Bray's Swamp Management Plan

March 2001

Environmental Management Program

Institute of Sustainable Irrigated Agriculture,
Department of Natural Resources & Environment

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**Cover: Aerial view of Bray's Swamp (looking south) after Trial flooding April 1997 and skirted by the recently constructed Mosquito 24 Primary Surface Water Management Scheme.
(Photo: Paul O'Connor).**

Acknowledgments

Bill and Lesley Bray, landholders of Bray's Swamp, who share a vision and desire to maintain the swamp as a high value wetland that it is. That the wetland occurred on property owned by successive generations of the family who also valued the wetland has indeed been fortunate otherwise the wetland may not now be present at all. An abundance of wildlife and all who appreciate the wetland are indebt.

Keith Ward Wetland Ecologist – North East Catchment Management Authority, (Formerly from the Flora Fauna Division of the Department of Natural Resources & Environment), for his expertise in developing this Wetland Management Plan and for providing the template for the development of Wetland Plans across the Goulburn – Broken Catchment.

Thanks are also owing to:

- Various members of the FGA for financial contributions to expedite the purchase of water required to undertake the 1997 trial flood at Bray's Swamp. At least one very mature Red Gum appears to remain alive as a result.

- GMW (Graham Smith, Central Goulburn Area Management) for contributing 30 ML of water towards the trail flood in 1997 after this volume of water was lost from the wetland into the Primary Surface Water Management Scheme which subsequently resulted in some channel structure and sill level modifications being undertaken.

- SKM design engineers and Bruce Campbell (Environmental Design Engineer) for incorporating the required modifications into the Surface Water Management Scheme design that will provide for the flood regime of Bray's Swamp. Also, Neville Paynter (Project Manager) with SKM assisted in providing a site inspection and cost estimation of the proposed northern channel upgrade.

- GMW Distribution and Assets (Construction and Works), namely Ross Plunket (Manager), Trevor Bassett & Peter Eggleston (Construction Management), and Ian Rodgerson (Works Foreman) & crew.

- Constructive reviews of earlier drafts of this manuscript were received from members of the DNRE Environmental Management Program ISIA Tatura and members of the SIR Implementation Committee.

Funding for the water management associated works and this wetland management plan were provided by DNRE, GBCMA, Salt Action and MDBC towards ensuring the sustainable management of our natural heritage.

Abbreviations

CSWMS	Community Surface Water Management Scheme
DNRE	Department of Natural Resources & Environment
EC	Electrical Conductivity (unit measure of salinity)
EMP	Environmental Management Program (part of DNRE Catchment and Agriculture Services Division)
EWA	Environmental Water Allocation
FF	Flora and Fauna division of DNRE
FGA	Field and Game Australia
GBCMA	Goulburn-Broken Catchment Management Authority
GMW	Goulburn-Murray Water
ha	Hectare
hr	Hour
km	Kilometre
MDBC	Murray-Darling Basin Commission
ML	Megalitre (one million litres)
ML/d	Megalitre per day (measure of flow)
PSWMS	Primary Surface Water Management Scheme
SIR	Shepparton Irrigation Region
SIRLWSMP	Shepparton Irrigation Region Land & Water Salinity Management Plan
SKM	Sinclair Knight Mertz (consulting firm responsible for the arterial drain design)
SWMS	Surface Water Management Scheme
µS/cm	Micro Siemens per centimetre (a unit measure of salinity)
FGA	Field & Game Australia
SPAC	Salinity Program Advisory Committee

Foreword

This Wetland Management Plan is the culmination of the efforts of a number of dedicated people who along with Bill and Lesley Bray share the vision of seeing Bray's Swamp remain as a viable and productive wetland ecosystem.

It identifies the Key Stakeholders, including Government and non – government organisations who along with Bill and Leslie accept the management responsibilities assigned to them through the Actions defined in the Management Plan.

The Wetland Plan has been developed as an Adaptive Management Plan to enable management actions to be modified in response to the monitoring of the Key Ecological Indicator Species.

Therefore all works and actions which may impact on the implementation of the Plan will only be carried out after consultation / approval from the identified Key Stakeholders and signatories to the Plan.

The Plan has been developed in conjunction with the Wetland and Surface Water Management Scheme infrastructure to provide for the flexibility required to manage this significant environmental feature in what is a highly modified irrigated catchment subject to the vagaries of man and nature.

While implementation of the Plan is an adaptive process the Plan will be formerly reviewed at five yearly intervals to ensure that it remains a living document. The review process will also be subject to consultation with, and sign off by, the identified Key Stakeholders.

On the understanding of this adaptive management process the Wetland Management Plan will form the basis for a 173 Agreement under the Victorian Planning and Environment Act (1989), to ensure the protection of the Wetland into perpetuity by binding All signatories to its future management.

I look forward to seeing the implementation of this Wetland Management Plan, which has become the template for developing Wetland Management Plans throughout the Goulburn – Broken Catchment, becoming the model for partnerships in sustainable ecological management.

Paul O'Connor
Environmental Assessment Coordinator
DNRE Catchment and Agricultural Services

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Management Agreement

We the undersigned representatives acknowledge this document as being the Adaptive Management Plan for the Bray's Swamp Wetland and accept our responsibilities in partnership as recommended for its ecological sustainability.

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Plate 1. Bray's Swamp Sunrise (looking South –East) after Trial flooding April 1997. (Photo: Merv Smith)

Plate 2. Bray's Swamp (looking South) after the Environmental Water Allocation Trial flooding December 2000. (Photo: Paul O'Connor)

1. Summary

Bray's Swamp is an 80 ha privately owned terminal wetland complex near Merrigum in Northern Victoria. The swamp is a shallow ephemeral wetland in a prior stream depression (Byrneside Depression), characterised by a vegetation community of sparse mature River Red Gum over Barren Cane Grass, Common Spike-sedge, and exotic Water Couch. The site is notable as a Brolga breeding site, but is also important as a breeding, feeding and roosting site for numerous waterbird species. The construction of the Primary Surface Water Management Scheme (PSWMS) bordering Bray's Swamp have presented an opportunity, for the first time, to control flooding into and out of the swamp. Structures have been specifically designed and incorporated into the PSWMS to provide the physical mechanisms for wetland water management. Funding for these works have been provided through the Surface Water Management Program (formerly the Drainage Program) of the SIRLWSMP to facilitate water management actions that aim to support the values of the wetland. It is for this reason that the Department of Natural Resources and Environment is providing a management plan for this privately owned wetland.

This Adaptive Management Plan presents the necessary geo-morphological, biological, utilisation history, management history and current landholder requirements to support the management recommendations as detailed. Wetland values, especially as a Brolga breeding site, and the continued careful utilisation activities within the wetland, form the basis of this plan.

Plate 3. Bray's Swamp in full production after the Environmental Water Allocation Trial flooding December 2000. (Photo: Paul O'Connor)

2. Introduction

2.1 Bray's Swamp

Bray's Swamp is an 80 ha privately owned wetland complex, situated approximately 2km southwest of the Merrigum township in northern Victoria (Figure 1). The swamp is a shallow (~ 0.5m deep) ephemeral wetland in a prior stream depression (Byrneside Depression) fed from a 4,605 ha catchment beginning to the southwest of Tatura. It has formed as a terminal wetland system at the bottom of the Byrneside Depression, Mosquito 24 Sub-Catchment. Outfall overspill from the swamp historically flowed 3km north to the main Mosquito Prior Stream Depression.

Prolonged seasonal inundation has been responsible for forming the open character of the wetland. Barren Cane Grass (*Eragrostis infecunda*), Common Spike-sedge (*Eleocharis acuta*) and exotic Water Couch[1] (*Paspalum distichum*) dominate the wetland floor with a sparse overstorey of mature and dead River Red Gum (*Eucalyptus camaldulensis*). The surrounding rises are dominated by a variety of terrestrial grasses (primarily exotic) with scattered mature Grey Box (*E. microcarpa*) and Buloke (*Allocasuarina luehmannii*) (Webster 1993).

The wetland is of state and regional significance, representing a habitat type that was once more common and as a Brolga (*Grus rubicundus*) breeding site (DCE & OE 1992, Webster 1993). A recent history of unseasonal or prolonged flooding at the site, arising from irrigation-induced runoff gravitating to the wetland, threatened these values.

However, the more recent construction of the Mosquito 24 Primary SWMS to service the irrigation community has similarly provided an ability to now manage the flood regime in the wetland. Flooding flows are able to enter the wetland via specifically designed overflow spillways in the Scheme, and outfall from the wetland is regulated with a drop-bar structure prior to flow rejoining the Primary SWMS. Provision of an Environmental Water Allocation (‘make-up’ supply) has been investigated and trialed to enable maximum flexibility in wetland water management. This enables, for the first time, control over the flood regime in the wetland.

The Department of Natural Resources & Environment (DNRE) has prepared this management plan in recognition of the site being of high value to flora and fauna. Background history of management and wetland characteristics is given to form an appreciation of the current wetland ecology and its value and of the management opportunities and constraints. It attempts to provide for the sustainability of the current ecological values of the wetland. The landholder's enterprise activities and future aspirations have been incorporated into the plan. However, it is a return to an appropriate flooding regime (more akin to natural conditions) that is the predominant driving force shaping wetland ecology and hence forms the main aspect of this plan.

[1] Water Couch (*Paspalum distichum*) used to be considered a cosmopolitan species (ie, native to both Australia and many other countries of the world) (eg, Willis 1970, Sainty & Jacobs 1981, Carr *et al.* 1992, Cunningham *et al.* 1992), though more recently is being regarded as introduced (eg, Walsh & Entwisle 1994, Ross 1996). This document accepts the exotic status and attempts to manage against the species, for which the plan would intend to do regardless of its exotic/native status because of the dominating colonisation ability of the species within many wetlands throughout the SIR.

