

NEW DROUGHT WATER MANAGEMENT PROCEDURES IN THE OVENS AND KING VALLEY.

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ABSTRACT

The Ovens and King catchments in Northern Victoria experienced their worst drought on record in the 2006/07 irrigation season. The catchments normally have a high reliability supply of water, with irrigation restrictions only being implemented in 3 years out of the 115 year record, but severe restriction rules had to be applied in 2006/07. The supplies in the Ovens and King catchments are regulated by Lake Buffalo and Lake William Hovell respectively. Both of these storages are small and only hold about a third of the annual demand. The remaining supply relies on inflows to the catchments. Current restriction rules, a function of reservoir levels over time, were not found to be sufficient during the latest drought and a new model for determination of restriction level has been developed. The new restriction rules are a function of demand in the catchments, recent and predicted future inflows and reservoir levels. The new model was tested using historic data and is currently being run on a pilot basis. The new rules were found to provide earlier warnings, more gradual transition to severe restrictions and less severe restrictions than would result from the previous curves. The model is expected to assist with improved drought management in the Ovens and King Valleys.

INTRODUCTION

The Ovens catchment is the only regulated supply system in Northern Victoria that operates under restriction rules rather than allocation water supply rules. The irrigation season of 2006/07 was the first time that triggers to restrict water supply had to be applied under the rules set out in the Bulk Entitlement (Ovens System – Goulburn-Murray Water) Conversion Order 2004 (BE) which includes the King River and the urban centres of Moyhu, Oxley and Wangaratta. Triggers for these restriction rules were developed after the drought of 2002/03 by the Victorian Department of Sustainability and Environment (DSE) and Goulburn-Murray Water (G-MW). These “old” restriction curves were first applied in 2006/07. The 2006/07 season had the lowest flows on record in the Buffalo, King and Ovens rivers for the months August through December and water supply for urban, agricultural and environmental use had to be restricted. The existing restriction rules did not allow for the possibility of the storages not being full by October-November. In 2006/07 both storages peaked in early October at a maximum of 75% capacity and as a result triggers for various levels of restrictions all the way to a total ban were reached in rapid succession and expensive pumping from dead storage became necessary. Both storages can hold only 30 to 45% of the total demand comprising urban, rural and environmental water needs and therefore rely heavily on inflows during the season.

As this response to unprecedented low flows and storage levels was not satisfactory, new procedures for determining triggers for water supply restrictions have been developed. The new restriction curves comprise a set of curves as function of antecedent inflows at three key locations in the Ovens Catchment, the level in the two reservoirs, and the remaining water supply demand for all users until the end of the season (May 30). The first set of curves is determined in September, at which time an estimate is made of the level of drought experienced in the antecedent period of three months. This indication is used to predict the risk profile for the remainder of the season. The process is repeated monthly until water levels in the lakes are sufficient to supply full demand for the remaining part of the season. Restriction curves are only applied after spilling from the lakes ceases. Spilling ceases when inflows are less than the demand.

The new curves are expected to implement restrictions earlier in the season to reduce the likelihood of a total irrigation ban. Their development had the benefit of hindsight with the extreme

inflow case of 2006/07. The new curves will be applied in the recently updated REALM model of the Lower Ovens Catchment and the effect of the curves on water security will be investigated. The methodology used to determine trigger curves for water supply restriction levels is recommended for use in water systems that have similar characteristics as the Ovens and King catchments.

THE OVENS CATCHMENT

The King and Ovens Catchments are in North East Victoria (Figure 1) and cover an area of 7,985 km². Both catchments have storage in order to regulate the supply to irrigation and urban entitlement holders as well as to help meet the environmental compliance flows as outlined in the Bulk Entitlement (Ovens System – Goulburn-Murray Water) Conversion Order 2004 (BE).

