ON-FARM WATER SAMPLING AND ANALYSIS PROJECT

IRRIGATION AND LIVESTOCK FARMS

This project is supported by Southern NSW Innovation Hub, through funding from the Australian Government's Future Drought Fund

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Background

The Future Drought Fund – On-farm Water Management will help farmers reduce the impact of drought by preparing and implementing an on-farm water management plan. Through these plans, landholders will undertake actions that aim to improve water security during times of drought and ensure that they have adequate water in the right places across the farm. Through this process, it is expected that there will be altered management and enhancement of dams and waterways which are likely to improve water quality.

Altering how water is distributed across a farm and the access stock has to water sources may impact on water quality. Ensuring stock have access to good quality water at all times and particularly during drought is important. Farm dam enhancement and improved water quality on farms may have multiple benefits to livestock, biodiversity and water availability and security. These benefits may include:

- Improved stock health and productivity through improved water quality and reduced pathogen loads.
- As water quality improves, stock need to drink less frequently and will travel further, reducing stress on surrounding pastures.
- Reduced evaporation due to reduced temperature and reduced wind. This becomes increasingly important during dry periods. These processes also help to maintain other components of water quality such as nutrient concentration and turbidity.
- Dams may trap and filter nutrients and sediments reducing loads transmitted downstream to other dams and streams.
- Water quality and biodiversity in enhanced dams may be more resilient to decline as dams dry.
- Increased biodiversity

The water quality monitoring component of the program aims to track changes and any improvements in water quality of the waterways, dams and watering troughs that have changed management actions implemented.

Specifically, the focus of this small sampling and analysis project is on irrigation farms with a livestock component to their operations.

Australian Government
Department of Agriculture, Fisheries and Forestry
Future Drought Fund
SOUTHERN NSW Innovation Hub
SUSTAINABLE AGRICULTURE, LANDSCAPES AND COMMUNITIES
Farm Water Management Planning

This project is supported by Southern NSW Innovation Hub, through funding from the Australian Government's Future Drought Fund

Project Objective

Undertake a small-scale water quality project to gather data on the water quality changes/ status from channel gravity fed or pumped to dams, water intended for stock and domestic use.

Sampling protocol

The sampling protocols adopted were provided by Murray Local Land Services.

The actual sites which were sampled were identified by AKS Advisory, based on local knowledge and observations.

Of the nine sites where sampling was conducted, five were identified as farm groundtanks (or dams), one farm drain and three water supply channels operated by the local water supply company (Murray Irrigation Limited).

A recent history of each of the farm sites was obtained to allow identification of specific management and/or livestock that utilised the sites.

One sample was collected at each of the identified sites. The full description of the sampling protocols and procedures utilised in the project are outlined in the documentation provided by Murray LLS (Murray LLS, 2024).

Table 1 outlines the analysis of the samples collected. Table 2 identifies the characteristics of each of the sites sampled, and Figures 1-7 provide photographic evidence of the conditions experienced at each site. It is noted that Dissolved Oxygen, conductivity, pH and turbidity were not analysed as part of this study. The YSI WQ probe, which is used to collect and analyse these parameters, was not available to AKS Advisory at the time the sampling was completed.

Table 1. Parameters to be sampled, definition and purpose of sampling

Parameter	Definition	Purpose for sampling
Temperature (°C)	Amount of heat energy	The distribution and abundance of aquatic plants and animals is affected by changing temperatures. Effects evaporation rate
Dissolved Oxygen saturation (%)	A measure of the concentration of oxygen dissolved in water relative to the oxygen holding capacity of the water	Oxygen is essential for respiration by all aquatic plants and animals
Dissolved oxygen concentration (mg/L)	A measure of the concentration of oxygen dissolved in water	Oxygen is essential for respiration by all aquatic plants and animals
Conductivity (u*S*/cm or *m*S/cm))	Electrical Conductivity (EC) measures the flow of electricity in a solution	Is an indication of salinity levels. Aquatic organisms have differing levels of tolerance to salinity. High levels are toxic and will cause mortality in most species.
pH	Is a measure of its acidity or alkalinity. Measured as the level of H^+ ions in the water	Plants and animals of varied tolerance range for pH and may become toxic
Turbidity (NTU or FNU)	Turbidity is a measure of the clarity of the water	Levels of suspended particulate matter, including clay, silt, detritus and plankton may be related to surrounding land use.
Total phosphorus (ug/L)	The level (concentration) of all the phosphorus in the water sample	Phosphorus may be a limiting nutrient in waterbodies, which means that increased concentrations can contribute to rapid plant growth including algal blooms and aquatic macrophyte infestations.
Nitrate + nitrite (NO_x) (mg/L)	The level (concentration) of these dissolved nitrogen compounds in the water sample	High levels can contribute to rapid plant growth including algal blooms and aquatic macrophyte infestations. Fertiliser and stock manure runoff can be a significant contributor
Total Kjeldahl Nitrogen (TKN) (ug/L)	the amount of organic nitrogen, ammonia (NH3), and ammonium (NH4+) in the water	An indicator of nutrient pollution. High levels can contribute to rapid plant growth including algal blooms and aquatic macrophyte infestations. Fertiliser and stock manure runoff can be significant contributor
E.coli and Total coliforms	rod-shaped bacteria that are present within the environment (faeces plant and soil)	An indicator of pollution/runoff particularly faecal contamination
Thermotolerant coliforms	Faecal coliform bacteria concentration (includes *E. coli* listed above)	A more specific indicator faecal contamination
Chloride	Ion commonly associated with salts (NaCl)	High chloride levels indicate a risk of salt toxicity
Blue Green Algae	Total and potentially toxic taxa and concentration in the water	An indicator of the potential risk of ingesting toxic blue green algae