2.2 Policy Support

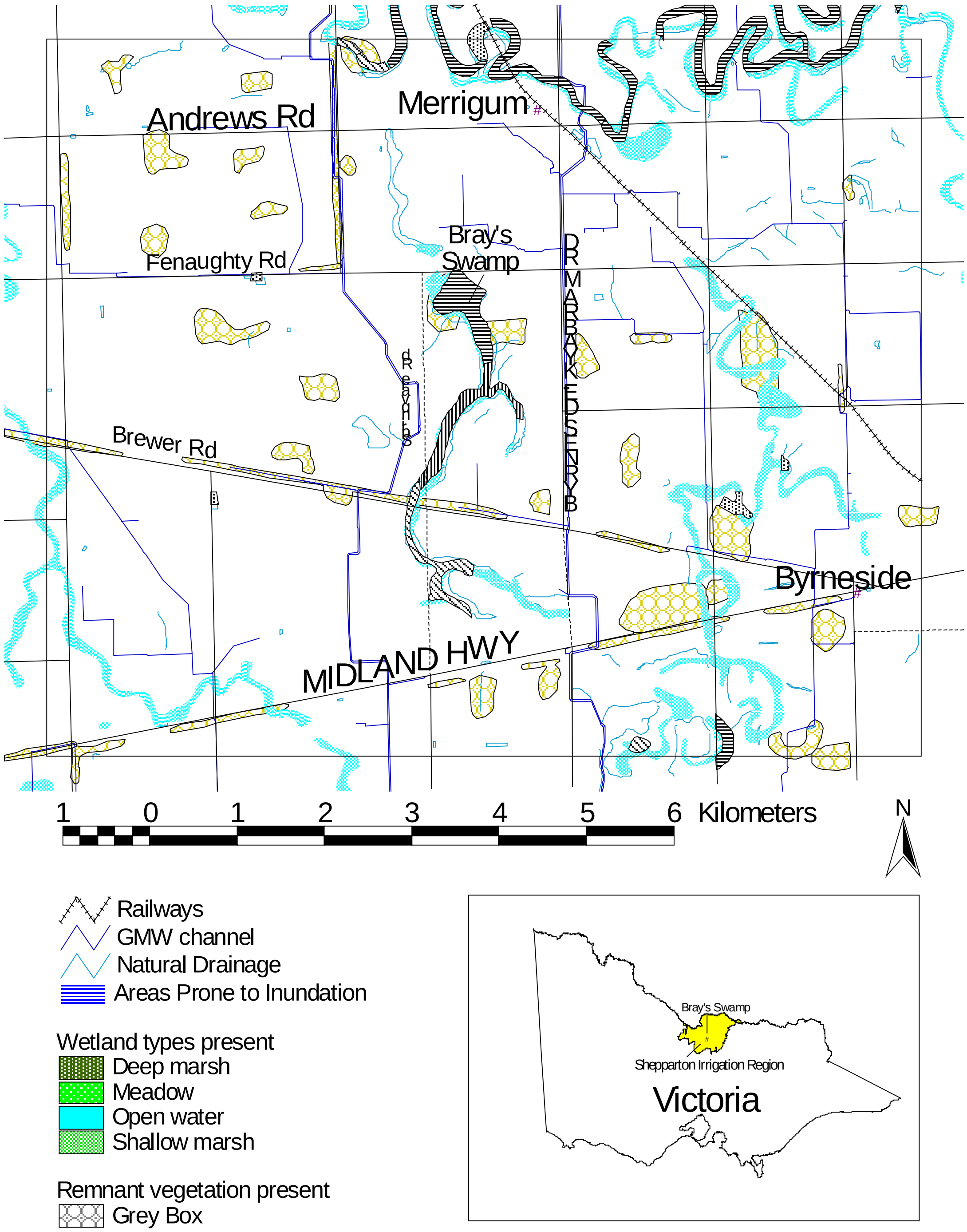
The issues and directions for wetland management are outlined in a number of federal, basin, state, and catchment management strategies. The primary emphasis of the strategies are to protect natural systems from degrading processes and, where possible, restore the natural functioning of degraded systems to enhance indigenous biodiversity.

Key policy documents and management strategies of influence for this management plan include:

- 'The National Strategy for the Conservation of Australia's Biological Diversity' (CoA 1996);
- 'Wetlands Policy of the Commonwealth of Australia' (CGoA 1997), including our international commitments via, JAMBA and CAMBA Agreements;
- 'Floodplain Wetlands Management Strategy for the Murray-Darling Basin' (MDBC 1998);
- 'Victoria's Biodiversity Strategy – Directions in Management' (DNRE 1997);
- 'The Goulburn-Broken Catchment Management Authority Catchment Strategy' (GBCMA 1998);
- 'Shepparton Irrigation Region Land and Water Salinity Management Plan' (GBCMA & NCCMA 1996).

50% of Victoria's non-permanent freshwater wetlands have disappeared since settlement, with 90% of these having occurred from private land. 78% of Shallow Marsh and 93% of Freshwater Meadow has disappeared from private property (DCE & OC 1992). Within the Shepparton Irrigation Region, a very high proportion of wetlands occur on private property. Bray's Swamp is one such wetland. It is consists of Shallow Marsh and Freshwater Meadow, and that it exists in relatively good condition, makes it a rarity and deserving of appropriate management to maintain and, where possible, enhance the indigenous biodiversity.

Figure 1: Location of Bray's Swamp



This map is based on publicly available data. The creator does not warrant that this map is definitive nor free of error and does not accept liability for loss arising from use of this product beyond its original purpose.

Produced by Keith Ward 24/09/99 Ph 03 5833 5947

3. Background

3.1 Wetland History:

The current landholders of the wetland, Mr William (Bill) and Lesley Bray, represent the fifth generation of continuous family ownership of the site initiating with original settlement selection. A mixture of dryland and irrigated pasture grazing for beef cattle constitutes the predominant enterprise currently being undertaken on the land.

The wetland has been regarded throughout the family generations as a valuable grazing paddock and waterfowl-hunting site (B. & L. Bray *pers. comm.*). The current landholders especially value the aesthetics of the wetland itself and the experience of observing the wildlife that the wetland attracts (B. & L. Bray *pers. comm.*) Although some areas of the property were modified for flood irrigation of paddocks, the wetland paddock was not and remained dryland grazing. It was for these reasons that the wetland was not drained as so many other similar wetlands within the state have been (DCE & OE 1992). The wetland now represents a type that is of state and local significance, due to being a Brolga breeding site, and as a representative example of a wetland type that was once much more common (DCE & OE 1992).

Management activities on the property have altered relatively little post clearing, at least for the last three generations (B. Bray *pers. comm.*). This is supported by aerial photographs of the region dating back 50 years which show a very similar view to today's in the immediate area (Figure 2). The wetland has altered relatively little, with wetland size, configuration, and land use in the surrounding area not appreciable different from today. The wetland and its immediate upstream catchment have essentially remained unaltered in the last half century.

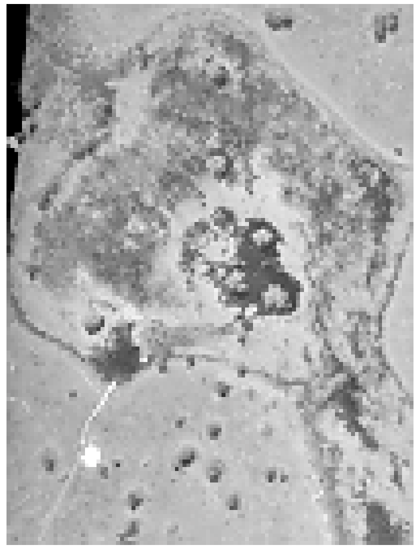
The most notable change has been the gradual loss of 86% of the trees, presumably all River Red Gum, within Bray's Swamp itself since the earliest aerial photographs. The greatest decline in the numbers of live trees occurred in the 30-year period between 1945 and 1974. As far as is detectable, an open community was formed from approximately 77 live trees with a further two dozen dead trees in 1945. By 1974, approximately 15 trees remained alive, representing a reduction of 81%.

Most of the trees to disappear were younger trees, as suggested by crown size in the aerial photographs and as girth size when recently ground truthed. No ringbarking was evident in the standing dead trees, and the landholder has never undertaken any management activities to kill the trees (B. Bray *pers. comm.*). That the topography is flat throughout the wetland with the larger trees occupying regions that exhibit similar flood regimes to the dead trees indicates that waterlogging has been the cause of stress to the smaller trees as the larger trees have a greater propensity to endure prolonged flooding (Dexter 1967, Dexter *et al.* 1986).

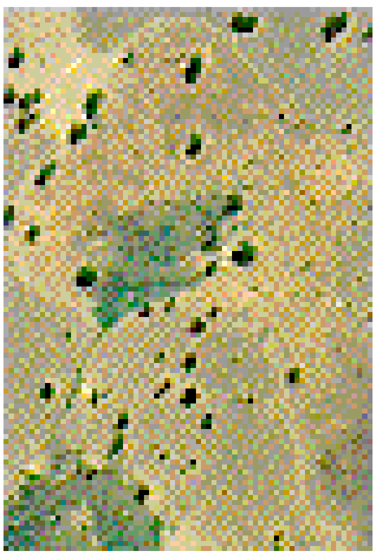
The remaining live trees have then slowly declined over the next 24 years. There existed 14 live trees in 1981, 13 live trees in 1990, and 11 live trees in 1997 (plus 50 dead trees). Currently (2001), it appears that a further two trees will soon or have already died. The latter deaths have presumably been caused by waterlogging in the wetland from successive wet years between 1989 to 1993 prior to the SWMS being constructed around the wetland in 1996, further accentuated by successive outbreaks of Gum Leaf Skeletoniser (*Uraba lugens*) defoliating the already stressed trees in 1996 and 1997 (O'Connor *pers. comm.*). Significant tree death and decline in the box trees occurring around the margins of the wetland have also occurred during this period.

Figure 2: Historic aerial photographs of Bray's Swamp.

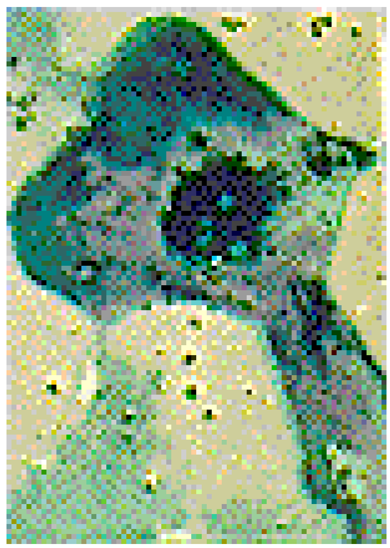
a) Bray’s Swamp - 1945



b) Bray’s Swamp - 1974



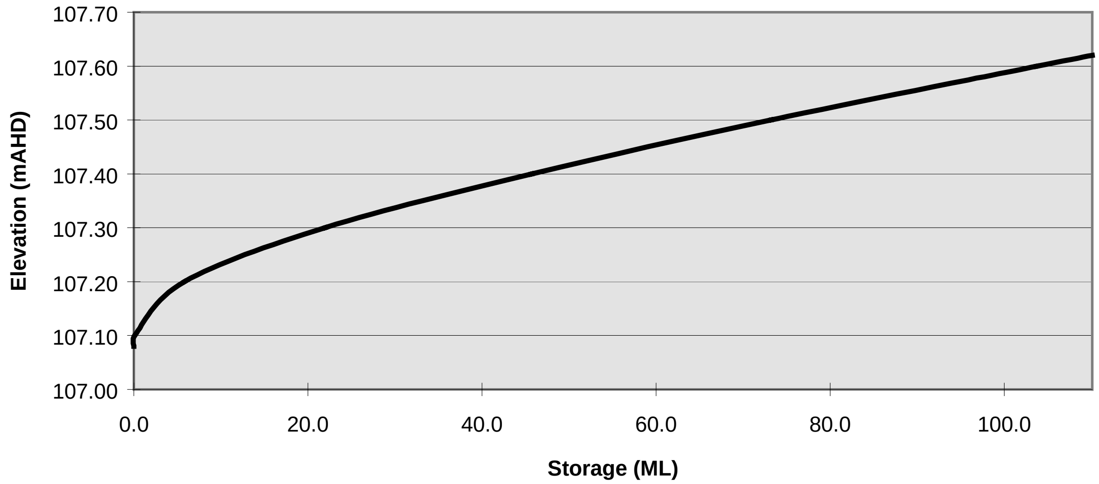
c) Bray’s Swamp - 1981



d) Bray’s Swamp - 1990

e) Bray’s Swamp - 1997

Figure 3: Stage-Storage relationship for Bray's Swamp (after Kelleher 1997).