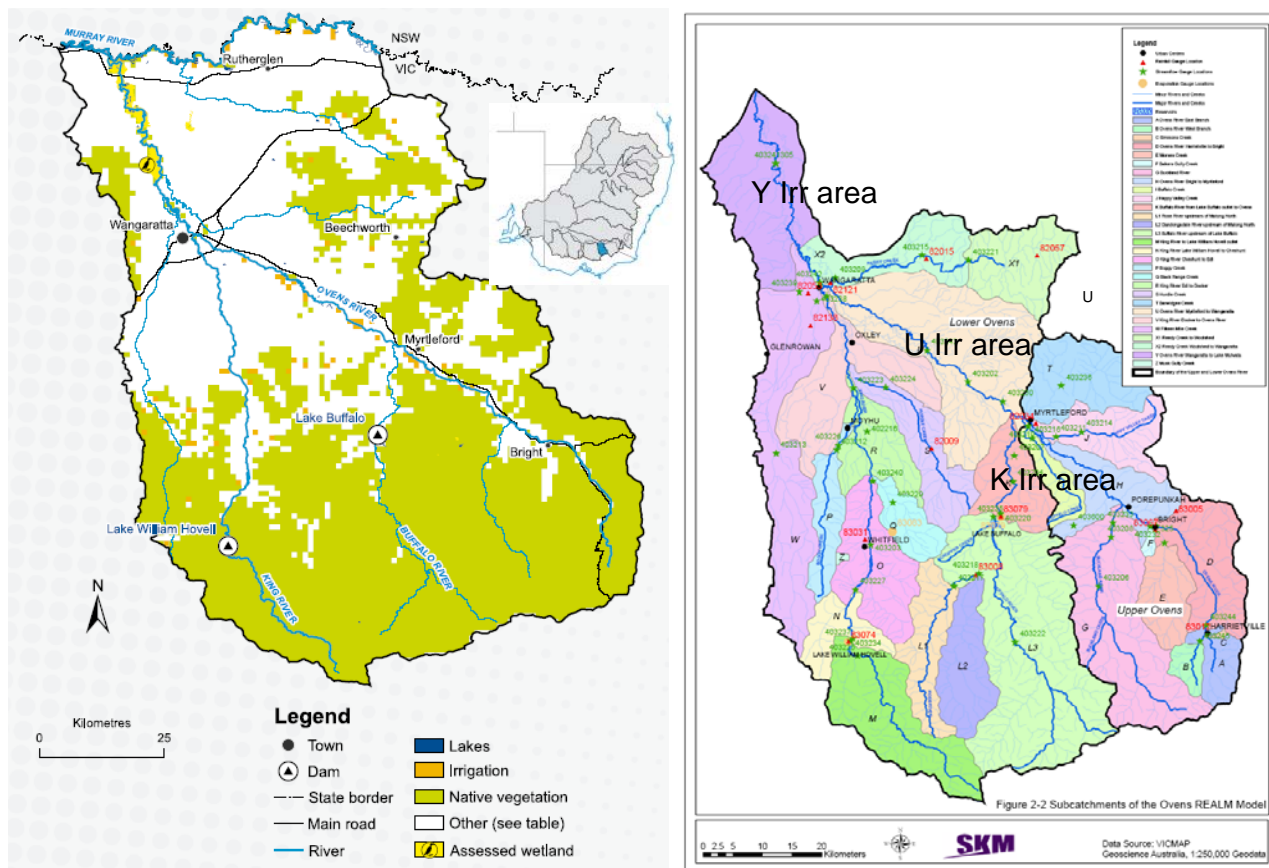


Figure 1 Ovens Basin and sub-catchments (CSIRO 2008, SKM 2007)

Lake Buffalo was constructed in 1965 and is located on the Buffalo River, 24 km south of Myrtleford. It lies at the foot of the western slope of Mount Buffalo, and is a popular fishing, water skiing and picnicking venue. The storage required the construction of a 31 metre high and 600 metre long earth and rock fill embankment, with a gated primary spillway and outlet works located within the dam wall. This structure was completed in 1965, and created storage with a capacity of almost 24,000 ML including dead storage of 4,500 ML. The water stored in Lake Buffalo is used to supplement flows in the Ovens River for irrigation and urban water supply (City of Wangaratta). The dam initially supplied a thriving tobacco industry in the valley; however, this has now changed to numerous vineyards and other cropping. The capacity of the storage represents only 6% of the mean annual flow in the Buffalo River.

