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DRAINAGE DIVERSION STRATEGY - PRIMARY DRAINS (June 2000)

EXECUTIVE SUMMARY

A. PURPOSE OF STRATEGY

The purpose of this strategy is to set the framework to manage drainage diversion from Goulburn-Murray Water's (G-MW) primary drains. This Strategy is a component of the Surface Drainage Strategy, which was endorsed by the Board in April 2000 (Meeting 70). The Surface Drainage Strategy has a number of elements, including:

10 - Drainage diversion practices will be managed to:
10.1 accord with the MDBC Cap and other water resource management agreements (BEs)
10.2 minimise outfalls to downstream waterways in accordance with the objectives of approved Water Quality Strategies
10.3 minimise any impacts on environmental flow requirements that have been established for natural depressions and significant wetlands as part of the drain design.

This Drain Diversion Strategy fits under the Surface Drainage Strategy and delivers the elements (10.1 to 10.3) of the Surface Drainage Strategy.

Implementation of the Drain Diversion Strategy will be via Drain Management Plans that will ultimately deliver, for each drain, the overall requirements of the Surface Drainage Strategy.

Drain Diversion Plans, which are part of Drain Management Plans, will deliver the Drain Diversion Strategy component of the Surface Drainage Strategy.

Rules for diversion from G-MW Community Surface Drains (CSDs) are detailed in 'Diversion Policy from G-MW Community Surface Drains' 9 February 1999, Appendix G of G-MW CSD Administration Manual.

B. AMENDMENTS TO PREVIOUS ARRANGEMENTS

This Strategy brings into a common framework, developments on drainage diversion that have taken place over the last five years. Different elements have undergone various levels of consultation and previous formal approval (some management arrangements were agreed in principle by the Board on 20 June 1996).

C. CONSULTATION

Preparation of this document has involved two rounds of consultation with Murray Valley, Shepparton, Central Goulburn and Rochester Water Services Committees, together with internal consultation via the Drain Coordinating Committee.

Pyramid-Boort and Torrumbarry Water Services Committees were consulted, with the conclusion that the strategy was not applicable to Pyramid-Boort due to the lack of G-MW arterial drains, but was applicable to Torrumbarry when new arterial drains are implemented.

D. OBJECTIVES OF DRAINAGE DIVERSION STRATEGY

The main objective of the consolidated drainage diversion strategy is to maximise drainage diversion from G-MW primary drains, as a means of reducing irrigation drain outfall, to improve the water quality of receiving waters.

The Drainage Diversion Strategy also seeks to deliver, so far as possible, equity amongst diverters and to satisfy G-MW's legal and environmental responsibilities.

The strategy provides Irrigation Area Managers with consistent and comprehensive guidelines for:

- Assessment of drainage diversion applications in gauged and ungauged catchments;

- Assessment of the effect of increased diversion on existing drain users; and
- Identification of realistic nutrient reduction targets that can be achieved by increasing drainage diversion.

E. DRAINAGE DIVERSION STRATEGY SUMMARY

E.1. Background

- This Strategy was developed using limited data (early to mid 1990s) and modelling of three representative drainage gauged catchments in the SIR. Additional modelling and some changes to the strategic approach may be required for catchments with different characteristics or climatic circumstances resulting in different hydrologic conditions;
- Drainage diversion is a highly unreliable source of supply as evidenced by the uncontrolled, unregulated and variable nature of drain flows;
- The proposed changes to management arrangements and recovery of additional costs through increased drainage or diversion charges are considered to be within legal bounds, provided the objectives and technical basis are clearly stated and existing users are given reasonable notice of proposed changes;
- G-MW is not under any obligation to provide or regulate water in its drains in any specific quantity or quality, and it is not liable for any damage caused to the consumer as a result of the quantity being insufficient or quality being inappropriate, unless the damage is clearly a result of G-MW’s negligence;
- The Strategy takes into account the need to comply with MDBC water cap restrictions and water accounting assumptions and mechanisms. Significant flows from upstream dryland catchments are not to be included in any estimates of volumes available for drainage diversion;
- This Strategy is aimed at reducing irrigation runoff and irrigation induced rainfall runoff. The limits set by the Strategy to diversion quantity will allow the non irrigation induced runoff to reach downstream destinations;
- The discharge of pumped groundwater into drainage systems is to comply with guidelines set by relevant salinity plans (including MDBC Salinity and Drainage Strategy). Compliance with these guidelines should ensure that drain salinities remain within limits suitable for irrigation;
- A catchment salinity network model is being developed to plan groundwater pump discharges into drainage systems;
- All drainage diversion allocations are to be subject to TWE salinity guidelines;

E.2. Strategy elements

E.2.1. Strategic approach

- *Separate arrangements for high and low flows* - The Strategy provides separate allocation arrangements for irrigation runoff (low flow) and irrigation induced rainfall runoff (high flow);
- *Diversion targets* - The Strategy aims to divert at least 50% of irrigation runoff and 30% of irrigation induced rainfall runoff based on flows which occurred in the early to mid '90s baseline period (this is consistent with the Surface Drainage Strategy);
- *Restricting adverse effects* - The above diversion limits have been set so as to restrict adverse effects on existing or first-time diverters while making a significant contribution to Water Quality Strategies nutrient removal objectives. These diversion limits may not achieve current WQS targets which may need reassessment. WQS targets were based on limited data and simple analysis. Diversion limits developed under this strategy are based on much more detailed analysis of data and are therefore more reliable.

- *Guidelines* - The Strategy uses consistent and comprehensive guidelines for assessment of drainage diversion applications in gauged and ungauged catchments;
- *Reviews* - The Strategy requires that there be regular reviews (allocations, diversion limits, decision criteria, effectiveness, potential impact on existing diverters, etc.) to ensure that the elements of the Strategy are amended if and when warranted. Additional reviews may be requested by WSCs with amendments made if appropriately justified;
- *Drain Diversion Plans* - The preparation of Drain Diversion Plans (DDPs) for each drainage catchment is a key part of the strategic approach;
- *Monitoring* - Monitoring data is to provide input into regular Strategy reviews and redefinition of agreed catchment targets, if necessary, subject to WSC recommendation and Board approval, as appropriate. Monitoring records may include drain flow outfalls into waterways, low-flow diversion volumes, channel outfalls, and any relevant information on wetlands, reuse systems, high flow storages, etc.

E.2.2. Implementation requirements

- *Priorities* - DDPs are to be prepared in accordance with an agreed schedule based on water quality priorities;
- *Compliance with G-MW requirements* - All drainage diversion installations are to comply with G-MW's requirements. Requirements include that reuse systems be separate from diversion arrangements and low flow systems be separate from high flow systems so that low flow diversion volumes can be monitored. Alternative arrangements may be accepted by Area Managers;
- *Rostering* - G-MW will, subject to approval by the relevant WSC, facilitate the development of rostering arrangements in a particular drain catchment provided the diverters agree (test to be developed) to both implement and police the new arrangements;
- *Fees and charges* - All drainage diversion agreements are subject to annual fees and charges as set by G-MW from time to time. Unless specific arrangements are put in place, drainage diversion charges for Tier 1 and Tier 2 low-flow drainage diversion agreements include payment of the allocation component, regardless of use. However, for Tier 2 low-flow drainage diversion agreements, payment of the allocation becomes compulsory only when sales is greater than or equal to 50% WR. High flow drainage diversion agreements only attract service fees (Tier 1 refers to diversion of low flow drainage water at any time during the irrigation season; Tier 2 refers to restricted diversion of low flows; Tier 3 refers diversion during periods of high flow);
- *No trading* - There is not to be trading of drainage diversion allocations unless otherwise recommended by the relevant WSC, and approved by the Board, for a particular drain catchment;
- *Metering* - All low flow drainage diversion sites are to be metered and all associated costs are to be normally recouped through Irrigation Area drainage or diversion charges, unless external funds can be obtained. Current and future demand prospects for high flow diversion across the whole of G-MW do not warrant a requirement for metering of high flow drainage diversion installations;
- *Monitoring* - Drain outfalls into waterways not currently gauged are to be monitored for flow with remote sensing equipment, if flow monitoring is deemed to improve drainage diversion management;
- *Review of yield calculations* - The assessment of drainage diversion applications requires estimation of catchment yield. The Strategy developed consistent methodologies for estimation of runoff volumes for both gauged and ungauged catchments. Irrigation and rainfall runoff coefficients or relationships currently adopted for such purposes may be reviewed over time to allow for new developments in catchment modelling techniques and inclusion of new or improved information from monitoring;
- *Allowance for channel outfalls* - To be conservative, channel outfall volumes are not to be

accounted for in estimates of flows available for diversion, unless the relevant Irrigation Area Manager considers that they cannot be reduced;

- *Contingent allocations* - Low flow drainage diversion agreements are to be subject to the contingent allocation process, that is, a regular review of allocations against usage. This process is aimed at aligning, over time, allocations with usage and available drain flows. Agreements are to specify minimum and maximum diversion limits;

- *Limiting adverse effects* - Initial decision criteria for assessment of new drainage diversion applications have been set with a view to limit adverse effects on existing diverters whilst encouraging increased drainage diversion. The agreed criteria limits for a specific catchment may be modified over time, subject to the amendments through the DDP review process with WSC recommendation and Board approval, as appropriate;

- *Current diversion ratio assessment criterion* - The criteria for assessment of new low-flow drainage diversion applications in a catchment are to be based on the Current Diversion Ratio (CDR). DDPs are to specify the maximum volumes that can be allocated under each tier without exceeding agreed CDR ranges. The relevant WSC may recommend variation of CDR ranges for a particular DDP if it is satisfied that such variations comply with overall strategy objectives as assessed by the review process;

- *Maximum storage capacity assessment criterion* - The criteria for assessment of new high flow drainage diversion applications in a catchment is to be based on an agreed maximum storage capacity (currently 200 ML) per every 1,000 ML of total estimated high flows. DDPs are to specify the maximum storage capacity that can be authorised in any sub-catchment. The maximum storage capacity in a catchment can be increased if it can be demonstrated that only irrigation induced rainfall runoff would be diverted.

E.3. Potential impacts/risks

Issues such as biocides, pathogens, soil degradation, etc. are potential risks resulting from drainage reuse for irrigation. The Drainage Diversion Strategy is based on the assumption that the risks of drainage reuse for irrigation purposes are acceptable. Other programs including regional water quality strategies and G-MW’s Environmental Management System, amongst others address these risks more comprehensively.

E.4. Cost and cost sharing

Annual costs of implementing a minimum set of measures were estimated for each of the Irrigation Areas. See Table 1. These costs take into account the preferred approaches in each of the Areas to diversion and drain flow metering, management etc. It was assumed that all the infrastructure (drainage diversion meters, drain flow meters, low level rock weirs, etc.) would be installed in the first five years of the Strategy to be able to measure performance in the following five years.

The Strategy has initially a 10-year life subject to review. At the end of this period drainage diversion is not expected to play an important role in reducing drain flows and because of this there is no allowance under the minimalist scenario recommended by the Strategy for renewal of drain diversion meters.

The current drainage diversion charging arrangements are to remain in place pending the review of the surface drainage tariff structure. Currently, standard low-flow drainage diversion charges are the product of the drainage diversion volumetric fee (25% of the gravity irrigation fee) and the volumetric allocation. To accommodate the increase in costs resulting from implementing the Strategy whilst maintaining the current charging arrangements, annual surface drainage charges are expected to vary as shown in Table 1. The total estimated cost, over 10 years, of implementing this strategy is $4.78M.

Table 1 - Costs and effect on surface drainage charges

Irrigation Area	Base costs (1998/99)	Base revenue (1998/99)	Years 1 to 5			Years 6 to 10		
			Annual costs	Drainage diversion revenue	Surface drainage charges change factor	Annual costs	Drainage diversion revenue	Surface drainage charges change factor
Central Goulburn	118,088	246,577	177,413	321,673	0.96	166,332	396,769	0.81
Murray Valley	37,542	37,827	116,367	86,532	1.05	137,882	135,237	1.00
Rochester-Campaspe	38,611	78,654	98,393	132,448	1.01	77,679	186,242	0.80
Shepparton	46,066	58,206	111,421	81,248	1.08	70,821	104,290	0.95
Pyramid-Boort								
Torrumbarry								

Change factor - indicates the change required in charges to cover cost of management. Costs for Pyramid-Boort and Torrumbarry are not available at this stage.

E.5. Outstanding issues

- Periodical strategy reviews will indicate if, when and what alternative supplementary options could be pursued should the strategy fail to deliver the expected results;
- A major review at the end of life of the Strategy (10 years) would verify or disprove the assumption that drainage diversion will no longer be a major factor in reducing drain flows. Such review would suggest whether a modified version of the Drainage Diversion Strategy should remain in place;
- Suitable and economic drainage diversion metering arrangements are yet to be identified.

E.6. Implementation

Implementation of some elements of the Drainage Diversion Strategy is taking place, to different levels and degrees, across all Irrigation Areas in the SIR. The Strategy formalises the minimum measures that Areas are required to put into action and leaves room for additional improvements on a catchment need basis.

Completion of DDPs for catchments in the Goulburn Broken is expected within the next two years with NHT funding (component of funding for implementation of Goulburn Broken Water Quality Strategy).

E.7. Evaluation

Regular reviews are part of the strategic approach to drainage diversion. These reviews will indicate when and what elements of the Strategy should be modified to achieve the desired results.

1. INTRODUCTION

The consolidated drainage diversion strategy is aimed at reducing annual flows, and consequently nutrient loads, discharged from the irrigation drainage system into receiving water courses to improve their water quality. It needs to be viewed in the context of Water Quality Strategies (Goulburn Broken, Campaspe and Loddon WQSs) whose aims are to improve the quality of the water in regional streams and the River Murray in terms of reduced nutrient loads and reduced frequency and magnitude of blue green algal blooms. These strategies identified irrigation drainage as major nutrient sources in the three catchments; and reduction in drain flows, given the increasing demand for reuse of drainage water, as a cost effective and fast method of targeting reduced nutrients. The WQSs set a target of 50% nutrient reduction in 1996 baseline levels, to be achieved over a 20-year period (GBWQS, 1996).

Other initiatives such as on-farm storage, farm reuse systems, in-line storages, wetlands (whether en route or off line), strategic G-MW water harvesting storages for diversion of extreme high flow summer events, reduced point source discharges (industry, urban stormwater, sullage, sewage treatment plants, etc.), channel injection; drainage irrigated plantations at strategic locations, etc., can further reduce runoff discharges and associated nutrients into natural water courses; in addition to improving water resource management.

Goulburn-Murray Water (G-MW), in consultation with its customers and with the assistance of consultant Sinclair Knight Merz (SKM), the Department of Natural Resources and Environment (DNRE) and the Goulburn Broken Catchment Management Authority (GBCMA), has developed two separate strategies to target reduction in irrigation runoff (low flow diversion strategy, Section 4) and irrigation induced rainfall runoff (high flow diversion strategy, Section 5). In the Goulburn Broken, Campaspe and Loddon WQSs, reduction of summer drain flows have a more immediate time frame (10 years) because of the underlying assumption that the nutrients carried by summer flows are more bioavailable and perceived to be the main factors responsible for algal bloom outbreaks. The effects of summer flows can be attenuated relatively easily and economically by encouraging drainage diversions during the irrigation periods.

The separate diversion strategies recognise that irrigation runoff and rainfall runoff result from two different mechanisms and require different approaches. They share common ground, particularly in relation to implementation issues. This strategy brings together strategies developed separately for low flow and high flow drainage diversion, into a unified framework for management.

2. OBJECTIVES

The main objective of the consolidated drainage diversion strategy is to maximise drainage diversion from G-MW primary drains, as a means of reducing irrigation drainage outfalls and so improve the water quality of receiving waters. The strategy provides Irrigation Area Managers with consistent and comprehensive guidelines for:

- Assessment of drainage diversion applications in gauged and ungauged catchments;
- Assessment of the effect of increased diversion on existing drain users; and
- Identification of realistic nutrient reduction targets that can be achieved by increasing drainage diversion.

The first bullet point relies on being able to estimate volumes available for diversion in the catchment. The other bullet points result in the identification of realistic targets for nutrient reduction based on drainage diversion.

3. BACKGROUND

There are many factors that influence the future availability of drainage flows for drainage diversion at any point in the drainage system. These factors include available flows, demand, land use, changes in water use which result from transfers in water entitlements, tenure of agreements (existing versus new), relative position in catchment, channel water allocation policy and pricing, availability of channel water sales, channel outfalls, farm management practices, on-farm drainage reuse, rostering arrangements, on-farm storages, groundwater pump flows and salt loads, reliance on drain water for farm enterprises, pump capacity, etc. Not all of these factors were specifically accounted for in the proposed framework. In fact, the influence of a number of them cannot be accurately assessed. As a result the strategy emphasises the need for ongoing monitoring and review to improve the database for resource assessment, and to accommodate changes in the catchments.

3.1. Catchment restrictions

The development of this Strategy was based on hydrological monitoring and analysis of three gauged drainage catchments in the Shepparton Irrigation Region (Bamawn Catchment in Rochester Irrigation Area, Deakin Catchment in Central Goulburn and Rochester Irrigation Areas and Drain 6 in Murray Valley Irrigation Area). The conclusions derived may not necessarily apply for catchments with different characteristics.

The low flow diversion strategy may need some local adaptation for Cohuna/Kerang drains, including targeted hydrologic analysis or modified Current Diversion Ratio (CDR) criteria (see Section 4.2.7). More detailed hydrologic modelling and targeted management strategies may be required for catchments with large upstream dryland areas and/or predominance of Community Surface Drains (CSDs).

Resource assessment guidelines in this Strategy assume that CSD catchments will capture their drainage (both low and high flows). Additional water which may discharge out of CSD catchments or undrained areas (when drained in the future) into G-MW primary drained catchments provides a factor of safety for runoff estimates in those catchments, except in extreme events.

Specific environmental needs should be identified when developing Drain Diversion Plans (DDPs) for individual catchments in the Cohuna/Kerang area. Downstream effects of increased diversion on areas such as Murphy’s Swamp and Richardson’s Lagoon in the lower reaches of the Bamawn Drain require special consideration and are to be studied in detail before preparing and implementing relevant DDPs.

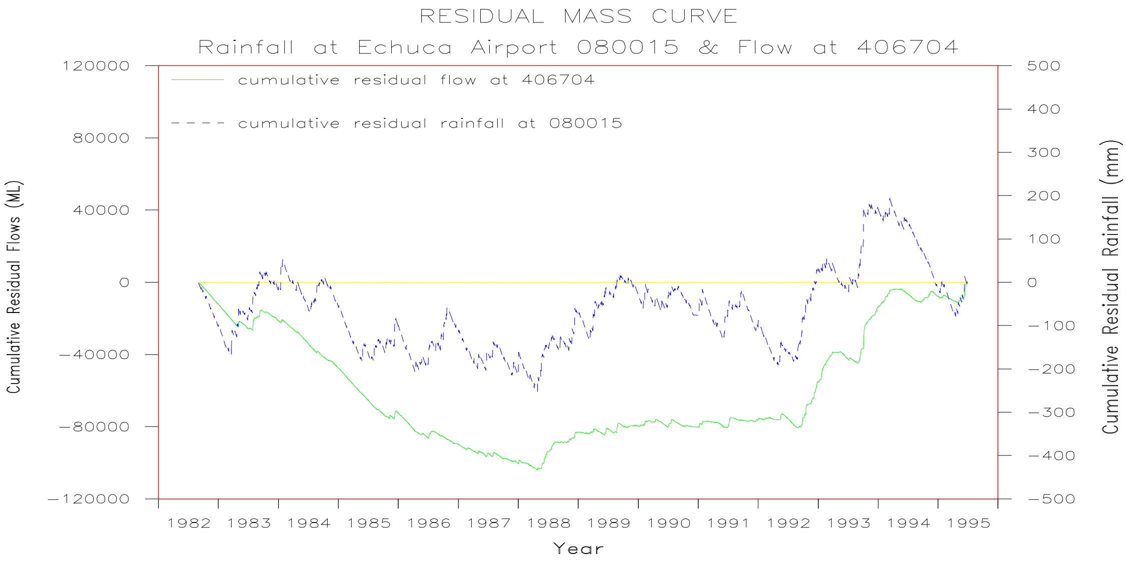
Drain catchments are to initially be fragmented into approximately 5,000 ha sub-catchments for resource assessment purposes and preparation of drain diversion plans for each catchment. Catchments of this size are expected to yield irrigation and rainfall runoff large enough to provide potential opportunities for drain diversion installations, whether low or high flow.

