteriorate, e.g. pipelines leakage), a suitable system of monitoring channel performance and then targeting interventions for replacement as channel performance deteriorates would need to be established.

As mentioned in Section 2.2.1, a macro level and micro level monitoring system and longer tem modelling to take into account the impact of water delivery variability is required to ensure agreed water savings are maintained and the security of Water Entitlement is not diminished.

As indicated in Section 3.2.1 it is essential to have target standardised flow dependent efficiencies against which change can be measures, The simplest method to ensure the sustainability of water savings is to determine the revised target system efficiency resulting from the revised water balance taking into account the accumulated water savings at the "deterioration target" or the "average intervention line" from each intervention. And then measure performance relative to that target. The revised target would depend upon the water savings utilised.

The efficiency of the system would be monitored at the macro level and when the standardised efficiency target is approached then either, the system is monitored at the micro (pool efficiency) level to identify which interventions in the system require renewal or, alternate water savings techniques are applied at a system level to maintain the system efficiency above the target.

Conclusions

i) **A water savings and allocation account should be established by G-MW to track and verify water savings and included expected and actual water savings**

ii) **The water savings calculation methods outlined in the Report 3 are aimed at determining the theoretical water savings. Pre remediation as well as post remediation measurements at a channel pool level are required to verify actual savings associated with each intervention**

iii) **Water savings should be monitored and accounted at a system level through the calculation of a standardised delivery and climate dependent water delivery efficiencies which are required to compare the actual overall delivery efficiency performance for a given year.**

3.3. Water Saving Products

3.3.1. Reliability Classes of Water Savings

This section assigns water savings achieved from various interventions to either high or low reliability water security rating. High Reliability water has a delivery reliability of 100 % of water entitlement being delivered 97 years in 100 years whereas Low Reliability water has 100 % of water entitlement being delivered 44 years in 100 years. Low Reliability water is only available if 100 % of High Reliability water can be provided first.

It is understood that by reference to the SKM modelling report for the Shepparton Irrigation Area outfalls that:

i) **Depletion losses** occur when water is, either used or removed, from a system in such a way that it is unavailable for further use. If saved, this water is of high value as it becomes available for use again. Depletion losses include leakage from channels and evaporation, seepage and opportunistic diversions from drains. It is assumed that leakage, seepage and evaporation do not make their way back to the system for re-use and are therefore lost to the system.

ii) **Non-depletion losses** occur when water is lost from a system, however it becomes available for use downstream. Non-depletion losses include return flow which is outfall water which flows back to the river. This water is then made available for use downstream to supply demands or as passing flows or both. Where short lengths of drain are down stream of outfalls, historically some channel outfall water may have reach the outfall point to the nearby river. It is however expected that the increased value of water and the low recovery cost of drainage water, along with the Catchment Management Authority's focus on reducing volume of river outfalls, will in future lead to little if any outfall water reaching rivers via drains in the GMID. For planning purposes it is therefore proposed that no outfall water reaching drains should be classed as non-depletion water.

The main difference between depletion and non-depletion water is that if depletion water is saved it can be reallocated as an entitlement and used without impacting on Water Entitlement Reliability, whereas non-depletion water may be being used as environmental water or to supply Water Entitlement to down stream users.

If part of the saved meter losses are returned to the irrigators, the volume must either be firstly converted to be Water Entitlement or alternatively, be added to the storage and improve Water Entitlement security. In either case, it would be still classified as depletion losses.

Q: What is the validity of the assigned water entitlement reliabilities to water savings volumes as summarised in the Table 5.6 of Report 3?

Table 10: Copy of Table 5.6 of Report 3

Remediation	Savings Type	Depletion	Non-Depletion
High Security (Water Right)			
Pipelines	Leakage, Seepage, Evaporation	Leakage, Seepage, Evaporation	N/A
Channel Automation	Outfall Reduction, Leakage by Maintaining FSL	Leakage, Outfalls to Drains	Outfalls to Rivers
Lining	Leakage, Seepage	Leakage, Seepage	
Outlet Removal	Meter Error	N/A	Meter Removal Volume
Low Security (Sales Water)			
G-MW Loss Management	Outfall Reduction	Leakage, Outfalls to Drains	Outfalls to Rivers
Outlet Upgrades	Meter Error		Meter Error

Table 10 included a number of obvious errors which have been corrected and shown in Bold Red in **Table 11.** The main differences between **Table 10** and **Table 11** are that:

i) outlet removal leads to leakage error loss reduction (i.e approximately 1.6 ML/yr/outlet). This loss must be classified as depletion loss because the water is currently being used downstream and not returned to river (a similar scenario to outfalls to drains).

ii) similar to point i) savings in meter error should be classified as depletion losses because the water is currently being used downstream and not returned to river.