Lake William Hovell has been in operation since 1971, and is located on the King River 18 km south of Cheshunt. Lake William Hovell takes its name from Australian explorer William Hovell, who trekked through the region in 1824. The reservoir has a capacity of 13,500 ML including a dead storage of 1,000 ML. Lake William Hovell supplies water for irrigated crops, vineyards and grazing properties along the King River from Cheshunt to Wangaratta. It supplies urban water to the communities of Moyhu and Oxley. The works also include a hydropower generation facility with a capacity of 1.6 MW. Power generation is subject to demand release. Irrigation in the area has been occurring for many years. Irrigation demand used to be predominately tobacco farming along with some annual and perennial pastures, hops, grapes, orchards, lucerne, millet and nut. In

September/October 2006 an announcement was made stating that no more tobacco farming would take place in the area and as a result the majority of tobacco farms converted to lucerne or millet.

MODEL DEVELOPMENT

Both the King and Ovens Catchments have relatively high rainfall and runoff resulting in significant inflows to the storages throughout the winter and spring months. However, both these catchments only have small storages and as a result consumptive water supply relies heavily on inflows continuing throughout the season in order to meet demand.

There are four main components of demand and these are irrigation demand, urban demand, environmental compliance demand and loss. This demand is based on supplying full entitlement (both irrigation and urban) and meet compliance flows, including losses. Historic irrigation demand varied from 30% of full entitlement in wet years to 80% of full entitlement in dry years. Inflows that can supply part of the demand are estimated and the remaining demand should come from storage. This can then be compared with the available water in the storage. If not enough water supply is restricted as follows:

Level 1 = 75% irrigation entitlement, rostered to supply a max 7.5% of entitlement over 10 days

Level 2 = 50% irrigation entitlement, rostered to supply a max 5% of entitlement over 10 days

Level 3 = 25% irrigation entitlement, rostered to supply a max 2.5% of entitlement over 10 days

Level 4 = suspension of irrigation.

When no restrictions are in place rostering is applied to reduce losses and optimise delivery. This is achieved by supplying a max of 10% of entitlement over 10 days.

Urban demand has been based on the maximum volume outlined in the Bulk Entitlement (Ovens System – Moyhu, Oxley and Wangaratta – North East Water) Conversion Order 2004. The maximum volume is not normally used, but as with irrigation demands it is assumed in the model that the maximum volume has to be supplied. The maximum volume has been distributed over the year using an estimated distribution curve similar to that used for irrigation. Restrictions in supply to urban areas and rural Domestic and Stock license holders areas that are equivalent to the irrigation restriction levels are:

Level 1 = summer urban demand less 50% of restrictable urban demand

Level 2 = summer urban demand less 80% of restrictable urban demand

Level 3 = summer urban demand less 95% of restrictable urban demand

Level 4 = summer urban demand less 100% of restrictable urban demand

Where summer urban demand means the average actual supply rate in ML per day recorded over the preceding five years in December, January and February, and restrictable urban demand means the summer urban demand less the average actual supply rate in ML per day recorded over the preceding five years in June, July and August.

The environmental compliance flows (eflows) are based on the compliance points outlined in the Bulk Entitlement (Ovens System – Goulburn-Murray Water) Conversion Order 2004 (BE). There are four compliance points for the Ovens and Buffalo catchment and two compliance points for the King catchment. A key compliance point is downstream from Wangaratta at Peechelba to supply the nationally significant wetlands along the lower Ovens up to its confluence with the Murray. Once the environmental flows have passed the compliance points that water can be used to meet other demands. There is no restriction policy for the environmental flow compliance flows. However, if Lake Buffalo ceases to spill prior to the end of November the Authority can request the Minister to review the minimum environmental flow. Based on historic records this never happened when Lake Buffalo was spilling, except that in 1967, 1982, 2006 the lake never filled and hence did not spill.