Note: Total nitrogen will be calculated by summing Nitrate + nitrite (NO_x) and total kjeldahl nitrogen

Table 2. Site characteristics

Site	Site ID	Type of water body	Water source(s)	Runoff from surrounds?	Livestock type	Smell	Recent history
Groundtank 1	GT1	Excavated groundtank with berm	Farm channel &/or Supply channel	No	Cattle	Nil	Not used for approx. 2 months. Not filled since Dec 2024. Grazing of irrigated annual pastures
Groundtank 2	GT2	Excavated groundtank with berm	Farm channel &/or Supply channel	No	Cattle	Yes - earthy	Not used for approx. 3 weeks. Not filled since Feb 2025. Grazing of native pastures and high quality hay
Groundtank 3	GT3	Excavated groundtank	Drainage runoff	Yes	Cattle	Nil	Recently desilted to deepen and reduce surface area. Currently in use. Filled in March 2025. Grazing of irrigated annual pastures
Groundtank 4	GT4	Excavated groundtank with berm	Farm channel &/or Supply channel	No	Cattle	Yes - Earthy	Currently in use. Filled in Feb 2025. Increased seepage losses. Visible signs of carp in water. Grazing of irrigated sorghum.
Groundtank 5	GT5	Excavated groundtank	Farm channel &/or Supply channel	Yes	Sheep	Nil	Currently in use. Filled Nov 2024. Grazing of stubbles.
Drain	Drain	Excavated drain as part of a recycling system	Irrigation runoff	Yes	Nil	Nil	Fenced to exclude livestock. Filled in Feb 2025 from irrigation runoff.
Blighty 6 channel	Ch1	Supply channel	Supply Channel	No	Nil	Nil	Irrigation company supply channel
Blighty 6 channel offtake	Ch2	Supply channel	Supply Channel	No	Nil	Nil	Irrigation company supply channel
Mulwala Canal offtake	Mulwala	Lake	Murray River/Lake Mulwala	No	Nil	Nil	MDBA water body

Figure 1. Groundtank 1

Figure 2. Groundtank 2

Figure 3. Groundtank 3

Figure 4. Groundtank 4

Figure 5. Groundtank 5

Figure 6. Drain

Figure 7. Irrigation supply channels

Results

The results of the sampling are provided in Tables 3-12 below.

Table 3. Results of sample analysis (excluding blue green algae)

Sample description	Sample Date	Chloride	Total Kjeldahl nitrogen as N	Total Coliforms (MPN)	E. coli MPN orgs/100ml	Temp.	Thermotolerant coliforms MPN	Total N by calculation	Nitrate + nitrite, as N	Phosphorus total, as P
Units		*mg/L*	*mg/L*	*orgs/100mL*	*orgs/100mL*	*° Celsius*	*orgs/100mL*	*mg/L*	*mg N/L*	*mg/L*
GT1	24/04/2025	48.3	3.66	>24,196	20	15.8	60	3.66	<0.0100	0.4
GT2	24/04/2025	42.1	7.5	5,794	613	20	500	7.52	0.018	0.5
GT3	24/04/2025	22.7	11.8	12,997	3,448	19.7	3,130	11.9	0.017	1.9
GT4	24/04/2025	33.9	14.4	>24,196	1,314	18.6	2,100	14.33	0.023	1.4
GT5	24/04/2025	29.7	2.86	>24,196	41	11.8	20	2.85	<0.0100	0.2
Drain	24/04/2025	17.3	2.96	6,488	52	15	30	2.95	<0.0100	0.7
Ch1	24/04/2025	3.03	<0.400	1,119	52	15.5	10	<0.30	<0.0100	0.02
Ch2	24/04/2025	2.84	<0.400	2,247	10	19.6	50	<0.30	<0.0100	<0.005
Mulwala	24/04/2025	2.86	<0.400	2,282	20	20.4	<10	<0.30	<0.0100	<0.005

Source: Waterview Laboratory (2025).

Table 4. Groundtank 1 – blue green algae

COMMENTS: + A moderately diverse algal community was observed. Presence of Microcystis is noteworthy, current levels are unlikely to impair water quality. Please note, excessive levels of debris may have obscured smaller algal cells.