Comments within this report have therefore been based on the information **Table 11.**

Table 11: Enhanced Copy of Table 5.6 of Report 3

Remediation	Water Savings Type	Depletion	Non-Depletion
High Reliability Water Entitlement (Formerly Water Right)			
Pipelines	Leakage, Seepage, Evaporation	Leakage, Seepage, Evaporation	**Nil**
Channel Automation	Outfall Reduction, Leakage by Maintaining FSL	Leakage, Outfalls to Drains	Outfalls to Rivers
Lining	Leakage, Seepage	Leakage, Seepage	**Nil**
Outlet Removal	**Leakage through meter**	**Leakage through meter**	**Nil**
Low Reliability Water Entitlement (Formerly Sales Water)			
G-MW Loss Management	**Leakage,** Outfall Reduction	Leakage, Outfalls to Drains	Outfalls to Rivers
Outlet Upgrades	Meter Error	**Meter Error**	**Nil**

A: In the Goulburn System when High and Low reliability water was created, for every Megalitre of High Reliability water there was 0.48 ML of Lower Reliability water created. These volumes were based on the reliability of providing both entitlement and sales water being modelled over 100 years of historic climatic data.

It should be noted that, although adjustments have been made to reflect the change as a result of the last 10 years of below average rainfall, no formal adjustment has been made for climate change.

The separation of products into depletion and non depletion losses enables the quality of the water product to be determined. A further division is to separate the savings into fixed and flow dependent (variable savings). The classification of each water loss type into each of these categories is shown in **Table 12.**

Table 12: Classification of Water Losses

Type of Water Savings	Depletion of Non Depletion Water Loss	Fixed or Variable Water Loss
Outfall Reduction - River	Non Depletion	Variable
Outfall Reduction - Drains	Depletion	Variable

Seepage	Depletion	Fixed
Evaporation	Depletion	Mainly Fixed
System filling	Depletion	Mainly Fixed
Diffused leakage – high level	Depletion	Variable
Diffuse leakage - below Supply level	Depletion	Fixed
Concentrated leakage	Depletion	Mainly Fixed
Meter outlet leakage	Depletion	Fixed
Meter accuracy loss	Depletion	Variable
D&S Deeming error loss	Depletion	Variable

However to convert these volumes of water savings into Water Entitlement requires the running of the Murray and Goulburn REALM models that were used to create and quantify the Water Entitlements for each of the river systems. As indicated in Section 3.1.4 of this report, the models will need to be enhanced to more closely reflect the water loss components of the supply systems and how these losses vary with time, operational management, climate variability and water delivery in each season.

To determine the type of products to be created from each intervention some scenario modelling could be undertaken with the aim of keeping the level of reliability constant and determining how, on average, the volume of each of High Reliability and Low Reliability water changes after each type of intervention.

It is expected that once these models have been developed, "rules of thumb" relating to High and Low Reliability water entitlement savings could be developed.

The scope of this Project does not allow for this detailed and time consuming task to be undertaken. It is however expected that the outcome of the modelling could be as indicated in **Table 13:** that is all forms of water savings product could contribute to both High and Low Reliability water. The amount applicable to each will depend upon the configuration of the systems (e.g. whether there is an ability to capture rainfall rejections within system storages or at diversion weirs.

Table 13: Indicative Matrix of Water Savings Products.