The environmental compliance is outlined as a minimum requirement in the BE. There are two options for the required flow and these are the lower of (1) a capped value based on a daily average flow or (2) a natural flow, which are based on flows at Victorian stream flow gauging stations in the unregulated catchments. The natural flow values with losses determined in the updated Lower Ovens REALM Model (SKM 2007) were used in the new Ovens restriction curve model. The data from the REALM model goes back to 1895 and this was used to determine the Probability of Exceedance (PoE) of the natural flows and historic inflows. These PoE's can then be

used to predict what environmental flows will be required later in the season based on what percentile inflows have been occurring. It was observed that due to the formulation of the determination of environmental compliance flows in the BE, the change in actual compliant monthly flows can be rather substantial, offsetting the extra inflows almost on one-to-one basis.

The loss required to meet the demand has been calculated in two ways depending on the level of total demands. For low demands the loss has been set at a daily rate for different compliance points. These fixed rates for the different compliance points are estimated values based on past experience (incl. the 2006/07 season) and are 60 ML/day at Peechelba, 60 ML/day at Wangaratta, 30 ML/day at Rocky Point, 0 ML/day at Buffalo d/s Buffalo, 30 ML/day at Docker Rd (King River), and 10 ML/day at Cheshunt (King River). For higher demands loss is determined using an efficiency of 69% (i.e. $Loss = Delivery * (1/0.69 - 1)$, SKM 2007). The loss value used in the model is determined as the maximum of the fixed value or the efficiency calculation.

To determine the storage demand required for the remainder of the season a cumulative demand was determined starting from June and working back to the current month. The distribution of usage throughout the season has been based on the distribution curve as shown in Figure 2.

