PART 2: MOST FREQUENTLY ASKED QUESTIONS MOKOAN—RETURN TO WELTAND

Question: ***I thought Lake Mokoan and Lake Nillahcootie were used to help control floods and protect the township of Benalla, what will happen after the decommissioning?***

Answer: The Lake Mokoan and Lake Nillahcootie storage system was developed primarily for water storage purposes and was not developed or operated for flood mitigation. Operation of the Mokoan inlet channel provides no significant decrease in flood height level during floods greater than a one in five year flow.

After the decommissioning of Mokoan, Nillahcootie water levels will be lower at the end of the irrigation season, therefore some minor extra flood alleviation benefit may be available.

Question: ***Will returning Mokoan to a natural system of wetlands result in more frequent flooding along Holland Creek and Broken River including Benalla Township?***

Answer: After decommissioning, some sections of the riverine system will return to more a natural flow condition, which means that flows will vary with rainfall and run-off. There will be an increase in minor floods for Holland Creek and the Broken River. While these flow variations and minor flooding are greatly beneficial to maintaining the health of our riverine system, they will have no impact on the Benalla Township.

Flooding of the Stock Bridge (Ackerly Avenue) will on average occur a little more frequently. Currently flooding of the Stock Bridge occurs once every 1¾ years and will change to once every 1½ years in the future assuming diversion to Lake Mokoan can occur on all occasions. Therefore, the change is frequency less three months.

This is similar for frequent flows elsewhere. The flow frequencies for flows greater than the 1 in 5 year remain unchanged.

Inspection of flow records has indicated that the change in duration of flooding exceeding bankfull flow capacity along the Broken River and Holland Creek is in the order of 5 hours.

Question: ***Will Mokoan Outlet and breached embankment create additional flooding.***

Answer: With a proposed 10 metre wide breach in the Mokoan embankment and retaining use of the existing outlet structure a rise of 10 millimetres has been determined for a range of floods in the Mokoan catchment.

Question: ***What about floods like that experienced in 1993, will they last longer or be bigger without Lake Mokoan?***

Answer: There will be no changes to the 1 in 100 year flood heights or duration as a result of the rehabilitation of the Mokoan wetland system. The peak flow during the 1993 floods was so great that even if the inlet channel had operated, the peak flood height would have only been reduced by about 20 mm.

Question: ***Why would river health improve with the decommissioning of Lake Mokoan?***

Answer: After decommissioning, parts of the Broken River system will return to natural flow conditions. These natural flow conditions, including more frequent minor flooding than experienced now, are essential for a healthy riverine system. During more frequent higher flows the floodplain environment receives an important wetting period. The floodplain wetlands can fill providing the river system with important nutrients (food), the movement of aquatic fauna between wetland and river systems to complete important parts of their life cycle, eg, breeding.

For More Information visit www.lakemokoan.com and follow links to:

- Fact Sheet No. 4 Broken System – Lake Mokoan – Management and Operation
- Fact Sheet No. 8 Mokoan – Return to Wetlands – Wetland Ecology and Management

July 2006

Flow Regime Fact Sheet

Mokoan - return to wetland flooding impacts

GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY

As part of the Victorian Government Our Water Our Future project, Lake Mokoan will be decommissioned. This will result in 44,000 megalitres of water being returned to the Broken, Goulburn, Snowy and Murray rivers each year. The re-adjustment to the flow regime towards natural conditions will generate waterway health benefits with minimal impacts on flood risks. This fact sheet has been presented in two parts, firstly with technical information, and secondly, responses to the most frequently asked questions.

PART 1: TECHNICAL INFORMATION

Nillahcootie and Mokoan Storage and its past operations

The Mokoan and Nillahcootie storage system was not developed, nor has it been operated with flood mitigation as its primary purpose. The 1963 Water Resources of Victoria Inquiry concluded that Nillahcootie and Mokoan were to be provided for water harvesting and storage purposes. Flood mitigation was to be and remains a secondary benefit if available.