Remediation	Savings Type	Depletion	Non-Depletion
High Reliability Water Entitlement and Low Reliability Water Entitlements			
Asset Removal	Outfall, Leakage, Seepage, Evaporation, meter error	Leakage, Seepage, Evaporation, Outfalls to Drains	Outfalls to Rivers
Pipelines	Leakage, Seepage, Evaporation	Leakage, Seepage, Evaporation	Nil
Channel Automation	Outfall Reduction, High level diffuse Leakage	Leakage, Outfalls to Drains	Outfalls to Rivers
Channel Lining	Leakage, Seepage	Leakage, Seepage	
Outlet Removal	Meter Leakage	Meter Leakage	
Outlet Upgrade	Meter Leakage meter Error	Meter Leakage meter Error	
G-MW Loss Management	Outfall Reduction	Leakage, Outfalls to Drains	Outfalls to Rivers

Conclusion

Long term system models should be developed to enable water loss savings to be translated to water entitlements as an appropriate mixture of High and / or Low Reliability water.

4. CONCLUSIONS

The G-MW report on "Methodology for Water Savings and Water Products" (Report 3) was produced in January 2007. This review was undertaken in September 2007. In the mean time some of the issues raised in this review have been addressed and where this is the case a comment to that effect has been included in this report.

The following are the key conclusions from the report. If more detail is required the respective sections of this report should be referred to.

Question 1: What is the validity of the procedure outlined in Report 3 that determines the approximate loss component volumes within an irrigation area?

Conclusion 1

The use of the G-MW Loss Management review data as part of the methodology is reasonable, however:

i) the more years of data that can be used to account for seasonal variation the better, and

ii) all data (including historic data) should be adjusted to ensure consistency of methodology in determining the volume for each loss type in each year.

Conclusion 2

If seasonal loss variations are required, it is reasonable to remove outfall volume and meter losses before applying the fixed apportionment of losses to the each of remaining loss categories. The former two loss categories are measured and are the more accurately known.

Conclusion 3

In priority order, any unknown losses should be allocated by either:

i) allocating unknown losses on an accuracy and volume weighted proportional basis across the losses which are known to be less accurate [i.e. excluding accurately known losses (e.g. outfalls and metering)], or

ii) allocating unknown losses on a volume weighted proportional basis across all losses, or

iii) as a last resort method, the unknown losses should be allocated to leakage which is the least accurately known significant loss.

Conclusion 4

The Hydro Environmental team believes that the use of the loss proportioning adopted in Report 2 maybe correct for the CG 1, 2, 3 & 4 channel system and similar systems at a large scale, but in most cases although the method may provide a first cut estimate, it is not an accurate fit for individual channel scale assessment, or for systems which vary significantly in engineering and geographic character from the CG 1, 2, 3 & 4.

Conclusion 5

The Report 3 procedure used to quantify the approximate loss component in each Irrigation Area is not appropriate in its current form and Section 3.1.2 of this report suggests possible improvements.

Conclusion 6

The G-MW Loss Management Review Methodology should be modified to account for all losses and to distribute the unallocated losses. Suggested improvements to the methodology are included in section 3.1.2.

Conclusion 7

The method used in Report 3 of combining the CG 1, 2, 3 & 4 outcomes with G-MW Irrigation Area specific Loss Management data is not appropriate unless the channel system in the Irrigation Area being analysed is similar in engineering and geographic character to the CG 1, 2, 3 & 4 or the CG 1, 2, 3 & 4 data is appropriately adjusted to take into account the Irrigation Area specific characteristics.

Question 2: What are the confidence levels that are associated with the use of measures outlined in Report 3 (average loss/km/season) and (average loss/outlet/season)?

Conclusion 8

In relation to this question it is concluded that:

i) ML/km/season is a reasonable way of articulating channel loss at a system and total loss scale but not at a Pod level

ii) scaling on basis of channel capacity is a reasonable assumption unless scaling is for dissimilar systems or loss components which are not capacity related

iii) average loss per outlet/season for meter error is considered irrelevant when considering metering error, but may be useful if applied to leakage loss around and through meters.

Question 3 : What is the base period that should be adopted to determine the pre intervention water savings potential using CG 1, 2, 3 & 4 and Shepparton areas as examples?