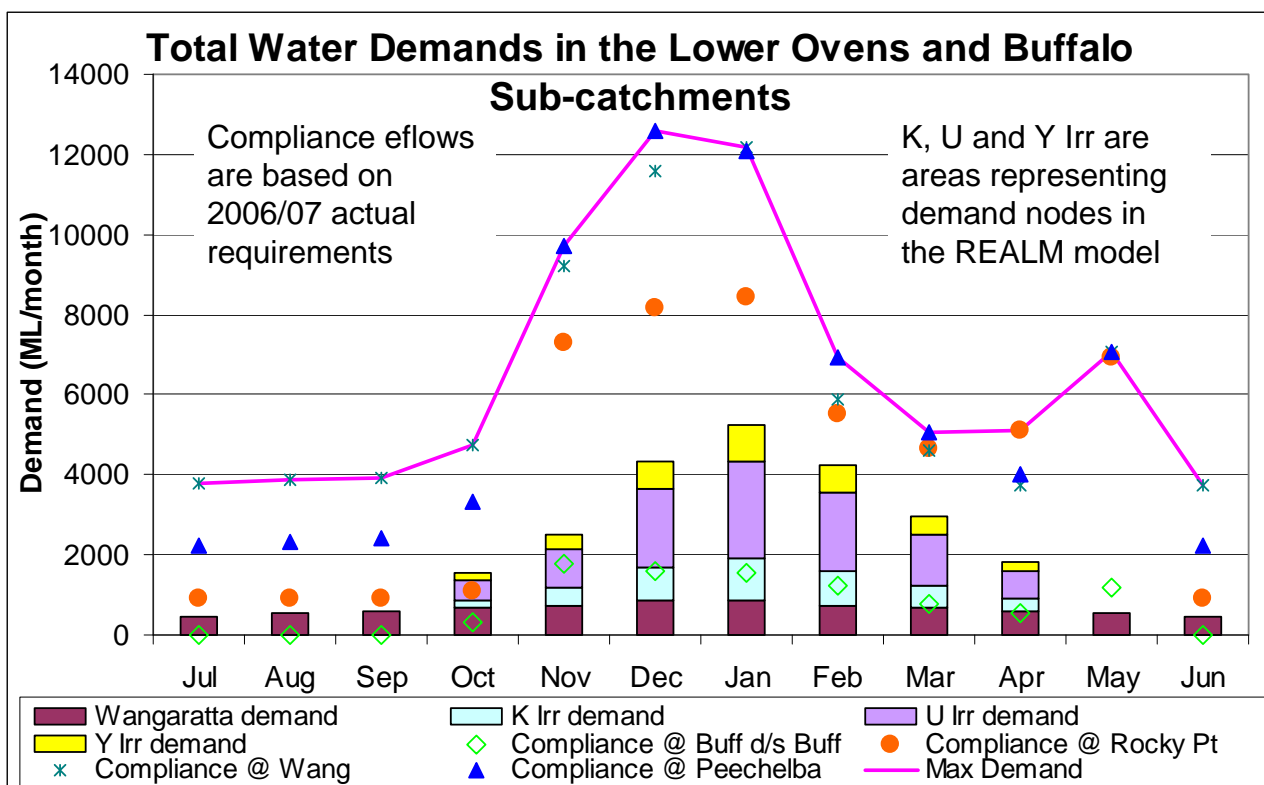


Figure 2 Monthly Water Supply Demand below Lake Buffalo with compliance flows based on the 2006/07 season

Total annual demand downstream of Lake Buffalo is 69,204 ML for the year (based on 2006/07 environmental flow needs). Lake Buffalo storage capacity is 24,000 ML including 4,500 ML dead storage. Storage is able to meet 28% of demand, therefore the other 72% of demand has to be met by inflows.

Total annual demand downstream of Lake William Hovell is 29,122 ML for the year (based on 2006/07 environmental flow needs). Lake William Hovell storage capacity is 13,500 ML including 1,000 ML dead storage. Storage is able to meet 43% of demand, therefore the other 57% of demand has to be met by inflows.

The demand from storage is determined on a monthly basis and is calculated based on demand minus predicted inflows. If the predicted inflows are greater than demand then the storage demand is set to zero in the model. If the storage is not at full supply level and the inflows exceed the demand the excess inflows can be used to fill the storage.

The compliance flows on the Buffalo River downstream of Buffalo and the demand from the Buffalo River can only be met by Lake Buffalo inflows and cannot be met by flows from the Ovens at Myrtleford. This was considered when determining storage demand.

River flow in the Ovens at Myrtleford and inflows of both lakes are predicted from historic records. There are 115 years of data available for both lake inflows and 35 years of data available of flows in the Ovens at Myrtleford. The monthly Probability of Exceedance (PoE) was determined at each of these three points. From September till April every year and every month the actual observed flows of the preceding 1, 2 and 3 months are classified according PoE and the maximum of these three PoE is used for predicting the inflows in the lakes and the flow at Myrtleford for the remainder of the season. A high PoE value indicates low flows. Of the years of observation the maximum PoE resulted in 40% of the years from the one month immediately preceding the period of prediction, 20% of the years from the two month period and 40% of the years from the three month period. The model determines the PoE for all three periods each month and uses the maximum PoE value (indicating the driest period) for prediction of the level of inflows, flows and compliant eflows in the remaining irrigation season till May. It was found that in 8/10 years the remainder period would be wetter than experienced to date, but that in 2 years it could be drier.

The Ovens restriction curve model is setup in Microsoft Excel using advanced Vlookup functions to determine PoE for each of the three periods and then to calculate the predicted flow in each month at the three key locations (Lake Buffalo, Ovens at Myrtleford and Lake William Hovell) to balance remaining water supply demands. Compliance flows are determined in a similar fashion. All these are then used to determine the balance of water supply that might be needed from storage. Hence the model does consider estimated actual usage of irrigation water, but does not consider sleeper licenses.

The restriction curves are not implemented until the storages cease spilling. Traditionally sales water has been available when storages spill. Spilling is not officially defined in the BE but operational procedures of G-MW define it as spillage stops when inflows are not sufficient to meet demand. Hence spillage in these terms has nothing to do with actual spillage, which is part of planned releases from the storage.