TAXA	Toxigenic (T) or Potentially toxic (P) **	* Relative Abundance	Total Cell Count (cells/mL)	Individual Algal Unit Volume (um3)	Total BGA Biovolume (mm3/L)
BACILLARIOPHYCEAE					
Pennales		F			
CHLOROPHYCEAE					
Ankyra		F			
Botryococcus		R			
Elakatothrix		O			
Monoraphidium		C			
Oocystis		O			
Schroederia		O			
Tetrastrum		R			
CRYPTOPHYCEAE					
Cryptomonads		O-F			
EUGLENOPHYCEAE					
Trachelomonas		O			
CYANOPHYCEAE					
Limnothrix/Geitlerinema/Anagnostidinema	P		796	17.5	0.01393
Microcystis	P		254	74	0.01880
Pseudanabaena			42	12.5	0.00053

	Total Cells	Total Biovolume
TOTAL BGA	**1092**	**0.03325**
TOTAL TOXIGENIC BGA	**0**	**0.00000**
TOTAL POTENTIALLY TOXIC BGA	**1050**	**0.03273**

Table 5. Groundtank 2 – blue green algae

COMMENTS: + A highly diverse algal community dominated by greens was observed. Current levels are likely to impair water quality eg. Odours/discolouration

TAXA	Toxigenic (T) or Potentially toxic (P) **	* Relative Abundance	Total Cell Count (cells/mL)	Individual Algal Unit Volume (um3)	Total BGA Biovolume (mm3/L)
BACILLARIOPHYCEAE					
Centrales		F			
Pennales		F			
CHLOROPHYCEAE					
Actinastrum		R			
Botryococcus		F			
Chlamydomonads		F-C			
Chlorococcoids		A			
Closterium		O			
Crucigenia		F			
Dictyosphaerium		A			
Didymocystis		C-A			
Kirchneriella		O			
Monoraphidium		C			
Oocystis		O			
Pediastrum		R			
Scenedesmus		C			
Tetraedron		O			
CRYPTOPHYCEAE					
Cryptomonads		F			
EUGLENOPHYCEAE					
Euglena		O-F			
Phacus		O			
Trachelomonas		F			
OTHER PHYTOPLANKTON					

COMMENTS: + A highly diverse algal community dominated by greens was observed. Current levels are likely to impair water quality eg. Odours/discolouration

TAXA	Toxigenic (T) or Potentially toxic (P) **	* Relative Abundance	Total Cell Count (cells/mL)	Individual Algal Unit Volume (um3)	Total BGA Biovolume (mm3/L)
Other flagellates		F			
CYANOPHYCEAE					
Limnothrix/Geitlerinema/Anagnostidinema	P		1900	17.5	0.03325
Microcystis	P		424	74	0.03138
Planktolyngbya			54000	3.8	0.20520
Planktothrix (small cells)			14	56	0.00078
Pseudanabaena			1250	12.5	0.01563
Synechococcales small (iauv <20)			910000	5.25	4.77750

	Total Cells	Total Biovolume
TOTAL BGA	967588	5.06374
TOTAL TOXIGENIC BGA	0	0.00000
TOTAL POTENTIALLY TOXIC BGA	2324	0.06463

Table 6. Groundtank 3 – blue green algae

COMMENTS: + Limited algal diversity was observed. Excessive levels of debris was noted, which may have obscured smaller algal cells.

TAXA	Toxigenic (T) or Potentially toxic (P) **	* Relative Abundance	Total Cell Count (cells/mL)	Individual Algal Unit Volume (um3)	Total BGA Biovolume (mm3/L)
BACILLARIOPHYCEAE					
Pennales		O			
CHLOROPHYCEAE					
Monoraphidium		F			
Oocystis		O			
Scenedesmus		O			
CRYPTOPHYCEAE					
Cryptomonads		F			
EUGLENOPHYCEAE					
Euglena		O			
Phacus		R			
Trachelomonas		F			
CYANOPHYCEAE					
Limnothrix/Geitlerinema/Anagnostidinema	P		86	17.5	0.00151

	Total Cells	Total Biovolume
TOTAL BGA	86	0.00151
TOTAL TOXIGENIC BGA	0	0.00000
TOTAL POTENTIALLY TOXIC BGA	86	0.00151

Table 7. Groundtank 4 – blue green algae

COMMENTS: + A highly diverse algal community was observed. High levels of low biovolume BGA were noted, combined algal levels are likely to impair water quality eg. Odours/discolouration.

TAXA	Toxigenic (T) or Potentially toxic (P) **	* Relative Abundance	Total Cell Count (cells/mL)	Individual Algal Unit Volume (um3)	Total BGA Biovolume (mm3/L)
BACILLARIOPHYCEAE					
Centrales		O-F			
Pennales		F			
CHLOROPHYCEAE					
Actinastrum		O			
Botryococcus		O			
Chlamydomonads		C-A			
Chlorococcoids		A			
Chlorogonium		F			
Closterium		O-F			
Crucigeniella		F-C			
Dictyosphaerium		A			
Didymocystis		F			
Elakatothrix		O			
Monoraphidium		C			
Oocystis		O			
Pediastrum		O			
Scenedesmus		C			
Tetraedron		O-F			
CRYPTOPHYCEAE					
Cryptomonads		F			
EUGLENOPHYCEAE					
Euglena		F-C			
Phacus		O-F			
CYANOPHYCEAE					

COMMENTS: + A highly diverse algal community was observed. High levels of low biovolume BGA were noted, combined algal levels are likely to impair water quality eg. Odours/discolouration.