The runoff coefficients developed for use in resource assessment for ungauged catchments are applicable only to catchments served by traditional drainage systems. They will need to be modified for use in catchments served by drains which incorporate nutrient stripping features, particularly any form of in-line storage or sumps. This will need to be done in consultation with drain designers.

3.2. Variability of drain flows

In developing the strategies, a key issue considered was the uncontrolled, unregulated and highly variable nature of drain flows which make drain diversion a very unreliable form of supply. In addition to this limitation, drainage systems have historically been mostly unmanaged and there is very limited drain flow and diversion monitoring information. The magnitude of drain flows changes over time and is influenced by factors over which Goulburn-Murray Water has nil, to some, to full control. These factors range from land management and climatic conditions, to channel outfalls, to authorisation of new drainage diversion allocations. Figure 1 (SKM, 1997a) below is an indication of how variable drain flows are.

Figure 1 - Residual Mass Curve of Rainfall and Flow at Echuca Station, Deakin Drain



The residual mass curve is a slightly more complicated version of the mass curve (cumulative frequency distribution) obtained by subtracting the mean from each value of the record (drain flow or rainfall). Note that the residual mass curve starts and finishes on zero.

3.3. Target period

The low flow diversion strategy started in 1994 before nutrient reduction targets in WQSs were set and ahead of the development of the high flow diversion strategy. The formulation of the strategy focused on the Deakin Catchment for which there are drain flow records since 1982 to date. It also considered, for comparison purposes, data for the Bamawn Catchment for which there are drain flow records since 1992. Flows were also synthesised back to 1982 for the Bamawn Catchment by adaptation of Lockington Drain records.

To set criteria for future drainage diversion management it was necessary to establish a methodology to estimate drain flow volumes. That methodology consists of the formulation of a simplified water balance model calibrated for three gauged catchments; Deakin, Bamawn and MV Drain 6. These catchments were selected because they have been used by other drainage studies, because of the availability of drainage diversion information, length of drain flow records, representativeness within the region and priorities identified by the Goulburn Broken and Campaspe WQSs (SKM, 1999a). Calibration of the model allowed the derivation of runoff coefficients for irrigation and rainfall.

In deriving an irrigation runoff coefficient for the low flow strategy, actual data (drain flows, rainfall, water usage) and best estimates for channel outfall volumes and drainage diversions were used for the 1994-1997 period in the three catchments.

Drain flow data for the 1992 to 1996 period was used in developing rainfall runoff coefficients (winter and summer) for the high flow strategy. This was the period used by the GBWQS in setting its nutrient reduction target.

It was considered desirable that both high flow and low flow drainage diversion strategies be based on the same period of data. Annual and irrigation season drain flows during 1994-97 for each of the three catchments studied were compared against the same flows during 1992-96. The low flow period, 1994-97, was found to yield, on average, 26% smaller annual drain flows and 18.5% smaller irrigation season drain flows, compared to the high flow longer period. Normalising drain flow data to the 1992-1996 period required having to re-run the water balance model to re-derive the irrigation runoff coefficient for the low flow strategy. The Drainage Diversion Working Group did not consider that this approach was warranted given the coarse and subjective assumptions in the model. A readjustment of the CDR to reflect the differences in the estimates of the available low flows for the two periods (Refer to Section 4.2.7) was the approach adopted.

Both strategies were developed for a planning time frame of 10 years. That is, diverters should have reasonable confidence in the basic resource assessment outcomes for that period. At the end of this period a major evaluation of the strategy is to take place (see Section 9.1), in particular in relation to the long term effectiveness of a nutrient reduction strategy which relies on runoff reduction and to ensure that changes in water use and management are identified.

3.4. Salinity and groundwater pump disposal

The development of the strategies for low and high flow drainage diversion concentrated on quantitative rather than qualitative aspects of drainage water resources. The only water quality aspect considered was salinity and that only to a minimum extent. Future discharge of pumped groundwater into drains in the SIR has the potential to significantly affect salinity of drain flows. A network model is being developed separately to manage, for planning purposes, the discharge of pumped groundwater into drainage systems in the SIR. The use of that model in conjunction with the Salt Disposal Guidelines for Surface Drains adopted for the Shepparton Irrigation Region Land and Water Salinity Management Plan (SIRLWSMP) should ensure that the salinities of drainage waters remain within limits suitable for irrigation.

3.5. TWE salinity guidelines

The current 'Permanent Transfer of Water Entitlement Salinity Guidelines' state - *In the Torrumbarry and Pyramid-Boort Areas drainage diversion water will not normally be considered as part of the annual available water entitlement. Where there is a consensus between a Water Services Committee and the relevant salinity group that, for sound technical reasons, drain diversion licences (or certain types of drain diversion licences) in an Irrigation Area (or part of an Irrigation Area) should not be included in the annual available water entitlement, then this will be taken into account. Such variations will require board approval and will become an attachment to the TWE salinity guidelines'* (G-MW, 1999a).

Any permanent transfer is assessed on the basis of maximum water entitlement which is determined to allow a maximum water use limit from all sources, including drainage diversion allocations (Tiers 1, 2 and 3). Thus, the Transfer of Water Entitlements (TWE) salinity guidelines applies to all drainage diversion agreements in respect of permanent transfers.

When assessing temporary transfers, the maximum water use limit will take into account the drainage diversion volume likely to be available in the current season regardless of the tier classification.

This Strategy acknowledges the constraint imposed by the inclusion of all drainage diversion allocations in permanent and temporary TWEs. However, the Strategy encourages WSCs to exercise their discretionary power, in particular with regards to Tiers 2 and 3 (subject to technical justification), to minimise the deterrent effect that TWE salinity guidelines have on increased drainage diversion.

3.6. Legal liability

G-MW sought legal advice in relation to the legality of proposed changes to management arrangements, recovering additional costs through increased charges (surface drainage or drainage diversion), and potential claims resulting from adverse effects on some users. According to that advice, in developing and implementing changes, G-MW must have regard to matters listed in Section 40 (Matters to be taken into Account) of the Water Act 1989 (Adams, 1996).

Although G-MW cannot and does not guarantee quantity or quality of drainage water, in authorising new diversions, it is under the obligation to consider both the environment and the interests of existing diverters. G-MW is not under any obligation to provide or regulate water in its drains in any specific quantity or quality. G-MW is not liable for any damage caused to the consumer as a result of the quantity being insufficient or its quality being inappropriate, unless that damage is clearly a result of G-MW's decisions or actions which have not given appropriate regard to matters listed in Section 40 (Adams, 1996).

3.7. Nutrient concentrations

This Strategy is fundamentally aimed at improving water quality in receiving waters by reducing drainage outfalls into waterways. The potential to reduce nutrient loads in drain outfalls is based on the assumption that nutrient concentrations remain relatively constant irrespective of flow discharges (GBWQWG, 1995). This assumption is widely used in the field and requires further testing.

3.8. MDBC water cap and private water rights

The purpose of this strategy is to harvest irrigation runoff or rainfall runoff induced by irrigation, not to harvest non-irrigation induced runoff. The low flow component targets, by definition, runoff induced by irrigation water. It is considered that the target set by this Strategy for high flow diversion will only capture additional rainfall runoff generated as a result of prior irrigation in the catchments (see Section 5.2.9).

4. LOW FLOW DIVERSION STRATEGY

The low flow diversion strategy aims to regulate drainage diversions during normal irrigation periods. It targets irrigation runoff and involves minimal on-farm storage of the diverted water.

Given that, in general terms, there is an unsatisfied demand for low flow drainage diversion and that it requires marginal resources to implement, there is relatively good potential for the low flow strategy to meet its limits. Although the Strategy aims for the same objectives as the GBWQS it identifies that the targets set by the latter are not attainable (see Section 9.1.1).

4.1. Development stages (Appendix A)

Appendix A. Low Flow Diversion Strategy - Development Stages, summarises the process followed in arriving at the low flow drainage diversion strategy. It presents a brief account of what the Deakin pilot projects comprised, its objectives, assumptions, surveys, specific models, outcomes, metering trials, etc. As such this section contains valuable background information which helps to better understand the key strategy elements listed in Section 4.2.

4.2. Key strategy elements

4.2.1. Tier structure

The tier structure in the type of drainage diversion agreements is aimed at providing diverters with greater equity and confidence in their ability to access available drainage flows. It aims to balance the need to protect the rights of diverters already authorised whilst providing an opportunity for new diverters at times when above 'average' flows can be expected.

Tier 1 agreements prescribe the conditions that allow access to available low flow drainage water at any time during an irrigation season.

Tier 2 low flow drainage diversion agreement arrangements allow access to drain flows during those years when flows are expected to be above average. Above average drain flows are anticipated to occur when channel water sales allocations are in excess of 50% of Water Rights. Based on past records for the Deakin Catchment, this is likely to occur 9 years out of 12, that is, a reliability of 75% (G-MW, 1997). Once the announcement is made about sales availability, both Tier 1 and Tier 2 agreement holders would have equal rights to the resource.

Low flow drainage diversion agreements are made available to supplement irrigation supply from other sources onto designated land.

Tier 3 refers to high flow diversion agreements and is covered in Section 5.2.1.

4.2.2. Contingent allocation

The contingent allocation redistribution mechanism aims at encouraging greater use of available flows by aligning drainage diversion volumetric allocations with availability and usage of the resource. Tier 1 agreements are to be issued with lower and upper limit volumetric allocations. Diverters are then expected to consistently use their minimum allocation, in years when drain flows are available, to retain their agreements.

Tier 1 and 2 agreement holders are entitled to divert up to 150% of their allocation without authorisation by the Area Manager. Diversions above this upper limit would be subject to express approval depending on the Area Manager's knowledge of local conditions about demand and flow conditions in the drain at the time of a particular requested overdraft.

Tiers 1 and 2 allocations would be adjusted up or down on the basis of historic usage and perceived effect on downstream users. Similarly, allocations would increase or decrease over time as drain flows vary. The aggregate of unused components of allocations would be made available for further diversion either by existing or new users.

The allocations calculated by the contingent allocation process may be increased or decreased subject to consideration of local issues, impact on other users and express requests from individual diverters to raise or lower their allocations. The contingent allocation would be reviewed every three years, unless extreme climatic conditions occurred. The main advantage of the contingent allocation process is that it compensates for the lack of knowledge and uncertainty with all the variables involved in the future availability of the resource. The allocation is calculated using monitored diversion data collected since the last review, excluding uncharacteristically dry or wet seasons.

$$contingent\ allocation = 0.8 * \frac{(UseY_1 + UseY_2 + UseY_3)}{3} = 0.8 * average\ usage$$

Equation 1

$$\text{maximum usage} = 1.5 * \text{contingent allocation} = 1.2 * \text{average usage}$$

$$\text{minimum usage} = 0.65 * \text{contingent allocation} = 0.5 * \text{average usage}$$

Those who exceed their maximum usage without express approval by the relevant Area Manager would incur penalties including termination of their diversion agreement.

There has been increasing dissatisfaction with the implementation phase of the Deakin pilot project because of two major reasons. Metering arrangements are perceived to not have provided the additional value expected. The maximum limit, 150% of the allocation is perceived to be benefiting some users more than others.

The 150% upper limit- which does not require express approval for diversion- in low flow drainage diversions for the Deakin was set because of the identified large volume available, 13,500 ML/year. The dry climatic conditions of the last three years have resulted in little rainfall, runoff and drain flows. These conditions have not allowed the strategy to be put the test and have been the main impediment to evaluation in the Deakin.

In years of below average drain flow conditions Area Managers have discretionary power to limit usage to contingent allocations or even reduce allocations.

4.2.3. Transfer of drainage diversion allocations

Drainage diversion allocations are not transferable unless otherwise recommended by the relevant WSC and approved by the Board for a particular drain catchment.

4.2.4. Metering

Metering was agreed as the only method to objectively determine whether allocations are used, how much water is being diverted and the effect of drainage diversions on drain flows.

Experience so far has demonstrated that metering arrangements, in particular indirect metering devices, have had limited success and the little data that G-MW has been able to record is not very reliable (see Appendix A). The indirect meters have not provided the additional value expected. In general terms the meters are inaccurate because of the operating conditions, unreliable, prone to damage given the harsh flow conditions, prone to being tampered with, require high maintenance resources and have relatively short life spans (1-10 years).

A trial and comparison of Davies Shephard propeller meter, revolution counters, Signet Paddle flow meter and power meters was conducted at some sites in the Bamawn and Deakin drain catchments. The trial assessed reliability and accuracy of the meters used and collected cost information (SKM, 1997b). The report presented information on the various sites and meters but was inconclusive in terms of recommending a uniform, suitable and economic method of metering.

Trials of direct/indirect flow metering options, both to minimise costs and take into account the physical requirements of individual installations, are to continue until a suitable arrangement is found, because metering is crucial to the implementation of the framework for low flow diversion management.

Metering costs (including initial survey and inspection of installations, supply, fitting, calibration, operation, maintenance and replacement of meters) of existing low flow drainage diversion sites are to be covered by G-MW. These costs are then to be recovered through charges (surface drainage or drainage diversion) levied by the relevant Irrigation Area.

Goulburn-Murray Water is to continue seeking metering funding contributions from external sources, eg Natural Heritage Trust, Victorian Nutrient Management Initiative, where appropriate.

Individual diverters are to cover the costs of supply and installation of meters for new sites, any metered installations altered by the diverter, or where there is change of ownership of an unmetered site. Design/specification costs associated with non-standard metering conditions will need to be covered by the individual diverter through the application assessment process. All ongoing costs are to be recovered through charges.

The decision on a direct or indirect method of metering is to be made by G-MW considering individual site conditions. Diverters who disagree with the method of metering selected by G-MW may install an alternative metering device, with the diverter paying the cost difference between the two methods, provided the alternative method is approved by G-MW.

G-MW is to provide all diverters with log books. Diverters are to fill in their log books irrespective of the method of metering. Failure to complete log books may result in alternative methods of assessing water usage (eg 100% calibration factor or area-depth method).

There are approximately 700 low flow diversion sites in the whole of the SIR. Some 200 of these sites have been fitted in the last three years with metering devices, mostly indirect meters. The Irrigation Areas expect to meter the remaining sites within the next three to five years in accordance with the catchment priority (see Section 7.2).

It is envisaged that with declining costs and improvements in technology, direct rather than indirect metering will become more affordable. The preferences of the Irrigation Areas in relation to methods of metering have been accounted for in the costing of the Strategy. The full cost implications to G-MW and its customers have been assessed and detailed in Section 8.

4.2.5. Rostering

The overall aim of the strategy is to maximise diversion of available flows and minimise outfalls to receiving streams. Rostering is an instrument for sharing the resource and thus is a means of enhancing the probability of increasing diversion. Rostering, however, may not be practical or necessary in all cases.

Goulburn-Murray Water will, subject to recommendation by the relevant WSC, facilitate the development of rostering arrangements on a particular drain catchment provided the diverters agree (test to be developed) to both implement and police the new arrangements.

The Rochester Irrigation Area manages a rostering arrangement for diverters in the Bamawn drainage system. There are five groups of diverters in the catchment. The roster system has been in operation for several years and is generally successful.

4.2.6. Fees and charges

Pricing for drainage water diverted under Tier 1 and Tier 2 agreement conditions is to be on the basis of allocations and volumes diverted above allocation.

Whilst a diversion site remains unmetered the diverter is required to pay charges based on the Agreement volume only.

Tier 1 charge = administration fee + volumetric fee x (volumetric allocation)

Tier 2 charge = administration fee + volumetric fee x (volumetric allocation)

In Central Goulburn and Rochester Irrigation Areas any actual diversion of low flows above the allocation stated in the Agreement is also charged at the same price. The volumetric fee is currently one quarter of the gravity irrigation fee in the relevant Irrigation Area. See Section 8 for implications of the Strategy on prices and Appendix C for a discussion on tariff options. The Tier 1 allocation component is payable regardless of the availability of the resource or the actual volume used. The Tier 2 allocation component is payable, irrespective of usage, only if water sales are greater than or equal to 50% Water Right (or any other agreed pre-set level in the drain catchment).

4.2.7. Decision criteria - CDR

The standard methodology for assessment of new or amended low flow drainage diversion applications is the use of the Current Diversion Ratio (CDR) decision indicator. This provides a measure of current use against estimated resource availability.

CDR is the ratio of utilisation of available low flows by existing diversions and is defined by:

$$CDR = \frac{CLFAV}{(CLFAV + ALFV)} = \frac{CLFAV}{LFV}$$ **Equation 2**

Where:

CLFAV = current total low flow allocated volume, ML

ALFV = available unallocated low flow volume, ML

LFV = total estimated low flow volume, ML.

For a more comprehensive discussion on the CDR refer to Appendix A, Section 6. The CDR is to be evaluated for the standard reference period, the irrigation seasons from 1994/95 to 1996/97, the criteria to be applied is that presented in Table 2 below.

Table 2 - Criteria for Issuing of Low Flow Drainage Diversion Agreements

Low Flow Diversion Agreement	CDR
Nil	0.7 - 1.0
Tier 1	0.0 - 0.5
Tier 2	0.5 - 0.7

4.2.8. Groundwater pump disposal

The adopted SIRLWSMP guidelines for controlled groundwater discharge into G-MW primary drains are:

- For existing drain salinities less than 530 EC, an upper limit of 800 EC; and
- For existing salinities more than 530 EC, an allowable increase of 50% with an upper limit of 1,700 EC.

These baselines and resultant salinities are irrigation season flow weighted averages for low flow periods and average seasonal conditions (SKM, 1998a). The existing salinities refer to best estimates of salinities for the period 1994 to 1997 used in developing the guidelines .

The salinity network model (see Appendix A Section 5) provides the necessary link between drainage diversion management arrangements and groundwater pump disposal, in accordance with disposal guidelines, to ensure that drainage water remains within limits suitable for irrigation.

4.2.9. Irrigation runoff modelling

Appendix A Section 4 presents a complete description of the model that is being used to estimate irrigation induced runoff. The currently adopted irrigation runoff coefficient C_I is 0.15, the average of irrigation runoff coefficients for the three catchments studied (SKM, 1998b). It should be noted that this coefficient was specifically derived for the purpose of managing drainage diversions. The use of this coefficient for other applications is at the discretion of the user.

The calibration of the model found better drain flow estimates when restricting the modelling to drained areas of the catchment. Consequently, the irrigation runoff coefficient should only be used for those areas of the catchment that are formally drained.

In some instances, local experience may suggest that the estimates arrived at using model coefficients are so much in error that they should be disregarded. In such cases adequate monitoring needs to be implemented to obtain reliable data. It might also be necessary to delay the issuing of any new allocations until such information is available.

The runoff coefficient implicitly takes into account the climatic conditions that were prevalent during the irrigation seasons in the base period of 1994 to 1997; and other conditions such as reuse systems, irrigation techniques and methods, etc. Thus, the irrigation runoff coefficient should not be expected to have a long term (greater than 10 years) life. That is, a major review of drain behaviour and diversion should occur within 10 years of the preparation of the initial DDP for any catchment (see Section 9.1).

4.2.10. Infrastructure

All drainage diversion installations must comply with G-MW's requirements. These requirements include the need for reuse systems to be separate from diversion arrangements; and low flow to be separate from high flow diversion.

New or existing diverters who cannot comply with these requirements must provide alternative arrangements to the satisfaction of the relevant Irrigation Area Manager, particularly in relation to monitoring of low flow diversion volumes.

4.2.11. Low level rock weirs

Various research projects have investigated the use of created wetlands in drains for nutrient removal. These projects have identified low level rock weirs as providing adequate conditions for the entrapment of sediments and nutrients, in addition to facilitating drainage diversion, which also removes nutrients.

This Strategy encourages the installation of low level rock weirs at the lower end of the catchments before they outfall into receiving waters, to enhance opportunities for drainage diversion. This practice, however, must be such that it has no impact on the hydraulic performance of the drains.

The Strategy does not support the installation of low level rock weirs throughout the catchments until the performance of the same at catchment outfalls is reviewed and found to be advantageous.

5. HIGH FLOW DIVERSION STRATEGY

The high flow diversion strategy mainly targets rainfall runoff during both irrigation and non-irrigation periods and requires substantial storage of diverted water for later use, as the flows occur at times of low demand for irrigation water. Appendix B presents a detailed description of the process followed to develop the high flow diversion component of the Strategy.

5.1. Development stages (Appendix B)

The initial development of the methodology for assessment of resource availability was carried out for the Bamawn Catchment using actual and synthesised records from 1982 to 1997. The methodology was then applied to the Bamawn, Upper Deakin and Murray Valley Drain 6 for the standard period 1992 to 1996.

5.2. Key strategy elements

5.2.1. Tier structure

The tier structure in the type of drainage diversion agreements is aimed at providing diverters with greater fairness and confidence in their ability to access available drainage flows.