MODEL APPLICATION

An example of restricted demand curves determined for the 2007/08 season for water supply demands below Lake Buffalo are shown in Figure 3. Restriction curves are produced at the end of each month during the irrigation season and four are shown. Spilling was not declared to have ceased in any of the months following the issue of the curves so no actual restriction had to be declared in 2007/08. Predictions in February 2008 show that there would be only a minimal demand from storage and because storage is still full and spilling in February it is safe to conclude that that no restrictions are necessary for the remainder of the season. The horizontal red line is the current level of storage volume in Lake Buffalo. When spilling stops this will gradually drawdown. The drawdown level should remain above the declared restriction level line. If it drops below the restriction level line a higher level of restriction will be declared. If the reservoir level drawdown moves above a lower level of restriction, the current restriction will cease and a less severe or no restriction will be announced. When in restriction mode the drawdown of the reservoir is monitored on daily basis. Inflows to the system are monitored as well.

Urban restrictions are implemented at the same level as irrigation restrictions in the model, according to rules specified in the appropriate BE.

Simulation of the actual situations in 1982/83, 2002/03 and 2006/07 showed that the new curves would have resulted in earlier restrictions compared to the approach developed as part of the BE process. Restrictions would have remained most likely the same for the remainder of the irrigation season, i.e. not increased in severity, but possibly relaxed earlier than actually occurred. They also showed that we would have recommended releases to be less than what actually occurred and thus reducing the risk of reaching critical levels that will require pumping of dead storage. In

2006/07 a full suspension of irrigation would have been declared earlier with the new curves than with the old ones.

Levels of Probability of Exceedance (PoE), i.e. drought levels, at which no flow restrictions are necessary, have been determined using the model. The model has the option to type in the PoE rather than have it determined from actual inflow and flow data. This allows for some scenario analysis to see what would happen to restriction levels if the PoE was slightly higher or lower. Changes may be significant around PoE values of 80% when there are substantial changes in environmental compliance flows. This is caused by the way eflows are formulated in the BE.