TAXA	Toxigenic (T) or Potentially toxic (P) **	* Relative Abundance	Total Cell Count (cells/mL)	Individual Algal Unit Volume (um3)	Total BGA Biovolume (mm3/L)
Microcystis	P		408	74	0.03019
Planktolyngbya			526000	3.8	1.99880
Pseudanabaena			59750	12.5	0.74688
Synechococcales small (iauv <20)			1960000	5.25	10.29000

	Total Cells	Total Biovolume
TOTAL BGA	**2546158**	**13.06587**
TOTAL TOXIGENIC BGA	**0**	**0.00000**
TOTAL POTENTIALLY TOXIC BGA	**408**	**0.03019**

Table 8. Groundtank 5 – blue green algae

COMMENTS: + A highly diverse algal community was observed. High levels of low biovolume BGA were present, current combined algal levels are likely to impair water quality eg. Odours/discolouration

TAXA	Toxigenic (T) or Potentially toxic (P) **	* Relative Abundance	Total Cell Count (cells/mL)	Individual Algal Unit Volume (um3)	Total BGA Biovolume (mm3/L)
BACILLARIOPHYCEAE					
Centrales		F			
Pennales		O			
CHLOROPHYCEAE					
Ankyra		F			
Botryococcus		C			
Chlamydomonads		O			
Chlorococcoids		F			
Chlorolobion		O-F			
Crucigenia		F-C			
Crucigeniella		F			
Dictyosphaerium		F			
Didymocystis		F			
Elakatothrix		O			
Monoraphidium		C			
Pediastrum		R			
Tetraedron		O			
Tetrastrum		O			
CRYPTOPHYCEAE					
Cryptomonads		C			
EUGLENOPHYCEAE					
Euglena		R-O			
Trachelomonas		R			
CYANOPHYCEAE					
Aphanizomenonaceae family - straight	P		< 50	67	< 0.00335

COMMENTS: + A highly diverse algal community was observed. High levels of low biovolume BGA were present, current combined algal levels are likely to impair water quality eg. Odours/discolouration

TAXA	Toxigenic (T) or Potentially toxic (P) **	* Relative Abundance	Total Cell Count (cells/mL)	Individual Algal Unit Volume (um3)	Total BGA Biovolume (mm3/L)
Planktolyngbya			328000	3.8	1.24640
Pseudanabaena			6600	12.5	0.08250
Synechococcales small (iauv <20)			844000	5.25	4.43100

	Total Cells	Total Biovolume
TOTAL BGA	< 1178650	< 5.76325
TOTAL TOXIGENIC BGA	0	0.00000
TOTAL POTENTIALLY TOXIC BGA	< 50	< 0.00335

Table 9. Drain – blue green algae

COMMENTS: + A highly diverse algal community dominated by greens was observed. Current levels are likely to impair water quality eg. Discolouration/odours

TAXA	Toxigenic (T) or Potentially toxic (P) **	* Relative Abundance	Total Cell Count (cells/mL)	Individual Algal Unit Volume (um3)	Total BGA Biovolume (mm3/L)
BACILLARIOPHYCEAE					
Centrales		F			
Pennales		O			
CHLOROPHYCEAE					
Ankyra		O			
Chlamydomonads		O			
Chlorococcoids		C-A			
Closterium		R			
Coelastrum		R			
Crucigeniella		O			
Dictyosphaerium		F			
Didymocystis		F			
Monoraphidium		F-C			
Oocystis		F			
Scenedesmus		R-O			
Sphaerocystis		R			
Tetraedron		R			
Tetrastrum		R			
CRYPTOPHYCEAE					
Cryptomonads		O-F			
EUGLENOPHYCEAE					
Euglena		R			
Phacus		R			
Trachelomonas		O			
OTHER PHYTOPLANKTON					

COMMENTS: + A highly diverse algal community dominated by greens was observed. Current levels are likely to impair water quality eg. Discolouration/odours

TAXA	Toxigenic (T) or Potentially toxic (P) **	* Relative Abundance	Total Cell Count (cells/mL)	Individual Algal Unit Volume (um3)	Total BGA Biovolume (mm3/L)
Other flagellates		F			
CYANOPHYCEAE					
Limnothrix/Geitlerinema/Anagnostidinema	P		76	17.5	0.00133
Pseudanabaena			2350	12.5	0.02938
Synechococcales small (iauv <20)			7700	5.25	0.04043

	Total Cells	Total Biovolume
TOTAL BGA	10126	0.07113
TOTAL TOXIGENIC BGA	0	0.00000
TOTAL POTENTIALLY TOXIC BGA	76	0.00133

Table 10. Blighty channel (upstream) – blue green algae

COMMENTS: + A highly diverse algal community was observed. Presence of potentially toxic BGA is noteworthy, current algal levels may impair water quality.