Tiers 1 and 2 agreements apply to low flow drainage diversion whose details are covered in Section 4.2.1.

Tier 3 drainage diversion agreements detail the conditions for diversion of high flows. Tier 3 gravity supply is based on the installation of a diversion structure with a fixed sill. This allows unrestricted access when drain water levels are above the sill level. Tier 3 pumped supply provides restricted (dependent on express approval by the relevant Irrigation Area Manager) access to high flows.

5.2.2. Transfer of drainage diversion allocations

Drainage diversion allocations are not transferable unless otherwise recommended by the relevant WSC and approved by the Board for a particular drain catchment.

5.2.3. Metering

For the purposes of this Strategy, neither current nor future demand prospects for high flow diversion across the whole of G-MW warrant a requirement for metering of high flow drainage diversion installations. There is, however, a requirement that low flow and high flow installations have separate arrangements to allow for appropriate metering of low flow diversion. In addition, G-MW may require the diverter to supply and install an approved meter as a condition of a specific high flow drainage diversion agreement.

The Strategy proposes that high flow drainage diversion agreements have a maximum annual diversion volume of twice the authorised storage capacity. Enforcement of the limit would require introduction of metering which, so far, is not envisaged. Even without metering, the limit provides a signal to diverters that high flow diversions will be restricted if and when the demand exceeds the available resource.

Diverters are to fill in log books provided by G-MW. Failure to complete log books may result in the agreements being revoked.

5.2.4. Rostering

G-MW will, subject to recommendation by the relevant WSC, facilitate the development of rostering arrangements on a particular drain catchment provided the diverters agree (test to be developed) to both implement and police the new arrangements.

5.2.5. Fees and charges

Currently, Tier 3 either pumped or gravity fed high flow drainage diversions installations only attract a service or administrative fee. However, WSCs have discretionary power (subject to Board approval) to alter these arrangements depending on particular circumstances relevant to the Irrigation Area. Central Goulburn Irrigation Area currently charges for pumped high flows during the irrigation season at the same price as low flows, that is 25% of the gravity irrigation fee.

5.2.6. Decision criteria - Storage/High Flow ratio

After considering the likely impact on individual diverters it is recommended that the maximum storage capacity in any drainage catchment be limited initially to 200 ML/1,000 ML of estimated annual high flow volume (based on the period 1992 to 1996), see Appendix B Section 6. The maximum storage capacity in a catchment can be increased if it can be demonstrated that only irrigation induced rainfall runoff would be diverted. Area Managers may recommend an increase in the storage-high flow ratio if it is clear that surplus flows are available and can be diverted without excessive effect on existing diverters. The modelling indicates that the adopted criteria will result in storage-fill ratios close to or greater than 1 in each of the three modelled catchments for the period July 1990 to June 1996; and diversion of more than 30% of the available high flows for that period (SKM, 1999a). However, storage-fill ratios would be much lower over a longer period of record including drier years as experienced in the early '80s.

5.2.7. Economic modelling

In the Shepparton Irrigation Region, DNRE offers grants of 25% of capital costs up to a maximum grant of $20,000 per high flow diversion storage installation under its Nutrient Removal Incentive Scheme. Modelling indicates that these installations are economically viable, based on the value of the additional resource provided, for both the diverter and DNRE if capital costs are less than $400/ML storage capacity and storage-fill ratios are greater than or equal to one (Gyles, 1999).

In the Loddon-Murray area, centred around Kerang, there are currently no incentives for construction of high flow diversion storages, although there are incentives for most other farm and drainage works.

The costs of systems constructed so far have generally been much greater than $400/ML storage capacity, however, landholders may perceive additional benefits not accounted for in the economic analysis. The proposed limit of 200 ML/1,000 ML of estimated annual high flow volume should ensure that storage-fill ratios will generally be greater than one for periods similar to 1992 to 1996.

5.2.8. Wetlands

Some catchments incorporate nutrient stripping features such as en route or off line wetlands, sumps, cut off loops, etc. or environmental enhancement/restoration of existing wetlands. The Strategy requires that the total annual volume required by these features be subtracted from the total high flow estimate before applying the decision criteria for assessment of high flow drainage diversion applications.

When available, historical information on flows diverted to existing wetlands features should be used rather than estimates. In such cases the decision criteria can be applied with greater confidence.

The design of new wetland-type features in a drainage system is to be in accordance with wetlands in drains design guidelines. The annual volume required to simulate the wetting and drying regime of the wetland must be made explicit by the designer so it can be subtracted from the high flow estimate. This volume should be specified on the basis of long-term catchment development rather than interim conditions.

Where environmental flows or special requirements (eg wetland management plans) have been agreed for an existing or proposed wetland-type feature, arrangements should be made for DNRE to undertake monitoring. Monitoring may include the frequency, flow and water quality (in addition to other agreed water quality indicators, eg health of wetland vegetation or fauna) of inputs to (and outputs from, if required) these wetlands. Monitoring will verify whether the commitment is being delivered in addition to allowing a long-term assessment of the effectiveness of the wetland from water resource management and water quality improvement perspectives. Where problems are identified, DNRE will need to negotiate with G-MW to either modify works (eg sill levels) or diversion rules to deal with the problems encountered.

5.2.9. MDBC water cap and private water rights

To account for the requirements under MDBC's water cap, significant flows from upstream dryland catchments are not to be included in any estimates of volumes available for diversion.

There is concern that volumes captured by high flow diversion storages may be in excess of volumes which farmers in dryland catchments are allowed to harvest under private water rights.

The purpose of G-MW Drainage Diversion Strategy is to improve the water quality of receiving waters by reducing irrigation drainage outfalls through increased drainage diversion. The drainage diversion is aimed at harvesting irrigation runoff or rainfall runoff induced by irrigation, not at harvesting non-irrigation induced runoff. The low flow component targets, by definition, runoff induced by irrigation water. It is considered that the target set by the Strategy for high flow diversion (30% of total rainfall runoff) will only draw from the additional rainfall runoff generated by prior irrigation in the catchments.

Refer to Table 3 for dryland-catchment rainfall-runoff coefficients (Beavis and Lewis, 1997). Given the heavy soil and annual rainfall (approximately 480 mm) characteristics of irrigated catchments in G-MW's areas, an equivalent dryland runoff coefficient of the order of 7.5% has been adopted for the purpose of a coarse comparison with irrigated catchments.

Table 3 - Percentage yield of average annual rainfall, north of Great Divide in Victoria and on the western slopes of the Great Divide in NSW and Queensland (Beavis S and Lewis B, 1997)

Average annual rainfall, mm	Light soil	Medium soil	Heavy soil
< 375	1	1.5	2
375 - 525	3	4	5
525 - 1,000	5	7	10
> 1,000	10	20	30

The runoff coefficients quoted in Table 4 below for irrigated catchments are the result of hydrologic modelling of three typical irrigated gauged catchments (Bamawn, MV Drain 6 and Deakin) in the SIR.

Table 4 - Irrigated vs Dryland Runoff Comparison

Dryland catchment	Irrigated catchment				Rainfall runoff above dryland runoff	Diversion target (30% of total rainfall runoff or Average Summer-Winter rainfall runoff)	Target as a percentage of runoff above dryland runoff
	Irrigation	Rainfall					
		Winter	Summer	Average			
0.100	0.150	0.12	0.175	0.1475	0.0475	0.0443	93%
0.075	0.150	0.12	0.175	0.1475	0.0725	0.0443	61%

Table 4 uses an average rainfall runoff coefficient of summer and winter. It should be noted that this appears appropriate as winter and summer rainfall in the region are approximately of the same magnitude. The winter runoff coefficient is considered to underestimate the amount of rainfall runoff that would occur under extreme rainfall events, particularly during winter or spring.

This brief and coarse analysis indicates that the set target for high flow diversion (30% of estimated runoff) would draw on average 60% (93% under worst case scenario) of the irrigation induced rainfall runoff.

5.2.10. Groundwater pump disposal

There are no specific salt disposal guidelines into surface drains for high flow periods. However, given that worse salinity conditions occur during low flow periods, the agreed guidelines detailed in Section 4.2.8 for low flow periods are considered to be adequate under high flow scenarios.

5.2.11. Rainfall runoff modelling

Summer and winter rainfall runoff coefficients have been determined for use in catchments that were not gauged during the standard period (1992 - 1996) used for resource assessment.

Based on the work done, the currently adopted summer rainfall runoff coefficient is 0.175. The winter rainfall runoff coefficient can be derived from the following linear relationship.

$$C_{Rw} = 0.124\, Drain\, Density - 0.0007$$ **Equation 3**

Where, Drain Density is the length of drain per drained area of the total catchment expressed in Km/Km^2.

The winter rainfall runoff coefficient derived with the linear relationship is to be used for the whole of the non-irrigation season. Such a coefficient is likely to underestimate drain flows following extreme rainfall events in spring. As a result, its use results in conservative water resource estimates from a high flow diversion perspective.

The summer rainfall runoff coefficient and winter runoff relationship may be reviewed over time to allow for new developments in catchment modelling techniques and monitoring.

5.2.12. Infrastructure

Drainage diversion applicants wishing to pump high flows are required to construct or utilise special purpose dams to store diverted high flows. Prospective diverters considering applying for incentives under the Nutrient Removal Incentive Scheme are required to prepare Whole Farm Plans (WFPs) which meet DNRE's design guidelines. The relevant Irrigation Area Manager should request WFPs and assess the plans unless the application has already been assessed and approved for an incentive by DNRE. Approval of the constructed works should be the responsibility of Local Government as part of the planning permit process.

Under the current Victorian Planning Provisions schedules a permit may be required to carry out earthworks or construct dams. A permit is required for earthworks that change the rate of flow or the discharge point of water across a property boundary or increase the discharge of saline water. Local government councils set the size/dimensions of the land to which these conditions apply. A permit is required to construct dams above a certain capacity, with councils setting the capacities above which these permit conditions apply. The schedules are common across the State for the various zones (eg rural living, environmental rural and rural), however, the specific requirements under each zone may vary amongst local government councils. Table 5 below shows the current (September 1999) conditions set by councils in their Planning Schemes.

Table 5 – Planning permit conditions for Dams and Earthworks by Councils within G-MW's area of jurisdiction

Local government council	**Zone**	**Permit for earthworks…**		**Permit for dams above capacity**
		that change the rate of flow or the discharge point of water across a property boundary.	*increase the discharge of saline groundwater.*	

Local government council	Zone	Permit for earthworks…		Permit for dams above capacity
Moira	Rural	All land except that for which an approval or an exemption has been made or granted under the 'Planning Controls for Earthworks in the Goulburn Broken Catchment, November 1997'.	All land except that for which an approval or an exemption has been made or granted under the 'Planning Controls for Earthworks in the Goulburn Broken Catchment, November 1997'.	All land in this zone - 5,000 m^3.
	Rural Living	As for Rural zone.	As for Rural zone.	All land – 3,000 m^3.
	Environmental rural	As for Rural zone.	As for Rural zone.	All land - 3,000 m^3.
Shepparton	Rural	All land in this zone	All land in this zone	All land in this zone - 0.0 m^3 except in accordance with a WFP certified by Council.
	Rural Living	All land in this zone	All land in this zone	All land in this zone - 0.0 m^3 except in accordance with a WFP certified by Council.
	Environmental rural	N/A	N/A	N/A
Campaspe	Rural	All land except that for which an approval or an exemption has been made or granted under the 'Planning Controls for Earthworks in the Goulburn Broken Catchment, November 1997'.	All land except that for which an approval or an exemption has been made or granted under the 'Planning Controls for Earthworks in the Goulburn Broken Catchment, November 1997'.	All land within the zone – 3,000 m^3.
	Rural Living	As for Rural zone.	As for Rural zone.	All land within the zone – 3,000 m^3.
	Environmental rural	N/A	N/A	N/A
Gannawarra	Rural	Any land within the Rural Zone excluding earthworks carried out with an approved WFP.	All land.	All land – 3,000 m^3.
	Rural living	N/A	N/A	N/A
	Environmental rural	N/A	N/A	N/A
Loddon	Rural	All land in the Loddon Shire.	All land in the Loddon Shire.	3,000 m^3.
	Rural living	All land.	All land.	All land.
	Environmental rural	N/A	N/A	N/A
Swan Hill	Rural	All land excluding earthworks carried out in accordance with an approved WFP.	All land.	All land – 3,000 m^3.
	Rural living	All land.	All land.	All land – 3,000 m^3.
	Environmental rural	N/A	N/A	N/A

Thus, all dams built in G-MW's area of interest for the purpose of high flow diversion require a planning permit, or equivalently, a certified Whole Farm Plan as in the case of Greater Shepparton City Council.

All drainage diversion installations must comply with G-MW's requirements. Subject to approval, inlet installations may provide for gravity or pumped diversion of drain flows. Generally, gravity intake installations do not require express approval by the Irrigation Area Manager to divert flows. Requirements include the need for reuse systems to be separate from diversion arrangements, and low flow to be separate from high flow diversion.

New or existing diverters who cannot comply with these requirements must provide alternative arrangements to the satisfaction of the relevant Irrigation Area Manager.

Effective diversion under good conditions of supply and demand can be achieved with a pump capacity of about 10 ML/d for every 100 ML of storage capacity. To limit adverse effects on existing diverters and ensure reasonable sharing of the water resource, new diversion agreements should be limited to an inlet capacity of 15 ML/d per 100 ML of storage capacity.

6. POTENTIAL IMPACTS/ RISKS

Irrigation with drainage water requires a comprehensive analysis even beyond the area where the water is applied. It needs a broader scope beyond the irrigation scheme taking into consideration soil degradation (in the form of worsening land salinitation, and increased nutrients and sediments), groundwater and downstream surface water resources of the catchment; amongst other things.

Other issues such as biocides and pathogens are a recognised concern. Field and laboratory surveys over two consecutive years in four drains in the SIR has found no evidence of the presence of biocides at the selected locations, however, the risks cannot be dismissed.

This strategy acknowledges that these are potential risks resulting from irrigating with drainage water. However, these potential risks are addressed more comprehensively by other programs including Water Quality Strategies, G-MW's Environmental Management System and salinity management plans. This strategy is consistent with current requirements under those programs.

7. IMPLEMENTATION

7.1. Current status

Implementation of the drainage diversion strategy in catchments depends initially on the assessment of the resource in those catchments. Resource assessment is being systematically addressed in the preparation of Drain Diversion Plans (DDPs) for each drain catchment.

Hydrologic modelling, and therefore resource assessment, was carried out for the Bamawn, Deakin and Murray Valley Drain 6 catchments as part of the development of the Strategy. In these three catchments the implementation of all aspects of the Strategy has progressed appreciably. For other drain catchments in the SIR, and whilst DDPs are completed, the implementation of the low flow diversion strategy is concentrating on metering drainage diversion installations.

Assessment of drainage diversion sites for suitability of a range of direct and indirect metering has taken place in Central Goulburn, Murray Valley and Shepparton Irrigation Areas. Rochester and Shepparton IAs are fundamentally opposed to indirect metering given the limited success experienced by the Central Goulburn IA and in particular in the Deakin Catchment.

High flow diversion is taking place in several catchments across the various Irrigation Areas but mostly in a very ad hoc manner. Both Rochester and Central Goulburn Irrigation Areas have halted the assessment of additional applications pending completion of this Strategy and DDPs. The Drainage Diversion Strategy is to standardise the different approaches and bring them into a common management umbrella.

7.2. Specification for preparation of Drain Diversion Plans (Appendix D)

Because of the uncertainties associated with much of the information available and the likely differences between catchments, it is proposed that the procedures detailed in Appendix D be followed in preparing DDPs for each drain catchment. The Drain Diversion Plans are to include catchment based diversion status, targets for drainage diversion, documentation of variations from standard approaches and recommendations about additional flow monitoring requirements.

Table 6 lists the priorities according to which DDPs are being developed. These priorities were set mainly from a water quality perspective, that is, impact on receiving waters as identified by the Goulburn Broken and Campaspe Water Quality Strategies.

On implementation of the DDPs the relevant Irrigation Area Manager should monitor uptake of drainage diversion agreements and volumes, channel outfalls and the response in drain flows to assess, in consultation with the Natural Resources Tatura unit, the need to either raise or lower targets in the catchment. Any changes in targets are subject to WSC recommendation and Board approval, should be clearly identified and justified and the plan amended accordingly. Irrigation Area Managers should consider the requirement for any upgrading of their current drain monitoring to support changes to the plans.

Table 6 - List of Priority Catchments for Preparation of DDPs

Irrigation Region	River Basin	No	Drainage catchments	Irrigation Area	Description, features and notes.	Drain sub-catchments	Priority	DDP Status
Shepparton	Goulburn Broken	1	Deakin	CG/R	CG Deakin and Rochester Drain 6. Features: Harston and Cornelia Creek.	no further sub-divisions	VH	in progress
		2	Barmah/ Nathalia	MV	Drains 7, 9, 10, 11, 13, 18, 19 and 20.	Drain 13 system: Drains 7, 10, 13 and 18.	VH	in progress
						MV Drain 18	VH	in progress
						All other	?	
		3	Strathmerton	MV	Drains 3, 5 and 6.	Drain 6	VH	in progress
						All other	?	
		4	Tallygaroopna	S	Drain 11	no further sub-divisions	VH	in progress
		5	Invergordon	S	Drains 12, 14A, 15 and 16	Drain 12	VH	in progress
						All other	?	
		6	Coram	CG/R	Coram	no further sub-divisions	H	in progress
		7	Mosquito	CG	Features: Mosquito Depression	no further sub-divisions	H	
		8	Shepparton/ Broken River.	S	Drains 1 to 10	Drain 2	M	
						Drains 3 and 4	H	in progress
						All other	M	
		9	Wyuna	CG	Drains 3, 4, 7, 13 and 15.	no further sub-divisions	H	in progress
		10	Rodney	CG	Undera and Rodney Drain 6.	no further sub-divisions	MH	in progress
		11	Tongala	CG	Drain 1. Features: Kanyapella Basin.	no further sub-divisions	H	in progress
		12	Corop Lakes	CG	Features: Timmering Depression, Woolwash Depression, Stanhope Depression, Lake Cooper and Greens Lake.	no further sub-divisions	L	
		13	Ardmona	CG			?	in progress
		14	Kaarimba	S	All CSDs		?	
		15	Kialla	S	Drain 13A. All CSDs.		?	
		16	Muckatah	MV		Drain 21 (to be constructed).	?	
						Drain 9 (Channel outfall).	?	
		17	Toolamba	CG	All CSDs		?	
		18	Coomboona	CG			?	
	Campaspe	19	Bamawn	R	Drains 1 and 3.		H	
		20	Lockington	R	Drains 1 to 10		H	
		21	Wharparilla	R	Mullers Creek Main Drain.		H	
		22	Campaspe	R			?	
		23	Strathallen	R			?	
Kerang	Campaspe	?	?	?	?	?	?	
	Loddon	?	?	?	?	?	?	

7.3. Monitoring

7.3.1. Drain Flow

The majority of existing drain monitoring stations are located at or near their outfalls into receiving waters, thus providing only whole of catchment data. Additional drain monitoring within the catchment can facilitate the alignment of diversion allocations with the available resource and usage.

This Strategy allows for the installation of drain flow monitoring stations at currently ungauged outfalls of major drains into waterways. Major drains are here defined as those where Irrigation Areas perceive that flow monitoring would improve drainage diversion management. See Section 8.5.1.

Alternatively, to satisfy the minimum drain flow management objectives identified by a drain monitoring proposal currently being developed (G-MW, 1999b) the Strategy analysed more intensive monitoring. The drain flow management objectives include:

- To assist in the identification of available flows for assessment of drainage diversion applications;
- To provide real time information assist in the operation of drainage diversions, that is, real time decisions about allowing specific diversions to occur at a particular point in time; and
- To provide information to improve revenue collection from drainage diversion installations;

To satisfy these requirements the Strategy assessed the cost effect of monitoring sites that represent the surface runoff conditions of segments of catchment of approximately 5,000 ha (refer to Section 3.1 for sub-catchment size justification and Section 8.4.1 for cost details). The cost assessment of smaller scale monitoring only took into account flow measurement as opposed to other important monitoring parameters that include salinity and nutrients. DDPs can provide a more accurate indication of where additional monitoring sites may be valuable.

Additional drain monitoring stations in either existing drains or new drains is an issue that may need to be negotiated amongst various parties/programs including Catchment Management Authorities, Salinity Program, Goulburn-Murray Water and others. The particular needs of stakeholders must be identified. This will assist in establishing their relative contributions. It is also important to utilise as much as possible the existing network of monitoring stations and define additional monitoring at strategic locations where several purposes and program objectives can be achieved simultaneously.