A target filling curve for Lake Nillahcootie which existed in the 1970s through to the early 1990s was founded on maximising the volume held in storage in Mokoan and Nillahcootie at the start of the irrigation season. Flow records indicate that the curve provided limited benefits for both harvesting and flood mitigation because of the low capacity of the Nillahcootie outlet structure relative to the Lake's inflows. This results in the storage filling and spilling very quickly.

The closures of Mokoan due to toxic blue green algae through the 1990s and more recently, led to the need to ensure that Nillahcootie was full at the start of the irrigation season, hence the target filling curve for Nillahcootie was modified significantly, to the extent that the storage filled much earlier.

For further details visit www.lakemokoan.com and follow the links to Fact Sheet No. 4 Broken System – Lake Mokoan – Management and Operation.

The Benalla Floodplain Management Study (Cardno Willing, 2002) found Lake Nillahcootie storage and Mokoan inlet channel were both assessed as non effective flood mitigation measures for Benalla. The catchment area to Benalla is some 1,460 km^2. The influence on flooding in Benalla by Lake Nillahcootie is limited as it only commends 29% of the catchment area to Benalla and its small storage volume. The Benalla Floodplain Management Study concluded even if the storage is empty at the start of a large flood it will fill within a few hours. The Mokoan Inlet channel would only show some benefits if it was reconstructed at 1 km wide but would incur significant cost and loss of agricultural land.

Future operations of Lake Nillahcootie will result in the storage being lower at the end of each irrigation season, therefore some minor additional flood mitigation benefit will be available. However, the future target filling curve will not specifically cater for flood relief.

Flow Regime with and without Mokoan Inlet Channel

WITHIN BENALLA TOWNSHIP

There will be no changes to the 100-year average recurrence interval (ARI) flood heights as a result of the rehabilitation of the Mokoan wetland system. The capacity of the Mokoan inlet channel is 2,400 ML/d while the peak flow during the 1993 flood was 111,500 ML/d. Even if the inlet channel had operated, the reduction in the peak flood height would only have been approximately 20 mm.

Table 1 provides flow and height information, together with the ARI in years at the Benalla gauging station which is located adjacent to the Art Gallery. This data has been taken from the Benalla Floodplain Management Study (Cardno Willing, 2002) and the Rating Table for Benalla Gauge (Thiess Services, Rating No. 21.02). Sinclair Knight Merz more recently plotted a peak flow frequency curve see Figure 1 (Shepparton Mooroopna Floodplain Management Study, 2003), this indicates how often a particular flow is likely to occur.

Tables 1 and 2 show for a flow greater than the 5-year ARI, the increase in flood heights would be generally less than 100 mm if the Mokoan inlet channel is operated.

Table 1: Summary of Flow and Height Data at Benalla

Design and Historical Floods ARI (years)	Benalla Gauge Flow (ML/d)	Benalla Gauge Stage (m)
1.11*	2,190	1.943
2*	11,000	2.543
~ 2 (2005 Flood)	11,000	2.54
5	28,425	3.454
~ 7 (1975 Flood)	36,288	3.781
~10 (1981 Flood)	41,385	3.941
10	42,940	3.985
~14 (1974 Flood)	50,110	4.281
20	59,530	4.464
50	86,445	5.066
100 (1993 Flood)	111,508	5.50*

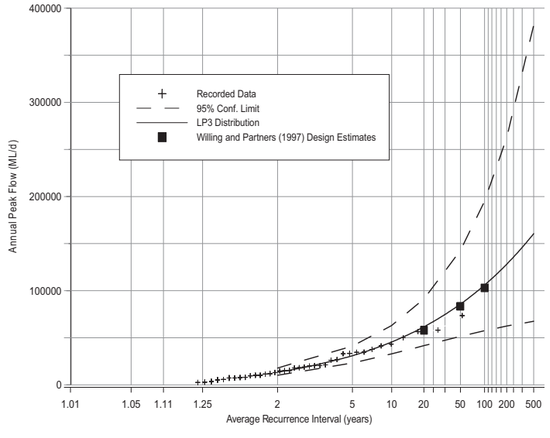
Table 2: Estimate of flood height differences at the Benalla gauge with and without Mokoan inlet channel operating.