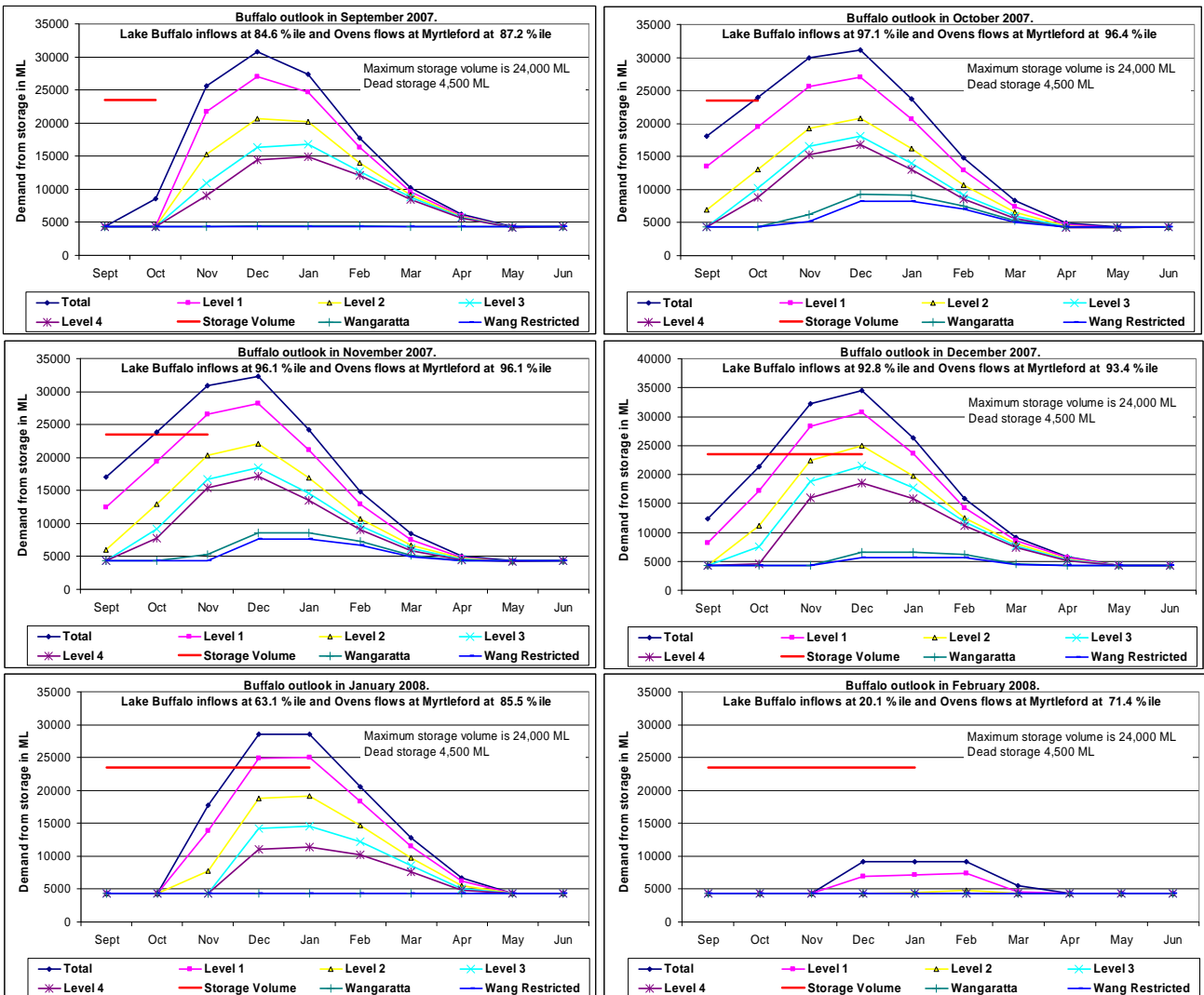


Figure 3 Restriction curves as determined during 2007/08

For Lake Buffalo, in combination with the same PoE flows from the Ovens at Myrtleford, no water supply restrictions are required for PoE values less than 70-75%. This is based on 115 years of inflow data for the lakes and 35 years of flow data of the Ovens at Myrtleford. For Lake William Hovell this occurs at PoE values from 80% to 85% of the inflows into the lake. This assumes that that level of PoE is valid for the full irrigation season.

SUMMARY AND CONCLUSIONS

In the last decade the Ovens catchment experienced two severe drought periods: 2002/03 and 2006/07, while 2007/08 may also be declared a relatively dry year. The Ovens catchment is not regulated via allocations but through restrictions when flows are low. It contains regulated and unregulated sections. The King River is a tributary of the Ovens and joins the Ovens just upstream of Wangaratta. The King Valley has its own storage (Lake William Hovell). The Ovens River has storage on its tributary the Buffalo River (Lake Buffalo). In the two drought periods both lakes did

not fill to capacity and inflows during the irrigation season were so low that restriction and even a total suspension of irrigation were necessary.

After the initial drought of 2002/03 the Victorian Department of Sustainability and Environment (DSE) and Goulburn-Murray Water (G-MW) developed restriction curves for both Lake Buffalo and Lake William Hovell in 2004. These curves were first applied in 2006/07 but it was not anticipated that the lakes were not going to be full by the end of September-October, nor was it fully taken into account that spillage might stop earlier than November-December. This had not occurred with minimum inflows before 2006/07. As a result the curves did not help satisfactorily with declaration of restrictions.

A predictive model to determine monthly restriction curves as a function of lake levels, predicted inflows and remaining water supply demands at various levels of restriction for both rural and urban needs was developed. The model also considers compliance with environmental flows at various points in the Ovens catchment. River losses are based on fixed losses as observed in the 2006/07 season at the various environmental compliance points and for higher flows on the function used in the REALM model.