Conclusion 9

In relation to this question it is concluded that::

i) the 2004/2005 Irrigation season should be the base year against which any change in supply system configuration and operation should be measured for determining water savings

ii) To facilitate the development of suitable modeling routines and measuring change, G-MW should accurately and comprehensively record the physical and operational procedures and process related to, or affecting, water delivery efficiency as at 30 June 2005 (2004/2005 season).

iii) savings in fixed losses (e.g. seepage) are directly convertible to High or Low Security Water Entitlement but modelling is required to determine the appropriate portions of each

iv) detailed modelling is required to enable the volumes of flow dependent variable water losses to be compared to Water Entitlement

v) an appropriate indication of the losses which are climate dependent (e.g. evaporation), can be determined by using long term average climate data (modelling is required to achieve the best accuracy)

vi) water saved by initiative undertaken prior to 2004/2005 may be exchanged for automation initiatives which improve water savings sustainability or reduce the costs of maintaining water savings.

Question 4 : What advice would you give on a suggested better alternative approach that would provide a more accurate approximation of relative losses within specific irrigation areas?

Conclusion 10

Combining detailed system knowledge held by the G-MW Area operators, refining the CG 1, 2, 3 & 4 report results, refining G-MW Loss Management Reporting methodology and developing a better Irrigation Area, and possibly Pod specific, Water Loss assessments will lead to more accurate results than the very generalised approach defined in Report 3. This process will be further assisted by the conduct of pondage tests and more accurate measurement using the new FlumeGateR. regulator gates.

Question 5: What is the validity of determining overall long term water saving associated with each intervention by multiplying the "effectiveness" and "sustainability factors?

Conclusion 11

In relation to this question it is concluded that::

i) determining overall long term water saving associated with each intervention <u>in isolation</u> by multiplying the "effectiveness" and "durability factors" is appropriate provided it is clearly understood what the two factors mean. This approach effectively quantifies the difference between the "baseline (no intervention) loss" and the "deterioration target"

ii) if considering long term water savings on <u>a whole of system</u> basis an approach which will lead to more water savings being claimed, is to add 50 % of the difference between "initial effectiveness" and the "deterioration target" to the difference between the "baseline loss" and the "deterioration target"

iii) in both cases (i) and (ii) above a cost effective intervention target (based on the cost of intervention renewal, asset durability and frequency) must be nominated for each intervention

iv) transferring water savings to investors for claiming water savings between the *Deterioration Target* and the *Initial Effectiveness* in Figure 8 should be done with care because generally any deterioration in water savings in one part of the channel system must be offset by an intervention in another if Water Entitlement security is not to be jeopardised

v) the process outlined in this report provides an indication of the theoretical water savings. Pondage tests undertaken before and after an intervention in each pool would provide a more accurate verification of the theoretical initial saving due to the application of particular interventions.

Conclusion 12

Overall the most accurate result for project water savings is obtained by using actual loss per unit length for those high loss pools to be targeted for intervention and using the length weighted average water savings for only those pools

Conclusion 13

The process outlined in this report provides an indication of the theoretical water savings. Pondage tests undertaken before and after an intervention in each pool would provide a more accurate verification of the theoretical initial saving due to the application of the intervention.

Conclusion 14

Care should be taken not to confuse the concepts *"delivery efficiency"* and *"water loss reduction efficiency"* when determining the effectiveness and durability of an intervention technique to determine with water savings. The most accurate results are achieved if each effectiveness and durability of each intervention is assessed in relation to each particular form of loss impacted.

Question 5a: What is the validity of the percentage effectiveness measures assigned to each intervention?

Conclusion 15

The **effectiveness** of a water savings intervention is a measure of the degree to which water savings occurs immediately after implementation (i.e. before any deterioration occurs).

The **effectiveness** of each of the water savings measures considered are listed in **Table 8**. The following is a summary of the findings:

i) Asset removal will be 100% effective in achieving water savings provided the water previously delivered by the assets are passed through accurate meters.

ii) Provided the pipelines are well constructed and pressure tested prior to commissioning, it is considered reasonable to increase pressure tested pipeline effectiveness from 90 % to 95 %. A more accurate approach is to consider the impact of piping on individual loss types (e.g. evaporation, seepage, leakage, etc.)

iii) The effectiveness for plastic channel liner could be 90% and 80 % could be used for well placed clay channel lining.

iv) Outfall losses must be considered as being a combination of operational losses and rainfall rejection losses. It is considered reasonable that FlumeGates and TCC will generally be effective in reducing rainfall rejections by 75 % and operational loss rejections by 95 %.

v) If the data is not available to split operational from rainfall rejection outfalls, then it seems reasonable to assume that 50 % of pre-scheme losses apply to each type of loss which will result in an average effectiveness of 85 % (determined by averaging the rainfall rejection and operational loss rejection effectiveness values).

vi) An effectiveness of at least a 5 % reduction in leakage losses would be achievable by maintaining supply closer to design levels on older type channel designs using TCC and FlumeGates.

vii) A 100% effectiveness is considered acceptable when new meters are installed on the basis that the National Standard compliant meters are being used for the Dethridge meter replacement.