7.3.2. Drainage Diversions

Goulburn-Murray Water is to meter all low flow drainage diversion installations within the next five years. Meters are to be read as often as necessary to ensure that usage is in line with allocations (see also Sections 4.2.4 and 8.5.2). Annual usage is to be recorded in the IPM database for assessment of the diversion program.

Metering of high flow drainage diversion sites is not a requirement, at this stage (see Section 5.2.3). Given that existing demand for high flow diversion is relatively small, the lack of metering might not pose any problems in the short to medium term. Drain flow monitoring will detect whether the diversion target is being achieved. The proposed high flow diversion agreement requirement to specify a maximum annual volume, even without metering, signals to the diverter that there might be a need to introduce metering in the future.

7.3.3. Channel Outfalls

There is very limited historical channel outfall metering information. The little data there is indicates that channel outfalls are highly variable. Some factors affecting the variability include seasonal allocations, the nature of monitoring itself and how diligently it is carried out, management practices by both Irrigation Areas and customers, etc.

Channel outfalls are a form of loss in irrigation supply systems. They represent on average 4% of the volume supplied at Irrigation Area offtakes and approximately 15% of the total losses. Goulburn-Murray Water is committed to improving water efficiency and therefore one of the underlying principles is to minimise channel outfall volumes (future options to reduce drain flows may include the direction of channel outfalls into on-farm storages rather than drains). Metering of channel outfalls is increasing, mostly in an effort to understand the nature of water losses in irrigation supply systems as part of a water savings study currently in progress.

When preparing Drain Diversion Plans, the relevant Irrigation Area Manager should always be consulted about appropriate short to medium- term allowances for volumes of channel outfall water available for drainage diversion, either low flow or high flow. Unless expressly requested by the Irrigation Area Manager, channel outfall volumes are to be set to zero when estimating available flows in any drain catchment. This assumption will avoid building customer ‘water security’ expectations that rely on channel outfall volumes.

Area Managers should ensure that adequate monitoring of all significant channel outfalls occurs. Monitoring of channel outfalls will indicate whether they should be included in resource assessment of individual catchments, and subsequently whether it will be necessary to revisit drainage diversion targets.

7.4. Advice to Area Managers (Appendix E)

Appendix E presents in a flow chart the main steps that are to be followed, and by whom (within G-MW and advice from DNRE, when appropriate) when assessing drainage diversion applications.

The assessment of individual applications is to be carried out by the relevant Irrigation Area Manager with technical input, where necessary, from Natural Resources Tatura. This assessment is to be generally based on Drain Diversion Plans.

Area Managers are to consider the location of the proposed diversion site and the ability of the upstream segment of the catchment to generate runoff for existing and future demand. Generally the further up the catchment, the less drainage runoff available. Other issues to consider include specific site location aspects and effects on adjacent and downstream individual diverters so as not to unnecessarily disadvantage current diverters.

Irrigation Area Managers should advise prospective diverters of:

- purpose of Drainage Diversion Strategy (high priority to nutrient reduction objectives);
- the assumptions made (actual data and modelling of 3 typical gauged catchments in the SIR over the early to mid 1990s period);
- increases in diversion under the strategy may result in some adverse impact on existing diverters;
- the targets that have been set and which seek to minimise adverse impact on existing diverters;
- potential limitations and risks.

7.5. Conditions of drainage diversion agreements

Table 7 summarises the current conditions set by Tier 1 (unrestricted low flow), Tier 2 (restricted low flow), Tier 3-P (pumped high flow) and Tier 3-G (gravity high flow) drainage diversion agreements.

Table 7 - Conditions of Drainage Diversion Agreements

General conditions:	Tier 1	Tier 2	Tier 3-P	Tier 3-G
source: drain name/number and point of diversion	✓	✓	✓	✓
type of use: irrigation	✓	✓	✓	✓
annual allocation: X ML	✓	✓	✓	✓
area to be irrigated: Y ha	✓	✓	x	x
designated land: lot, plan of subdivision, allotment, section, parish.	✓	✓	✓	✓
frontage to Goulburn-Murray Water's land/easement/reserve	✓	✓	✓	✓
diversion is allowed only if annual season sales allocation is ≥ 50% WR	x	✓	x	x
storage required (other than reuse) and maximum capacity	x	x	✓	✓
maximum daily diversion rate	✓	✓	✓	✓
tenure: 12 months	✓	✓	✓	✓
approved infrastructure and diversion methods	✓	✓	✓	✓
automatic annual renewal (if not terminated due to breach of agreement conditions or Water Act 1989)	✓	✓	✓	✓
Whole Farm Plans/ Planning Permits	x	x	✓	✓
Diverter is to:				
seek G-MW's approval before diverting at any particular time	x	x	✓	x
pay annual charges as fixed by G-MW from time to time	✓	✓	✓	✓
construct and maintain the works to the satisfaction of G-MW	✓	✓	✓	✓
keep log book records of frequency and volumes used	✓	✓	✓	✓
provide G-MW with information about drainage diversion schedules and land to be irrigated (if required).	✓	✓	x	x
own infrastructure other than flow meter	✓	✓	✓	✓
not waste water	✓	✓	✓	✓
not interfere with flow meters	✓	✓	✓	x
not obstruct the flow of water in the drain	✓	✓	✓	✓
not pollute the water through the spillage of fuel, lubricant, etc.;	✓	✓	✓	x
not use the land for any purpose other than that stated in the agreement	✓	✓	✓	✓
Goulburn-Murray Water:				
is not under obligation to regulate water in the drain in any quantity or quality	✓	✓	✓	✓
will not be liable for damages suffered by the consumer due to insufficient or inadequate quantity or quality of water	✓	✓	✓	✓
has the right to revoke agreements when conditions are not met	✓	✓	✓	✓
may give notice to the consumer to cease or reduce diversion if it believes the flow to be insufficient	✓	✓	✓	✓
may require the consumer to install and maintain an approved meter, of which it becomes the owner	✓	✓	✓	✓
may authorise the diversion of volumes greater than those in the agreement, subject to additional fees and other conditions;	✓	✓	x	x
may, when a meter is not available or not in working order, estimate volumes diverted by applying its operating tariff criteria;	✓	✓	x	x

8. COST AND COST SHARING ARRANGEMENTS

8.1. Development stages (Appendix C)

As part of the development process, several options for sharing the cost of implementing the Strategy between drainage users and drainage diverters were considered. These options included the current drainage diversion tariff (base case), a polluter pays tariff (ie drainage user), a beneficiary pays tariff (ie drainage diverter) an arbitrary 50/50 share between polluter and beneficiary, and a market-based tariff.

Full details of what these options involve and the effects on drainage diversion rates and/or surface drainage charges in each of the Irrigation Areas can be viewed in Appendix C. 'Cost Sharing Arrangements Discussion Paper'. The Appendix shows how the options changed through consultation with interested groups to arrive at the final costs and cost sharing of the Strategy, as presented below.

8.2. Assumptions

The Strategy assumes that the only land generating surface runoff that G-MW can allocate in drainage diversion agreements is that land served by primary drains. CSDs are assumed to divert all irrigation induced runoff during the irrigation season.

There are no records of areas served by primary (formerly known as arterial) drains at the start of the Surface Drainage Strategy (SDS) in 1989. This Strategy assumes that all land drained at the start of the SDS was serviced by primary drains since there were very few CSDs, and those in existence at the time served small areas.

The costing of the Strategy has been fundamentally based on low flow drainage diversion. High flow drainage diversion, as set up by this Strategy, is neither to generate any revenue nor to be metered. Costs incurred in operating and administering high flow diversion have not explicitly been accounted for. However, it has been assumed that the unit rates for management of low flow drainage diversion can adequately cover operation of high flow diversion.

To be able to estimate future costs it was necessary to predict future irrigation-induced runoff and low-flow drainage diversion allocations. The 'Drainage Volumes Estimates' spreadsheet records actual progress of the SDS to the end of 1999 and makes projections about irrigation runoff generation over the next 10 years. Coincidentally, it is expected that the SDS will be completed over the same period of time. The different assumptions and calculations in the spreadsheet are documented as notes at the bottom of the spreadsheet.

Table 8 below is referenced in Column AB of the 'Drainage Volumes Estimates' spreadsheet. The data collected at these monitoring points is used to establish annual flows, salt and nutrient loads leaving the Goulburn Broken Catchment.

Table 8 - Monitored drain outfalls for regional balance

Irrigation Region	Irrigation Area	Station No.	Flow: Sum of Station annual average drain flows for available period (Sinclair Knight Merz, 1998)
Shepparton	Central Goulburn	406704	Deakin Main Outfall at Echuca
		405297	Warrigal Creek
		405720	Rodney Main Drain at Wells Creek
	Murray Valley	409712	Murray Valley Drain 6
		409711	Murray Valley Drain 3
		404210	Broken Creek at Rices Weir
	Rochester	406758	Bamawn Main Drain downstream of Murphy's Swamp
	Shepparton		
Kerang			

8.3. Options

The Strategy analyses two options, the first being the 'top of the range' and the second being the 'minimalist' option. The 'top of the range' option involves a rigorous degree of monitoring and management whilst the 'minimalist' option only accounts for the bare minimum requirements.

There is a range of intermediate and slightly different steps between the 'top of the range' and the 'minimalist' options by which Irrigation Areas can increase and manage, to different degrees, drainage diversion. The two options outlined by the Strategy are only two of many available options; however, ones that are expected to apply uniformly across the Areas. The Strategy proposes that Areas adopt the 'minimalist' option and work towards higher levels of management as they see fit on a catchment basis.

8.4. Costs 'Top of the range' option

8.4.1. Drain flow monitoring

8.4.1.1. Capital

The 'top of the range' option proposes to install additional in-catchment drain flow monitoring. Although this drain flow monitoring would help understand catchment yield it would mostly provide information to manage drainage diversions. This is the reason the cost is wholly attributed to the Drainage Diversion Strategy.

There are existing monitoring stations at the main outfalls of drain catchments into waterways. These stations monitor the entire upstream catchment but do not provide information at a smaller scale. The Strategy assumes that each Irrigation Area will, over the first five years of the Strategy, install additional drain flow monitoring stations within the drain catchments at a ratio of 1 station per every 5,000 ha of primary drained land (Refer to Section 3.1).

The in-catchment flow-monitoring stations are to provide real time flow data that Managers can use for drainage diversion decision-making purposes. That is, these stations are to be fitted with SCADA-type instrumentation.

The number of additional monitoring stations is obtained by dividing the total area to be drained by primary drains at the end of the Surface Drainage Strategy by 5,000 ha and subtracting the number of current monitoring stations.

8.4.1.2. Operation

Allowance for operation (data retrieval, validation, processing and reporting) of drain flow monitoring stations, see spreadsheets.

8.4.1.3. Maintenance

Allowance for routine maintenance of probes and instrumentation on the sites, regular visits, etc. See spreadsheets.

8.4.1.4. Renewals

The renewal of drain flow monitoring instrumentation is assumed as a maintenance cost (but calculated separately) as the equipment and software become obsolete within a short period of time (less than 10 years). The discount rate used is 4%.

8.4.2. Drain diversion meters

8.4.2.1. Capital

The Strategy assumes that G-MW will meter all existing drainage diversion sites within the first five years of the Strategy. Any number of diversion sites above those existing at the end of 1998/1999 financial year will either be metered by individual diverters or funded by the implementation of the SIRLWSMP. The latter applies when the sites are reinstated as part of the construction of new primary drains, where the Surface Drainage Strategy covers the costs of infrastructure, metering and setting up administration costs.

Each Irrigation Area has its preferences about type of metering and these have been taken into account in cost estimates for capital, operation and maintenance (including renewals) expenditure. Other alternatives for cheaper, more accurate and reliable direct metering may be considered prior to implementation depending on availability of information.

8.4.2.2. Operation

Unit rates for labour and vehicles for each of the IAs were developed on the basis of actual/estimated operating expenditure for the existing 1998/1999 number of low flow diversion sites.

As the implementation of the Surface Drainage Strategy progresses, the surface runoff increases and so would the number of diversion sites. Surface drainage runoff has been assumed to grow linearly along the continuum until the end of implementation of the SDS. The unit rates were used to estimate future expenditure assuming a linear growth for the number of diversion sites. All operation, maintenance and renewals costs associated with drainage diversion reflect this growth.

8.4.2.3. Maintenance

The 'top of the range' option considers the necessary expenditure on materials to maintain and repair drain diversion flow meters. A breakdown ratio depending on the type of metering favoured by the IA was assumed in consultation with Drainage Officers. It was assumed that the expenditure on repairs, materials, replacement parts, etc per meter would be of the order of 10% of the capital cost of the meter.

8.4.2.4. Renewals

The 'top of the range' option allows for the renewal of drainage diversion flow meters. It considers the renewal of meters as a maintenance cost given the relatively short life expectancy of meters. The cumulative increase in the number of meters per year was used to estimate renewals using a 4% discount rate.

8.4.3. Low level rock weirs

8.4.3.1. Capital

Low level rock weirs are arrangements of rocks across the profile of the drain that can provide good conditions for trapping sediments and nutrients, in addition to enhancing opportunities for drainage diversion. The Strategy allows for the construction of low level rock weirs, over the first five years of the Strategy, at the lower end of each of the major drain catchments before they outfall into waterways (See Section 4.2.11).

8.4.3.2. O&M

The Strategy does not make any specific allowance for their O&M.

8.4.4. Contribution to other internal units

Allowances for annual contributions to other internal units, eg Natural Resources and Distribution Assets. The Irrigation Areas (Central Goulburn, Murray Valley, Rochester and Shepparton) have committed $10,000 annually for preparation of DDPs, DMPs, contingent allocation reviews, periodical evaluation of the Strategy, etc. The Strategy makes allowance for expenditure by Distribution Assets on issuing licences for construction and use of private works, and level survey input into works associated with drainage diversion.

8.4.5. Other allocated charges

Cost pools, that is contributions to Information Technology, Manager Water Services, Finance, Corporate Services, Corporate Governance, Human Resources, Land and Water Administration, Legal and Property Services, Accounts Receivable, Research and Development, Buildings and Storeyards Areas and Environmental Management Program are termed 'Other Allocated Charges' (OAC). These are allocated on the basis of budgeted recurrent expenditure, agreed shares, 10 year average of offtake deliveries or work time; as applicable. The method of allocation is established by the Finance Group in consultation with Service Managers through the budget setting process.

The Strategy assumes that OAC will remain constant because the functionality and structure of G-MW internal units are comprehensive enough to handle the increased workload without incurring significant cost increases. That is, internal units such as Finance and Land & Water Management, for instance, are capable of handling the changes without having to employ more staff, or acquire additional software, etc.

To estimate the contribution from Drainage Diversion to cost pools, actual drainage diversion expenditure for 1998/99 was expressed as a percentage of total surface drainage expenditure in each of the Irrigation Areas. This percentage was then multiplied by each of the Other Allocated Charges.

8.5. Costs 'Minimalist' option

8.5.1. Drain flow monitoring

8.5.1.1. Capital

Under the 'minimalist' option IAs will, over the first five years of the Strategy, install flow-monitoring points at currently ungauged outfalls of major drains into waterways. The criteria for definition of major outfalls are those where flow monitoring would improve drainage diversion management. This criteria is by definition covered in the 'top of the range' option.

According to this criteria Central Goulburn and Rochester-Campaspe would not require additional drain flow monitoring, Murray Valley would only require monitoring of MV Drain 13 (there are plans to monitor this drain already) and Shepparton would require three stations (Drains 3, 4 and 6).

Although not included as part of this Strategy, in the long-term it might be necessary for G-MW to install flow (and possibly some water quality) monitoring stations at all outfalls from drains into waterways.

8.5.1.2. Operation

As for 8.4.1.2, it depends on the number of monitoring stations.

8.5.1.3. Maintenance

As for 8.4.1.3, it depends on the number of monitoring stations.

8.5.1.4. Renewals

As for 8.4.1.4, it depends on the number of monitoring stations.

8.5.2. Drain diversion meters

8.5.2.1. Capital

As for 8.4.2.1.

8.5.2.2. Operation

As for 8.4.2.2.

8.5.2.3. Maintenance

As for 8.4.2.3.

8.5.2.4. Renewals

The 'minimalist' option considers that beyond the initial life of the Strategy (10 years) drain flows will reduce to a point where drainage diversion will no longer play such an important role in their reduction. It is expected that other factors such as drainage reuse on-farm, improved irrigation methods and techniques, etc will account for the majority of drain flow reduction. Consequently there would not be a need to meter diversions, or to allow for their renewal.

8.5.3. Low level rock weirs

8.5.3.1. Capital

As for 8.4.3.1.

8.5.3.2. O&M

As for 8.4.3.2.

8.5.4. Contribution to other internal units

As for 8.4.4.

8.5.5. Other allocated charges

As for 8.4.5.

Three spreadsheets 'Drainage Diversion costs per Irrigation Area – Semi actual 1998/1999 Costs', 'Drainage Diversion Costs per Irrigation Area – Years 1 to 5 of Strategy' and 'Drainage Diversion Costs per Irrigation Area – Years 6 to 10 of Strategy' present annual estimates of expenditure related to drainage diversion activities. The expenditure is grouped under capital, operations and maintenance in each of these spreadsheets. The cost estimates are calculated for both the 'top of the range' and the 'minimalist' options. Calculations are documented in notes at the bottom of the spreadsheets.

The 'Drainage Diversion costs per Irrigation Area – Semi actual 1998/1999 Costs' spreadsheet shows 1998/1999 'actual' expenditure. The current financial administrative process does not allow accurate identification of resources used because drainage diversion is encompassed within surface drainage service as a whole. Therefore, this expenditure was identified/ estimated in consultation with Irrigation Areas.

The 'Cost Summary' spreadsheets summarise costs for the two options from cost estimates for base costs (1998/1999), years 1 to 5 and years 6 to 10 spreadsheets. These summaries present the costs under drain flow monitoring, drain diversion meters and low-level-rock weir categories.

8.6. Cost sharing arrangements

8.6.1. Pricing

Current pricing for low flow drainage water diverted under Tier 1 and Tier 2 Agreement conditions is on the basis of allocations (and volumes diverted above allocation in Central Goulburn and Rochester). Whilst a low flow diversion site remains unmetered the diverter is required to pay charges based on the allocation in the Agreement.

Low flow (Tier 1 or Tier 2) diversion charges = (volumetric fee) x (volumetric allocation)

The volumetric fee for drainage diversion is set at 25% of the gravity irrigation fee in the relevant Irrigation Area.

Under Tier 1 Agreements the volumetric allocation component is payable, regardless of the availability of the resource or the actual volume used. Under Tier 2 Agreements the volumetric allocation is payable, irrespective of usage, only if water sales are greater than or equal to 50% of Water Right (or any other agreed pre-set level in the drain catchment).

Diversion of drainage water under high flow conditions (Tier 3) whether pumped or by gravity only attracts a service or administrative fee. However, WSCs have discretionary power (subject to Board approval) to alter these arrangements depending on particular circumstances relevant to the Irrigation Area.

High flow (Tier 3) diversion charges = administrative fee

When the drainage diversion fee tariff system was set little consideration was given to recouping actual costs. The objective at the time was to acknowledge that the drainage water was a valuable resource.

The Strategy sets to maintain the current pricing arrangements based on volumetric fee (volumetric drainage diversion fee equivalent to 25% of gravity irrigation fee) and volumetric allocation pending a full review of the surface drainage tariff structure. To maintain status quo of the structure of drainage diversion fees the surface drainage charges would need adjustment to cover shortfalls or surpluses to meet the costs of implementing the drainage diversion strategy. The resulting prices, given projected costs to Year 5 and Year 10, are compared against the base case (Year 0 or 1998/1999) in each of the Irrigation Areas.

Metering of low flow diverted volumes was agreed as the only method to objectively align allocations with usage and availability of the resource, determine whether allocations are used, how much water is diverted and the effect of drainage diversion on drain flows. These aims can all be grouped under the objective of improved water resource management. Therefore, with current pricing being based on allocations, metering is indirectly used for customer billing.

The different methods being used for metering involve a combination of direct and indirect metering. All these methods are very inaccurate, unreliable, short lived and maintenance hungry. This paper proposes to maintain status quo (that is pricing based on volumetric allocations) until the review of the surface drainage tariff considers the issue of metering and volumetric charging in detail.

8.6.2. Effects on surface drainage charges

In assessing the effect of the Drainage Diversion Strategy on surface drainage charges, no allowances were made for:

Increased costs due to renewals and maintenance of surface drainage infrastructure;

Increased revenue as more land receives a drainage service when drains are constructed; and

Increased revenue as a result of increases in gravity irrigation prices, because of inflation or otherwise.

