

WATER TURBIDITY AND CATCHMENT MANAGEMENT WITHIN THE MURRAY RIVER SYSTEM

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ABSTRACT

Turbidity can reach high levels in the Murray River catchment, particularly during flood events. The Murray Sediment Working Group was established in November 1994 and is comprised of agencies in Victoria and NSW. One of the major tasks of this group was to collect daily water turbidity data from Water Treatment Plants along the Murray and tributary rivers. A computer-based data set has now been assembled using data from ten plants. A number of other projects have also been completed including a comparison of water turbidity data with daily flow levels and an airborne video exercise to evaluate the potential of remotely estimating water quality from the air. These activities will all be discussed.

1. INTRODUCTION

Turbidity represents the light scattering properties of water and is commonly reported in Nephelometric Turbidity Units (NTU). Turbidity in water is caused by suspended matter such as clay, silt, finely divided organic and inorganic material and soluble coloured organic compounds (Olive and Fredericks, 1995). The Murray River is used for a wide variety of purposes, many of which are not compatible with high turbidity levels. Highly turbid water can affect irrigation and industrial water users and recreational users. It can also interfere with the growth of aquatic plants and fish (Murray et al, 1993).

The paper is broken up into four major parts, and includes information on the Murray Sediment Working Group; an assessment of daily water turbidity data at seven Water Treatment Plants (WTPs); an airborne video water quality assessment project along the Murray River and consideration of

future actions of the Murray Sediment Working Group and researchers.

2. MURRAY SEDIMENT WORKING GROUP

During November, 1994 a meeting was convened by the NSW Environmental Protection Authority (EPA) to discuss turbidity issues, problems and use of Water Treatment Plant datasets in the Murray River Catchment above the Murrumbidgee River Junction. Representatives from both NSW and Victoria attended this meeting as did experts in the turbidity/sediment field from CSIRO Division of Water Resources and Australian Defence Force Academy (ADFA) in Canberra. One of the outcomes of this meeting was the establishment of the Murray Sediment Working Group. This working group includes representatives from the NSW EPA, NSW Murray Catchment Management Committee, NSW Department of Land and Water Conservation (2 representatives), Victorian Department of Conservation and Natural Resources, Goulburn-Murray Water and the Victorian EPA. The working group is chaired by the NSW EPA. Meetings were conducted in November 1994, January 1995 and May 1995. To date, a major focus of the working group has been the collection and input of the raw WTP turbidity data into the computer package Excel. WTP data is valuable since it is measured using Hach turbidity meters and is normally collected on a daily basis. The best similar data in the catchment is collected weekly on behalf of the Murray-Darling Basin Commission. Other data, including raw water colour and pH was also collected and entered into the computer. In many cases the data has been collected for long periods, for example Mulwala since 1944 and Echuca since 1971. Given that flood events are often of short (2-3 days) duration (Olive and Fredericks, 1995) and may not be sampled by weekly monitoring, daily data sets more accurately

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reflect the increases in turbidity associated with flood peaks much better than weekly data. The data sets collected include Albury, Mulwala, Yarrawonga, Cobram, Echuca, Swan Hill, Wangaratta, Shepparton, Deniliquin and Jerilderie (Figure 1).

This data was entered into the Excel by two systems. One involved the input of data as part of a consultancy for the NSW EPA by the Australian Defence Force Academy (ADFA) and the other was through a Skillshare project.