Question 5b: What is the validity of the percentage durability measures assigned to each intervention

Conclusion 16

The **durability** of the water savings associated with each intervention measure is the deterioration on loss in water savings before renewal of the intervention is proposed / required.

The **durability** of each of the water savings measures considered are listed in **Table 8.** The following is a summary of the key conclusions related to durability.

i) Unless overall meter accuracy on the remainder of the system decreases with time, removal of assets will lead to 100% durability in water savings.

ii) On the basis of a 50 year replacement cycle, it is considered warranted to decrease pipeline durability to 85 % for rubber ringed jointed pipelines; however, 90 % would be realistic for welded joint pipelines.

iii) Unless only a very short pipeline replacement interval is used, on an overall basis it is considered warranted to decrease pipeline durability to 85% for rubber ringed jointed pipelines; however, 90% would be realistic for HDPE welded joint pipelines.

iv) If a 15 year replacement profile is assumed, it is considered that a durability of 75 % for channel lined with uncovered plastic is reasonable, however, the lining of channels with clay covered plastic would lead to a durability of 90 % and if clay lining with a 15 year replacement is used a durability of 75% would be appropriate. This compares with the 75% used in Report 3.

v) The durability of channel automation should be 95%.

vi) The durability of retail meter standardisation should be 100 % but may be reduced if some of the water saved is to be allocated to increased water entitlement security.

Question 6: What is the validity of the assigned water entitlement reliabilities to water savings volumes as summarised in the Table 5.6 of Report 3?

Conclusion 17

Long term system models should be developed to enable water loss savings to be translated to water entitlements as an appropriate mixture of High and / or Low Reliability water.

Miscellaneous issues

Conclusion 18

A water savings and allocation account should be established by G-MW to track and verify water savings and included expected and actual water savings.

Conclusion 19

The water savings calculation methods outlined in the Report 3 are aimed at determining the theoretical water savings. Pre remediation as well as post remediation measurements at a channel pool level are required to verify actual savings associated with each intervention.

Conclusion 20

Water savings should be monitored and accounted at a system level through the calculation of a standardised delivery and climate dependent water delivery efficiencies which are required to compare the actual overall delivery efficiency performance for a given year.

Conclusion 22

The potential volume of water saved as indicated in Report 3 are conservative.

5. RECOMMENDATIONS

As indicated in the introduction to this report advances in the water saving technology and analysis are dynamic with adaptive management leading to many changes in approach and outcome. Report 3 was produced in January 2007 whereas this review was undertaken in September 2007. In the mean time some of the issues raised in this review have been addressed.

As many of these changes and the conclusions in this report will impact on the methodology used by G-MW to analyse, quantify and record water savings it is recommended that:

1. Each of the conclusions in this report be considered and actioned
2. A Water Savings analysis methodology guideline be developed by G-MW possibly by updating Report 3
3. A water savings register be established by G-MW to monitor and record the output and distribution of water entitlements from water savings initiatives.

xxxXXXxxx

ATTACHMENT 1 – Scope of Consultant's Brief

REVIEW OF METHODOLOGY FOR WATER SAVINGS AND WATER PRODUCTS PROJECT
REVIEW OF GMW REPORT #2078394
"METHODOLOGY FOR WATER SAVINGS AND WATER PRODUCTS" (10 January 2007)

BACKGROUND

Investment in water saving projects relies heavily on confidence in the water loss attributable to a water loss category as well as the effectiveness and sustainability of the loss reduction solution chosen.