Mokoan Inlet Channel Diverting Max Flow Capacity 2,420 ML/d	Mokoan Inlet Channel not Diverting Flows	Height Difference at Benalla Gauge Stage (m)
2,190	4,610	0.152
11,000	13,420	0.156
28,425	30,845	0.102
42,940	45,360	0.076
59,530	61,950	0.062
86,445	88,865	0.047
111,508	113,928	0.022*

Stock Bridge - Benalla

Flow will exceed the Broken River bank full capacity and cross on the Stock Bridge (Ackerly Avenue) once 2.2 m on the Benalla Gauge is reached. This gauge height represents a flow of 6,000 ML/d, which equates to a 1½-year ARI. Assuming Mokoan Inlet channel does not exist (or operate) the flow may increase to a maximum 8,400 ML/d, which equates to 1¾-year ARI. By deduction, if the Mokoan inlet channel can be relied upon to provide mitigation then the frequency of flooding would be reduced by three months under the current arrangements. However, analysis of flow records on the Holland Creek and Mokoan Inlet channel (detailed later) indicates that the changes will be less than three months as diversions to Lake Mokoan only occur during a fraction of time on occasions when bank full capacity is exceeded.

Figure 1: Peak Flow Frequency Analysis, Broken River at Benalla



Source: Sinclair Knight Merz (Shepparton Mooroopna FMP Study, 2002)

Flow Frequency Change

Table 1 and **Figure 1** provide a guide to minor shifts in frequency for lower flows. **Figure 1** includes the degree of uncertainty in terms of the average recurrence interval (frequency) for a particular flow, which is represented as confidence limits on the graph. For instance, the flow for 5-year ARI may range from 25,000 ML/d to 40,000 ML/d.

For less frequent floods, the confident limits for corresponding flows become significantly wider. For large flows, the possible minor changes in flow height equate to minor changes to flow, resulting in negligible changes. The change in flow frequency beyond the 5-year ARI therefore remains unchanged particularly bearing in mind the Mokoan Inlet channel is not likely to operate.

HOLLAND CREEK TO BENALLA

There will be no change to flows in the Holland Creek upstream of the Mokoan inlet channel. Downstream of the inlet channel flows will return to natural conditions. Table 3 below quantifies these changes. The height differences represent the 'worst' case scenario as it assumes that the inlet channel is operating at full capacity of 2,400 ML/d even where small flows are present in the Creek. Furthermore, the results are over estimating the height differences due to the ground surveys not spanning the entire floodplain ie, the wider the floodplain the depth of flooding is reduced.

Table 3: Estimate of flood height differences along Holland Creek with and without Mokoan inlet channel operating.

Holland Creek ARI (years)	Flow With / Without Inlet Channel (ML/d)	Holland Creek Flood Height Difference between Inlet Channel and Benalla (m)
2	6,220 / 8,640	0.265
5	14,860 / 17,280	0.110
20	33,005 / 35,424	0.007
100	54,605 / 57,024	0.006

Source: Earth Tech (2005)

Inspection of flow records since 1987 at Kelfeera and Mokoan inlet channel gauging stations reveals that the Holland Creek bank full flow capacity of 4,300 ML/d (Earth Tech, 2005) would have been exceeded on 22 occasions if the inlet channel did not operate. Records show during these occasions the Mokoan inlet channel operated 14 times of which 10 events still exceeded bank full. The average duration of flow, greater than bank full flow capacity, is some 10 and 14 hours with and without Mokoan inlet channel diversion.

BROKEN RIVER TO BENALLA

Broken River flows upstream of the Mokoan inlet channel will remain lower than naturally occurring frequent flows due to the influence of Nillahcootie storage. Downstream of the inlet channel, the 100-year ARI flood heights will not change however the frequency and height of minor events will, but to a lesser degree than shown in **Table 3** assuming Mokoan inlet channel can operate. The smaller changes are due to the larger carrying capacity of the river compared with Holland Creek.