The 'Projection Summary' spreadsheets summarise drainage diversion allocation projections per IA for both the 'top of the range' and the 'minimalist' options. As before, the calculations are documented at the bottom of the spreadsheet with notes.

The 'Effect on Surface Drainage Charges' spreadsheet shows how the surface drainage charges might change over time due to the implementation of the Drainage Diversion Strategy. The surface drainage charge in each of the IAs might raise or decrease and this is shown with the change factors which compare future situations against the base case (Year 0) for both the 'top of the range' and the 'minimalist' options.

The change factors indicate the range over which surface drainage charges can be expected to move depending on the degree of management appropriate to the individual catchment and implemented between the 'minimalist' and the 'top of the range' options.

Under the Strategy each IA is to implement the 'minimalist' option and adopt higher level of management as appropriate depending on catchment needs.

9. EVALUATION

9.1. Effectiveness in light of WQS nutrient reduction targets

It should be noted that the nutrient reduction targets set by the Water Quality Strategies were based on very limited knowledge and understanding of how nutrients behave in irrigation drains and the hydrology of the drains themselves. These knowledge gaps may make the targets unrealistic and unachievable. The strategy requires continuous monitoring and progress assessment to verify, modify or refute initial targets (see Section 9.2).

9.1.1. Low flow diversion

It is very likely that there will be low demand for Tier 2 low flow drainage diversion agreements given that they provide less access to the available resource than Tier 1 agreements (in fact, no Tier 2 agreements have been issued since their introduction in the Deakin Catchment). On this premise and through the application of the adjusted CDR criteria (see Section 4.2.7), an attainable target for diversion of total low flows appears to be 50%.

Application of the adjusted CDR criteria effectively sets a target for diversion of 50% of the total low flow drainage volume (effectively the drainage runoff). The target set by the Water Quality Strategies is to increase drainage diversion to ensure that future drain outfalls are less than 50% of current drain outfall (GBWQWG, 1996). This generally requires diversion of more than 50% of total low flows.

However, whether this target is realistic and achievable depends on initial assessments of utilisation of drainage diversion in individual catchments. For instance, studies of the three catchments analysed found that there is no scope for increased diversion from the Bamawn Catchment, scope for increased diversion from Deakin under Tier 2 agreement conditions and scope for further diversion from MV Drain 6 under Tier 1 agreements (SKM, 1998c).

An initial assessment will only be available once Drain Diversion Plans for all the drainage catchments are completed. At that time it will be possible to aggregate estimated available flows and total volumes diverted. The ratio of these two quantities will effectively allow an appraisal of the potential for effectiveness of drainage diversion in light of nutrient reduction targets.

It should be noted, however, that channel outfalls have in general been excluded from the assessment of resources available for low flow diversion on the basis that these flows are to be reduced by better management. If outfalls are reduced this will also contribute towards achieving WQSs' targets.

9.1.2. High flow diversion

A realistic overall target for diversion of high flows appears to be in the order of 30% of estimated high flows (conditions similar to those in the early 90's period). A higher target would be desirable to meet the diversion objective of the Water Quality Strategies. However, each new diversion installation has an impact on the supply available to existing diverters downstream and therefore on the feasibility of increased diversion, and may be seen to lead to harvesting of non-irrigation induced rainfall runoff (refer to Section 5.2.9).

The proposed target of 30% of total estimated high flow limits the adverse effect on existing diverters by maintaining storage fill ratios (average annual ratios of water diverted to storage volumes) close to one. A minimum storage fill ratio of one is required to make the high flow installation economically feasible for both the diverter and DNRE, the government agency providing some capital grant contributions.

The initial nominal target of 50% reduction of drain outfalls set by the Water Quality Strategies for early 90's conditions (GBWQS, 1996) is unlikely to be met because there would be insufficient demand.

9.2. Framework for review

A review process needs to:

- Capture metering information into a reliable and secure database;
- Review historical metering data for evaluation of contingent allocations; and
- Assess the effectiveness of the strategy at regular intervals.

The Irrigation Planning Module (IPM) software package can be used to capture and store metering data. Some Irrigation Areas have started to utilise it to take advantage of some of its features, namely, the storage of historical records on drainage diverted volumes and the linkage with the Billing and Customer Care System (BICCS) for billing purposes. This process is taking place progressively as metering of drainage diversion sites is implemented.

Provided data on drainage diversion volumes is collected by Irrigation Area staff and stored in the IPM database, Natural Resources Tatura will provide the service to Irrigation Area Managers to comprehensively, from a whole of catchment perspective, review contingent allocations and the effectiveness of the strategy. Refer to Section 8.4.4 for funding arrangements.

In addition to annual catchment drainage diversion statistics, a major evaluation of the potential effectiveness of the strategy is to be undertaken once Drain Diversion Plans for all catchments in the Irrigation Areas are completed (see Section 9.1). This evaluation, expected to take place by the end of 2000/2001 financial year, is to be done in conjunction with assessment of historical flow, salinity and water quality monitoring data.

It is likely that, over time, increased farm reuse will lead to some net reduction in the available drain flows (particularly low flows) and therefore lessen the opportunity to increase drainage diversion. Drainage diversion has been agreed as an efficient short-term means of reducing drain flows (particularly irrigation runoff flows), and consequently nutrients (refer to Section 8.5.1.4 for the implications of this assumption on meter renewals). However, in the medium to long-term, increased farm reuse and improved farm management practices may achieve the desired goal of reducing drain flows. G-MW will, nevertheless, still require a management strategy to deal with drainage diversion from a resource perspective.

The drainage diversion strategy has a 10 years time frame in recognition of the extreme variability of drain flows and their uncontrolled and unregulated nature, amongst other things. Midway throughout this time frame a review is to take place to evaluate progress and modify the strategy, if necessary. This review is essential because there are concerns about the long-term effectiveness of nutrient reduction strategies which rely on runoff reduction (because of the current assumption that nutrient concentrations are independent of drain flows). At the end of the 10-year period another review is to be conducted and this will establish whether the strategy becomes one of water resource management rather than a combined water resource/ water quality strategy.

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APPENDIX A - LOW FLOW DRAINAGE DIVERSION STRATEGY - DEVELOPMENT STAGES

This Appendix summarises the process followed in arriving at the low flow drainage diversion strategy. It presents a brief account of what the Deakin pilot projects comprised, its objectives, assumptions, surveys, specific models, outcomes, metering trials, etc. As such this section contains valuable background information which helps to better understand the key strategy elements listed in Section 4.2 of the Strategy.

1. DEAKIN STUDY

The low flow diversion strategy is the result of a pilot project undertaken for the Deakin Drain Catchment. The project started in late 1994 with a view to consider increased drainage diversion from the catchment.

1.1. Objectives

The Deakin project set out to achieve the following objectives (G-MW, 1997):

- To reduce water and nutrient loads entering the Murray River during the irrigation season by increasing drainage water diversion from irrigation drains in the Deakin Catchment;
- To develop a cost effective management strategy that is fairer, and more flexible and equitable for the majority of stakeholders;

These two objectives gave rise to more specific purposes:

- To reduce disputes among diverters in times of shortages;
- To optimise monitoring and administration commitments; and
- To define the conditions under which the terms of existing drainage diversion agreements can be changed without diminishing the traditional rights of access to available drainage flows by existing diverters.

1.2. Basis and assumptions

The main data used in the study was that corresponding to Deakin drain flows and salinities in the period 1982 to 1995 collected at 22 monitoring stations distributed within the catchment, 16 of which recorded spot flow and/or salinity readings and have been discontinued.

In addition to drain flow records, other data such as rainfall for the total period and channel outfall volumes during the irrigation seasons between 1989/90 and 1994/95 was collected. The irrigation season was defined as the actual start and end of water deliveries in the Central Goulburn Irrigation Area.

1.3. Customer survey

The project commenced in 1994 by surveying the practices of the then 160 existing diverters in the Deakin Catchment. The volume claimed to have been diverted in 1994/95 was found to generally approximate the aggregated volume in Diversion Agreements, 23,000 ML (G-MW, 1997). The project imposed a moratorium on new diversions to estimate, as accurately as possible, the availability of the resource. The project then developed a flow monitoring program to correlate actual diversion with volumes in agreements and available flow.

1.4. Low flow diversion management model

As mentioned in Section **Error! Reference source not found.** of the main text, there are many variables that influence the future availability of the resource. The Deakin pilot project considered some of these aspects in more detail. It did this by developing a spreadsheet model to assist in assessing the impacts of various management decisions, over the following 10 years, on drain flow availability and salinity for low flow conditions. The model broke up the Deakin drainage system into segments and for each of those segments it explicitly accounted for changes in runoff volume and channel outfalls, groundwater inputs (as water volumes and salt loads) and additional diversion.

The outcomes of the model in terms of surplus flows, salinity, reduced runoff and increased diversion are described in Section 1.6 of this Appendix.

1.5. Metering of low flow drainage diversions

Essentially, metering was agreed to corroborate the success or otherwise of increased diversion targets. Metering will ensure that allocations are issued only to those diverters who can and will consistently use the available water. Such consistent use of allocation is demonstrated through metering records. If consistent use of allocated diversion volumes is not accomplished, those volumes should be able to be redistributed to other diverters who can use the water. Furthermore, metering improves the reliability in sharing the resource amongst diverters by ensuring adherence to minimum and maximum usage limits guidelines.

A drain diversion metering trial was conducted in the Deakin and Bamawn catchments (refer to Section 2.1 of this Appendix). A conclusion drawn from this trial was that direct measurements may be very unreliable in a significant number of sites due to weed blockage. There is no reliable basis for assessing which sites are likely to pose major problems. When direct metering is less feasible, there are indirect flow metering options which include revolution counters or hour meters (for electric and diesel pumps). Although these methods give a reasonable estimate of volume used over a period of time, individual flow measurements can be highly inaccurate. No ideal meter was found to suit the requirements in terms of accuracy, reliability, cost, and physical installation constraints. Inaccuracies of ±15 % for indirect metering were deemed acceptable for the purposes of the diversion estimates (SKM, 1997b). Other alternate indirect methods such as the tailor made 'tiny-tach' hour meter and vibration hour meters are still being tested.

The use of indirect metering is recognised as the most appropriate solution at present. It is envisaged that with declining costs and improvements in technology, direct metering will become more affordable. The preferences of the Irrigation Areas in relation to type of meters have been taken into account in the cost estimates (see Section 8 of the main report).

1.6. Outcomes

1.6.1. Surplus low flows

Assumptions about future changes in runoff and channel outfall volumes are critical to flow availability and maintenance of acceptable drain salinities.

At the time the Deakin pilot project commenced, late 1994, there was a backlog of about 20 drainage diversion applications that needed assessment. A key objective of the study was to identify surplus (unallocated) low flows in the Catchment to assess the feasibility of increased drainage diversion. The study identified approximately 13,500 ML/year, average of 13 year flow records, available for low flow diversion in the Deakin Catchment (G-MW, 1997).

A spreadsheet model was formulated for the Deakin to assess the impact of various management decisions. The model indicated that a 20% reduction in runoff and channel outfall volumes is likely to reduce the volume available for allocation by about 54% (G-MW, 1997).

1.6.2. Salinity

The Deakin study focused on quantifying available resources. It did not consider water quality aspects, other than assessing the salinity impact of summer disposal from public pumps under the Sub-surface Drainage Program.

The Deakin drainage diversion management spreadsheet indicated that if groundwater pump salt inputs are in accordance with the Salinity Management Plan, the salinity in the drain is likely to remain within limits acceptable for irrigation at least for the first 10 years of the strategy, that is, until 2006 (G-MW, 1997). The model indicated that disposal of groundwater flows will not pose a major problem in the short term, however, it might be necessary to check each pump for any specific local issues. Groundwater pump salt inputs combined with reductions in runoff volumes and channel outfalls could cause high salinity levels in the middle reaches of the drain. These impacts in the drain are significantly reduced if diversion increased.

There are already very high salinities in the upper reaches of the Deakin Catchment. The model showed that the salinity in the middle and upper parts of the drain would increase significantly, with or without groundwater pump inputs, but diversions would potentially result in some improvement in salinity in the lower part of the drain. Continued monitoring of the drain will be required. The worst case scenario in the model showed that salinities in the mid-catchment could be in the order of 1,000 EC (G-MW, 1997).

Guidelines for the disposal of groundwater pump flows into drains have been developed (see Section 4.2.8 of the main document). There is a need to integrate the operation of these guidelines with drain water quality monitoring to understand the processes involved.

1.6.3. Reduced runoff

For the Deakin Catchment the salinity model assumed 72 pumps by 2006 (first 10 years of strategy), a 20% reduction in irrigation runoff and channel outfalls and a total of 3,550 ML/year in increased low flow diversion in the whole of the Catchment (G-MW, 1997). A reduction of 20% in irrigation runoff and channel outfalls is likely to result in 50% reduction in drain flows. The model made no provision for reduced runoff salt loads as a result of controlled water tables; or increased runoff as a result of increased drained area in the Mosquito Depression.

1.6.4. Increased diversion

The issue of new or increased allocations in the Deakin Catchment is necessary to encourage the diversion of surplus flows in most years. However, increased diversion may impact on the availability of the resource for existing diverters, particularly in dry years. Thus a fundamental issue was to increase low flow diversion to reduce the flows leaving the catchment whilst at the same time limiting the adverse effects on the interests of existing diverters.

Careful management of both the allocation of new diversion agreements and the location of new groundwater pumps will be required to get maximum overall management. Some individual diverters may be adversely affected because of their location even though the system as a whole may be able to accommodate both the increased salt loads and increased diversions.

1.6.5. Contingent allocation

This is a measure designed to encourage reuse of drainage water. Diverters are allowed to retain their diversion agreements provided regular diversion takes place. Agreement allocation volumes are to be reassessed every three years (or as appropriate), with the annual allocation for each diversion agreement being 80% of the average water usage for the previous period (G-MW, 1997).

1.6.6. Factor of safety

The process for definition of low flows in ungauged catchments and the arbitrary determination of the threshold limit to define low and high flows for gauged catchments involve a large degree of subjectivity. Because of this subjectivity, a factor of safety is to be introduced by making allocations in new, increased or decreased diversion agreements on the basis of 50% of the unallocated volume. The factor of safety also minimises the risk of over allocation of the resource.

Whether additional allocations above the 50% safety limit can be issued without adversely affecting existing users is one of the issues to be evaluated at the time the first review of allocations is conducted.

2. IMPLEMENTATION

2.1. Deakin pilot

The single most important implementation component of the Deakin pilot project was the metering of low flow drainage diversion installations

A flow metering trial started in 1996 to establish a range of economic, reliable, durable and accurate options under varying circumstances. Sinclair Knight Merz and Thiess Environmental Services conducted the metering trial on behalf of G-MW. The trial analysed various direct and indirect flow measurement options at selected sites. It studied the performance of different options in 21 diversion sites (Deakin and Bamawn Catchments) comprising 10 revolution counters, 10 propeller flow meters and 7 electric hour meters. Some sites had multiple metering devices. Flow estimates from those sites which had indirect metering were compared against conventional hydrographic flow measurements (area-velocity or ultrasonic flow meters).

During the first stage of implementation of the Deakin pilot, 142 meters (mostly indirect meters) were installed, 13 sites were found not in use and a suitable arrangement was not found for the remaining 5 sites. Thus, there were 160 low flow drainage diversion sites and those which enabled metering were fitted with variety of devices including hour counters (Tiny Tachs), revolution counters, Davies Shephard propeller actuated flow meters, electric hour counters, large Dethridge outlet wheels and vibration meters (SKM, 1997b).

2.2. Other catchment implementation

In its June 1996 meeting G-MW's Board of Directors agreed in principle to the Deakin Drain Diversion arrangements, and endorsed their implementation on a pilot basis in the Catchment. These arrangements include two categories of low flow diversions (Tier 1 and Tier 2) and one category for high flow diversion (Tier 3).

Stage I of the pilot project concluded in August 1997 with approval by the Manager Water Services to progressively implement the Deakin arrangements for management of surface drainage diversions in the Shepparton Irrigation Region. The methodology developed for the Deakin Catchment is currently being implemented in other catchments in the SIR, including MV Drain 6, MV Drain 13 and Shepparton Drains 11 and 12.

3. HYDROLOGIC MODELLING

The Deakin Catchment was subdivided into sub-catchment areas based on key monitoring stations.

Residual mass curves for rainfall and drain flows over the irrigation seasons in the total length of records available were constructed. The curves show a period of below average rainfall and drain flow conditions between 1982 and 1988; and a period of above average conditions between 1988 and 1995 (see Figure 2) (SKM, 1997a). Rainfall was found to contribute significantly to drain flows, even during the irrigation season. This suggested the definition of a threshold flow above which any drainage diversion during the irrigation season would be targeting high flows.

30% of time exceedence was defined as the threshold that would identify the limit between low and high flow (see Figure 3). This threshold was defined using a combination of flow duration curves (cumulative frequency distributions), hydrographs (flow discharge graphs prepared for the locations of the key gauging stations), and general consensus among interested parties. Flow duration curves show the percentage of time during which specified discharges are equalled or exceeded during the period of record. The flow duration technique combines in one curve the flow characteristics of the drain throughout the range of discharge, albeit without regard to the sequencing of these flows.

For gauged catchments, flows below the 30% exceedence threshold in the flow duration curve (which are available for 70% of the time) are the flows available for low flow diversion allocations in the portion of catchment immediately upstream of the gauging station.

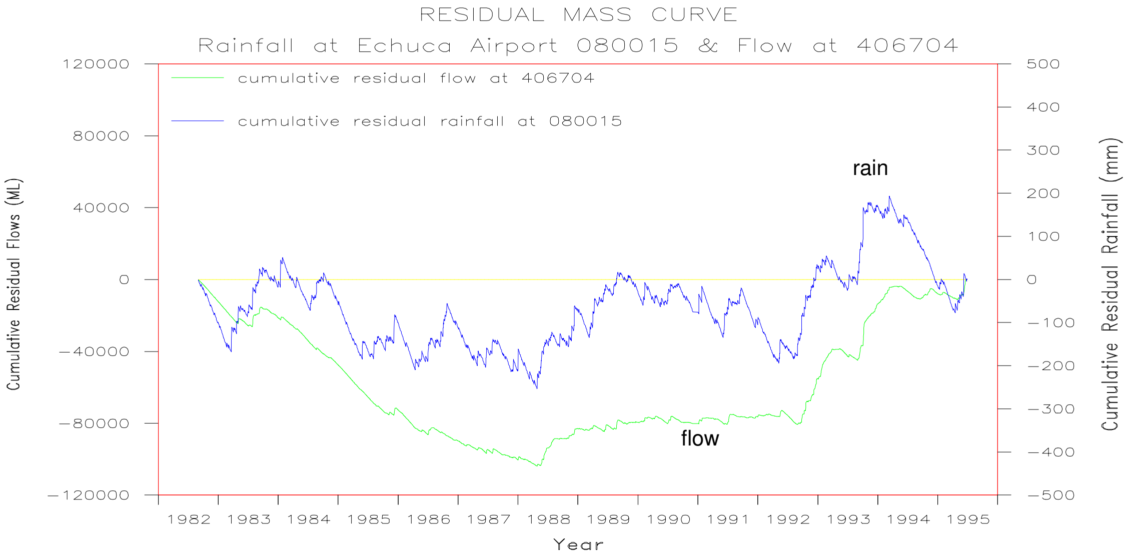


Figure 2 - Residual Mass Curves of Rainfall and Flow at Echuca Station, Deakin Drain (SKM, 1997b)

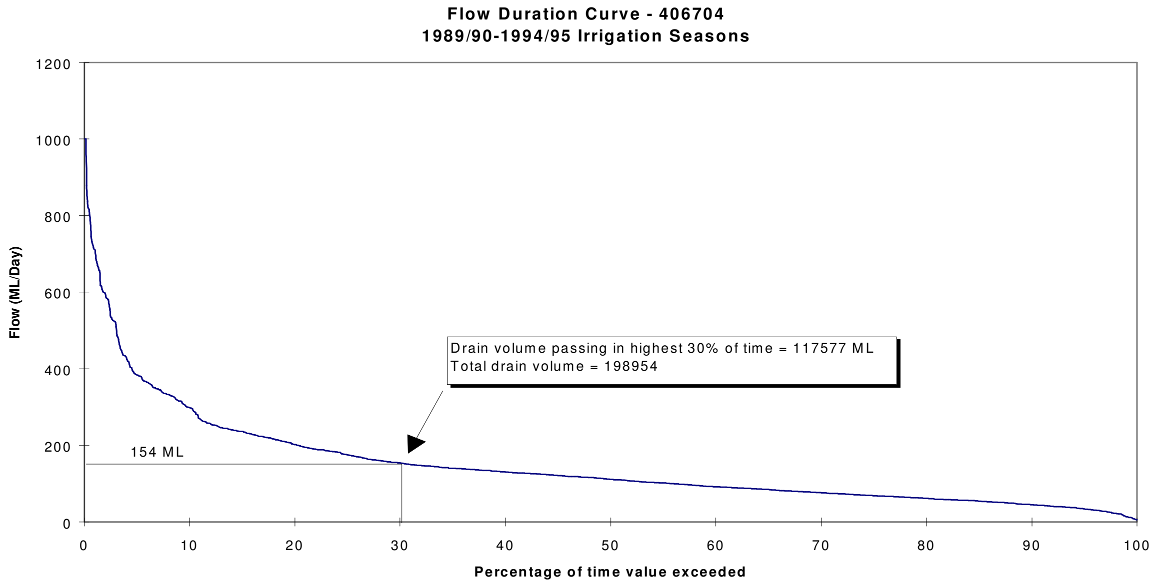


Figure 3 - Flow Duration Curve at Echuca Station, Deakin Drain (SKM, 1997b)

4. IRRIGATION RUNOFF ESTIMATION

Stage II of the Deakin project included the development of a methodology to estimate drain flows in ungauged catchments. The project attempted to use rainfall runoff routing methods. The project formulated a simplified water balance model using only the major factors contributing to the generation of drain flows, to derive runoff coefficients for irrigation and rainfall. The magnitude of inputs from groundwater intrusion and groundwater pump disposals was assumed to be insignificant and was therefore neglected. The simplified model can be written as follows:

$$Q = IC_I + RC_R - DD + COF$$ **Equation 4**

In particular, for the low flows within the irrigation season period in a catchment of interest, the same equation can be written as:

$$Q_{LF} = IC_I - DD_{LFs} + COF_{LFs}$$ **Equation 5**

Where:

Q_{LF} = annual low flow, ML;

I = annual irrigation water usage in ML. It is obtained by the use of an Arcview GIS application developed by the Institute of Sustainable Irrigated Agriculture (ISIA) for G-MW;

C_I = irrigation runoff coefficient;

DD_{LFs} = total of low flow drainage diversions, ML; and

COF_{LFs} = annual volume of channel outfalls resulting from the normal operation of the irrigation system.