To assist in the evaluation of water saving project viability a guide has been developed by GMW that has been designed to readily apply existing data and experience to:

(1) Quantify and apportion water loss within an irrigation area.
(2) Determine the expected water loss reduction associated with a variety of known water loss reduction interventions.
(3) Assign water savings to either high or low reliability status.

To gain confidence in the accuracy of this guide, external investors have sought an external review.

PROJECT SCOPE

Section 2: Methodology to assess potential savings

This section describes the recommended procedure that draws on recent experience and historic loss analysis to quantify potential water loss in an irrigation area.

Review tasks include:

- Comment on the validity of the procedure outlined that determines the approximate loss component volumes within an irrigation area. Include assessment of method used to combine CG 1, 2, 3 & 4 outcomes with local area data.
- Comment on confidence levels that are associated with the use of measures (average loss/km/season) and (average loss/outlet/season)
- Comment on the base period that should be adopted to determine the pre intervention water savings potential using CG 1, 2, 3 & 4 and Shepparton areas as examples. Look at differing periods and conditions.
- Provide advice on a suggested better alternative approach that would provide a more accurate approximation within an irrigation area.

Other reference documents should include Section 4 of the Shepparton Business Case, and the report prepared by SKM and URS on the determination of outfall flows from the Shepparton area.

Section 3: Methodology for assigning savings to various intervention project types

This section identifies a range of project types designed to reduce water loss. An assessment is made on the effectiveness of each intervention in reducing water loss immediately following implementation and then a further assessment of the sustainability of the intervention over time.

Review tasks include:

- Comment on the validity of the percentage effectiveness measures assigned to each intervention.
- Comment on the validity of the percentage sustainability measures assigned to each intervention.
- Comment on the validity of determining overall long term water saving associated with each intervention by multiplying the two factors.
- Identify any other known interventions that should be considered (including channel remodelling)

Other reference documents to be used in the assessment include the GMW's report #1876265v2 "Methodology for water Savings".

Section 4: Metering

This section is considered to be a policy issue relating to change management associated with improved meter accuracy. It is not included in the project scope.

Section 5. Water saving products

This section assigns water savings achieved from various interventions to either High or Low Reliability security rating.

Review tasks include:

- Comment on the validity of assignment proposed which is summarized in the table 5.6.

TIMEFRAME

It is anticipated that the project would be completed within four weeks of commencement.

FUNDING.

The project will be co funded by GMW, DSE and WFR. WFR will arrange engagement.

ATTACHMENT 2 – Appendix G of the G-MW Loss Management Reports

Appendix G of the G-MW 2005/06 Loss Management Report with Suggested comments for improvement

Loss Component	2003/04 Loss Management Report Calculation Method	2004/05 Loss Management Report Calculation Method	2005/06 Loss Management Report Calculation Method	Comment for Improvement
Outfalls	As per volumes submitted by individual Areas. A 30% increase adjustment made to un-metered volumes to allow for error.	As per volumes submitted by individual Areas. Areas to make any adjustments as required allowing for unmetered sites.	As per volumes submitted by individual Areas. Areas to make any adjustments as required allowing for unmetered sites.	Use actual metered outfalls by rationalising and metering all outfall sites with meters which do not have a systematic bias and are accurate to ± 5%.
Leakage	Based on average volumes per leak calculated as part of the water savings program multiplied by the number of leaks submitted by Areas. This was then doubled to account for leaks through meter outlets and undetected leaks.	Areas to collate total number of leaks. The following was allowed: 5 ML – for bank leaks or leaks around meter outlets 1% of deliveries allowed for leaks through meter outlet structures. Overtopping submitted by Areas.	Areas to collate total number of leaks. The following was allowed: 5 ML – for bank leaks or leaks around meter outlets 1% of deliveries allowed for leaks through meter outlet structures. Overtopping submitted by Area Managers.	Leakage is the balancing item and comprises:- i) Bank point source leaks ii) Meter outlet leaks (Dethridge meter) iii) Overtopping leaks iv) Diffuse bank leakage. These losses should be determined as follows; 1. Determine the number of leaks detected (excluding leaks around Dethridge meters)and allow an average of 5 ML/year/leak (or the amount determined through measurement) per leak 2. through and around Dethridge meters use 1.6 ML/year /Dethridge meter 3. As estimated by the Area Manager for each back over topping event 4. Determined from the reworked CG 1, 2, 3 & 4 calculations on a per km of channel basis adjusted for the conditions (e.g. length of channel with Supply level below ground level) in each Area.