BROKEN RIVER - BENALLA TO SHEPPARTON

The 100-year ARI flood heights between Benalla and Shepparton will not change. Assuming that Mokoan inlet channel can operate, and at a maximum 2,400 ML/d, a calculated 40 mm and 80 mm increases have been modelled relative to the 100-year and 5-year ARI flows respectively at Casey's Weir located some 10 km downstream of Benalla (GHD, Report on Hydrology and Downstream Hydraulics, 2006). These results are similar for Benalla. Closer to Shepparton increase in flood heights will be less due to attenuation of flows provided by the Broken River and Broken Creek floodplains. Information contained in the Shepparton Mooroopna Floodplain Management Plan (SKM, 2002) indicates the height differences for the 100-year ARI flow will be smaller for the Shepparton East area compared with Benalla.

Flow Regime with the Modification to the Mokoan Outlet

The decommissioning of Lake Mokoan will revert to the pre-development of Lake Mokoan. The outlet will allow overflow to occur at the same level as that which existed for Winton Swamp. A Report on Hydrology and Downstream Hydraulics (GHD, 2005) concludes the following:

1. The preferred option for the decommissioned Mokoan embankment and outlet works is for a 10 m breach and provision of a modified outlet works to maintain an overflow crest level of 161.14 m AHD for Winton Swamp.
2. With the preferred outlet arrangements (i.e. 10 m breach with outlet), a 100-year ARI event over the Mokoan catchment would result in:
3. A peak water level in Winton Swamp of 161.72 m AHD (0.58 m above the overflow level of 161.14 m AHD);

   An area of land, around and including the future Wetland, liable to flooding of about 5,300 ha;

   Durations of flooding above the overflow level (161.14 m AHD) would be greater than eight days; and

   Flood level surcharges of between 0.4 to 1.1 m would be experienced in the seven swamps within the Lake Mokoan area.
3. Increases in peak water levels in the outlet channel for a range of flood events in the Mokoan catchment with the preferred outlet (ie, 10 m breach with outlet) arrangements combined with the 1993 flood level at Casey Weir are in the order of 0.01 m ie, Future Wetland overflows will add a maximum of 10 mm to flood levels at Casey's Weir in a 100-year ARI event.
4. For more frequent floods in the Broken River than the 1993 event, the estimated peak discharges from the Future Wetland will not significantly increase (ie,. by less than 0.01 m) the water levels above the existing compacted banks along the outlet channel.

Flow Regime with and without Mokoan Inlet Channel

The Water Management Scheme for Benalla was approved by the Minister for Water in 2002, and is unrelated to decommissioning of Lake Mokoan.

The Approved Scheme for Benalla includes environmentally sensitive vegetation management adjacent to the urban environs, improvement to the railway culverts near the East Main Drain, and the acquisition of the Market Street Floodway. Flood height reductions of 50 and 200 mm are expected for larges floods along the Broken River and up to 750 mm near the East Main Drain and Northeastern Railway.

Benalla Floodplain Management Study (Cardno Willing, 2002) and earlier Benalla Flood Study (Willing & Partners, 1995) formed the basis of the Approved Water Management Scheme. These documents are available from the Benalla Rural City Council.

The Approved Scheme for Benalla and the flood warning arrangements do not rely on diversions to Mokoan during floods, and in practice diversions to Mokoan do not take place during large floods.

Conclusions

The operation arrangements of the Mokoan and Nillahcootie storage system was established for water harvesting purposes and on occasions may provide incidental minor reductions in flow height, duration for Benalla and its surrounding environs. This is true only if the Mokoan inlet channel operates, which can not be no guaranteed. There will be a slight change in frequency for lower flows. Further downstream towards Shepparton East changes to flow heights will be further reduced due to attenuation of flows provided by the Broken River and Broken Creek floodplains.

The minor changes in flow regime, particularly for frequent floods are environmentally favourable for waterway and riverine health. Flows above bank full provide a number of important functions including the wetting of riparian areas delivering important organic matter (food) to waterway species, and providing access for some native fish species to nearby wetlands. Minor increase in flood heights for frequent floods are important as a way forward to restore waterway and riverine health back towards natural conditions. This is particularly important as climate change predictions suggest inland areas of Australia will, in the long-term, become drier with less catchment runoff entering waterways.