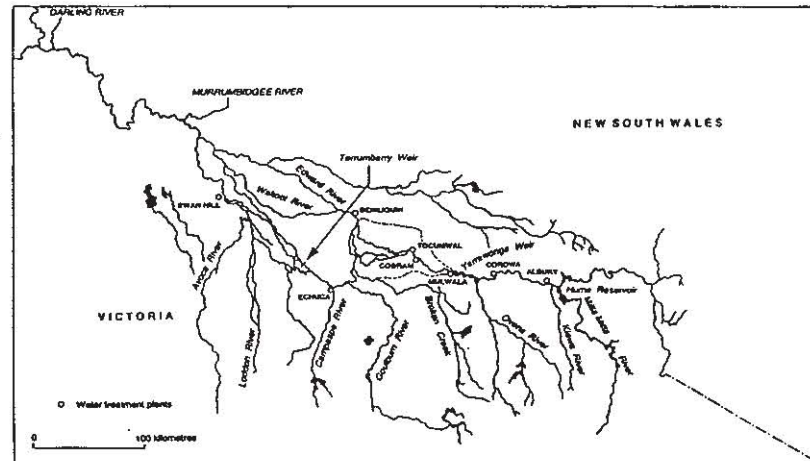


Figure 1. River Murray

3. DAILY WATER QUALITY PROJECT FOR SEVEN WATER TREATMENT PLANTS ALONG THE MURRAY RIVER SYSTEM

This project was undertaken by ADFA as a consultancy for the NSW EPA, with CSIRO Division of Water Resources being the project manager. The project involved the input of daily raw water WTP data into Excel (turbidity, colour, pH), analysis of this data against Murray River and tributary flow levels and where possible determination of the main sources of turbidity. This was completed for seven sites including Albury, Mulwala, Tocumwal, Cobram, Echuca, Swan Hill and Deniliquin. Six reports have been prepared by Olive and Fredericks (1995) for these WTPs with one report being produced for Tocumwal and Cobram due to the proximity of the two sites. It must be emphasised that the data in these reports is raw with minimal checks on the accuracy of observations and no cross calibration between locations. However turbidity is determined with HACH turbidity meters at all locations with regular internal calibration checks and the data does reflect the pattern of responses.

3.1 Albury

The turbidity response of the Murray River at Albury (Albury WTP) during flood events is relatively small (Olive and Fredericks, 1995). This was based on WTP data between May 1992 and December 1994. This response pattern is likely to be related to the location at Albury; immediately downstream of the Hume Weir on the Murray and Dartmouth Dam on the Mitta Mitta. Both of these structures act as sediment traps which result in a reduction of turbidity in discharged waters (Thoms and Walker, 1991).

3.2 Tocumwal/Cobram

WTP records of turbidity span the period of June 1986 to April 1995 for Cobram and January 1991 to December 1993 for Tocumwal. The report of Olive and Fredericks(1995) concluded;

- * highest turbidity levels are associated with floods;
- * duration of very highly turbid flows is generally only 1-3 days;
- * daily flow data cannot be used to infer turbidity fluctuations because of the variation in flood sources;

- * high turbidities are generally associated with floods from, or which include a large proportion of flow from the tributaries downstream of Albury rather than from the catchment upstream of Hume Weir. This is emphasised in Figure 2.

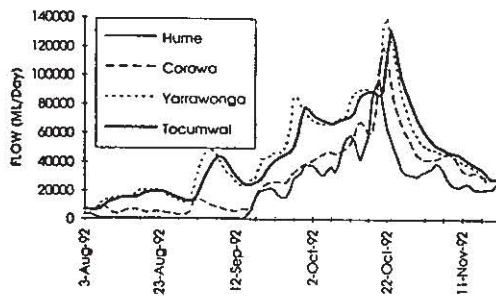
- * there is a large difference in observed turbidities at Tocumwal and Cobram. However, the trends in turbidity are very similar at the two locations (refer to figure 2). More recent data indicates that it is possible that the Tocumwal WTP may be overestimating turbidity.

- * high turbidities are associated with floods with the highest turbidities levels associated with the large floods of 1973 and 1974. The turbidity in one flood event in 1974 reached 450 NTU;

- * the turbidity showed a peak response pattern during floods despite the subdued flood hydrographs;

- * there are marked turbidity rises associated with the early winter relatively small river rises and then a decrease in the magnitude of subsequent responses (Figure 3);

- * many turbidity peaks are associated with flood events in the Goulburn River, while others are associated with flow events in tributaries further upstream with the peak transmitted downstream though the system.



Murray River flood hydrographs 1992.

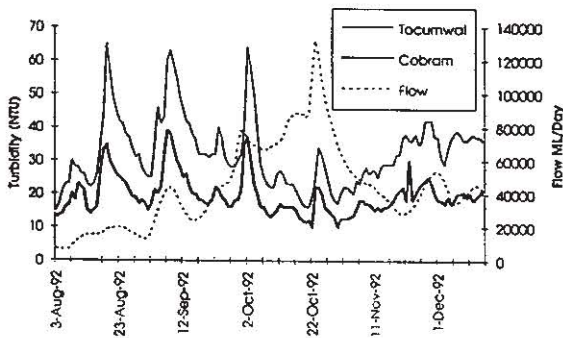


Figure 2. Murray River at Cobram/Tocumwal, flow and turbidity 1992

3.3 Echuca

Echuca WTP records of turbidity span January 1971 to March 1995. The Echuca report concluded;