Loss Component	2003/04 Loss Management Report Calculation Method	2004/05 Loss Management Report Calculation Method	2005/06 Loss Management Report Calculation Method	Comment for Improvement
Seepage	Based on volumes as estimated in SKM Water Savings in Irrigation Areas report.	Based on surface area of channels (from assets register) and seepage rates taken from SKM data.	Based on surface area of channels (from assets register) and seepage rates taken from SKM data..	Seepage should be constant from year to year where the system is full for the whole year. Channel width (and possibly length) should be more accurately determined from aerial photography or field inspection or taken to be as per Asset Life plus as allowance for bank erosion based on asset condition to allow for bank erosion. Seepage rates should at least be adjusted to reflect the typical soil types in each area and ideally be based on the channel area weighted by the soil type.
Evaporation	Based on surface area of channels and storage's (where applicable) calculated using Kyabram and Kerang Class A Pan Evaporation rates using a pan factor of 0.8.	Based on surface area of channels and storage's (where applicable) calculated using Kyabram and Kerang Class A Pan Evaporation rates using a pan factor of 0.8.	Based on surface area of channels and storage's (where applicable) calculated using Kyabram and Kerang Class A Pan Evaporation rates using a pan factor of 0.8.	Channel width (and possibly length) should be more accurately determined from aerial photography or field inspection or taken to be as per asset life plus as allowance for bank erosion based on asset condition to allow for bank erosion. Losses should be determined using the nearest Class A Evaporation Pan and its relevant pan factor for clear water (pan factor of 1) and ensure that the evaporation minus rainfall figures and used to determine the net loss.
System filling	As per volumes submitted from each area	As per volumes submitted from each area	Net Diversion into area minus remaining 7 components of Loss (unallocated not included) and delivery equals system fill.	Channel fill is assumed to be the unallocated losses during system filling less the volume of any negative unallocated losses during the channel draining period at the end of the season. Unallocated losses during the season should be relatively small and are the losses remaining after subtracting the quantifiable losses and measured outflows from the inflows.

Loss Component	2003/04 Loss Management Report Calculation Method	2004/05 Loss Management Report Calculation Method	2005/06 Loss Management Report Calculation Method	Comment for Improvement
Unauthorised and unmetered (Theft)	Estimate only	Estimate only	Estimate only	Should be based on the sum of prosecuted, detected and suspected thefts plus an allowance of 20% for undetected theft.
Unmetered D&S	Based on estimated 2002/03 volumes as provided by Bill Heslop less deemed 2003/04 volumes	Based on estimated 2002/03 volumes as provided by Bill Heslop less deemed 2004/05 volumes	Based on estimated 2002/03 volumes as provided by Bill Heslop less deemed 2005/06 volumes	Should be based on 20% of the sum of the deemed volumes for 2004/05 reducing to 10 % in 2006/07 or a percentage of deemed volumes as estimated by Bill Heslop for the "unmetered" deliveries. Only this percentage should be regarded as loss and the total of the deemed delivery D&S volumes should be added to the metered delivery volumes when determining the total losses.
Meter outlet inaccuracy	Based on 5% of actual deliveries.	Based on 8% of actual delivery. Due to the recognised connection between delivery and unallocated losses in the 2003/04 report	Based on 8% of actual delivery. Due to the recognised connection between delivery and unallocated losses in the 2003/04 report	Should be increased to 10% of actual delivery or based on more recent Area specific Dethridge meter field testing. Meter error is a function only of deliveries and generally confined to Dethridge meters which have systematic errors (this loss generally dose not apply to MagFlow and FlumeGate meters which do not have a systematic error but may apply to Mace meters).
Unallocated losses	Balance	Balance	Balance	Balance (should become a smaller percentage due to improved accuracy other losses) and should be proportionally distributed as additions to the other losses with the proportions being adjusted to refect the relative understanding of the accuracy with which each loss can be determined. In most cases this will mean that these unallocated losses will also be assumed to be leakage losses except when channel filling is occurring. If unallocated losses are negative it should be assumed that they are subtracted from the channel filling losses.