The model was formulated and calibrated for three gauged catchments Deakin, Bamawn and MV Drain 6. It used actual drain flow, rainfall and water usage data in conjunction with reliable estimates of channel outfall and drainage diversion volumes for the irrigation seasons in the period 1994/95 to 1996/97. The calibration of the models allowed the derivation of individual irrigation-induced runoff coefficients for each catchment.

Calibration and optimisation of the water balance model, for low flows, in the three gauged catchments produced the following results shown in Table 9.

Table 9 - Irrigation Runoff Coefficients (SKM, 1998b)

Catchment	Irrigation runoff coefficient, C_I
Murray Valley Drain 6	0.177
Deakin Drain	0.133
Bamawn Drain	0.141
Average	0.150

5. GROUNDWATER PUMPS DISPOSAL

The following guidelines have been adopted in principle by the Irrigation Committee (IC) in consultation with relevant WSCs for controlled groundwater discharge into Goulburn-Murray Water primary and Community Surface Drains in the Shepparton Irrigation Region:

- For existing drain salinities less than 530 EC, an upper limit of 800 EC; and
- For existing salinities more than 530 EC, an allowable increase of 50% with an upper limit of 1,700 EC.

These baselines and resultant salinities are irrigation season flow weighted averages for low flow periods and average seasonal conditions (SKM, 1998a).

A salinity network spreadsheet model has been formulated as a means of assessing and accounting for controlled groundwater inputs, resultant salinities and downstream effects. The objective of this model is to indicate likely impacts of disposal of groundwater pump volumes on drain low flow salinities, under the prospects of increased diversion and reduced drain flows which would result in reduced dilution opportunities.

The model is a flow weighted salinity balance equation, which builds on the equation used for the irrigation runoff modelling (see Section 4 of this Appendix). The equation has an additional component, which explicitly accounts for groundwater pump inputs.

$$Q_{LF}\,EC = I\,C_I\,EC_I - DD_{LFS}\,EC_{DD} + COF_{LFS}\,EC_{COF} + GWP\,EC_{GWP}$$ **Equation 6**

EC are typical Electric Conductivities, or salinities, of delivered irrigation water (EC_I), drainage diversions (EC_{DD}), channel outfalls (EC_{COF}), and groundwater pumps (EC_{GWP}) (SKM, 1999b).

Actual flows and salinities for the irrigation seasons between 1994/95 to 1996/97 are to be used with the model to derive baseline conditions. The catchment is fragmented into sub-catchments and the configuration of the drainage system is obtained by connecting nodes. The nodes represent known locations of inputs and outputs. The irrigation runoff contribution is modelled as a linear discharge function along the length of the drainage system rather than a series of point discharges.

The model has so far been used for Murray Valley Drain 6 Catchment with reasonable results. Application of the model will continue as part of the preparation of Drain Diversion Plans. See Section 7 of main document.

6. DECISION CRITERIA - CDR

The decision to authorise increased low flow drainage diversion from a drain depends on various influencing factors including drain flows, current drainage diversion, irrigation channel outfalls, reuse systems and location within the catchment, amongst others.

To standardise the assessment of diversion applications a decision indicator termed Current Diversion Ratio (CDR) was formulated. CDR is the ratio of utilisation of available low flows by existing diversions and is defined by:

$$CDR = \frac{CLFAV}{(CLFAV + ALFV)} = \frac{CLFAV}{LFV}$$ **Equation 7**

Where:

CLFAV= current total low flow diversion (known from metered data or total volume allocated in Drainage Diversion Agreements). Initially CLFAV would be the total of allocations in the catchment. Eventually, with the implementation of the Strategy the allocations would match actual usage and the two figures should be interchangeable.

ALFV = available unallocated low flow volume, ML

LFV = total estimated low flow volume, ML. The total estimated low flow volume is the best estimate of annual low flow in the drain for conditions similar to those which prevailed during the low flow periods in the irrigation seasons between 1994/95 to 1996/97 (reference period).

The estimate of the total low flow volume is to be based on data for the irrigation seasons from 1994/95 to 1996/97. This period was chosen for its representativeness of typical irrigation season low flow conditions. The irrigation runoff coefficient was estimated for this period. This is also the period being used for the Drain (salinity) Network Model. The CDR criterion for the 1994-97 period were agreed by consensus amongst the members of the Drain Diversion Working Group that the resulting allocations in a drain catchment were reasonable management targets for use in initial drain diversion plans.

The 1994-97 period yields on average18.5% smaller irrigation season drain flows compared to the 1992-96 period, the length of record used in the development of the high flow diversion strategy. To align low flow and high flow strategies to similar rainfall and drain flow conditions, the CDR criteria has been adjusted for the longer and wetter period of records. Decisions about what type of low flow drainage diversion agreement to issue, if any, are to be based on the adjusted CDR.

Table 10 - Criteria for Issuing of Low Flow Drainage Diversion Agreements

Low Flow Diversion Agreement	CDR (1994-97 period)	Adjusted CDR (1992-96 period)
Tier 1	0.0 - 0.6	0.0 - 0.5
Tier 2	0.6 - 0.8	0.5 - 0.7
Nil	0.8 - 1.0	0.7 - 1.0

The adjustments are explained by the definition of the CDR

$$CDR = \frac{CLFAV}{(CLFAV + ALFV)} = \frac{CLFAV}{LFV}$$ Equation 7

$$CDR_{1994-97} = \frac{CLFAV}{Y_{1994-97}}$$ **Equation 8**

$$CDR_{1992-96} = \frac{CLFAV}{Y_{1992-96}}$$ **Equation 9**

Since $Y_{1994\text{-}97}$ are 18.5% smaller than $Y_{1992\text{-}96}$, the correction factor is 1.185^{-1}, that is, approximately 0.85. When the boundary limits in each range of the CDR for the 1994-97 period are multiplied by the correction factor, the limits become those shown under the adjusted column in Table 10.

Note that these adjusted boundaries are conservative and consequently in line with the intent of the initial boundaries set for the 1994-97 period. The original CDRs were agreed by consensus amongst members of the Working Group that the resulting allocations in a drain catchment were reasonable management targets for use in the initial drain diversion plans.

7. CONSULTATION

Given that the pilot project was conducted in the Deakin Catchment, consultation took place mainly with the Central Goulburn Water Services Committee and customers in the Central Goulburn Irrigation Area (CGIA) via public comment and information sessions. The proposal gained endorsement by a Project Coordinating Committee chaired by the Manager of Water Services, which had Area Manager representation from Central Goulburn, Murray Valley, Shepparton and Rochester Irrigation Areas. Regular project progress reports to Irrigation Committee and Irrigation Area Managers were prepared and distributed as well as media releases for information sessions in the CGIA.

In its June 1996 meeting, the Board of G-MW agreed in principle to the Deakin Drain Diversion arrangements, and endorsed their implementation on a pilot basis in the same catchment. These arrangements include two categories of low flow diversions (Tier 1 and Tier 2) and one category for high flow diversion (Tier 3).

Subsequent developments including the development of runoff coefficients have been carried out with support from a Working Group consisting of G-MW staff from Distribution Assets and Natural Resources (Tatura and Kerang), and relevant DNRE staff.

APPENDIX B - HIGH FLOW DRAINAGE DIVERSION STRATEGY - DEVELOPMENT STAGES

This Appendix summarises the findings of the feasibility, hydrologic and economic modelling studies carried out into high flow diversion options. It also recommends a decision criteria for the administration of high flow diversion. The contents of this Appendix are intended to provide background information to help understand the key strategy elements listed in Section 5.2 of the main document.

1. OBJECTIVES

- To provide Irrigation Area Managers with consistent and comprehensive guidelines for assessment of drainage diversion applications in gauged or ungauged catchments;
- To assess the effect of increased diversion on existing drain users; and
- To identify realistic nutrient reduction targets to be achieved by increasing drainage diversion.

2. FEASIBILITY OF HIGH FLOW DRAINAGE DIVERSION

Diversion of high flows is feasible if it is possible to divert significant volumes of high flow drainage water to either provide a benefit in terms of reduced nutrient loads to downstream waterways or meet a significantly large crop demand for irrigation water.

To investigate the feasibility of high flow drainage diversion, three gauged catchments were studied in detail. The catchments were the Deakin in Central Goulburn Irrigation Area, Murray Valley Drain 6 and Bamawn in Rochester Irrigation Area. The feasibility of high flow diversion was assessed using a conceptual model consisting of a single storage, single demand point, supplementary supply source, pump and irrigated crop area to aggregate the numerous pumps, storages and cropped areas which would be part of any system in the real world.

To assess the viability of high flow diversion the Resource Allocation Model (REALM) was used using storage sizes and crop area/crop demand as inputs to the model. In general terms REALM simulates the harvesting and bulk distribution of water resources within a water supply system. In the context of high flow diversion, REALM was used to estimate the volume of high flow drainage water that could be diverted from the drainage system taking into account system parameters such as the flows within the drain, available storage capacity, pumping rates and the area to be irrigated. REALM enabled optimisation of storage capacities and pumping rates. Crop demand was estimated using another computer model developed by the former Rural Water Commission known as PRIDE. PRIDE was used to estimate the irrigation demand of a unit area of perennial pasture based on the climatic history of the period studied (SKM, 1999a).

2.1. Options considered

There is an unlimited number of practical high flow diversion options which landholders may choose to implement in the future. These include use of diverted water as a sole irrigation supply or as a supplementary supply, integration into a range of farming enterprises of different types and sizes, different land uses and different physical infrastructure combinations such as pump capacities and storage sizes.

It was clearly impossible to forecast all likely combinations for the future. The studies focussed on a limited number of options that were thought to represent the more common options that would be adopted. The concept of a ‘standard farm’ was developed. This is one with an area of 100 ha (comprising 50 ha of perennial pasture, 30 ha of annual pasture and 20 ha of fallow or low land) and a 300 ML annual Water Right (SKM, 1999a).

2.2. Diversion target

The effectiveness of the diversion target was assessed against a nominal diversion target of 50% of the recorded high flows for the early 1990s period. This was the period of nutrient data used in developing the targets for the Water Quality Strategies. Given that this was also a period of above average rainfall and drain high flow conditions, higher diversion percentages would be expected in drier periods for the same installed diversion capacity.

Modelling indicates that the nominal 50% target is unlikely to be achieved for this period because high flow diversion would be uneconomic for individual diverters at the corresponding level of irrigation demand. Higher percentages of drain flow diverted would be achieved during drier periods when drain flows would be lower.

2.3. Sole supply versus supplementary supply

Modelling of the use of diverted water as a sole source of supply for an irrigated area highlighted the unreliability of the available supplies. It was considered that users would, in general, be unlikely to proceed with significant developments on this basis. The proposed strategic approach assumes that most high flow diversion systems will be installed to supplement surface water supplies (SKM, 1999a). Drainage diversion applicants wishing to rely fully on diversion as the sole supply for irrigation should be made aware of the unreliability of the resource. They should be encouraged to make allowance for this factor in their operational, management and financial analyses.

The modelling showed that with increased diversion the percentage of irrigation demand met by drainage diversions reduces and the number of times storages are filled during the year also reduces. Larger overall demand reduces available supply for individual diverters, hence reducing the reliability and the economic attractiveness for individual users.

2.4. Pump capacity/storage ratio

Storage capacity is considered the primary measure of the potential extraction from any drain because it determines the demand area which can be supplied during extended periods of high flow. However, high flows tend to be highly variable. The efficiency of use of any storage is therefore dependent on pump capacity to ensure that short periods of high flow are effectively utilised. As a result, the ratio between pump capacity and storage volume can be critical in determining effectiveness of any high flow diversion installation.

Sensitivity testing of a range of pump capacity/storage ratio values indicated that, when there is significant storage and/or demand in any drainage catchment, best diversion efficiency is obtained with a pump capacity of about 10 ML/day for every 100 ML of storage. Increased pump capacity made little difference to the total volume diverted (SKM, 1999a). The results were similar for the three catchments modelled and apply to the distribution of drain flows modelled for the early '90s period. Individual diverters, particularly those located upstream in the catchments, might increase their share of available flows by installing relatively higher pump capacities, but this would be at the expense of downstream diverters. Overall there would not be any increase in the efficiency of diversion from the drain.

It is therefore proposed that high flow diversion agreements should not be approved with extraction capacities in excess of 15 ML/d per 100 ML storage capacity. This would allow reasonable flexibility for individual designs without having excessive effects on other diverters. However, it is recommended that the rate of diversion be controlled, if possible, by appropriate hydraulic design of the drain access structure instead of placing a limit on installed capacity. This will allow a diverter to install a greater pumping capacity if required for other purposes, for instance in cases where diversion and reuse systems are combined.

2.5. Storage-fill ratio

The storage-fill ratio has been defined as the ratio of the average annual volume of water diverted to the constructed storage volume, that is, the number of times per year that the storage is expected to be filled. This has been used as the primary indicator for hydrologic assessment of various options and for economic modelling. The hydrologic assessments were carried out on the same three catchments for the early '90s period. The currently drained areas in each catchment are similar, ranging from 16,162 ha to 16,411 ha (SKM, 1999a). Additional hydrologic model runs were carried out for the Bamawn Catchment for the period from 1980 to assess the impacts of the drier conditions.

Table 11 below presents a comparison of the model outputs from the three catchments based on a common period of time (5/92 to 4/96). This provides a direct comparison between the three catchments for a period of relatively high drain flows, and allows a reasonable assessment to be made against the objectives of the Water Quality Strategies. The 60 farm option modelled, with high flow diversion system, represents a relatively high level of high flow diversion in each catchment and results in storage-fill ratios of 1 to 2.

Table 11 - Common period model output comparisons (SKM, 1999a)

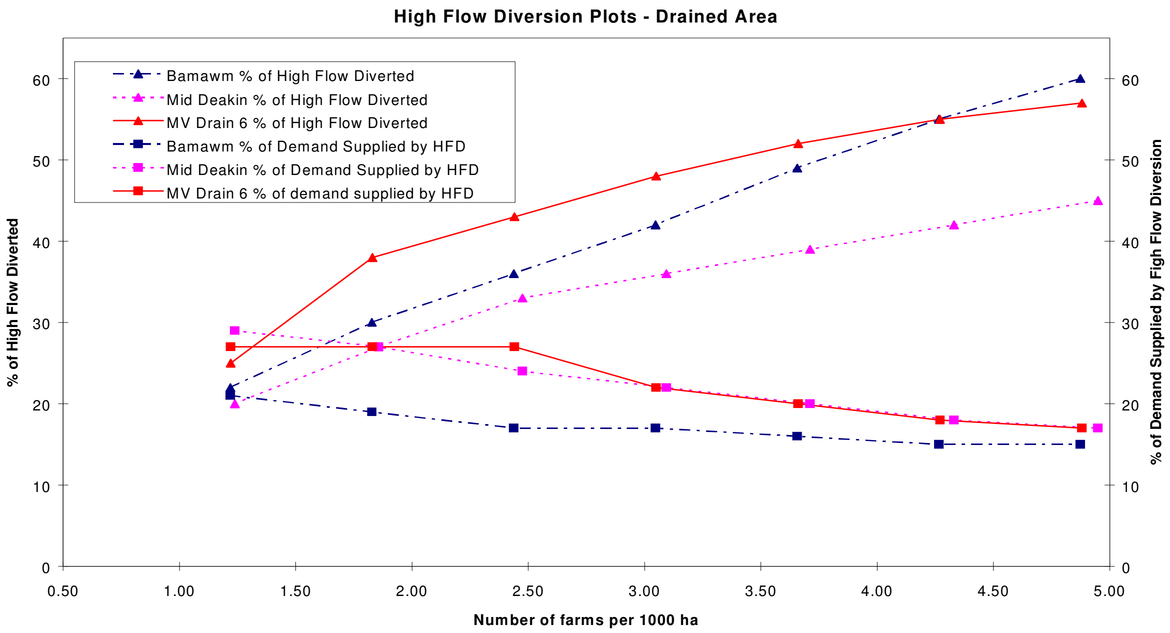
Variable (60 farms using 10 ML/d pump capacity and 100 ML storage, ie, 600 ML/d pump capacity, 6,000 ML storage and 4,800 ha irrigated area)	Bamawn	Deakin	MV Drain 6
% of total high flow diverted	48	28	43
% of summer high flow diverted	40	15	38
% of crop demand supplied by high flow diversion	22	20	26
Storage-fill ratio	1.02	0.96	1.22
% of actual diversion diverted during summer	60	34	64
% of actual diversion diverted during winter	40	66	36

Other model runs for longer periods indicate that very much lower storage-fill ratios would result during drier conditions, as occurred in the '80s (and are currently occurring). They also clearly show that increasing the number of farms with diversion systems from 30 to 60 increases the volume of water diverted but significantly reduces the storage-fill ratio.

2.6. Optimum catchment storage capacity

Figure 4 below indicates that as the percentage of drain flow diverted increases with increased volume of authorised storage in each catchment, the percentage of irrigation demand met by drainage diversion decreases. Clearly there is a conflict between the objective of the Water Quality Strategies (reduced nutrient discharges through increased drainage diversion) and the desire of individual diverters to maximise the value of their investments by minimising the volume of additional diversions authorised by G-MW (see Section 6 of this Appendix).

Figure 4- Relationship between the percentage of high flow diverted and the percentage of demand supplied by high flow diversion (SKM, 1999a).



3. HYDROLOGIC MODELLING

Flow duration curves for the irrigation season in the three catchments were produced by ranking flows from highest to lowest and plotting them against the percentage of time exceeded. Significant proportions of overall drain flows passed during high flow events when, due to rainfall in the catchment, there is low demand for drainage diversion and crop demand. The 30% exceedence flow for the irrigation season was assumed to define the threshold limit between low flow and high flow (see also Section 3 of Appendix A). Flow which is exceeded for 30% of the time is the flow which normally occurs during wet periods when immediate irrigation would not be required, while flows below this threshold, which occur for 70% of the time, occur during drier periods when irrigation is likely to be required. The threshold was selected following assessment of flow duration curves, examination of hydrographs for each site and consultation with various key staff within G-MW.