Unfortunately, changes over time in the understorey species or communities could not be discerned from the aerial photographs. It is expected that the wetland would have been dominated by an understorey of native grasses, herbs, sedges and rush prior to the influence of irrigation runoff causing prolonged flooding regimes (Frood 1983).

3.2 Cultural Significance:

The wetland is likely to have had significance to aboriginal people prior to European settlement. Waterbodies such as Bray’s Swamp and the remainder of the prior stream depressions in a semi-arid landscape, otherwise dominated by Grey Box woodland and open grassland (Frood 1983), would have provided a valuable water and food gathering resource (Curr 1883). Archaeological significance is evidenced by a double-sided canoe scar on a mature Grey Box still surviving on the eastern boundary of the swamp.

3.3 Catchment Activities:

The broader catchment contains agricultural activities primarily centred around irrigated pastures for dairy cattle, with some dryland grazing and cropping enterprises also being undertaken (Webster 1993). Until the construction of the PSWMS in the catchment in 1996, surface runoff from the catchment (whether it be from excess irrigation water or rainfall) all gravitated into the Byrneside Depression which terminated in Bray's Swamp. As such, the wetland increasingly experienced prolonged flood regimes via a cycle of winter rainfall followed by a greater prevalence of irrigation-induced runoff in spring and summer. Runoff has increased in the catchment because of landforming and development associated with the intensification of irrigation in the catchment.

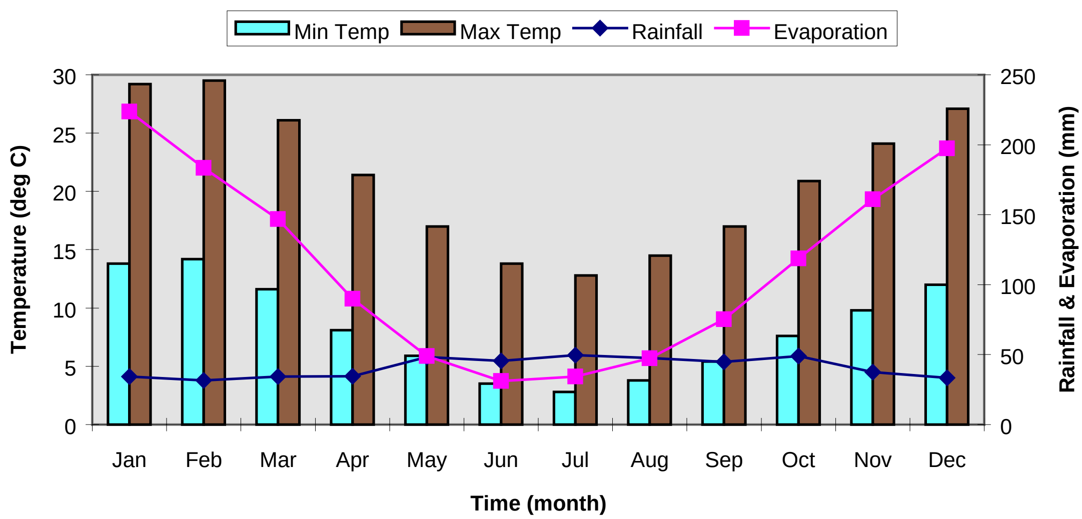
The extended flood regimes within the wetland are expected to have caused a range of deleterious physico-chemical changes in the wetland substratum and alterations to its biology (Mahar 1984, Briggs & Mahar 1985).

An interruption to the drying regime of naturally ephemeral wetlands such as Bray's Swamp causes decreased indigenous macrophyte (aquatic plant) diversity (Frood 1983, Cottingham *et al*. 1994, Brook 1994, Ward *in prep.*), and a corresponding decrease in fauna diversity (Mahar 1984, Souter 1996, Puckridge *et al.* 1997). Some of the changes within Bray's Swamp are discussed in Section 3.4 'Flood Regime', below.

3.4 Flood Regime:

Bray's Swamp is a terminally located wetland in the Byrneside Depression Mosquito 24 sub-catchment. It has evolved as a receptacle for the catchment's surface runoff from rainfall. With an average climate of 491 mm of annual rainfall, monthly totals of which are relatively evenly spread throughout the year with only a minor increase in winter and spring, and a total annual evaporation rate of 1358 mm strongly peaking in summer from a winter low (Figure 4), the wetland would have usually experienced flood inflows during winter/spring following an autumn wet up (wetland system priming).

Figure 4: Mean monthly climatic parameters at Tatura (closest station to Bray's Swamp). *(Data from the Institute of Sustainable Irrigated Agriculture. Temperature data averaged from records dating back to the year 1965, rainfall to 1942, & evaporation to 1966).*



The generally flat natural topography of the wetland, evidenced by the current distribution of mature tree species both within and outside the wetland giving reference to relatively unaltered substrate levels for at least two hundred years (based on the size of the mature trees), would mean that flood depths would have rarely exceeded 0.75 m. Due to the shallowness of the wetland, ponding of water would generally have been less than 0.50 m deep lasting for 2-3 months [*from full inundation level plus rainfall minus evaporation. Although the seepage rate is unknown, it is suspected to be minor due to the clay soils of the site*]. Therefore, the wetland is expected to have had a natural autumn wetting up period (priming), a winter/spring core flooding period and a summer/early-autumn dry phase.

However, typical of an Australian semi-arid environment, climate would have been annually variable and hence would impart variability in the natural flood regime of the wetland. The wetland would have dried on average 7 years in every 10, being wet throughout the year during 3 periods in 10 years.

In general, the wetland's natural flood regime could be categorised as a Type 3 regime (medium duration seasonal wetland; Corrick & Norman 1980) in which flood frequency is annual in most years, generally occurs in winter-spring, persists for approximately 4-6 months, and annually dries in most years in summer-autumn. However, the altered flood regime prior to the construction of the PSWMS could be categorised as a Type 4 bordering on Type 5 regime (prolonged duration seasonal open wetland ranging to a semi-permanent open wetland; Corrick & Norman 1980) in which flood frequency is annual, occurs throughout winter-summer and sometimes into autumn, persists for between 6-12 months, and dries in some years only.

Flood regimes required by Cane Grass and Spike-sedge are in the order of an annual 6-9 months shallow flooding and 3-6 months dry (Corrick & Norman 1980, Ward *in prep.*). Cane Grass is a perennial species that survives soil moisture drought, discourages heavy grazing pressure, and generally tends to grow only with high soil moisture from heavy rainfall or shallow flooding on the site (Cunningham *et al.* 1992). Cane Grass flowers mainly from September to April (Cunningham *et al.* 1992), though vegetative reproduction appears to be the most important method of spread in this species (Carr 1993). Spike-sedge is a seasonal perennial in that it becomes senescent during dry soil conditions but rapidly re-shoots from its short underground rhizomes upon wetting up. Growth is generally most rapid in the spring months after water levels pond below the plants' height of 300-400mm (Ward *in prep.*). Flowering occurs throughout spring-summer (Walsh & Entwisle 1994).

3.5 Surface Water Management Scheme:

The issue of waterlogging was symptomatic of many areas within the catchment rather than restricted to Bray's Swamp. Rising watertable and increasing salinisation are also issues of concern within the Mosquito Region (SPAC 1989). This had arisen because of human altered landscape changes combined with the introduction of irrigation into the catchment. It was for this reason that a Surface Water Management Scheme was proposed for the catchment in 1989 to provide appropriate drainage for the catchment (SPAC 1995).

An Initial Environmental Assessment process was undertaken of the proposed scheme alignment in 1991. Bray's Swamp was recognised at that time as a high value wetland requiring an deviation to the proposed route, of the scheme plus design modifications to cater for an appropriate flood regime to the wetland (Webster 1993).

As a Surface Water Management Scheme designed to provide drainage to the Mosquito 24 catchment, construction was initiated at the Scheme's outfall to the main Mosquito Depression, progressing upstream. It was not until 1996 that the construction of the Mosquito 24 Primary Scheme had reached and bypassed around Bray's Swamp. Although construction of the scheme has since progressed upstream of Bray's Swamp, many of the associated Community Surface Water Management Schemes (CSWMS) have not yet been built.

The Primary Scheme has been designed to provide effective drainage from the catchment over a five day period in the event of a 1 in 2 year rainfall event (ie, 50ml rainfall occurring within a 24hr period) occurring in a catchment that has two thirds of its area irrigated prior to the rainfall (SPAC 1995). The Scheme is essentially designed to remove the irrigation-induced component of water within the catchment in the rainfall event. The design capacity of the Scheme is 100 ML/d (B. Campbell pers. comm.).

A sill level has been constructed at three points within the scheme where it skirts Bray's Swamp and the associated wetland depression system so as to provide drainage overflow into the swamp. Combined with a choke (or throttle) constructed into the scheme a short distance downstream of an overflow sill constructed above the Drought Refuge Area and another below the overflow sill on Bray's Swamp itself, flows are expected to flood into the wetland system during 1 in 1 year flow events (B. Campbell pers. comm.). These works were incorporated into the schemes design by SKM under direction of the EMP specifically to provide seasonal flooding into the wetland.
As part of these works, a small drainage channel was also constructed in the natural drainage course at the north-western end of Bray's Swamp to the outfall into the Primary Scheme. A regulating structure (drainage inlet with drop-bars) was constructed at the drainage channel outfall point to provide an ability to

either pond the floodwaters at a desired level within the wetland or to drain the water from the wetland altogether.

A potential threat to the frequency and volume of inflows into Bray's Swamp is the recent proliferation of private re-use systems being constructed upstream in the catchment. The systems are designed to fill from Primary Scheme spills (overflows) in a similar fashion to that designed for Bray's Swamp. Their construction is being encouraged as part of the implementation of the SIRLWSMP to encourage nutrient management by harvesting high flows from the SWMS (GBCMA & NCCMA 1996). However, the re-use systems potentially impact on Bray's Swamp by causing peak flows in the Mosquito 24 PSWMS upstream of the wetland to effectively be reduced as they are now having to be shared between the various high flow water diverters.

However, the re-use systems built to date have been authorised and generally constructed to take only a relatively small volume of excess flow from the scheme. For example, a re-use system constructed approximately 3 km upstream of Bray's Swamp can divert only around 3 ML/d off the 150 ML/d Primary Scheme's capacity. Also, there exists two spur catchments entering the main Byrneside Depression downstream of this re-use system which remain upstream of Bray's Swamp, from which additional flow can enter the Primary Scheme. In addition, the spillways for Bray's Swamp, designed for a 1:1 share of full Primary Scheme flows, are lower than those on the upstream re-use system. By way of example, this means that if 150ML/d were to flow in the Scheme, Bray's Swamp would have been in receipt of 75 ML/d. However, the upstream re-use system diverts 3 ML resulting in Bray's Swamp diverting the remaining 72 ML/d plus any additional flows entering the Scheme via the two spur depressions. This flow would still be responsible for flooding Bray's Swamp in a period of around two days. And the higher sill levels of the re-use systems than of Bray's Swamp also means that the potentially greater impact of removing the excess flow at lower flow rates (eg, 78 ML/d) is removed. Hence the impact of the current re-use systems on the flooding of Bray's Swamp should be minor, though nevertheless could alter if larger systems with lower sills were permitted to be built.

