

A referee report on
2023 Menindee Mass Fish Kill: How it happened.
A desktop investigation unravelling the operational decisions that preceded the
death of 20 million fish
by Megan Williams and Dan Schulz

Compiled by

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Dated 18 April 2023

Overview

This well written and comprehensively documented report assembles in an innovative manner publicly available information in the form of satellite imagery and field observation, coupled with photography, which together make a strong case that the release of blackwater from Lake Wetherell to the regulated section of the Darling-Baaka River contributed to the huge fish kills that commenced on 16 March 2023.

The report's findings are in sharp contrast to the Menindee Lakes Community Update published on 21 March 2023 by WaterNSW which states 'The fish death is a natural event associated with record flooding in the area. There are very limited management actions that could have been taken to prevent it from happening.'

Overall, the interpretation of the satellite images along with the field observation and photography are highly plausible and provide defensible evidence of the claims made in this report. The claims of blackwater movement from Lake Wetherell to the regulated section of the Darling-Baaka River are also well supported by the river flow data.

This report provides three reasonable lines of evidence and a tested methodology which together suggest that the delivery of blackwater from Lake Wetherell to the regulated section of the Darling-Baaka River contributed to the huge fish kills that commenced on the evening of 16 March 2023.

It is affirmed in this review that the evidence assembled in the report is more than sufficient to make a case for a full, open, and independent inquiry into the river management that resulted in the 2023 fish kills in the Darling-Baaka River. Therefore, it is strongly supported that the recommendations contained in the report be made available to the NSW Inquiry into the 2023 Menindee Mass Fish Kills, chaired by the NSW Chief Scientist & Engineer and Commissioner of the Natural Resources Commission, Professor Hugh Durrant-Whyte.

Examination of evidence

Blackwater discharge documented in February 2023

The evidence provided in the report is supported by the reports and public communication from the NSW DPE to the community over the period 17 to 27 February 2023. The satellite images and photographic record of events as set out in Figures 4, 5 and 6 provide good evidence of:

- the blackwater held in Lake Wetherell having black colour compared to the lighter coloured water in Lake Pamamaroo;
- the penetration of a wedge of darker water into Lake Pamamaroo;
- significant fish kills on 18 and 27 February 2023 within the regulated section of the Darling-Baaka River (see Figure 2 of the report).

This sequence of images is consistent with the NSW DPE Water Quality Update of 2 March 2023 which states ‘It was identified that the poorer quality water entering Lake Pamamroo [sic] was being drawn through the Pamamaroo outlet and being discharged into the Darling River. To address this issue, the inlet structure between Lake Wetherell and Pamamaroo was closed.’ (DPE Water Quality Update – 2 March 2023).

The report confirms with visual data the claims made by the NSW DPE that the efforts to limit releases from Lake Wetherell had improved oxygen levels in the regulated section of the Darling-Baaka River and potentially avoided further fish deaths (as implied in Figure 7 and evidenced in the photograph in Figure 8). This gives me confidence that the visual interpretation of the satellite images and photographs provide good evidence of the consequence of river management operations on the fish kills during the period 17 to 27 February when the trials by NSW DPE occurred.

In a scientific sense, the interpretation of these satellite images and photographs which correlate well with the observational statements of the NSW DPE, provide a period of testing or validation of the methodology used in the report. This gives confidence to the subsequent findings set out in the report.

Blackwater discharge in March 2023

Evidence provided by satellite imagery on 14 March shows dark colouration in Lake Pamamaroo along the edge of the lake from the outlet regulator from Lake Wetherell and the outlet regulator from Lake Pamamaroo. This is evident in Figure 10 and particularly in the contrast enhancement in Figure 11. The image indicates a plume of much darker colouring entering Lake Pamamaroo from Lake Wetherell and travelling south along the edge of Lake Pamamaroo to the Pamamaroo outlet, where it would be discharged into Pamamaroo Creek as indicated in Figure 9. From there it would flow into the regulated section of the Darling-Baaka River where the fish kills took place.