4. RAINFALL RUNOFF ESTIMATION

The development of a methodology to estimate drain flows was required as part of the assessment of new drainage diversion applications. A model based on a simplified water balance equation was formulated. The model for high flows can be written as follows:

$$\begin{aligned} Q_{HF} &= Q_{HFs} + Q_{HFw} + COF_{HFs} \\ &= R_S C_{Rs} + R_W C_{Rw} + COF_{HFs} \end{aligned}$$

Equation 10

Where:

Q_{HF} = annual high flow, ML;

R_S = summer rainfall in the catchment, ML;

R_W = winter rainfall in the catchment, ML;

C_{Rs} = summer rainfall runoff coefficient;

C_{Rw} = winter rainfall runoff coefficients; and

COF_{HFs} = annual volume of channel outfalls resulting from rainfall rejection of water delivery orders. By definition, channel outfalls only occur during summer (irrigation season).

Inputs and outputs such as groundwater intrusion, groundwater pump disposal, evapo-transpiration, seepage, leakage and road drainage were not considered in the model. Actual data on drain flows, rainfall, channel outfall and drainage diversion volumes was used for each of the three gauged catchments modelled, Bamawn, Deakin and Murray Valley Drain 6.

It was evident that to account for the different rainfall and drain flow conditions during summer and winter (June, July and August), it was necessary to derive individual rainfall runoff coefficients.

Calibration and optimisation of the water balance model for irrigation season (summer) high flows in the three catchments, for the 1994 to 1997 period, derived the coefficients shown in Table 12.

Table 12 - Summer Rainfall Runoff Coefficient, C_{Rs} (SKM, 1998b)

Catchment	Summer rainfall runoff coefficient, C_{Rs}
Murray Valley Drain 6	0.201
Deakin Drain	0.145
Bamawn Drain	0.180
Average	0.175

Initially the formulation of the simplified water balance equation for winter drain flows did not produce adequate results.

$$Q_{HFw} = R_W\, C_{Rw}$$

Equation 11

An attempt was made to use the Modified Semi-Arid Zone (MOSAZ) soil moisture deficit model in the same three gauged catchments throughout the study. MOSAZ consists of a linear reservoir of finite capacity with three outlets that simulate baseflow, interflow and surface runoff. The model requires drain flow, rainfall and evapo-transpiration data (SKM, 1999a).

Starting values for lower soil storage and baseflow recession constant parameters are essential. These parameters were difficult to calibrate. The main difficulty was the lack of modelling experience with irrigated catchments. It is not clear whether the original developers of MOSAZ included any irrigated catchments in the sample base.

Winter runoff coefficients derived by the water balance method for the three gauged catchments studied varied in too wide a range (10 - 18% of total runoff) to be considered suitable. An additional catchment, the Lockington, was subsequently analysed and the resulting winter rainfall runoff coefficient was 10%.

The model simulated a relatively reasonable fit for Deakin and Lockington Drains but a poor fit for MV Drain 6 and Bamawn. The Drainage Diversion Working Group considered that MOSAZ was not providing sufficient additional value and the modelling did not proceed further. Instead the DDWG opted for deriving a winter rainfall runoff coefficient as the average percentage of rainfall as runoff in the catchments analysed. That is, the water balance equation was revisited. Table 13 shows the derived runoff coefficients for the catchments analysed.

Table 13 - Winter Rainfall Runoff Coefficient, C_{Rw} (SKM, 1999c).

Catchment	% of rainfall as runoff (total area)	% of rainfall as runoff (drained area)	Drain density, Km/Km^2 (total area)	Drain density, Km/Km^2 (drained area)
Murray Valley Drain 6	0.134	0.151	0.85	0.77
Deakin Drain	0.129	0.202	0.74	1.16
Bamawn Drain	0.153	0.162	1.13	1.19
Lockington	0.095	0.095	0.77	0.95
Rodney (including Ardmona and Undera)	0.270		0.56	0.76
Murray Valley Drain 3	0.087	0.124	0.54	0.78
Average without Rodney	0.120			
Average with Rodney	0.145			

The Rodney Catchment was excluded because of some factors not accounted for, including cross catchment input from Mosquito Depression, Phase A groundwater pump inputs, runoff from Mooroopna, etc.

Detailed analysis found that there is a reasonably well defined linear relationship between the winter runoff coefficient and the drain density of the drained area of the total catchment. This relationship is to be used to derive the runoff coefficient in ungauged catchments and sub-catchments, rather than an average figure (SKM, 1999c).

$$C_{Rw} = 0.124\, Drain\, Density - 0.0007$$
$$r^2 = 0.8036$$

Where Drain Density is the length of drain per drained area of the total catchment, expressed in Km/Km^2.

The winter rainfall runoff coefficient derived with the linear relationship is to be used for the whole of the non-irrigation season. Such coefficient is likely to underestimate drain flows following extreme rainfall events in spring. However, it has the advantage that it results in conservative water resource estimates from a high flow diversion perspective.

5. ECONOMIC MODELLING

One of the keys to the success of high flow diversion is its economic feasibility. The economic modelling considered factors influencing co-investment in nutrient diversion and agricultural use by government and landholders. The storage fill-ratio, defined as the ratio between the average annual volume of water diverted and the constructed storage capacity (see Section 2.5 of this Appendix), was used as the main indicator of the economic value.

The analysis compared the annual costs of implementing high flow diversion for a range of expected fill ratios and capital and O&M costs against the annual costs of channel water supply. The market price of irrigation water right was taken as the private capital value of additional water at the expected long-term average of $600/ML (Farmanco, 1997). The public benefits of reduced nutrient flow to the Murray River were estimated in a separate study and their annualised present value was estimated at $84/ML (Gyles, 1999).

The economic modelling showed that the current incentives provided under the Drainage Nutrient Removal Incentive Scheme (grants of 25% of capital costs up to a maximum of $20,000) are justified for projects with capital costs less than $400/ML of storage and storage-fill ratios of more than one. Projects are generally likely to be viable if capital costs are less than $400/ML of storage and storage-fill ratios are more than one (Gyles, 1999).

Based on the current experience with schemes installed and the results of the hydrologic modelling it is likely that many projects do not satisfy the above criteria because capital costs to date have been about $1,000/ML storage and because storage-fill ratios are likely to be between 1 and 2 for periods of average and above average rainfall, but much lower over extended dry periods.

A reduction in storage-fill ratio of 5%/year over the 10 years time frame of the strategy (totaling 40% decrease) would represent a loss to existing diverters in the range of $43/ML (if the initial storage-fill ratio was 1) to $90/ML (if the initial storage-fill ratio was 2) of storage capacity (Gyles, 1999).

Benefits to some landowners may be significantly greater than assumed in the modelling because of local site and enterprise differences. However, it is likely that those landowners who have already installed works will suffer some loss as additional diversions are authorised.

6. DECISION CRITERIA - STORAGE/ HIGH FLOW RATIO

The storage/High flow ratio is defined as the aggregate of the authorised storage volume in the catchment divided by the estimated total high flow in the catchment (for the standard period 1992 to 1996), and is expressed as ML of storage volume per 1,000 ML of estimated high flow.

The proposed framework for allocation of high flow diversion agreements gives weight to both Water Quality Strategy objectives and the financial interests of diverters. It does so by using the storage/High flow ratio in any catchment as a measure of the likely effect of authorised diversions on the actual diversion of water and nutrients from the drain (as measured by the % of high flow diverted) and the storage-fill ratio (as a measure of any diverter's ability to access available drainage flows).

Table 14 shows the effect on the % high flow diverted and the storage-fill ratio in each of the modelled catchments as the storage/high flow ratio is increased.

Table 14- High Flow Diverted and Storage Fill Ratios for specified Storage/High Flow Ratios (SKM, 1999)

Storage/High Flow Ratio (ML/1,000 ML storage)	Bamawn		Upper Deakin		Murray Valley Drain 6	
	% diverted	storage fill ratio	% diverted	storage fill ratio	% diverted	Storage-fill ratio
150	22	1.10	27	1.48	31	1.96
200	27	1.02	33	1.34	40	1.87
250	32	0.96	37	1.19	44	1.65
300	36	0.91	40	1.07	48	1.48

To balance the conflicting objectives of increasing diversion and limiting the adverse effects on existing diverters (see Section 2.6 of this Appendix), it is proposed that the maximum storage capacity in any drainage catchment be limited, initially to 200 ML/1,000 ML/year of estimated high flow. This decision criteria can be justified on the basis that:

- storage-fill ratios are greater than one in each of the three catchments modelled, which are representative of the catchments in the SIR;
- the percentage diverted (approximately 30%) is close to the nominal 50% target set by the Water Quality Strategies, whilst limiting adverse effects on existing/prospective high flow diverters; and
- increased diversion above 30% of available flows reduces storage-fill ratios by about 40% over a 10 year period and causes losses which in NPV terms range from $43/ML to $90/ML for initial storage-fill ratios between 1 and 2.

The modelling results suggest that diverters will seldom be able to achieve an annual storage-fill ratio greater than 2 if significant high flow diversion is occurring in any catchment. It is therefore proposed that the maximum annual diversion volume be set at twice the authorised storage capacity.

7. CONSULTATION

The high flow drainage diversion strategy underwent a round of consultation with Manager of Water Services; MVIA, CGIA, SIA and RIA Water Services Committees (WSCs); Surface Drainage Working Group (SDWG); Plan Implementation Sub-Committee (PISC) and River Environment Water Quality Committee (REWQC).

The recommendation was put to these groups to endorse a 250 ML storage /1,000 ML/year of estimated high flow in any catchment. Whilst most groups concurred with the recommendation others favoured a more conservative upper limit of 200 ML storage /1,000 ML/year of estimated high flow. For consistency, the latter figure was the adopted target.

APPENDIX C – COST AND COST SHARING ARRANGEMENTS – DEVELOPMENT STAGES

APPENDIX C – COST AND COST SHARING ARRANGEMENTS – DEVELOPMENT STAGES

Memorandum

To:	**Distribution List**
From:	Nancy Gonzalez, Drain Management Officer
Subject:	**'Drainage Diversion Strategy – Cost sharing arrangement options'. Discussion Paper**
Date:	1 May 2000
File No:	1998/02118/2 Doc No: 275187 v2

1. BACKGROUND

This paper should be read in conjunction with 'Drainage Diversion Strategy – Executive Summary'. The full draft of the Drainage Diversion Strategy should be consulted for more details.

2. DRAINAGE DIVERSION STRATEGY JUSTIFICATION

- Relative importance of irrigation drainage as nutrient source - irrigation drainage contributes approximately 50% of total nutrient load into the River Murray. (GBWQS, 1996);
- Drains for controlled disposal of saline groundwater pumped volumes (subject to disposal guidelines which take into account that the environmental impact of some discharges may be reduced by discharge in flood conditions rather than in dry weather);
- Irrigation drainage causes the water quality of the River Murray River and other receiving waters to exceed water quality standards (EPA, SEPP, ANZECC) thus creating the risk of attracting penalties (SKM, 1996);
- Irrigation drainage reuse and its contribution to sustainable irrigation in the region and water use efficiency. The reuse of irrigation drainage through drainage diversion allows development of land that does not have a water right. Counter-argument that stopping water from getting into drains also contributes to the sustainability of the region and to water use efficiency;
- Improvements to drainage water resource management to encourage equitable sharing of the resource and reduce complaints, disputes and customers dissatisfaction;
- Consistency of procedures for assessment of drainage diversion applications across Irrigation Areas;
- Informal G-MW's endorsement of Goulburn Broken, Campaspe and Loddon Water Quality Strategies (WQSs). G-MW made earlier submissions to State Government for Goulburn Broken WQS on behalf of the catchment;
- Acceptance of State and Federal funding totalling $1,5M over three years. These external contributions are aimed at implementing initiatives formulated under the WQS for the Goulburn Broken Catchment to improve the water quality of the River Murray;
- G-MW's Board approval of drainage diversion initiatives eg 'Deakin Pilot Project' and 'Management Arrangements for Drainage Diversion from the Warrigal Creek System';
- Establish significant and realistic contributions towards the irrigation drainage reduction targets set by the WQSs;
- G-MW's commitment to management of drainage diversions through appointment of Drainage Officers; and

- G-MW's implicit commitment to providing a reasonable 'level of service' to drainage diverters by its charging of volumetric fees.

3. COSTINGS

The Strategy assumes that G-MW can only make drainage diversion allocations based on the surface runoff derived from land served by primary drains. CSDs are assumed to divert all irrigation induced runoff during summer.

Assumptions have been made about the generation of runoff from primary drained areas. Irrigation runoff estimates obtained from studies in three gauged catchments allowed the derivation of an irrigation runoff rate per primary drained area of catchment. These rates were used to estimate irrigation runoff volumes to be generated by areas yet to be served by primary drains once the Surface Drainage Strategy (SDS) is completed. These volumes were assumed to increase linearly over the remaining period (10 years) for SDS implementation.

The costing of the Strategy has been fundamentally based on low flow drainage diversion. The administrative costs incurred in operating and managing high flow diversion have not explicitly been identified. The assumption has been made that the unit rates for operation and management of low flow diversion can sufficiently cover the activities involved in similar tasks for high flow diversion.

Current (1998/99) expenditure on drainage diversion has been identified/estimated for each of Central Goulburn, Murray Valley, Rochester and Shepparton Irrigation Areas. Implementation costs over the first ten years of the Strategy have also been estimated for each of the Irrigation Areas. These costs have been broken down into Capital, Operation and Maintenance.

3.1. Capital

3.1.1. Drain diversion flow meters

The Strategy assumes that G-MW will meter the remainder of existing low flow diversion sites currently unmetered within the first five years of its life. Any number of diversion sites above those existing will either be metered by individual diverters or funded by the implementation of the SIRLWSMP. The latter applies when the sites are reinstated as part of the construction of new primary drains where the Surface Drainage Strategy covers the costs of infrastructure, metering and setting up administration costs.

Each Irrigation Area has its own preferences about the type of metering and these have been taken into account in cost estimates for capital, operation, maintenance (including renewal) and other allocated charges.

3.1.2. Drain flow monitoring

The Strategy assumes that each Irrigation Area, over the first five years of the life of the Strategy, will install additional drain flow monitoring stations within the drain catchments at a ratio of 1 station per every 5,000 ha of primary drained land.

These flow monitoring stations are to provide real time flow data that Area Managers can use for decision making purposes. That is, the Strategy allows for SCADA instrumentation fittings for each of these additional monitoring stations.

3.1.3. Low level rock weirs

The Strategy allows for the construction of low level rock weirs at the lower end of each of the major drain catchments.

3.2. Operation

3.2.1. Labour

Unit rates for labour and vehicles for each of the IAs were developed on the basis of actual/estimated operating expenditure for the existing number of low flow diversion sites.

As the implementation of the surface drainage strategy progresses, the surface runoff increases and so would the number of diversion sites. Surface drainage runoff has been assumed to grow linearly along the continuum until the end of implementation of the SDS. The unit rates were used to estimate future expenditure assuming a linear growth for the number of diversion sites. All operation, maintenance and renewals costs associated with drainage diversion reflect this growth.

3.2.2. Vehicles

See 3.2.1.

3.2.3. Contribution to other internal units

Allowances for annual contributions to other internal units, eg Natural Resources and Distribution Assets. The Irrigation Areas (CG, MV, R and S) have committed $10,000 annually for preparation of DDPs, DMPs, contingent allocation reviews, periodical evaluation of the Strategy, etc. The Strategy makes allowance for expenditure by Distribution Assets on issuing licences for construction and use of private works, and level survey input into works associated with drainage diversion.

3.2.4. Drain flow monitoring

Allowance for operation (data retrieval, validation, processing and reporting) of drain flow monitoring stations.

3.3. Maintenance

3.3.1. Labour

Unit rates for labour and vehicles for each of the IAs were developed on the basis of actual/estimated maintenance expenditure for the existing number of low flow diversion sites.

As the implementation of the surface drainage strategy progresses, the surface runoff increases and so would the number of diversion sites. Surface drainage runoff has been assumed to grow linearly along the continuum until the end of implementation of the SDS. The unit rates were used to estimate future expenditure assuming a linear growth for the number of diversion sites. All operation, maintenance and renewals costs associated with drainage diversion reflect this growth.

3.3.2. Vehicles

See 3.3.1.

3.3.3. Materials

3.3.3.1. Maintenance of drain diversion flow meters

A breakdown ratio depending on the type of metering favoured by the IA was assumed in consultation with Drainage Officers. It was assumed that the expenditure on repairs, materials, replacement parts, etc per meter would be of the order of 10% of the capital cost of the meter.

3.3.3.2. Renewal of drain diversion flow meters

The renewal of these meters was assumed as maintenance expenditure since, given past experience with meters in irrigation drains, they need to be replaced relatively frequently (2-10 years). The cumulative increase in the number of meters per year was used to estimate renewals using a 4% discount rate.

3.3.3.3. Renewal of drain flow monitoring (instrumentation and civil works)

The renewal of additional drain flow monitoring instrumentation was also assumed as a maintenance cost as the equipment and software become obsolete within a short period (less than 10 years). The discount rate used is 4%.

3.3.4. Drain flow monitoring

Allowance for routine maintenance of probes and instrumentation on the sites, regular visits, etc.

3.4. Other allocated charges (OAC)

The Strategy assumes that OAC will remain constant because the functionality and structure of G-MW internal units are comprehensive enough to handle the increased workload without incurring significant cost increases. That is, internal units such as Finance and Land & Water Management, for instance, are capable of handling the changes without having to employ more staff, or acquire additional software, etc.

4. COST SHARING OPTIONS

Pricing for low flow drainage water diverted under Tier 1 and Tier 2 Agreement conditions is on the basis of allocations and volumes diverted above allocation. Whilst a low flow diversion site remains unmetered the diverter is required to pay charges based on the Agreement allocation only.

Diversion of drainage water under high flow conditions (Tier 3) whether pumped or by gravity only attracts a service or administrative fee. However, WSCs have discretionary power (subject to Board approval) to alter these arrangements depending on particular circumstances relevant to the Irrigation Area.

No allowances were made for:

- Increased costs due to renewals and maintenance of surface drainage infrastructure;
- Increased revenue as more land receives a drainage service when drains are constructed; and
- Increased revenue as a result of increase gravity irrigation prices.

4.1. Current drainage diversion tariff (base case Year 0)

Low flow (Tier 1 or Tier 2) diversion charges = volumetric fee * (volumetric allocation + actual volume used above allocation)

Under Tier 1 Agreements the volumetric allocation component is payable, regardless of the availability of the resource or the actual volume used. Under Tier 2 Agreements the volumetric allocation is payable, irrespective of usage, only if water sales are greater than or equal to 50% of Water Right (or any other agreed pre-set level in the drain catchment). The volumetric fee is currently one quarter of the gravity irrigation fee in the relevant Irrigation Area.

High flow (Tier 3) diversion charges = administrative fee

When this tariff system was set little consideration was given to recouping actual costs. The objective at the time was to acknowledge that the drainage water was a valuable resource.

To maintain status quo of drainage diversion fees the surface drainage tariff would need adjustment to cover shortfalls or surpluses to meet the costs of implementing the drainage diversion strategy. The resulting tariffs, given projected costs to Year 5 and Year 10, are compared against the base case (Tariff 1 Year 0).

4.2. Polluter pays tariff

This tariff option relies on the polluter pays principle. It provides an incentive to reduce pollution as the lower the discharge (as assessed by the area and consumption components of the surface drainage charge) by each drainage users the lower their fee. The fee however, would not be related to the relative harmfulness of the pollutants, the state of the receiving environment or the manner of discharge. These are aspects that should be considered as we improve our knowledge about irrigation drainage.

In this option there would not be any revenue from drainage diversion and there would not be any need to explicitly identify costs associated with drainage diversion activities. Surface drainage charges need to increase substantially to cover full cost of drainage diversion.

4.3. Beneficiary pays tariff

Full cost of drainage diversion would be recovered from drainage diverters. This tariff option recognises that even though drainage diverters are also polluters, they are benefiting from utilising the drainage water resource to make improvements in the productivity of their farm enterprises.

The surface drainage rates would vary compared to the base case but remain constant over time. The surface drainage charges are in fact the same as if there was no drainage diversion (see Section 4.6). The drainage diversion consumption fees would increase substantially to recover full cost.

4.4. Arbitrary 50/50 tariff share between drainage users and drainage diverters

This is an arbitrary compromise between tariff options 2 and 3. It attempts to both apportion responsibility for pollution to all drainage users and recognise the benefit to drainage diverters from drainage reuse.

4.5. Market-based tariff

The volumetric charge for consumption of drainage water would be based on the willingness of diverters to pay for the resource. This value could be established by identifying and advertising the availability of the resource and then conducting a public auction.

The successful bidder would need to enter into a drainage diversion agreement with G-MW and be made aware that the quantity or quality of the resource is not guaranteed.