Recently the Lower Ovens REALM model was updated to reflect the situation from July 1891 – December 2006 and demand and stream flow files of the updated model have been used as a basis for the Ovens restriction curves model. Lake Buffalo started operating in 1965 and Lake William Hovel in 1971. The REALM model did not include the driest year on record 2006/07.

The new restriction curve model is being tested during the 2007/08 year and simulated runs for the 1982/83, 2002/03 and the 2006/07 seasons were implemented. With the benefit of hindsight and actual data it appears that with the new restriction curves restrictions would have been declared earlier than what happened under application of the old restriction curve triggers. Both the old and new model comply with the BE restriction levels. Although restriction curves are determined for each month from September till February, they do not come into effect unless spilling has been declared to stop from the lakes.

Simulating all years since 1965 (Lake Buffalo) and 1971 (Lake William Hovell) showed that restrictions would have been declared in 10 and 8 years respectively, while on record there are 3 years of restrictions. The reason for this is that the model uses maximum entitlements based on 2006 values for all years, while in reality the number of active entitlements in any year may have been different and usage and maximum entitlements may have been less. Actual usage and variation in maximum entitlements were available from 1992 onwards and only in 1997/98 would restrictions have been declared in addition to the years of actual restrictions, using the new restriction curves.

The risk of declaring too severe restrictions is real as the only information currently available is the maximum entitlement and the model does not take the level of active entitlements into account. The model does take actual estimated usage into account by deducting estimated inflows from the full entitlement. Actual usage is only known in hindsight and from records it would appear that total actual usage in dry years reached up to 80% of maximum entitlement. The persons knowing the current situation are the Diversion Inspector based in Wangaratta and the staff of the Regulated Systems Department of G-MW in Tatura which receive daily flow records from various points in the catchment. It is recommended that when spilling from the lake is declared to have ceased and the model indicates that a certain restriction should be declared, that then an informed decision be made on the actual level of restriction to be declared. Consideration can be given to an estimate of actual usage based on water orders to date. For the time being it is recommended that the irrigation demand be set at 80% of full entitlement until such a time as actual usage exceeds 80% when it can be reset to 100%. The latter may also be necessary when water trading opportunities extend outside of the Ovens system.

The effect of the restriction curves on the reliability of supply depends on the definition of reliability. If we use the definition commonly used in areas that have allocations (i.e. high reliability is 97/100 years full entitlement and low reliability is 64/100 years full entitlement), then it can be concluded that even without restriction curves only 95% reliability was achieved in the 41 years of operation of

the lakes. With the new restriction curves Level 1 and Level 2 restrictions would have been called for in 7/41 years for Lake Buffalo and 7/36 for Lake William Hovell in December or January. Depending on the actual inflows in January – April for those years' restrictions may have been lifted before the end of the season. Hence the effect on the irrigation would have been during peak demand and less severe later in the season compared to what was experienced in 2006/07. The new curves do not affect reliability seriously, rather as was shown (G-MW 2008) and desired by irrigators, they would have been made aware earlier of potential restriction, the restriction would have been declared earlier and farmers could have made more informed decisions when planning for the current season as well as the forth coming winter season.

The simulations also showed that the requirement of compliance with environmental flows in certain months, and the subsequent increase in flows triggering higher compliance flows, is not in proportion with the restrictions imposed on the other users. The environmental compliance rules preferably should not require flows higher than the restricted demands from urban and rural water users that include losses incurred to supply these restricted demands. On several occasions it was observed from the model results that the compliance flows were nearly double that of the restricted demands plus losses, triggering higher levels of restrictions than necessary to meet the restricted demands.

From the simulations and the pilot trial underway currently it would appear that the new curves will have the desired effect of informing various stakeholders earlier that we are experiencing certain drought levels. It was further determined based on simulation of application of the curves, and with the benefit of hindsight and actual data, that in 8/10 years the predicted Probability of Exceedance (i.e. the drought level) will be lower, but that in 2/10 years it might be higher (i.e. a more severe drought). The curves however, will generate a level of confidence for both the operators and users that the best possible practice is applied to avoid total suspension of supplies and pumping of dead storage.

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