TAXA	Toxigenic (T) or Potentially toxic (P) **	* Relative Abundance	Total Cell Count (cells/mL)	Individual Algal Unit Volume (um3)	Total BGA Biovolume (mm3/L)
BACILLARIOPHYCEAE					
Aulacoseira		O-F			
Centrales		O			
Pennales		O-F			
Urosolenia		R			
CHLOROPHYCEAE					
Actinastrum		O			
Ankistrodesmus		R			
Chlamydomonads		O			
Chlorococcoids		C			
Chlorolobion		O			
Dictyosphaerium		O-F			
Filamentous Green		O			
Golenkinia		O			
Micractinium		O			
Monoraphidium		F			
Planktosphaeria		R			
Staurastrum		R			
Tetrastrum		R			
CHRYSOPHYCEAE					
Dinobryon		R			
CRYPTOPHYCEAE					
Cryptomonads		O			
EUGLENOPHYCEAE					
Euglena		R			

COMMENTS: + A highly diverse algal community was observed. Presence of potentially toxic BGA is noteworthy, current algal levels may impair water quality.

TAXA	Toxigenic (T) or Potentially toxic (P) **	* Relative Abundance	Total Cell Count (cells/mL)	Individual Algal Unit Volume (um3)	Total BGA Biovolume (mm3/L)
OTHER PHYTOPLANKTON					
Other flagellates		F			
CYANOPHYCEAE					
Aphanizomenonaceae family - straight	P		1342	67	0.08991
Cuspidothrix issatschenkoi			26	57	0.00148
Dolichospermum - straight (≥8µm)			118	433	0.05109
Limnothrix/Geitlerinema/Anagnostidinema	P		64	17.5	0.00112
Planktolyngbya			22700	3.8	0.08626
Pseudanabaena			52	12.5	0.00065
Synechococcales small (iauv <20)			25100	5.25	0.13178

	Total Cells	Total Biovolume
TOTAL BGA	**49402**	**0.36230**
TOTAL TOXIGENIC BGA	**0**	**0.00000**
TOTAL POTENTIALLY TOXIC BGA	**1406**	**0.09103**

Table 11. Blighty channel (offtake) – blue green algae

COMMENTS: + A highly diverse algal community was observed. Presence of potentially toxic BGA is noteworthy, current levels of Aulacoseira may mildly impair water quality eg. Filter blockages

TAXA	Toxigenic (T) or Potentially toxic (P) **	* Relative Abundance	Total Cell Count (cells/mL)	Individual Algal Unit Volume (um3)	Total BGA Biovolume (mm3/L)
BACILLARIOPHYCEAE					
Aulacoseira		F			
Centrales		F			
Pennales		O			
Urosolenia		R			
CHLOROPHYCEAE					
Actinastrum		R			
Chlorococcoids		F			
Crucigeniella		R			
Dictyosphaerium		O			
Euastrum		R			
Golenkinia		R-O			
Kirchneriella		R			
Oocystis		O			
Pachycladella		R			
Pediastrum		R			
Scenedesmus		R			
Staurastrum		R			
CHRYSOPHYCEAE					
Dinobryon		O			
CRYPTOPHYCEAE					
Cryptomonads		O			
OTHER PHYTOPLANKTON					
Other flagellates		O-F			
CYANOPHYCEAE					

COMMENTS: + A highly diverse algal community was observed. Presence of potentially toxic BGA is noteworthy, current levels of Aulacoseira may mildly impair water quality eg. Filter blockages

TAXA	Toxigenic (T) or Potentially toxic (P) **	* Relative Abundance	Total Cell Count (cells/mL)	Individual Algal Unit Volume (um3)	Total BGA Biovolume (mm3/L)
Aphanizomenonaceae family - straight	P		242	67	0.01621
Cuspidothrix issatschenkoi			20	57	0.00114
Dolichospermum - coiled (≥6µm)	P		< 50	280	< 0.01400
Dolichospermum - straight (≥8µm)			168	433	0.07274
Microcystis	P		122	74	0.00903
Synechococcales small (iauv <20)			24500	5.25	0.12863

	Total Cells	Total Biovolume
TOTAL BGA	< 25102	< 0.24175
TOTAL TOXIGENIC BGA	0	0.00000
TOTAL POTENTIALLY TOXIC BGA	< 414	< 0.03924

Table 12. Lake Mulwala (Mulwala Canal offtake) – blue green algae

COMMENTS: + A highly diverse algal community was observed. Current algal levels may mildly impair water quality eg. Filter blockages

TAXA	Toxigenic (T) or Potentially toxic (P) **	* Relative Abundance	Total Cell Count (cells/mL)	Individual Algal Unit Volume (um3)	Total BGA Biovolume (mm3/L)
BACILLARIOPHYCEAE					
Acanthoceras		R			
Aulacoseira		F			
Centrales		O			
Pennales		R			
Urosolenia		R-O			
CHLOROPHYCEAE					
Actinastrum		R			
Botryococcus		R			
Chlorococcoids		O			
Dictyosphaerium		O			
Elakatothrix		O			
Euastrum		R			
Filamentous Green		R			
Golenkinia		R			
Micractinium		O			
Monoraphidium		F			
Nephrocytium		R			
Oocystis		O			
Pachycladella		R			
Pediastrum		R			
Scenedesmus		R			
Sphaerocystis		R			
Staurastrum		R			
CHRYSOPHYCEAE					

Table 12. con't.