The report adds a second line of evidence of blackwater discharges to the regulated section of the Darling-Baaka River (where the fish kills took place) by using enhanced and enlarged satellite images in Figure 13 to show dark coloured water in the Pamamaroo Creek directly below the outlet from Lake Wetherell. Further support for this hypothesis is provided by enhanced imagery, field observation and river photography on 14 March in Figure 14. The difference in colour and

the presence of a darker colour on 14 March compared to 4 March (Figure 14) is less convincing to me than the colour differentiation provided in Figures 10 and 11. However, both lines of evidence in satellite imagery and the on-ground river observations appear consistent with the hypothesis that two sources of blackwater, each derived from Lake Wetherell, were delivered over the period 14 to 18 March to the regulated section of the Darling-Baaka River where the fish kills occurred beginning on the evening of 16 March 2023.

The report also provides evidence that following the fish kills (which commenced on 16 March 2023) blackwater discharges continued to flow from Lake Wetherell via Lake Pamamaroo to the regulated section of the Darling-Baaka River. In Figure 22 of the report, there is strong satellite image data to show blackwater movement from Lake Wetherell to Lake Pamamaroo and to Pamamaroo Creek and into the regulated section of the Darling-Baaka River. This is particularly striking in the image of 24 March 2023.

These increased flows of blackwater from Lake Wetherell via Lake Pamamaroo to the Darling-Baaka River are very clearly reflected in the increased river flows in the regulated section of the Darling-Baaka River following the fish kills. This evidence is clearly apparent in Figure 24 of the report. These flows appear to have continued at the increased level until the end of March 2023, as depicted in Figure 24 of the report.

Overall, the interpretation of the satellite images along with the field observations and photography are highly plausible and provide defensible evidence of the claims made in this report. The claims of blackwater movement from Lake Wetherell to the regulated section of the Darling-Baaka River is well supported by the river flow data.

Conclusions and recommendations

This report provides three reasonable lines of evidence and tested methodology which together suggest that the delivery of blackwater from Lake Wetherell to the regulated section of the Darling-Baaka River contributed to the huge fish kills which commenced on the evening of 16 March 2023.

The report is careful not to address the other factors in the management of the waters of the Darling-Baaka River which will have also contributed directly and indirectly to the fish kill. The report gives focus to the management of blackwater accumulation in Lake Wetherell immediately prior to the fish kill.

The purpose of the report is to provide sufficient evidence for further investigation into the role of controlled releases of blackwater in the 2023 Menindee fish kills, and the reasoning behind these releases.

The report assembles a strong case for a full, open and independent inquiry into the management of the Darling-Baaka River systems which include lakes, floodplains and river channels in order to manage blackwater events and healthy fish populations under river regulation as climate change impacts on river flows, flooding, drought, and the magnitude and frequency of blackwater events.

River regulation has increased the frequency and severity of hypoxic blackwater events in lowland river systems, necessitating management intervention to mitigate the impacts of these events on aquatic biota.

The issues raised in the report require full examination of how to manage blackwater events in regulated river systems where the natural flow processes are constrained by infrastructure. Climate change, river regulation and water extraction create the conditions where destratification-driven hypoxia will become more common in rivers. Preventing this and the fish deaths that can result, requires options that prevent stratification and create oxygen refuges for fish. It is well known that flow management that maintains fish refuges and storage reserves during drought is the best way to guard against fish deaths.

Further reading

Australian Academy of Science. 2019. *Investigation of the causes of mass fish kills in the Menindee Region NSW over the summer of 2018–2019*. Canberra: Australian Academy of Science.

Boys, C. A., D. S. Baldwin, I. Ellis, J. Pera, and K. Cheshire. 2021. “Review of options for creating and maintaining oxygen refuges for fish during destratification-driven hypoxia in rivers.” *Marine and Freshwater Research* 73 (2): 200-210. <https://doi.org/10.1071/MF20364>.

Whitworth, K. L., J. L. Kerr, L. M. Mosley, J. Conallin, L. Hardwick, and D. S. Baldwin. 2013. “Options for managing hypoxic blackwater in river systems: case studies and framework.” *Environmental Management* 52 (4): 837-850. <https://doi.org/10.1007/s00267-013-0130-9>.