Plate 4. Bray's Swamp throttle structure Mosquito 24 PSWMS October 2000. (Photo: Paul O'Connor)

3.6 Water Quality:

The quality of drainage water in the Primary Scheme is of importance to Bray's Swamp as it is the major source of flooding to the wetland. No known studies have been undertaken of water quality at the site, though GMW monitoring of outfalls indicate that the water quality (as per the major physico-chemical parameters) is generally good (A. Piani *pers. comm.*). An isolated spot recording at Bray's Swamp in 1997 showed a water salinity level of 300 EC (180 mg/L)(P. O'Connor *pers. comm.*), and a slight crystallised salt line was visible in the dam within Bray's Swamp when observed dry in July 1998 (K. Ward *pers obs.*).

Water quality can be variable during the year, reflecting flow rates and seasonal farm activities (eg, superphosphate application to pastures). In addition, watertable height in the area is currently within 2m of the surface and can also be variable and hence is also of importance to the swamp and its management. Good background water quality and watertable data is required to be monitored to build a history of levels and its variability to enable future management to seek ways of minimising the impact that extremes in these parameters can impart on the wetland ecosystem (see Salinity Bureau 1989 for review).

Of some current concern is the presence of a number of 'salt indicator plants' growing within the region of the wetland. As the name suggests, these plants are usually found at sites where soil salinity is raised and hence are useful as indicators of this issue (Matters & Bozon 1989). Species currently present at Bray's Swamp in varying densities and distribution are Couch (*Cynodon dactylon*), Wimmera Rye-grass (*Lolium rigidum*) and Windmill Grass (*Chloris truncata*) (Webster 1993). Such species are listed as Class 1 ranging into Class 2 indicator species, which means that they generally indicate raised though relatively low (< 600 EC) to moderate (< 1400 EC) saline soil conditions (Matters & Bozon 1989).

Sublethal impacts of water salinities below 1000 EC have been recorded for some common local wetland plants (Hart *et al.* 1990, James & Hart 1993, Warwick & Bailey 1997), and hence enforces the need to monitor water quality over time as the salinity may restrict the type of plants that can be established within the wetland.

Nutrients, such as P and N, can also potentially be in high levels within drainage water and therefore also of concern to the wetland, especially following rainfall after widespread application of superphosphate or urea for pasture fertilisation within the catchment. Elevated nutrients can cause alterations to botanical communities via modifying the competitive ability of different species and hence can be responsible for large shifts in the vegetation communities of a site. Unfortunately in Australia, where most plants have evolved to cope with low nutrient conditions, the shifts in vegetation communities often mean a shift to domination by exotic species and often a corresponding decrease in indigenous diversity (Cottingham *et al.* 1994).

Also, elevated nutrient conditions can lead to an algae dominated system as the main source of primary production within the wetland (Bowling 1994, GoV 1995). Major impacts can result if algal biomass reduces light penetration or otherwise smothers aquatic plants. Cyanobacteria, more commonly though incorrectly known as Blue Green Algae, can also bloom in very large number and may be toxic to a range of organisms, particularly mammals (GoV 1995, Soranno 1997). For the aquatic faunal assemblage of a wetland, a senescing algal or cyanobacterial bloom requires oxygen from the water as a result of decay (Biological Oxygen Demand), thereby often reducing oxygen levels in the water to levels below that required for fish and some invertebrates (GoV 1995). Such a collapse in trophic levels can have reverberating impacts on the remainder of the ecosystem (Cottingham *et al.* 1994).

However, there is limited ability to exclude first flush flows within the SWMS exist because of the fixed sill level. The sills cannot be modified into variable height sills (ie, regulators) as the Primary Scheme and downstream throttles are not designed to carry the additional rejected flows. Instead, if monitoring of drainage water deems water quality at particular periods to be an issue, then draining the wetland and topping with an Environmental Water Allocation (EWA) should occur immediately following the undesirable spill event into the wetland.
Also, monitoring the water directly within the wetland, particularly if the water is ponded or has minimal flow-through, will be required to determine if the wetland should be flushed with the use of an EWA

(preferred option, especially if wetland contains breeding Brolga) or to drain the wetland prematurely to prevent further concentration of salts or other impurities from increasing due to evaporation. Ongoing monitoring of Bray's Swamp could be undertaken by incorporating the site within the Environmental Monitoring Program being undertaken by the Environmental Management Program of DNRE, or other similar program where appropriate.

3.7 Flora and Fauna:

A Detailed Environmental Assessment of the Byrneside Catchment for the Mosquito 24 CSWM Scheme was undertaken between 24 March and 22 April 1993 by an environmental consultant employed by DNRE prior to the construction of the then proposed SWMS (Webster 1993). This report should be consulted for details of the recorded species. However in general, a total of 121 plant species were identified in the catchment. Fifty-five of these were native and 66 were exotic species.

Pasture grasses associated with grazing generally dominate the catchment. The general wetland vegetation consists mainly of:

- Grasses (*Paspalum distichum, Eragrostis infecunda, Typha orientalis*);
- Sedges *(Carex appressa, Cyperus difformis, C. eragrostis, and Eleocharis acuta*);
- Forbs *(Damasonium minus, Ottelia ovalifolia, Triglochin procera, Marsilea drummondii*);
- Rushes (*Juncus usitatus, J. articulatus, J. ingens, J.* sp.);
- Floating aquatics (*Azolla filiculoides*, *Spirogella oligorriza*).

The flood requirements of many of these species have been researched in Ward (1991) and Ward (*in prep*), and references therein.

Notable fauna found to frequent Bray's Swamp include:

- Brolga (*Grus rubicundus*) - rare (breeding pair); The flood and habitat requirements of Brolga have been reported in detail by Arnol *et al.* (1984).
- Barking Marsh Frog (*Limnodynastes fletcheri*) - insufficiently known (suspected threatened) in Victoria;
- Peregrine Falcon - Worldwide depleted species (breeding pair).

Plate 5. Brolga successfully bred in Bray's Swamp in 1992. (Photo: Paul O'Connor)

3.8 Tree Health:

Former failing health of the River Red Gums in the wetland was an obvious symptom of the flood stress. For some of the trees, the construction of the SWMS to intercept the inflows came too late. Suspected of having survived a range of flood and drought conditions in the wetland for periods far in excess of the period of European occupation in Australia, 3 of the remaining 11 'alive' trees have only recently died in the last few years prior to the SWMS construction. Some other trees currently remain in poor health but are expected to survive given a reinstatement of an annual cycle of flooding and drying. It remains unknown to what extent the trees are utilising ground water (Thorburn *et al.* 1994).

The wetland was deliberately drained to alleviate the waterlogging stress for the first time following construction of the Mosquito 24 PSWMS up to Bray's Swamp in 1996. By December 1996, the wetland was dry for the first time in summer for 10 years (B. Bray *pers. comm.*). All of the remaining River Red Gums displayed 'improved' health by producing fresh growth, much of it as epicormic growth presumably following release from the waterlogging stress.

However, some of the trees soon had their foliage totally stripped away by the activities of insects taking advantage of the fresh growth, notably the Gum Leaf Skeletoniser (*Uraba lugens*). Fresh growth of *Eucalyptus* leaves are known to have reduced phenolic acid content which is otherwise a deterrent used by the plant as defence against insect herbivory and can have elevated nutrient levels further encouraging herbivory (Bacon *et al.* 1993, Stone & Bacon 1995). Gum Leaf Skeletonisers often feed on fresh growth and have often been responsible for tree defoliation when occurring in large numbers (Dexter *et al.* 1986).

It had appeared that some of the already weakened trees from prior waterlogging stress might now have ultimately been further weakened from the defoliation to the point of death.

The wetland remained dry for 15 months when it was apparent that the some of the remaining River Red Gums that survive the insect attack of their canopies were now again appearing stressed. River Red Gum has been known to undergo physiological adaptations that enable them to cope with a prolonged flooding regime (Heinrich 1990). Such changes include the development of meristematic roots within the aerobic water zone and a coating over the roots to protect them from rot. Now that the wetland was experiencing a rapid and seemingly prolonged dry, the surviving albeit weakened trees may have ironically been experiencing drought stress.

Thus imparting a natural flood regime too quickly after that flood regime has been modified for a long period of time may be another stress factor in itself. It is therefore likely that the wetland community has to be weaned back onto the natural flood regime, otherwise the possibility exists that much of the resident biota will be further weakened or killed and early colonising species or weeds could take their place.

A similar situation was suspected of occurring in Millewa Forest in 1996/97 when areas of the Edwards River system were strategically dried following prolonged flooding because concerns existed for the failing health of the River Red Gum. Although healthy River Red Gums thrive in similar environments within that forest which regularly undergo extended flood then drought, many of the existing flood-stressed trees may have survived if weaned onto the dry conditions (D. Leslie pers. com.).

3.9 Grazing:

The wetland is expected to have had a long history of grazing pressure because of the site offering both extended water supply and green feed in a semi-arid environment. Kangaroos are expected to be the main large vertebrate herbivore in pre-European times, being replaced by a more recent history of stock grazing. It is expected that early pastoralists droving sheep and cattle throughout northern Victoria in the early 1800's would have similarly concentrated on regions such as Bray's Swamp for extended feeding and

Plate 6. Red Gum epicormic regrowth Bray's Swamp, following the Trial EWA flooding December 2000. (Photo: Paul O'Connor)

Plate 7. Cattle grazing Water Couch regrowth in Bray's Swamp, following the Trial EWA flooding December 2000. (Photo: Paul O'Connor)

watering opportunities (Curr 1883, Robertson 1998). Grazing pressure is likely to have accelerated from the period of the early settlement selection of the site through to the current day where the wetland paddock remains highly valuable to the current landholder’s grazing enterprise.

The long and presumably continuous grazing history of the site is therefore likely to have exerted, in conjunction with the flooding regime, a major controlling factor in the vegetation associations and other characteristics of the wetland. High grazing pressure can result in the demise of palatable species which in turn can facilitate the domination of less palatable species (Williams 1969, Arnold 1971, DCLS 1977, Cheal 1993, DNRE 1996, Robertson 1998). Trampling and pugging of the substrate is also known to adversely affect some species and encourage others (O'Brien 1986). However, grazing at low intensities at appropriate times of the year may facilitate plant diversity by preventing the domination of a particular species (Blanch & Brock 1986).

Controlled grazing can also be a very useful management tool in association with flood regime manipulation. Grazing the wetland prior to an EWA delivery or prior to natural flood event can help remove the extensive biomass of terrestrial pasture grasses and weeds. In doing so the risk of rotting terrestrial plant biomass deoxygenating the water and leaving the wetland vulnerable to a 'Blackwater event' is significantly reduced.

Of the three most common macrophyte species present in Bray’s Swamp (Webster 1993), all are grazed to varying intensities. Barren Cane Grass tends to have the tips browsed, whereas the exotic Water Couch is grazed to ground level though withstands the grazing pressure with prostrate growth. However, Common Spike-sedge is being continually eaten to water level or ground level and the species is expected to be weakened as a result as the lack of emergent stems prevents photosynthetic capability. It is expected that in the present grazing and flooding regime, Water Couch is likely to be at a competitive advantage over the Spike-sedge and hence may ultimately take over the species current distribution within the wetland. This may further be facilitated by increases in salinity levels (James & Hart 1993, Walsh & Entwisle 1994).