COMMENTS: + A highly diverse algal community was observed. Current algal levels may mildly impair water quality eg. Filter blockages

TAXA	Toxigenic (T) or Potentially toxic (P) **	* Relative Abundance	Total Cell Count (cells/mL)	Individual Algal Unit Volume (um3)	Total BGA Biovolume (mm3/L)
Dinobryon		R			
Mallomonas		R			
CRYPTOPHYCEAE					
Cryptomonads		O			
DINOPHYCEAE					
Ceratium		R			
Gymnodiniales		R			
EUGLENOPHYCEAE					
Euglena		R			
Trachelomonas		R			
OTHER PHYTOPLANKTON					
Other flagellates		O-F			
CYANOPHYCEAE					
Aphanizomenonaceae family - straight	P		86	67	0.00576
Dolichospermum - straight (≥8µm)			< 50	433	< 0.02165
Oscillatoriales (iauv 1-100)	P		< 50	60.8	< 0.00304
Synechococcales small (iauv <20)			24450	5.25	0.12836

	Total Cells	Total Biovolume
TOTAL BGA	< 24636	< 0.15881
TOTAL TOXIGENIC BGA	0	0.00000
TOTAL POTENTIALLY TOXIC BGA	< 136	< 0.00880

Notes: In relation to Tables 4-12, the following must be considered when interpreting the results:

* Relative Abundance: (Indicative values only)
A = Abundant > 50,000 cells/mL, C = Common 5,000-50,000 cells/mL, F=Frequent 500-5,000 cells/mL,
O = Occasional 50-500 cells/mL, R = Rare 1-50 cells/mL

+ The comments are discretionary and are for the purpose of helping to understand WQ implications.The comments are not accredited by NATA.

The biovolume values reported are those derived from documented information, including scientific literature. These are average values and not those measured on individual samples.

A Certificate of analysis will follow, linked by the above batch number. Independent algal reports are forwarded to clients expeditiously to facilitate operational decision making.

*** P's and T's denote those cyanobacteria/blue-green algae (BGA) associated with toxin production in Australian waters. Overseas studies have shown other cyanobacteria to produce toxins. All contain lipopolysaccharides (LPS) in their cell wall and many have been found to produce β-N-methylamino-L-alanine (BMAA) and its analogues. Therefore all cyanobacteria could be considered to pose a level of risk.*

In addition to the specific sampling conducted as part of this project, routine sampling and analysis is conducted on behalf of the Murray Regional Algal Coordination Committee (Murray RACC). Sampling is conducted at a number of sites along the Murray River.

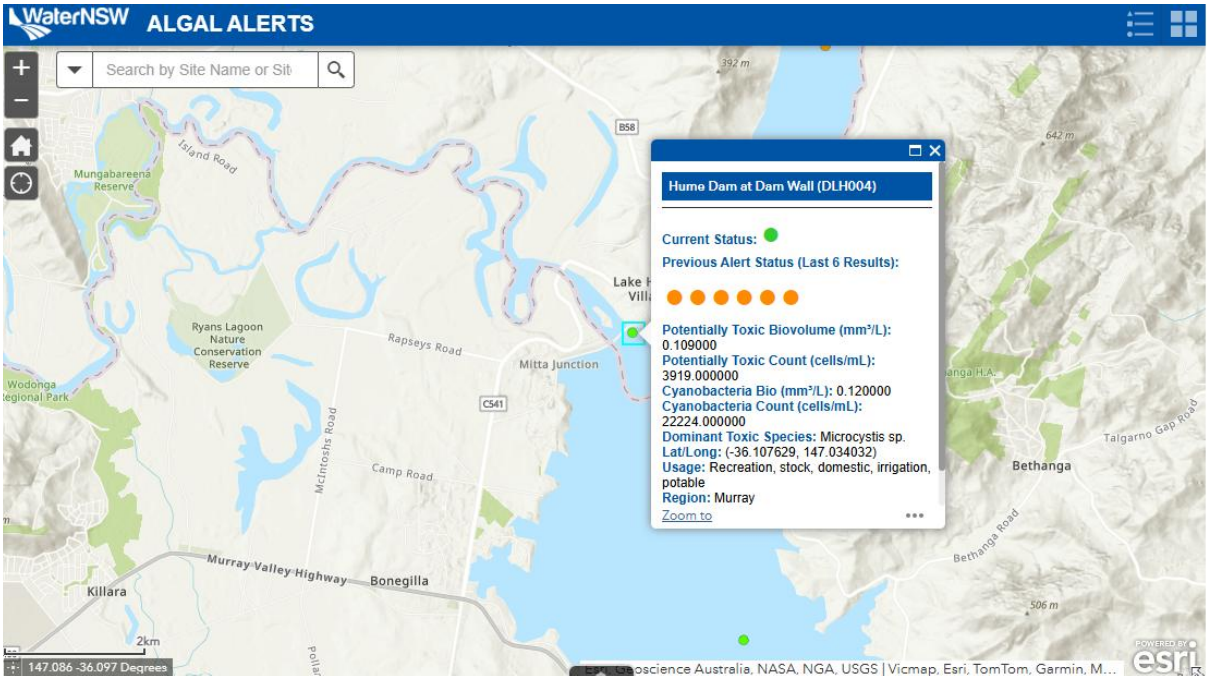
Results of sampling conducted around the date of the samples taken specifically for this project are outlined in Table 13 and Figure 8.