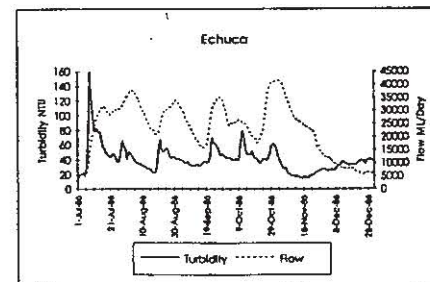
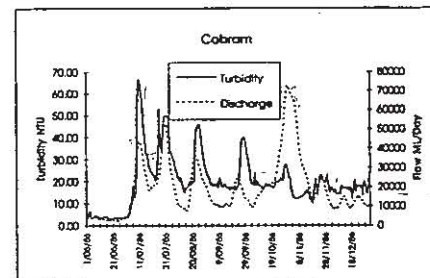
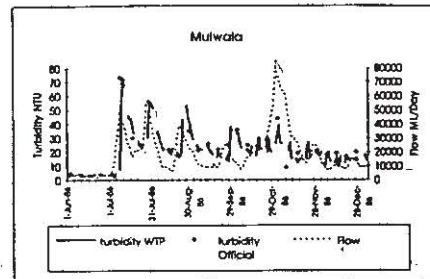


Figure 3. Flood hydrographs and turbidity at Mulwala, Cobram and Echuca during the 1986 flood

Further detailed information on each of these sites can be obtained from the six individual reports.

4. MURRAY AIRBORNE VIDEO PROJECT

In February, 1995 an exercise was carried out along the Murray River to evaluate the potential of an airborne video system (ABVS) to measure a number of selected water quality parameters from the air including turbidity, total suspended solids and apparent colour. The ability to remotely assess water quality parameters from the air provides the user with the potential to save the many person-hours consumed with routinely obtaining and analysing water samples in the field, an ability to extend assessment over a much larger area, an unlimited increase in density of effective sampling points and allows access into regions often unavailable for ground-based sampling. Advantages associated with airborne video over other aerial imaging techniques include high-medium ground resolution (0.7-3.0 m), high revisit capability and provision of multi-spectral digital images. The ABVS comprises 4 downward-looking high resolution video cameras, along with camera controlling and image acquisition hardware, carried in a Cessna 210 aircraft. Each camera acquires information in a preset spectral band determined by an interchangeable filter. General purpose imaging filters of blue (450 nm), green (550 nm), red (650 nm) and near infrared (770 nm) were used. Composite multi spectral images are acquired and recorded using a frame grabber and a 486 computer (Louis et al, 1995). A global positioning

system (GPS) is incorporated into the system to automatically provide location coordinates for each image. Images were obtained at 26 specific locations in a region stretching from Khancoban to the junction of the Murray and the Murrumbidgee Rivers, where water samples were acquired for laboratory/field testing of parameters including turbidity, suspended solids and apparent colour (Clesceri et al, 1989). The raw digital information provided by ABVS imagery was used to assess the correlation with one or more of the measured water quality parameters from the sample sites. Images were obtained at other non-sample sites for estimation of the water parameters based on the calibration provided by the sample sites. Reasonable levels of rainfall were recorded over the catchment in the weeks immediately preceding the flight, resulting in rain rejection flows in the Murray River, downstream from Lake Mulwala, at the time of the flight. The locations of sampling sites were determined by the Environmental Protection Authority prior to the flight. Extracting the digital information from each image was performed on a SUN workstation using a conventional image processing software package. Linear multiple regression analyses, based on least squares, were performed to link the digital information from images of the sample sites to measured values of turbidity, total suspended solids and apparent colour. The resulting equations are listed in Table 1. The R² values of each regression equation suggests a significant correlation exists between the combined waveband data and each water quality parameter.

Water quality parameter	Intercept	Infrared coefficient	Red coefficient	Green coefficient	Blue coefficient	R ²	No. sample sites used
Combined Turbidity	-1.80051	0.524678	0.541532	1.182209	-1.48641	0.844	21
Horiba Turbidity	-35.9102	3.975116	-1.63118	2.915288	-2.577	0.968	8
Total Suspended Solids	-52.5023	3.621483	-0.91218	-1.97971	1.600126	0.994	9
Apparent colour (EPA lab)	224.238	-2.056	8.485	1.736	-8.745	0.971	10

Table 1. Regression coefficients for fitted data.

Note: The value of each water quality parameter = Intercept + (a x IR) + (b x R) + (c x G) + (d x B), where a, b, c and d are the infrared, red, green and blue regression coefficients respectively.