It is preferable to attempt to control the growth and spread of Water Couch within the wetland. Apart from being an exotic species, it is now unfortunately a very common component of wetland systems throughout the SIR and it often dominants sites as a monospecific stand. Mats of Water Couch can totally cover water surfaces, preventing light penetration into the water, restricting atmospheric-waterbody gas exchange which creates anaerobic aquatic conditions, a reducing Redox potential and a build up of lethal hydrogen sulfide and methane (Crawley 1986). Aquatic invertebrate diversity and densities can be severely depressed, and feeding and breeding opportunities to amphibians and water birds can be restricted (Mahar & Carpenter 1984, Crome 1986). Water Couch can also threaten the health of stock with a condition known as staggers if the flowerheads of the grass are infected by an 'ergot' fungus and then grazed in sufficient quantities (Cunningham *et al.* 1992).

Complete eradication of water couch will never be achieved because seeds and fragments will continually wash into the wetland from sources upstream in the catchment (Cunningham *et al.* 1992, Webster 1993), and seeds have been found to remain viable in bird droppings (Middleton *et al.* 1991). Instead, management should focus on attempting to reduce the current favourable growing conditions of the species. The species grows best in waterbodies that are eutrophic (nutrient rich), lentic (stagnant or slow moving), shallow, and have long periods of inundation. Growth is particularly rapid when water temperature exceeds 20^{o}C. The species tolerates heavy grazing although this reduces its spread and problems associated with it forming dense mats or rafts on the wetland. The species can lay semi-dormant during drought though is relatively frost sensitive (Cunningham *et al.* 1992)

Therefore of the environmental variables that that can be controlled, management should aim to create a variable flood regime outside of the summer period, preferably grazing the species low prior to flooding and possibly targeting grazing again if growth becomes profuse after flooding. During years with no flooding or late flooding on the wetland, grazing may facilitate exposure of the plant to an increase threat from frost sensitivity via removal of covering senescent biomass.

Continuous grazing of stock in low densities (less than 50 head), particularly during productive Winter-Spring periods, (as was observed during the 2000 trial flood), can also assist in Water Couch management.

During this flood event the low numbers of stock initially fed on the extensive pick of the terrestrial pasture grasses that were available throughout the wetland paddock. They then switched to the new growth of the Water Couch as the wetland receded and the Couch density increased as the Summer draw down progressed.

An appropriate management regime to encourage Spike-sedge will be difficult if stock have full access to its current distribution for grazing. Medium to dense stands of the herb form an extremely valuable habitat for aquatic invertebrates, amphibians and waterbird feeding areas (eg, Painted Snipe *Rostratula benghalensis* and dabbling species of ducks like *Anas*). Unfortunately, the species can be selectively grazed by stock which readily crop it to the water line and below. Cropping below the water line or immediately prior to an increase in flood depth can essentially cause the plant to drown (Blanch & Brock 1994). At a minimum, stock should be excluded from grazing the wetlands Spike-sedge stands during flooding and preferably not until seed set in summer/autumn (Walsh & Entwisle 1994).

Alternatively stock densities in the main paddock could be lowered to less than 50 head during periods of extended flooding to help reduce the potential grazing impacts.

Grazing is best undertaken between February and May when flowering occurs within Water Couch (Walsh & Entwisle 1994). This can be a period that the Cane Grass and Spike-sedge are not restricted for flowering, as they can flower earlier (Cunningham *et al.* 1992).

3.10 Fire:

Fire is another natural process that has imparted an evolutionary and community structure effect within Australian plant, and therefore animal, ecology (Walker & Singh 1981, Flannery 1994). Aboriginal burning regimes were practiced within the region for promoting fresh grass growth to entice foraging game species (Curr 1883). However, no specific records are known to exist of the incidence of natural or man-induced fire within Bray's Swamp or surrounds.

In general, human settlement has limited the incidence of uncontrolled natural fires because of active suppression by landholders and Country Fire Authorities to protect life and assets. Further impacts on the native vegetation can occur without fire, which for some species and communities (such as grasslands) require burning every few years to maintain diversity and vigour (Morgan & Lunt 1999).

In attempt to provide habitat diversity within Bray's Swamp, especially for the creation of a mosaic distribution of Cane Grass vigour and height, then management of the wetland will need to explore opportunities for an appropriate fire regime. It is anticipated that intermittently burning small areas within the wetland in autumn (following curing of the grasses in summer and immediately prior to flooding in winter-spring so as to reduce weed growth in the disturbed site) would create structural habitat diversity and promote indigenous biodiversity.

Waterbirds (including Brolga) and frogs would be expected to have the opportunity to select their preferred microhabitat type within the wetland given an appropriate mosaic, and hence may provide enhanced feeding and breeding opportunities.

In the Autumn of 1999 two sites covering approximately 3.5 ha were selected for a trial burn. The areas chosen were in two different locations within the wetland covering two different plant assemblages.
The first site in the main body of the wetland was selected because it covered the Cane Grass zone and more open areas which were typically colonised by Water Couch and terrestrial grasses and/or environmental weeds. The second site chosen was in the shallower narrow neck on the Southern end of the main wetland which contained a broad zone of Water Couch which was interspersed with scattered Juncus rushes and Eleocharis Spike-sedges.

The aim of the trial burns was to remove the dry wetland plant and terrestrial plant biomass to see if burning prior to the expected Winter-Spring flooding would give the wetland species a competitive advantage.

A triple band firebreak was slashed around the perimeter of the sites by the landholder on the day and the fresh cut wetland down prior to back burning the sites. Heavy fuels (logs, stumps and standing trees) were prevented from burning by the DNRE-EMP staff that were involved in the trial burns.

The accumulated biomass including the proliferation of environmental weeds was successfully removed from the two selected sites. Unfortunately the wetland was not flooded during the Winter-Spring as was anticipated, however the Cane Grass did re-shoot along with the other terrestrial grasses and the spread and development of many of the environmental weed species was notably impaired.

The second trial flood with the EWA delivery starting in September 2000 did however reveal the success of the trial burn when both sites exhibited strong regrowth and consolidation of the desired wetland species and further suppression of the environmental weeds.

Plate 8. Trial Ecological Burn in Bray's Swamp, May 1999. (Photo: Paul O'Connor)

3.11 Community Involvement:

The Kyabram Branch of Field & Game Australia has had an interest in the wetland as a major site for the establishment of a nest box program to encourage the breeding of waterfowl. Since 1989, 67 nest boxes have been made by FGA and students from the St Augustines College in Kyabram and erected in the wetland. This has already resulted in numerous numbers of at least 5 species of waterfowl (Black Duck, Grey Teal, Chestnut Teal, Wood Duck and Mountain Duck) having been recorded nesting that might otherwise not have had the opportunity to (D. Peters & P O'Connor *pers. comm.*). The boxes have also provided successful nesting sites for Welcome Swallows. FGA members evict exotic species, notably European Starling and Common Mynah, during regular nest box monitoring and maintenance.

Also undertaken by FGA members and various interested locals are fox drives within the district. Bray's Swamp and its surrounds are regularly targeted for specific drives due in part for the importance of the wetland for waterfowl breeding but also primarily to the site being a Brolga breeding area. Foxes have been blamed for past chick disappearances on both. Brolga are held in high regard within the local community as they are obvious stately birds that many people can personally identify a marked local reduction in number.

Weed eradication days by community members have also occurred in more recent years, mainly in response to a rapid colonisation of some areas of the swamp by Bathurst Burr (*Xanthium spinosum*) threatening the native understorey vegetation communities. The reason for this species recent establishment is thought to be due to soil disturbance associated with the development of the PSWMS. Water management of the site alone was unlikely to control this species, as it is known to rapidly recolonise wetland sites following flood recession from seed (Hocking & Liddle 1995).

The success of the extensive efforts of the FGA members in removing environmental weeds during the 1997 trial flood is particularly evident in the drought refuge area which has now been recolonised by a diverse array of rushes and other desirable wetland plants which hosted the breeding of some notable species during the Spring 2000 flood event.

Waterfowl hunting remains an important utilisation of the wetland for various members of the community with permission from the landholder. Hunting occurs within the officially declared game season and on agreement with the landholder is usually confined to Saturday mornings (B. & L. Bray *pers. comm.*). Hunting etiquette and hence care for the wetland appears exemplary, presumably because of the private property status of the wetland combined with the high rate of direct hunter management and sense of stewardship for the wetland.

Further, some FGA members had voluntarily became involved with both financial and management aspects of a trial flood conducted in Bray's Swamp in 1997 (*refer to section 3.13 'Trial Flood' below for further details*), and the members have also volunteered their services for on-going weed eradication and for tree and shrub planting and associated fencing on site in conjunction with the SIRLWSMP Environmental Program (GBCMA & NCCMA 1996).

Plate 9. Field and Game Australia and Student representatives erecting nesting boxes in Bray's Swamp, April 1997. (Photo: Paul O'Connor)

Plate 10. Environmental Weed infestation in the Drought Refuge Area Bray's Swamp prior to removal by Field and Game Australia members April 1997. (Photo: Noel O'Connor)

Plate 11. Drought Refuge Area Bray's Swamp after Environmental Weed infestation removal by Field and Game Australia members April 1997. (Photo: Noel O'Connor)

3.12 Environmental Water Allocations:

The need for Environmental Water Allocations (EWAs) have been identified for Bray's Swamp primarily for topping up flood levels for maintenance of inundation or extending flood durations following initial natural flooding for successful Brolga breeding. The EWA would also be used to provide an ability to manipulate the wetland watering regime to cater for given key indicator species, such as the selection of grasses for Brolga breeding material via providing an autumn flood following a summer dry.

However, in the initial years of implementing this plan at least, potentially larger volumes of water may be required to wean the vegetation communities back to a more naturally sustainable regime that should be maintained mainly via SWMS overflow, as designed (*refer to section 3.5 'Surface Water Management Scheme' above for details*).

It is possible that the current occurrence of Cane Grass within the wetland has been enhanced as a result of the prolonged flood durations arising after irrigation was first developed in the catchment. If this is the case, then management of the wetland still aims to maintain the Cane Grass as it represents a rare wetland type and has added significance as the site is being used as a Brolga breeding site within the vegetation community (Corrick & Norman 1980, Webster 1993). As such, specific water deliver to the wetland as an EWA may have to be given further credence if wetland management finds that the new given flood regime derived from overbank SWMS flows is insufficient to alone maintain the Brolga nesting habitat.

Provision of EWAs to Bray's Swamp is best served through supply from GMW Supply Channel No. 8 into the private irrigation channel system on the property of the wetland's landholder. Two outfalls exist to the system that can potentially be used to fill the wetland. One outfall of 2 ML capacity flows into a site known as 'Drought Refuge Area', a small but broad and shallow area on the natural depression line that ultimately feeds into the main body of Bray's Swamp from the south west (hereafter known as the southern route). The name 'drought refuge' is derived from the site often holding water from irrigation runoff even at times when the main body of Bray's Swamp was dry, and hence it was observed to offer feeding sites for a large number and diversity of waterbirds. A small drop-gate regulator has recently been constructed on the outlet of the Drought Refuge Area to offer an ability to pond water in this area before otherwise flowing down approximately 500m of low aquatic vegetated depression line to the main body of Bray's Swamp. Consideration will be given to holding water within the Drought Refuge Area prior to overflowing into the main body of Bray's Swamp whenever conditions allow.