Table 13. Results of blue green algae sampling conducted by WaterNSW

Site	Description	Latest Sample Date	Cyanobacteria Total Count (cells/mL)	Cyanobacteria Biovolume (mm3/L)	Potentially Toxic Cyanobacterial Count (cells/mL)	Potentially Toxic Cyanobacterial Biovolume (mm3/L)	Current Status (based on Latest Sample)	Previous Status	Cyanobacteria dominant potentially toxic taxa	Cyanobacteria Comments
MURRAY RIVER SYSTEM										
	Manus Lake (SVC) Lake pontoon	26/01/2025	30,000	1.156	27500	1.153	AMBER	GREEN		
DLH003	Lake Hume, Ebden	3/02/2025	74,501	0.326	10,122	0.292	AMBER	AMBER	*Microcystis sp.*	Potentially toxic, taste & odour
DLH001	Lake Hume, Heywoods Bay nr Bethanga	3/02/2025	58,053	0.168	4,895	0.141	GREEN	No Alert	*Radiocystis sp.*	Potentially toxic
DLH002	Lake Hume, Hume Dam Resort	3/02/2025	206,164	0.404	10,279	0.307	AMBER	GREEN	*Microcystis sp.*	Potentially toxic, taste & odour
DLH004	Lake Hume, Dam Wall	3/02/2025	31,941	0.222	5,913	0.165	GREEN	No Alert	*Microcystis sp.*	Potentially toxic, taste & odour
N1000	Murray R. Union Bridge Albury	9/01/2025	4,831	0.011	340	0.008	No Alert	GREEN	*Microcystis sp.*	Potentially toxic, taste & odour
N1001	Murray R. Corowa	9/01/2025	40,814	0.041	0	0.000	GREEN	GREEN		
	Yarrawonga Weir (outlet) GMW	4/02/2025	30,500	0.475	0	0.000	AMBER	GREEN		
N1008	Mulwala Canal Offtake	9/01/2025	34,057	1.098	5,695	0.170	AMBER	GREEN	*Radiocystis sp.*	Potentially toxic
N1007	Murray R. @ below Yarrawonga	9/01/2025	31,506	0.193	544	0.013	GREEN	GREEN	*Microcystis sp.*	Potentially toxic, taste & odour

Source: www.waternsw.com.au/algae (modified)

Figure 8. Biovolume analysis of sampling conducted at the Hume Dam in April, 2025.



Source: www.waternsw.com.au/water-services/water-quality/algae-alerts

Discussion

Livestock production in Australia relies on surface water, groundwater and reclaimed water supplies. All water for livestock must be fit-for-purpose and adhere to the relevant regulatory and technical requirements. The Livestock drinking water guidelines provide recommended values for biological, chemical and radiological substances that may occur in livestock drinking water The guideline values are based on the current evidence and literature, with preference given to data from Australia and New Zealand.

If levels of the substance in drinking water are below these values, there should be little risk of harmful effects on animal health. Indeed, many of the ions and metals in drinking water are essential for animal health, but can be toxic at higher levels. The values may not be appropriate for all stock types, ages and feeding systems. For example, young livestock or non-ruminant species may be more sensitive to some substances.

In addition, higher concentrations may sometimes be tolerated. If values are exceeded, potential management actions include water treatment, changes to water sources, changes to livestock diet, or veterinary treatment. The action to be taken will depend on the risk level, which will in turn depend on the type of substance and the livestock species and age.

Regular assessment of water quality and livestock health are important to ensure producers continue to provide the water quality that is essential for successful livestock production.

In relation to the analysis of specific parameters conducted as part of this investigation, the following is applicable:

Substance		Guideline value	Notes
Biological parameters	Cyanobacteria	Toxin-producing cyanobacteria <0.4 mm^3/L, (equivalent to 5,000 cells/mL of *Microcystis aeruginosa*, or 1 µg/L of total microcystins-LR)	Algal blooms should be treated as toxic; remove livestock from the water source until the algae are identified and toxicity is determined
	Pathogens and parasites	<100 cfu/100 mL (median value) of *E. coli*	*E. coli* is a critical indicator to manage pathogenic infection risk
Main ions of concern	Calcium	<1,000 mg/L	If dietary phosphorus levels are adequate
	Magnesium	<500 mg/L (ruminants in general) <250 mg/L (lactating cows and ewes with lambs) <125 mg/L (poultry)	
	Nitrate and nitrite	<100 mg/L nitrate and <10 mg/L nitrite (livestock in general) <25 mg/L (poultry) <400 mg/L (cattle)	Levels of nitrate tolerance are lowest in poultry, medium in pigs and highest in cattle
	Sulfate	<500 mg/L (livestock in general) <250 mg/L (poultry)	Pigs may tolerate higher levels
	Total dissolved solids (salinity)	<500 mg/L	

Source: ANZEEC, 2023.