- Area by Area approach to account for local differences?
- Determine a minimum price?
- What is a reasonable price for drainage water (comparison against irrigation water prices at point of delivery)?

4.6. No drain diversion

This option is fundamentally a ‘what if’ scenario in which we have made the assumption that there is no drainage diversion. Therefore reduction of drainage water, and consequently water quality improvements, would be achieved through other options such as water use efficiency on-farm, reduction of channel outfalls, loss reduction through refurbishment of water distribution infrastructure, etc.

Since there is no drainage diversion, there are no associated costs or revenue. The surface drainage charges are as for Tariff 3 and constant over time.

5. RECOMMENDATIONS

5.1. That the Drain Coordinating Committee endorses the widely accepted view by regional water quality strategies that drainage diversion is the most cost effective and fastest method of reducing irrigation drain flows;

5.2. That pending a full review of surface drainage tariffs, to retain Tariff 1 for the interim; and

5.3. That the full review of surface drainage tariffs examines the most appropriate basis for the tariff system with the ‘polluter pays tariff option’ as the starting point for discussion.

Nancy Gonzalez
DRAIN MANAGEMENT OFFICER

Distribution List:
John Mapson, Manager Water Services;
Geoff Earl, Manager Water Reform Development;
Garry Smith, Manager Production and Catchments;
Water Services Committees (Central Goulburn, Murray Valley, Pyramid-Boort, Rochester, Shepparton and Torrumbarry); and
Drain Coordinating Committee.

Refer to DOC#219268 for costs data

APPENDIX D - SPECIFICATION FOR PREPARATION OF DRAIN DIVERSION PLANS

APPENDIX D - SPECIFICATION FOR PREPARATION OF DRAIN DIVERSION PLANS

This Appendix lists the procedure that is to be followed by consultant(s) to prepare Drain Diversion Plans (DDPs).

1. CATCHMENT AND SUB-CATCHMENT STATISTICS

1.1. Drainage diversions

Document drainage diversions (types, locations, allocations, user identifiers, usage, etc.) for catchments and sub-catchments.

1.1.1. Low flow

Document and/or estimate the current total volume of low flow diversions in the catchment. Options may include:

- Using records of metered diversions, if available; or
- Assuming that the total volume in existing low flow diversion agreements is being diverted; or
- Conducting a survey of current practices; or
- Transferring drainage diversion usage patterns from other drain catchments.

The preferred option is to be agreed with G-MW Project Manager.

1.1.2. High flow

The level of existing high flow diversion is to be estimated by accounting for the number and capacity of high flow storages in each sub-catchment. This information is to be documented in the report and also graphically (locations, storage sizes, user identifiers, etc.).

1.2. Channel outfalls

Document channel outfalls (locations, volumes, and distribution over time – eg daily, monthly, annual as available).

If records are available, consider the quality of the information (daily/weekly/monthly records, difference between readings at end and start of irrigation season, etc.). If there are no records, obtain best estimates of channel outfall volumes for low and high flow based on advice from Area Managers (AMs).

Estimate the proportion of channel outfalls that contributes to low/high drain flow. This can be done by comparing daily channel outfall records, if available, against channel deliveries and rainfall data in the Irrigation Area.

To be conservative, and since channel outfall volumes are targeted for reduction, they are to be documented but not accounted for (unless otherwise agreed with G-MW) in the estimates of volumes available for further diversion allocations. When channel outfalls are considered, Area Managers will need to make predictions about short to medium term variations. These predictions should be based on sound knowledge of the catchments and the use of Best Management Practices (BMPs) for channel outfalls. Documentation of channel outfall significance in relationship to drain flows will indicate whether they should be included in volumes made available for diversion.

1.3. Groundwater pump flows

Document groundwater pumps (locations, identifiers, volumes and distributions over time if available).

Estimate the proportion of groundwater pumped volumes that contributes to low and high drain flows:

GW_{LF} = 70% of groundwater pumped volumes during irrigation season.

GW_{HF} = 30% of groundwater pumped volumes during irrigation season (GW_{HFs}) plus all groundwater pumped volumes during winter (GW_{HFw}).

1.4. Rainfall

Rainfall is assumed to fall uniformly across the drainage catchment.

Document the annual average rainfalls per catchment and the rainfall stations, or combination of stations, in each catchment, as indicated in the table below (the table needs to be completed for the remaining catchments in the Goulburn Broken):

Table 15 - Rainfall in Goulburn Broken Catchments Over Standard Period

Catchment	Rainfall Station (see note below)	Rainfall in standard period (mm)		Rainfall per 1,000 ha in standard period (ML/1000 Ha)	
		Irrigation season	Non-irrigation season	Irrigation season	Non-irrigation season
Deakin	080091 Kyabram				
Bamawn	406751 BMD at WMC				
MV Drain 6	080125 Ulupna				
MV Drain 13					
MV Drain 18					
MV Drain 6					
MV Drains 3 & 5					
S Drain 11					
S Drain 12					
Coram					
Mosquito					
S Drain 3					
S Drain 4					
Wyuna					
Rodney					
Undera					
Tongala					
Corop Lakes					
Ardmona					
Kaarimba					
Kialla					
Muckatah					
Toolamba					
Coomboona					
Wharparilla					
Campaspe					
Strathallen					

Note: In some instances the catchment of interest may not have a rainfall gauge or the existing gauge may not be representative for the catchment. In those instances, the equation below is to be used to obtain rainfall estimates based on records for nearby rainfall gauges.

$$R_c = R_s \frac{\overline{R_c}}{\overline{R_s}}$$ **Equation 12**

Where:

R_c = estimated rainfall for the catchment of interest for the standard period

R_s = observed rainfall at nearby rainfall gauge(s) during the standard period

$\overline{R_c}$ = long - term catchment average rainfall (obtained from Bureau of meteorology GIS)

$\overline{R_s}$ = long - term station average rainfall (obtained from Bureau of Meteorology GIS)

1.5. Irrigation water usage

Document the actual irrigation water usage during the standard period (irrigation seasons from 1994/95 to 1996/97). This information is obtained from ISIA's GIS application.

1.6. Reuse systems

Obtain information from ISIA's records on the number, location and capacity of existing reuse systems in the catchment.

Estimate the proportion of catchment area with installed reuse systems. If the proportion is low, it is likely that more will be implemented in the short to medium term. If the proportion is high, the available low flows are likely to reduce even further.

Assess how existing reuse systems are being managed. If there is poor management, there is potential for improvement which will result in lower low flows. If reuse management practices are sound, low flows should already be low.

2. ESTIMATE OF FLOWS

Estimate available low and high drain flows at various locations (sub-catchment outlets and catchment outfall). The catchments are to be fragmented into sub-catchments of approximately 5,000 ha judged capable of yielding drainage runoffs to support several diverters.

The procedure detailed in this specification was developed for drainage catchments in the Shepparton Irrigation Region (SIR) with characteristics similar to those of the Bamawn in Rochester Irrigation Area, Drain 6 in Murray Valley Irrigation Area and Deakin in Central Goulburn Irrigation Area. More detailed hydrologic modelling and targeted management strategies may be required for catchments with large upstream dryland catchments and/or predominance of Community Surface Drains (CSDs).

Runoff from upstream dryland catchments is not to be included in the estimates of volumes available for diversion in the catchment of consideration. In any case where the available volume is based on real outfall monitoring, it will be necessary to estimate the likely component of flows from the dryland catchment and reduce the available volume accordingly.

The runoff coefficients developed for use in estimating available volumes for ungauged catchments are applicable only to catchments served by traditional drainage systems. They will need to be modified for use in catchments served by drains which incorporate nutrient stripping features, particularly any form of inline storage or sumps.

The DDP is to document variations to the standard procedure outlined in this specification. Variations may be the result of catchment characteristics that differ significantly from those of the catchments used to develop the procedure. These catchment characteristics may include constructed or natural wetlands, nutrients stripping features, considerable input from upstream dryland catchments, significant catchment area served by CSDs, etc.

2.1. Definitions

2.1.1. Low flow

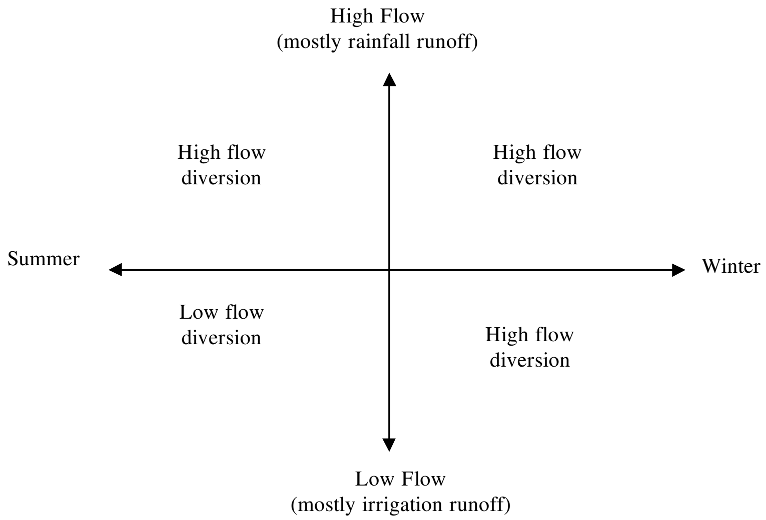
Drain flows occurring during the irrigation season which are mostly derived from irrigation runoff (tailwater).

2.1.2. High flow

Drain flows occurring either during the irrigation or the non-irrigation season which are mostly derived from rainfall runoff in the irrigated catchment. In DDPs they are to be estimated separately from the irrigation and non-irrigation season standard periods, see Section 2.1.3 below.

Figure 5 shows in diagrammatic form the agreed definitions for low and high drain flows. Note that although in theory there is no drainage diversion of low flows during winter, these volumes are nevertheless accounted for under high flow estimates.

Figure 5 - Schematic Definition of Drain Flows



Actual rainfall, water usage and drain flow data in the Deakin, MV Drain 6 and Bamawn drain catchments was used to derive regional runoff coefficients. To be consistent with those analyses, future works must adhere to the following definitions.

2.1.3. Standard periods

Standard irrigation season period: irrigation seasons between 1994/95 and 1996/97 (October to April, inclusive). This period is to be used for both low and high flow estimates. The irrigation periods used in the assessment for the drains in the original study were actual periods based on start and end of each irrigation season in Central Goulburn, Murray Valley and Rochester Irrigation Areas.

Standard non-irrigation season period: non-irrigation seasons from 1992 to 1996 (May to September, inclusive). This period is to be used to estimate high flow during winter.

$$\begin{aligned} Q &= Q_{LF} + Q_{HF} \\ &= Q_{LF} + (Q_{HFs} + Q_{HFw}) \end{aligned}$$ **Equation 13**

Where:

Q = annual drain flow, ML

Q_{LF} = annual drain low flow which, by definition, is irrigation runoff and occurs during summer (irrigation season), ML

Q_{HF} = high flow which may occur during summer (Q_{HFs}) or winter (Q_{HFw}). Low flows during winter though not separately estimated, are accounted for in total high flow estimates.

2.2. Low flows (irrigation season - summer)

The estimation of low flows is to be based on the drained areas only of the catchments as defined in consultation with G-MW

2.2.1. Gauged catchments (monitoring and modelling)

Compile and analyse recorded drain flow data over the irrigation seasons between 1994/95 and 1996/97.

Estimate available low flow, Q_{LF}, by constructing a flow duration curve, for the irrigation seasons in the standard period, at each flow monitoring station, and in particular, at the catchment outfall. The available low flow, at a particular station, is the area below the curve for a time exceedence greater than 30%.

$$\begin{aligned} Q_{LF} &= Q_{30\%} \\ &= I\,C_{LF} + COF_{LF} + GW_{LF} - DD_{LF} \end{aligned}$$ **Equation 14**

Where:

Q_{LF} = $Q_{30\%}$, annual irrigation season low flow volume as defined by the 30% exceedence threshold from the flow duration curve;

I = standard-period average annual irrigation water usage;

C_{LF} = low flow runoff coefficient;

COF_{LF} = standard-period average annual channel outfalls contributing to low flows (that is, when data is available, the total of daily outfalls corresponding to the highest 70% of irrigation deliveries);

GW_{LF} = standard-period average of 70% groundwater pumped volumes during irrigation season; and

DD_{LF} = standard-period average annual low flow drainage diversion volumes.

Model the distribution of the base flow within the catchment, if necessary, by reconciling estimates (see procedure described under Section 2.2.2) against monitored data.

To be conservative, and unless otherwise agreed with G-MW, the final estimate of flows available for low flow diversion is not to take into account channel outfall volumes. When these are included, it would be necessary to consider expected reductions in channel outfalls according to advice from Area Managers.

If, in addition to the catchment being gauged, there is reliable information on drainage diversions, channel outfalls and groundwater pumped volumes, a different catchment calibration procedure to estimate irrigation and rainfall runoff coefficients can be followed. However, this procedure is to be followed upon direct agreement with or instruction from G-MW's Project Manager.

The model in this case is described by:

$$Q_{IS} = I\,C_I + R\,C_{Rs} + COF + GW - DD$$ **Equation 15**

Where:

Q_{IS} = irrigation season drain flows, ML

C_I = irrigation runoff coefficient

C_{Rs} = summer rainfall runoff coefficient

All other terms are as defined above. The procedure is described in Sinclair Knight Merz 'Irrigation Season Runoff Coefficients for Ungauged Catchments' 1998, with adjustments detailed in attachment to letter dated 23 November 1999 (Nancy Gonzalez).

2.2.2. Ungauged catchments (modelling)

$$Q_{LF} = IC_{LF} + COF_{LF} + GW_{LF} - DD_{LF}$$ **Equation 16**

Where:

I = actual irrigation water use during the calibration period (obtained from GIS application).

C_{LF} = low flow runoff coefficient obtained by adjusting the irrigation runoff coefficient ($C_I = 0.15$). See letter 23 November 1999, Nancy Gonzalez.

DD_{LF} = estimated/monitored drainage diversions during the standard period.

COF_{LF} = standard-period average annual channel outfalls contributing to low flows (when data is available, the total of daily outfalls corresponding to the highest 70% of irrigation deliveries. If data is not available, use information provided by Area Managers).

To be conservative, and unless otherwise agreed with G-MW, the final estimate of flows available for low flow diversion is not to take into account channel outfall volumes. When these are included, it would be necessary to consider expected reductions in channel outfalls according to advice from Area Managers.

Winter low flows are implicitly accounted for in the estimate of high flows and assumed available for diversion. It may be necessary to correct volumes for very saline low flows, if these are known to occur.

2.3. High flows

The estimates of high flows are to apply to G-MW primary drained areas (existing and proposed) unless otherwise specified.

High flow volumes are the total of high flows during the irrigation season (Q_{HFs}) and high flows during winter (Q_{HFw}).

$$Q_{HF} = Q_{HFw} + Q_{HFw}$$ **Equation 17**

2.3.1. Gauged catchments (monitoring and modelling)

$$Q_{HF} = Q - Q_{30\%}$$ **Equation 18**

Where:

Q = annual recorded flow at gauging station.

Q_{HF} = total annual high flow volume.

$Q_{30\%}$ = annual irrigation season low flow volume (see Section 2.2.1).

Model the distribution of the high flow within the catchment, if necessary, by reconciling estimates (see procedure described under Section 2.3.2) against monitored data.

To be conservative, and unless otherwise agreed with G-MW, the final estimate of flows available for high flow diversion is not to take into account channel outfall volumes. When these are included, it would be necessary to consider expected reductions in channel outfalls according to advice from Area Managers.

Although it is not necessary to identify the summer and winter components of high flow in gauged catchments, it can be done to check that results are realistic:

2.3.1.1. Irrigation season (summer)

High flow during summer (Q_{HFs}) is the area below the flow duration curve for a time exceedence greater than 30%, that is:

$$Q_{HFs} = Q_{IS} - Q_{30\%}$$ **Equation 19**

Correct the volume of high flows summer available for diversion to account for unsuitable (too saline) flows, if significant.

2.3.1.2. Non-irrigation season (winter)

$$Q_{HFw} = Q_{HF} - Q_{HFs}$$ **Equation 20**

2.3.2. Ungauged catchments (modelling)

2.3.2.1. Irrigation season (summer)

$$Q_{HFs} = R\,C_{HFs} + COF_{HF} + GW_{HF} - DD_{HF}$$ **Equation 21**

Where:

R = average annual actual rainfall during the irrigation season for the standard period

C_{HFs} = high flow runoff coefficient obtained by adjusting the summer rainfall runoff coefficient (C_{Rs} = 0.175). See letter 23 November 1999, Nancy Gonzalez.

COF_{HF} = standard-period average annual channel outfalls contributing to high flows

GW_{HF} = standard-period annual average of 30% groundwater pumped volumes during irrigation season

DD_{HF} = standard-period annual average of high flows diverted during irrigation season

To be conservative, and unless otherwise agreed with G-MW, the final estimate of flows available for high flow diversion is not to take into account channel outfall volumes. When these are included, it would be necessary to consider expected reductions in channel outfalls according to advice from Area Managers.

2.3.2.2. Non-irrigation season (winter)

$$Q_{HFw} = R_W\,C_{Rw}$$ **Equation 22**

$$C_{Rw} = 0.124\,Drain\,Density - 0.0007$$ **Equation 23**

Where:

R_w = standard-period average annual rainfall during the winter months in the catchment

C_{Rw} = winter rainfall runoff coefficient

3. MANAGEMENT OF ALLOCATIONS

The DDP is to outline potential for additional drainage diversion under separate low flow and high flow diversion arrangements based on the criteria established by this specification or any variations resulting from consideration of non-standard catchment aspects.

3.1. Setting of diversion limits

3.1.1. Low flows (Tier 1/Tier 2 Agreements)

The decision indicator to assess new low flow drainage diversion applications is the Current Diversion Ratio (CDR) defined as the ratio of utilisation of available low flows by existing diversions.

$$CDR = \frac{CLFAV}{(CLFAV + ALFV)} = \frac{CLFAV}{LFV}$$

Where:

CLFAV= current total low flow diversion (known from metered data or total of agreements volumes - see Section 1.1.1)

ALFV = volume available for further low flow diversion (See Section 2.2)

LFV = total low flow volume

For consistency, it is important to use volumes for actual diversions and total inputs for the standard period (1994/95-1996/97).

The type of diversion agreement to be allocated should be based on the CDR value set out in Table 16 below.

Table 16 - Criteria for Issuing of Low Flow Drainage Diversion Agreements

Low Flow Drainage Diversion Agreement	CDR
Tier 1	0.0 - 0.5
Tier 2	0.5 - 0.7
Nil	0.7 - 1.0

3.1.2. High flows

Allocations are to be managed to achieve the following objectives based on modelling of catchment behaviour for the period July 1990 to June 1996:

- Minimum diversion target of 30% of available high flow; and
- Minimum storage-fill ratios of one (note that long-term storage-fill ratios will be lower).

Based on the hydrologic modelling carried out in the study the objectives will be achieved if:

- The maximum total storage in any catchment (or sub-catchment) is limited to 200 ML/1,000 ML of estimated high flow; and
- The diversion capacities for individual diverters are limited to 15 ML/d per 100 ML storage capacity.

The equivalent annual volume required by wetland-type features must be subtracted from the total high flow estimate before applying the decision criteria for assessment of high flow drainage diversion applications. The required volume is that required to simulate the wetting and drying regime of the wetland and must be made explicit by the designer. This volume should be based on the long-term catchment development rather than interim operating conditions.

3.2. Allocation

The information collected and estimated prepared as part of DDPs is to be put into spreadsheets with formats similar to those shown below. These spreadsheets will be updated as often as necessary (by G-MW) when assessing/approving new applications.

3.2.1. Low flow

	current scenario				forward projection with new diversions				
sub-catchment and sequence	irrigation runoff	current drainage diversions	estimated available low flow	CDR	irrigation runoff	current + proposed drainage diversions	revised available low flow	revised CDR	recommended low flow diversion allocation
outfall totals									

3.2.2. *High flow*

	current scenario				forward projection with new diversions				
sub-catchment and sequence	rainfall runoff	current high flow storage capacities	estimated available high flow	storage per 1,000 Ml available high flow	rainfall runoff	current + proposed high flow storage capacities	revised available high flow	revised storage per 1,000 Ml available high flow	recommended high flow diversion allocation
outfall totals									

4. DRAIN FLOW MONITORING

The DDP is to make recommendations about changes/improvements to the existing drain flow, channel outfall and drainage diversion monitoring facilities in respect of location, type, method, frequency, etc. These recommendations are to be justified in terms of economic considerations.

APPENDIX E – PROCEDURE FOR ASSESSMENT OF DRAINAGE DIVERSION APPLICATIONS