The other outfall exists from a channel running close the western boundary fence on Springvale Road before outfalling into the southwest corner of the main body of Bray's Swamp. This supply route is north of the southern route (hence is hereafter termed the northern route). The capacity of this northern outfall is 5 ML/d and hence is larger than the southern outfall, and its more direct and channelled route means that improved water delivery efficiency to the main body of the wetland can be achieved via its preferential use over the southern route (refer to section 3.13 ''Trial Flood' below for details). However, the size of the northern outfall route is functionally small, and therefore consideration should be given to seek funding and landholders permission to enlarge this outfall as a major strategic route for supply of the EWA to the wetland. The upgrade should be up to the maximum capacity within the current constraints of water wheel and under-road culverts volume of approximately 10 ML/d (estimated cost of $6000; N. Paynter, *pers comm.*).

In times when an EWA is in short supply or required to be rapidly delivered into the main body of Bray's Swamp, then use of the northern outfall route is the preferred option for water delivery as it cuts transmission times and water losses due to its constructed design and more direct course.

However, in times when water is not in short supply or is not required to be urgently delivered into the main body of Bray's Swamp, then the preferred route for transfer is via the southern route through the Drought Refuge Area. This will enable a greater, and more natural, area to benefit from flooding and will provide a flow supply into the main body of Bray's Swamp that will potentially contain a broader diversity of invertebrates and beneficial organic compounds (FEG 1995, Souter 1996, Puckridge *et al.* 1997).

Supply of an EWA into the wetland via the private irrigation supply channel system will require agreement with the landholder. The landholder has indicated that he is willing to allow use of his channel system (and operate the required structures) to supply EWAs to the wetland, though their delivery will have to be constrained in between periods that he is not using the channel system for irrigation on the property. Irrigation in the paddocks adjoining the wetland is for a mix of both permanent and annual pasture. This form of irrigation normally has requirements for a seven-day return period in between watering. Opportunity therefore exists to pulse EWAs to the wetland without unduly clashing with the irrigation schedule on the property.

The incorporation of Bray's Swamp into a broader management strategy promoting time-share flooding or the rotation of wetlands as drought refuges will be explored in greater detail at a later date. For example, if the volume or supply of an EWA is limited in a given year, then it may be possible to target a select few wetlands within the Region and flood them properly rather than attempt to inadequately flood all of the wetlands. Similar management techniques and issues arise when attempting to create strategic drought refuge areas in the region during dry years for waterbirds. However, considerations such as these, although important, will have to wait until a greater range of individual wetlands within the Region have had their management options more fully explored.

Plate 12. Environmental Water Allocation delivery into the Drought Refuge Area Bray's Swamp October 2000. (Photo: Paul O'Connor)

3.13 Trial Floods:

A trial flood was conducted in Bray's Swamp initiating in late February 1997 and in early May. The trial was initially planned to test the supply channel delivery rates and efficiency, constructed sills and associated earthwork levels, and wetland volume.

However, negotiation with various agencies in attempt to secure the required water volumes to undertake the trial flood was complex and involved considerable time (P. O'Connor *pers. comm.*). In the meantime, the dry wetland over the hot summer of 1996/97 was causing some community concern over the health of some mature Red Gum trees, especially as this was occurring after the wetland had previously been wet for so long (refer to section 3.8 'Tree Health' above for discussion on impact of prolonged waterlogging on trees). In response, approximately 25 local community members affiliated with FGA rallied together to personally purchase the volume of water required to immediately undertake the trial flood.

Water was initially delivered in late February 1997 exclusively via the southern route at capacity flows of 2 ML/d (refer to section 3.12 ‘Environmental Water Allocations’ above for discussion of supply routes) until it was found that the northern route was operational and was added to the program. The northern supply channel route was found to be delivering a greater volume of water - up to 5 ML/d.

Of the calculated wetland volume of 110ML (Kelleher 1997), the trail flood had used 160ML to only achieve a 3/4 flood capacity within the wetland when the trial concluded because of lack of water. This high water usage was attributed to slow delivery rates through the existing private irrigation supply channel system, seepage via attempting to flood a very dry wetland with deep cracking clays, evaporative losses due to the above average weather conditions, soakage losses into the new and relatively uncompacted earthworks associated with the recent construction of the PSWMS near the wetland, and diversion losses from flows backing up the wetland depression near the Drought Refuge Area due to blocked flow paths from the neighbouring PSWMS earthworks which resulted in the water draining directly into the SWMS via an overflow sill then discovered to be set too low. Approximately 30 ML was calculated to have been lost via this latter route, for which GMW subsequently compensated the trial by donating this volume of water.

Assuming a 25% loss of water via evaporation and seepage to flood a dry wetland, the volume of water required for Bray's Swamp is approximately 140ML. This equates to 28 days of maximum channel capacity to deliver the water, although this would be spread in between periods that the landholder is not irrigating. The above period could therefore double or triple if periods of lower rates of delivery are also experienced. Three months to fill a relatively small wetland is unacceptably slow.

Thus in order to be able to fill Bray's Swamp exclusively from an EWA, the make-up supply channels would be required to be upgraded to the capacity of current infrastructure (water-wheel, culverts, etc) to ensure flows can be supplied at a rate of at least 10 ML/d. This would enable the wetland to be filled within 15 days given no competition for use of the channel with the landholder, and possibly up to four weeks with sharing the channel.

The trial flood also revealed that water ponded in the wetland for approximately 4 months following the cessation of inflows. Unfortunately, the winter and spring rainfall was well below average, resulting in the wetland drying prematurely. No inflow contributions from the Primary SWMS overflow occurred during that year after construction and until Spring 2000 due to the drought conditions.

During this time, the adult breeding pair of Brolga returned the wetland and proceeded to prepare for nesting but eventually abandoned the attempt in October 1997, presumably due to the receding water levels in the wetland. Had an EWA been available, supply to Bray's Swamp could have resumed in August 1997 to encourage the Brolga to complete the breeding attempt.

However, it is thought that the trail flooding saved at least one of the mature trees that was otherwise expected to die. Unfortunately, one other Red Gum appears to have now succumbed to the previous stresses of waterlogging, insect attack then drought.

Although the flooding regime for the wetland is anticipated to be satisfactorily catered for by overflows from the SWMS, additional top-up flows or full flooding flows are expected to be occasionally required. However, a repeat of the water purchasing activity undertaken for the 1997 trial flood is unlikely to be repeated (as per discussions with relevant FGA members). The community prefers that management of the health of the wetland and bird-breeding attempts be supplied via a formal Environmental Water Allocation specific to the wetland's requirements. This management plan will aim to make best use of the community's interest in the wetland by encouraging broader, though targeted, wetland management activities and the monitoring of progress.

The wetland was by the year 2000 again showing signs of drought stress. This was a result of another 3 dry Winter-Spring seasons in the Goulburn Catchment and the failure of the incomplete SWMS to deliver a flooding event despite the installation of temporary flow restrictors on the throttle structures.

Following discussions with the landholders it was revealed that the resident pair of Brolga had returned to the dry wetland in the July of 2000. The decision was then made to see if an allocation from the DNRE Bulk Environmental Entitlement held in the Murray River system could be acquired and transferred.

An allocation of 230ML was secured for a one off delivery to the wetland in September 2000. Delivery of the allocation commenced shortly after and continued until the October when there were 2 successive rainfall events in the Mosquito 24 catchment that generated sufficient flow to spill water from the PSWMS. At that point 196ML of the 230ML EWA had been delivered, with the wetland still not quite filled. The delivery of the EWA was ceased at this time as the flows from the PSWMS continued. It is estimated that at least 80ML were spilled from the scheme which topped the wetland and continued to through flush it for 5 days until the temporary throttle restrictors were removed.

By this time the ecology of the wetland was moving into full production and the diverse array of wetland plants and animals were commencing their reproductive cycles.

The delivery of the remaining 34ML of EWA recommended in the second week in December following two hot dry weeks. This ensured that all the wetland plants completed their lifecycles and that the waterbirds were able to fledge their young.

The water level in the swamp progressively receded with the wetland dry by the third week in February 2001. As the result the Red Gums put on significant new growth and the Cane Grass and the Spike sedge consolidated and successfully flowered and seeded. Unfortunately the Brolga did not return and attempt to breed, however a vast array of waterfowl and other wetland dependant species did utilise the wetland with many species having bred.

In regards to the management implications identified with this trial flood several key issues were highlighted. The delivery mechanism for an EWA via the current farm channel system is inadequate and needs further upgrade particularly for the Northern route as identified in the 1997 trial.

The is a problem with delivery to the drought refuge area via the Southern route because the upper reaches of the wetland connect into the neighbouring property and if their drainage inlet is open the water that is backed up is lost to the PSWMS. A small check bank across the Depression in the narrow section of the upper reaches of the drought refuge area has been identified as the most appropriate way of preventing this loss without interfering with higher through flows.

If the wetland is to be protected into the long term installation and retention of some form of restricting regulators on the PSWMS wetland throttle structures is now seen as critical. This is particularly the case until the catchment is fully serviced, with only one design event out of five having spilled into the wetland in the last five years.

Alternative means of surface water runoff delivery to the wetland would be required if the negative impacts of the throttle restrictors are considered to out way the benefits to the wetland.

The Spring flooding particularly with ponding into the Summer months was seen to favour the spread and development of the Water Couch despite being grazed throughout by the low numbers of stock. An Autumn flood or priming the wetland in Autumn is therefore seen as a better alternative for Water Couch management.

The fact that the Brolga did not return to the wetland to breed despite the duration of the flooding would suggest that an Autumn priming followed by a Winter – Spring flooding / EWA top up could potentially give the best result for this Key Species.

Overall the EWA delivery with the second trial flooding was seen as a great success with significant benefits to a range of wetland dependant flora and fauna species and the wetland being released of its drought stress.

Plate 13. The Mosquito 24 Primary Surface Water Management Scheme spilling water into Bray's Swamp following the Environmental Water Allocation delivery October 2000. (Photo: Paul O'Connor)

3.14 Wetland Seeding:

Given the appropriate provision of a watering regime and grazing regime to the wetland, it is expected that additional wetland plants will self establish from seed or fragments deposited naturally within the area (Britton & Brock 1994). However, it is highly possible that many of the former indigenous wetland plant species have become too rare or have vanished from the catchment and therefore will unlikely self-establish within the wetland, even given the appropriate conditions (eg, *Amphibromus*, *Nymphoides*, *Paspalidium*, *Pseudoraphis*, etc).

In this case, deliberate targeted seeding of desirable species may be required to re-introduce indigenous macrophyte diversity and hence facilitate general biodiversity into the wetland. This is best achieved by transplanting a small quantity of the required species directly into the wetland, concentrating on the more upstream reaches so as to allow water flow to facilitate vegetative and seed spread within the remainder of the wetland.