Figure 4, for example, compares values of turbidity calculated from the regression equation with those measurements obtained from the sample sites. If the regression equation was 100% accurate then data would lie on a 45° line (indicated by a solid line).

The established regression equations were then used to estimate values of turbidity, suspended solids and colour for the other non-sampled sites, resulting in a synoptic profile along the extent of the Murray River covered in the mission.

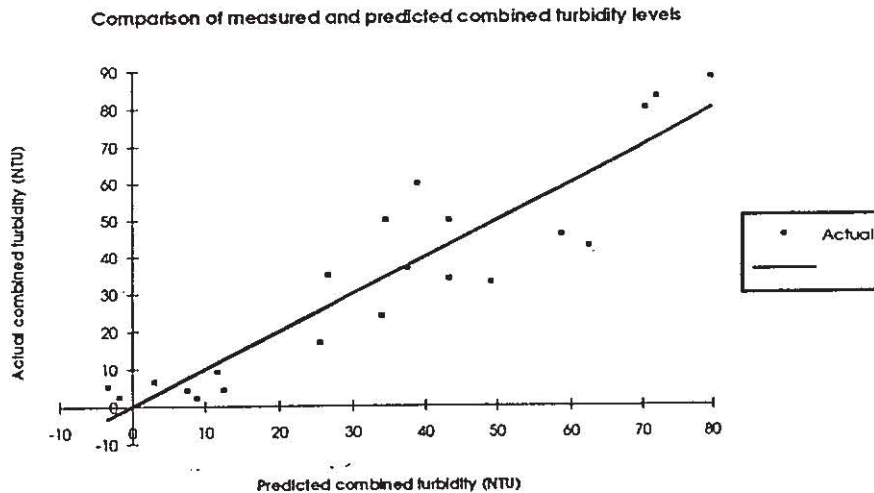


Figure 4. Comparison of predicted turbidity (NTU) from regression equation and measured value.

The results of this preliminary work has clearly demonstrated the potential of an airborne video system for estimating selected water quality parameters from the air. Although in this mission strong correlations were identified between each measured water quality parameter and raw information provided by the ABVS, further work is required to reduce the standard error associated with the estimation of parameters at image-only sites (for example approximately 10 NTU for turbidity). This will include developing the ABVS to provide target reflectance data rather than raw data, a detailed characterisation of water quality parameters and their effect on detected radiance, use of river-only calibration sites and careful selection of appropriate water quality filters.

5. FUTURE ACTIONS OF THE MURRAY SEDIMENT WORKING GROUP AND RESEARCHERS.

The Murray catchment now has many valuable new datasets for use in understanding turbidity and sediment sources. Such information allows for an improved assessment of loads of sediments, and

potentially nutrients, and for the ranking of projects by catchment committees. The Murray Sediment Working Group, and researchers including Mr L Olive, Mr D Post and Dr D Lamb, is now in an excellent position to further develop this work. Options currently under consideration include;

- i. calibration of daily turbidity and suspended solid data at all WTPs and use of this data in sediment load estimation.
- ii. assessment of attributes of all catchments and effect of attributes on water quality;
- iii. attaining a better understanding of the high initial turbidity levels resulting from early winter flooding events, and consequent sediment exhaustion with later events;
- iv. assessment of the influence of rainfall intensity on turbidity levels;
- v. consideration of radionuclide studies to assess topsoil and subsoil influence on turbidity.
- vi. further refinement of the air video technique to further improve estimates of water turbidity and suspended solids.

6. CONCLUSIONS

The main findings and conclusions of this paper are highlighted below:

*The Murray Sediment Working Group has obtained ten daily turbidity datasets for the Murray River catchment. These datasets more accurately reflect fluctuations in turbidity associated with flood peaks than weekly data since flood events most often occur over a duration of a few days.

*Highest turbidity levels are associated with floods

*At Tocumwal and Cobram WTPs, high turbidities are generally associated with floods from, or which include a large proportion of, flow from the tributaries downstream of Albury.

*At Echuca WTP, many turbidity peaks are associated with flood events in the Goulburn River, while others are associated with flow in tributaries further upstream.

*An airborne video system has clearly demonstrated its potential for assessing water quality from the air. Strong correlations were identified between measured water quality parameters and raw digital number information provided by the ABVS, allowing an estimation of the same parameters from images taken at selected locations along a major inland river. Further work is required to improve the accuracy of estimation of water quality parameters.

*The Murray Sediment Working Group, and associated researchers, is currently considering six options to progress understanding of turbidity and suspended solids in the Murray River.

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