Also, natural regeneration of trees within the vicinity of the wetland is likely to be a rare event, especially in the presence of cattle grazing. As the wetland was previously more timbered, as evidenced in the 1945 photographs (Figure 2), and the trees would persist with the new flooding regime to the wetland once established, then it is recommended to consider <u>sparingly</u> planting some River Red Gum in throughout the wetland to replace the existing maturing trees and recently dead trees. It is anticipated that the differing age class trees will provide nesting habitat for a broader range of waterbirds (Briggs *et al.* 1997). However, it is very important to maintain the bulk of the wetland as open meadow and marshland as this is the preferred habitat sought after by the Brolga (Arnol *et al.* 1984).

Black Box could be considered for the wetland margins and additional Grey Box and Buloke planted on high ground. Tree guards will have to be initially provided to prevent cattle browsing impacts on the establishing trees, including the Red Gum in the wetland.

3.15 Monitoring and Indicator Species:

Very little monitoring is known to have occurred in the past within this catchment. GMW generally only monitors water quality of drainage flows at outfalls close to rivers and streams, and hence no program exists within the Byrneside Depression (A. Piani *pers. comm.*). Waterwatch and Saltwatch programs (Pfueller *et al.* 1997) have undertaken small isolated tests in the past. A monitoring program with local Landcare and schools is therefore required to be encouraged to provide relevant information needs for the management of Bray's Swamp.

A monitoring program designed to collect the required background information that will allow for appropriate adaptive management of Bray's Swamp is recommended in the following chapter. The program needs to be coordinated and include basic water quality issues, wetland hydrology and biological response of management.

Indicator species that should be used in monitoring during adaptive management of the wetland include:

- Brolga successfully breeding (fledged chick).
- River Red Gum health (in initial years until they will be able to tolerate a broad range of flooding regimes).
- Water Couch - attempt contraction in distribution and abundance.
- Spike-sedge - attempt expansion of distribution and abundance.
- Presence of other vegetation species establishment - attempt expansion of desirable indigenous species and contraction of exotic species.
- Presence of waterbird breeding - attempt diversity and productivity.

Plate 14. **Monitoring Bray's Swamp following the Environmental Water Allocation delivery and Trial Flood December 2000. (Photo: Paul O'Connor)**

Plate 15. **Key Indicator species Spike-sedge (*Eloecharis acuta*) consolidation following the Trial Flood December 2000. (Photo: Paul O'Connor)**

4. Recommendations

4.1 Flood regime:

4.1.1 Gradually wean the wetland ecosystem to an Autumn primed Winter-Spring flood regime, generally aiming to have complete flooding by July with drawdown by late November early December. This flood regime is expected to be predominantly catered for by SWMS design overflow periods and hence places less reliance on supplying an Environmental Water Allocation. However, the flood regime should begin to be weaned from a flood initiating in late February/early March and conclude in November/December over a 5-year timeframe (delaying flooding by one month per year). This period represents the lower evaporative losses for the current core flooding period, whilst allowing approximately 3 months of natural summer drying.

4.1.2 Aim to have the wetland flooded continuously between yearly flood events on 3 occasions in every 10 year period.

4.1.3 Attempt managing for maximum flood depth, recognising that this goal will not always be obtainable due to the lack of water. However, this shortfall will create desirable variability in wetland depth and area inundated. Exceptions to this goal reside with nesting attempts by Brolga, whereby a suitably stable flood depth should be closely managed during nest building and incubation so as to not flood the nest or give the parent bird cause to abandon the nest from concerns of falling water levels. Upon hatching, the rate of drawdown will need to be monitored to ensure that sufficient shallow marsh areas exist for foraging chicks yet retain sufficient depth to discourage terrestrial predators from venturing into the wetland (eg, dogs, cats and foxes). [*refer to sections 3.12 and 3.13 on how to manage water levels within the wetland - eg, use private irrigation channels to deliver water, and use of drop bars on the wetland outfall to set the required depth. Anticipate larger inflow events from broader catchment rainfall events and activities (eg, full reuse systems), and compensate by allowing greater wetland outflow at lower levels (ie, remove a few more drop bars)*].

4.1.4 Pond water within the 'Drought Refuge Area' in the depression upstream of Bray's Swamp whenever conditions during the flooding period allow and provided that the site received adequate drying for at least three months within the last year. Construct low check bank in upper section of Drought Refuge Area to prevent backup water losses.

4.1.5 Strive for a continual flow through the wetland system in very wet years when conditions allow (ie, through Drought Refuge Area before entering Bray's Swamp then outfall into PSWMS). Pond water within Bray's Swamp and the Drought Refuge Area when inflows begin to decline.

4.1.6 Manage the 'Drought Refuge Area' and Bray's Swamp semi-independently of one another to reflect limited water supplies. Highest priority is the appropriate management of Bray's Swamp, especially for breeding Brolgas, but in a drought year may have to flood the 'Drought Refuge Area' only.

4.1.7 Design and install (permanent / semi-permanent) wetland throttle flow restrictors on the PSWMS throttle structures to ensure delivery of the design event flow regime. These structures should take the form of a control gate or regulating structure that can be fixed in place and locked down to prevent interference or inappropriate manipulation. The operation and performance of the structures should be managed by GMW in cooperation with / on advice from DNRE – EMP.

4.1.8 If design investigations reveal that the there are difficulties in installing and operating fixed throttle restrictors on the wetland flow control structures, then GMW in conjunction with SKM should look at alternatives to ensuring that the design surface water flows can be delivered to the wetland.

4.2 Environmental Water Allocations

4.2.1 Seek to formalise an Environmental Water Allocation (EWA) for wetlands within the Shepparton Irrigation Region as a collective group, of which Bray's Swamp could share. The allocation should offer high security water for use specifically in meeting environmental objectives of the wetlands. The water should be sought as a Goulburn – Broken Catchment Bulk Environmental Entitlement with GMW responsible for storeage and delivery of the entitlement as the responsible authority for irrigation water supplies and hence moral management responsibilities for wetlands within the irrigation area that have been impacted on by irrigation activities. This water may come from a formal negotiated allocation and/or from uncommitted water supplies or claw back opportunities from conditions on re-use or redemption of sleeper licences. In the interim a water allocation or temporary supply may be sourced from DNRE, especially the purchase of water in the relevant catchment from a share in the revenue generated through temporary sale proceeds of a part of the Department's wetland water entitlement held in Dartmouth Reservoir, or even a direct cross catchment transfer of part of the Victorian Murray floodplain EWA.

4.2.2 Seek to enlarge and upgrade the current private irrigation outfall channel on the south-west corner of the main body of Bray's Swamp (northern supply route) to improve the ability to supply water to the wetland from irrigation water supply sources. The upgrade should be to the maximum capacity possible within the constraints of current infrastructure (water-wheel, under-road culverts, etc). This will improve water delivery rate and efficiency at times or providing the EWA, and hence also minimise periods of supply channel use conflict with the landholder. The cost of such an upgrade is estimated at $6000.

4.2.3 Seek to supply water allocations to the wetland at times when the private irrigation channel network is not used by the landholder (ie, work in around the landholder's irrigation schedule). [*This should generally not be a problem as during dry periods the wetland should only require periodic topping to negate evaporative losses when attempting to maintain a stable water level for breeding Brolga. During wet years, when wetland flood regimes may require augmentation between drain overflows to prolong flooding events or increase depths, the landholder is likely to not require a high frequency of channel use to supply irrigation water anyway*].

4.2.4 Encourage landholder of Bray's Swamp to operate regulating structures to the wetland in accordance with this management plan. DNRE should initially oversee management and offer direct advice on adaptive management, though ultimately aim to have the plan wholly implemented by the landholder with appropriate monitoring for adaptive management undertaken by interested though committed community groups or personnel with the permission of the landholder.

4.3 Grazing Management:

4.3.1 Assist and encourage the landholder to consider the removal of stock from the wetland paddock during the period that Brolga has, or is suspected of having, either eggs in the nest or very young chicks so as to avoid threat of trampling. This period may be in the order of 12 weeks duration around August and October, and may be able to be easily incorporated into the landholder's grazed paddock rotation schedule with minimal disruption to the enterprise. The removal of grazing during this occasional period may also assist Spike-sedge growth and regeneration.

4.3.2 Control the spread of Water Couch in the wetland by a targeted combination of grazing and water regime management at periods that should discourage the growth of Water Couch in relation to more desirable native species. Adaptive management to this end may be necessary involving some experimentation and observations of cattle impact and the response of the vegetation with the season. Grazing in summer-autumn when the wetland is dry and Spike-sedge is dormant, followed by stock exclusion and wetland flooding in winter-spring, is expected to provide satisfactory results.

Incorporation of a fire regime, at least to part of the wetland, could also be appropriate to facilitate the spread of Cane-grass at the expense of Water Couch.

4.3.3 Assist and encourage the landholder to fence off sections of the wetland, its margins and the surrounding swamp paddock/catchment to enable native plant regeneration/establishment. Ensure that any sections of fence near or over flood prone regions have at least the top strand of wire made highly visible to flying waterfowl by threading through the middle of plastic conduit or similar solution. No barbed wire is to be used. Alternatively, temporary or permanent electric fencing using ribbon may be appropriate. The cost of approximately 1.4 km of suitable fencing, with two access gates, is estimated at $4500 for electric fencing (assuming power is at the location) or $8000 for 7 plain-strand boundary-style fencing. Landholder to maintain fence to ensure that it remains an effective barrier to stock.

4.4 Pest Plants & Animals:

4.4.1 Encourage an integrated and a coordinated fox control program for at least one kilometre surrounding Bray's Swamp and at least immediately prior and during the Brolga breeding season (including chick raising period). Encourage FGA and other interested community members to undertake fox drives prior to Brolga nesting at the wetland, and away from the immediate wetland during nesting. [*NB: incentives to landholders to participate in a fox program may have to be explored, as foxes tend to cause less direct impact on enterprises based on cattle than if they had been based on sheep. However, it would be preferable to refresh landholders knowledge of other problems caused by foxes that could impact on them directly (eg, vectors implicated in the spread of Blackberries and Prairie Ground Cherry on their properties, or mange to their domestic dogs, etc.) rather than offer financial or physical assistance incentives. This should all occur before enforcement of the landholder's legally enforceable vermin control responsibilities that, although exist, are rarely enforced elsewhere and hence would likely to breed resentment to the management objectives by the landholders*].

4.4.2 Monitor growth of terrestrial weeds (Bathurst Burr, Black Nightshade, Prairie Ground-Cherry, Thistles, Prickly Lettuce, etc) and aquatic weeds (Swamp Meadow Grass and Parrot’s Feather/Brazillian Water Milfoil) from within the wetland, especially upstream sites and remove prior to allowing water to flow from the Drought Refuge Area into the main body of Bray’s Swamp.

4.4.3 Control the spread of weeds from the GMW PSWMS reserve by appropriate active management.

4.4.4 Explore the use of electrified netting (eg, Electranet Masterfence by Gundaroo Tiller, NSW) or similar product around the margin of the wetland to deter foxes, cats and dogs from impacting on fauna breeding, especially Brolga.

4.5 Other Management Issues:

4.5.1 Maintain all dead trees and fallen timber in situ within the wetland to continue to provide habitat.

4.5.2 Undertake intermittent ecological burns within small areas of the wetland to promote habitat structural diversity, encourage indigenous biodiversity, and provide an improved selection of breeding and feeding areas for wetland fauna, especially Brolga.

4.5.3 Assist and encourage the landholder to set a self-regulatory 'human exclusion' zone on the wetland during periods that the Brolga is present or at least nesting. This is important from minimising disturbance to the Brolga so as not to give cause for abandonment of nesting and to minimise the risk of foxes discovering the nest via trailing human scent to the site (DNRE 1998).

4.5.4 Assist and encourage the landholder to establish a Section 173 Agreement under the provisions of the Victorian Planning and Environment Act (1989), to ensure the wetlands protection into perpetuity in the event that the wetland is sold or the property passed on to another party. In the event of sale, consideration could be given to purchasing the property as a conservation reserve.

4.5.5 Continue to encourage landholder/FGA to establish, maintain and monitor waterfowl nest box program in Brays Swamp. Discourage use of nest boxes by exotic species.

4.6 Monitoring:

4.6.1 Monitor water quality in supply channels, particularly first flush flows in the drain. Avoid, where possible, poor water quality inflows to the wetland [*these levels should be based on local knowledge of the range of water quality experienced in the supply and drainage channels or the Goulburn-Broken Catchment Water Quality Guidelines*].

4.6.2 Monitor water quality in the wetland, particularly upon drawdown or extended flood periods, to ensure that quality does not endanger long term wetland health. Notable parameters to monitor are salinity concentrations and Cyanobacterial (Blue Green Algae) concentrations. Knowledge of normal variations within the wetland will assist in the adaptive management of supplying an appropriate flood regime to the wetland. For example, if Cyanobacterial blooms generally become prevalent late in the season, then water draw down or release may need to occur earlier. This is similar to salt concentrations within the wetland, except that the wetland may have to be flushed with water prior to drawdown to prevent the accumulation of salt on the wetland floor.

4.6.3 Establish at least one Watertable Bore, preferable two or more, in the wetland and monitor watertable levels and salinity concentrations over time. Other bores could be located outside the wetland to assist in determining the relationship of groundwater with wetland flooding.

4.6.4 Monitor growth and spread of the major wetland understorey species. Notable concerns should centre on restricting the spread or domination of Water Couch, and where possible encourage establishment, growth and seed set in Cane Grass and Common Spike-sedge. Also seek to encourage a diversity of indigenous wetland vegetation where practically possible, and aim to create a suitable mosaic within the plant community structure.

4.6.5 Establish monitoring at Bray's Swamp to meet the requirements of the Environmental Monitoring Program of DNRE's EMG group, and encourage monitoring by other suitable programs (eg, Saltwatch, bird censuses, etc).

4.6.6 Utilise appropriate indicator or flagship species in monitoring and implementation of adaptive management of the wetland. Such species should include:

- Red Gum health (in initial years until they will be able to tolerate a broad range of flooding regimes);
- Water Couch - attempt contraction in distribution and abundance;
- Spike-sedge - attempt expansion of distribution and abundance;
- Cane-grass - attempt healthy mosaic of distribution and abundance;
- Presence of other vegetation species establishment - attempt expansion of desirable indigenous species and contraction of exotic species;
- Frog species successfully breeding (tadpole metamorphosis);
- Presence of waterbird breeding - attempt diversity and productivity;
- Brolga successfully breeding (fledged chick).

4.7 Steering Committee:

4.7.1 Establish a local steering committee/key contacts that can respond to specific issues associated with Brays swamp as the need arises. Primary management advice should rest between DNRE and the landholder, with further wider input invited from GMW and FGA were appropriate.

4.7.2 Utilise SIR – PISC as the regional steering committee (with DNRE, GMW, CMA representatives) to oversee annual water management activities and allocations to a range of SIR wetlands, which includes Bray's Swamp. The committee would be responsible for subjectively reviewing water requirements of the wetlands within its charter, and make considered and coordinated recommendations to the relevant management authorities (landholder in the case of Bray's Swamp, DNRE/Parks Victoria for public wetlands).

4.8 Summary of Recommended Management Responsibilities:

Issue	Action	Estimated Cost	Frequency	Timeline	Priority	Responsibility	Reference to plan
Flood Regime.	1. Operation of EWA supply and drainage outlet structures.	$100-$300	Annual	Ongoing	High	Landholder on advice from EMP.	4.1 (p. 28) 4.2.4 (p. 29)
	2. Monitoring to ensure regime is delivered/maintained.	$200	Annual	Ongoing	High	EMP (DNRE) & landholder.	4.2.4 (p. 29)
	3. Make-up supply (EWA) provision and operation.	$variable ①	②	②	High	EMP & FF (DNRE), GMW & landholder.	4.2.1 (p. 29) 4.2.3 (p. 29)
	4. Design, install and maintain fixed throttle flow restrictors on PSWMS wetland throttles.	$variable	One-off	ASAP	High	SKM & GMW	4.1.7 (p.28)
	5. Investigate and provide alternative means of surface water regime delivery (If 4. above cannot be provided).	$variable	One-off	ASAP	High	SKM & GMW	4.1.8 (p. 28)
	6. Construct backflow check bank up stream of the drought refuge area.	$750	One-off	ASAP	High	EMP & landholder.	4.1.4 (p. 28)
	7. Northern supply channel upgrade.	$6000	One-off	③	High	EMP & landholder.	4.2.2 (p. 29)
	8. Structure maintenance and monitoring.	$100	Annual	Ongoing	High	GMW & landholder.	4.2.3 (p. 29) 4.2.4 (p. 29)
Grazing Management.	9. Temporary / permanent protective fencing for sections within the wetland / surrounding paddock.	$4000 - $8000 ④	One-off	ASAP	Medium	EMP and landholder.	4.3.3 (p. 30)
	10. Fencing maintenance.	$400	As required	Ongoing	Medium	Landholder.	4.3.3 (p. 30)
	11. Grazing regime recommendations for wetland.	$200	Seasonal	Ongoing	Medium	EMP (DNRE).	4.3.1 (p. 29) 4.3.2 (p. 29)
	12. Stock management (grazing cycle & stocking densities).	$variable ⑤	As required	Ongoing	Medium	Landholder.	4.3 (p. 29)

4.8 Summary of Recommended Management Responsibilities – Continued:

	13. Monitoring.	$200	Annual	Ongoing	High	EMP (DNRE), GMW, landholder & FGA.	4.4 (p. 30)
Pest Plant and Animals.	14. Control: a) PSWMS reserve; b) Wetland & surrounds.	 a) $variable b) $variable	 a) As required b) As required	 a) Ongoing b) Ongoing	 High High	 a) GMW; b) Landholder and FGA.	 a) 4.4.3 (p. 30) b) 4.4.1 (p. 30) 4.4.2 (p. 30)
Other Management	15. Timber management	$Nil	Continual	Ongoing	High	Landholder	4.5.1 (p. 30)
	16. Human disturbance management	$Nil	As required	Ongoing	Low	Landholder	4.5.3 (p. 31)
	17. Nest box program	$400	Annual	Ongoing	Low	Landholder/FGA	4.5.5 (p. 31) 4.6.6 (p. 31)
	18. Ecological burns.	$1500	3-4 years	As required	Medium	DNRE & landholder.	4.5.2 (p. 30)
	19. Brolga welfare management.	$200	As required ⑥	Ongoing	High	DNRE, landholder & FGA.	4.3.1 (p. 29) 4.5.3 (p. 31)
	20. Section 173.Agreement	$variable	One-off	As required	Medium	DNRE, GMW & landholder.	4.5.4 (p. 31)
Monitoring.	21. Vegetation monitoring.	$200+ ⑦	Annual ⑦	Ongoing	Low	EMP (DNRE).	4.6.4 (p. 31) 4.6.6 (p. 31)
	22. Wildlife utilization and nesting box monitoring.	$400	Annual	Ongoing	Low	EMP (DNRE) & FGA.	4.6.5 (p. 31) 4.6.6 (p. 31)
	23. Watertable bore: a) establishment; b) monitoring.	 a) $1000 b) $100	 a) One-off b) ⑧	 a) Ongoing b) Ongoing	 a) Low b) Low	 a) EMP (DNRE)/GMW. b) EMP (DNRE)/GMW.	 a) 4.6.3 (p. 31) b) 4.6.3 (p. 31)
	24. Water Quality Monitoring.	$200	< Seasonal	Ongoing	Medium	EMP (DNRE).	4.6.1 (p. 31) 4.6.2 (p. 31) 4.6.3 (p. 31) 4.6.5 (p. 31)
Steering Committee	25. Oversee water management: a) local; b) regional SIR -PISC.	 a) $500 ⑨ b) $1500 ⑨	 a) As required b) Annual	 a) Ongoing b) Ongoing	 a) Medium b) High	 a) Landholder, DNRE, GMW, FGA. b) DNRE, PV, GMW, GBCMA, community reps (incl. FGA).	 a) 4.7 (p. 31) b) 4.7 (p. 31)

Key:

① Costs dependent upon agreement with NRE on provision of Environmental Water Allocation, GMW delivery charges etc. The costs will depend on the volume required; this could be greater than the 220 ML as delivered in Spring 2000, if the delivery is to be split into an Autumn prime and Spring top up.

② Assumes EWA provision. Requirement may initially be annual for the first 5-6 years, decreasing to occasional specific use once the wetland is weaned to a lesser flooded regime and assuming Primary Surface Water Management Scheme overflows alone are satisfactory.

③ Channel upgrade required only if Environmental Water Allocation provision rules are determined and/or funding available to purchase water (refer to Action 3). May also be contingent on appropriate land covenant (refer to Action 17) and/or Whole Farm Plan.

④ Lower cost associated with plain strand electric fencing. Higher cost associated with permanent 6 strand standard stock fencing (@ 1.4 km fencing). Use of temporary electrified ribbon would be a relatively cheap option though would incur proportionately more monitoring to ensure that it remains an effective barrier. Use of electrified netting around the perimeter of the wetland, with appropriate buffer zone, could be considered for deterrent of foxes etc during Brolga nesting.

⑤ Although stock management is a business cost to the landholder as part of the grazing enterprise, there potentially exists extra stock management associated with specific grazing recommendations for the ecology of the wetland.

⑥ Frequency of Brolga management to intensify when Brolga is breeding, otherwise need only be a watching brief.

⑦ Frequency and cost of vegetation monitoring dependant upon program and issue under investigation. Could be as simple as general observations before and during flooding, though preferably would accurately document species diversity, abundance and distribution to assist in adaptive management.

⑧ Frequency of watertable bore monitoring dependant on other programs being undertaken in the district, but would ideally be monthly (at least in the first few years).

⑨ Steering Committee costs dependant on frequency required, issues to be resolved, site inspections required, etc.

ASAP	= As soon as possible
EMP	= Environmental Management Program (a unit with Catchment & Agriculture Services of DNRE)
EWA	= Environmental Water Allocation (Make-up Supply)
DNRE	= Department of Natural Resources & Environment
FGA	= Field & Game Australia
FF	= Flora & Fauna (business unit within DNRE)

Cont.

GBCMA = Goulburn-Broken Catchment Management Authority
GMW = Goulburn-Murray Water
PSWMS = Primary Surface Water Management Scheme
PV = Parks Victoria
SIR–PISC = Shepparton Irrigation Region – Plan Implementation Support Committee.
SKM = Sinclair Knight Merz

Note: One-person day costed @ $200 per staff member,
No actual costs to be incurred in implementing the Plan by the landholder,
Landholder costs based on in-kind labour / time contribution.

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