Based on the information above, Table 14 provides a summary of the results, and provides an interpretation of the results when compared to the draft Livestock drinking water quality guidelines.

Table 13. Summary interpretation of results

Parameter	Units	Site									Draft (2023)
		GT1	GT2	GT3	GT4	GT5	Drain	Ch1	Ch2	Mulwala	ANZECC
Cl	mg/L	48	42	23	34	30	17	3	3	3	< 1,000
Total N	mg/L	4	8	12	14	3	3	<0.4	<0.4	<0.4	
Nitrate + Nitrite	mg/L	<0.01	0.02	0.02	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	< 10
Total P	mg/L	0.4	0.5	1.9	1.4	0.2	0.7	0.02	<0.005	<0.005	
Total coliforms	orgs/100ml	>24,200	5,800	13,000	>24,200	>24,200	6,500	1,100	2,200	2,300	
E. coli	orgs/100ml	20	600	3,400	1,300	40	50	50	10	20	< 100
Thermotolerant coliforn	orgs/100ml	60	500	3,100	2,100	20	30	10	50	<10	
Total BGA	cells/ml	1,100	968,000	90	2,546,200	<1,178,600	10,100	49,400	<25,000	<24,500	< 5,000
Potentially toxic BGA	cells/ml	1,100	2,300	90	400	<50	76	1,400	400	140	

Where:

Cells highlighted in green suggest results are below thresholds and not likely to impact animal health/performance
Cells highlighted in yellow suggest results are marginal, and may have impacts on animal health/performance
Cells highlighted in red suggest results exceed current guidelines, and high likelihood of impacting animal health/performance

In general terms, the following observations can be made:

1. Nitrate, nitrite, chloride and phosphorus levels are all below or within acceptable limits
2. E. coli levels exceed threshold levels in several of the groundtank samples
3. Faecal coliform levels exceed thresholds in all groundtanks, except GT5 which was utilised by sheep
4. Total blue green algae levels exceed thresholds at all sites, including the irrigation supply channels and Lake Mulwala
5. Several of the sites exceed threshold levels for potentially toxic blue green algae

Generally speaking there is good knowledge of the impacts of the specific chemical parameters/ions considered as part of this investigation.

However, there is much less known on the impacts on livestock health and performance of the biological parameters considered here. As such, further detail on blue green algae and faecal coliforms are provided for some context.

What are blue-green algae?

Blue-green algae is the commonly used term for several types of photosynthetic bacteria (Cyanobacteria) that sometimes impart a blue-green tinge to water or form blue-green scums on the surface when present in large numbers. They are extremely small organisms visible under a high powered microscope as single cells, or clumps of cells. They need sunlight to grow.

What is a blue-green algal bloom?

"Bloom" is commonly used to describe a rapid increase in algal numbers to a point where they discolour water, form scums produce odours and reduce water quality for human and livestock use.

Often, blue-green algal blooms occur because conditions suitable for their growth are created by human activities (towns, farming, industry) in the catchment of a farm dam, river or large public dam. These conditions include increased levels of phosphorus and nitrogen in the water, calm water behind weirs, in farm dams or in slow-flowing rivers, lack of fresh water inflows to rivers or dams, murkiness, removal of other vegetation that might compete for light and nutrients, chemicals toxic to organisms that eat algae, strong sunlight and high air and water temperatures.

Some blue-green algae have tiny gas bubbles in their cells allowing them to float to the surface for sunlight or sink to the bottom to feed. This explains why a bloom of blue-green algae can appear, disappear and reappear quickly even during a single day. Wind stirring also plays an important part in this process.

Dangers of blue-green algae

Aside from the aesthetic problem caused by their appearance, and their taints and odours, the worst feature of blue-green algae is their ability to produce poisons including neurotoxins and liver toxins.

The recorded effects of these toxins on humans and animals coming into contact with the water include allergic reactions and skin eye irritations. Gastroenteritis and liver damage may result if the water is taken into the body.

Each year in Australia, livestock deaths are reported due to the toxic effects of blue-green algae. Human deaths and illness have not been verified in Australia (although deaths have been reported in other countries), but evidence strongly suggests that the toxins are a hazard to human health.

Not all blue-green algal blooms are toxic, and toxicity may occur for only part of the time or in only part of the bloom. Blue-green algal blooms often persist for several weeks, sometimes months, depending mainly on the weather or water flow. Cooler, windy, cloudy weather or increased flows usually reduce or stop a bloom fairly quickly.

In addition, wastewater can contain toxic cyanobacteria and there has been increasing concern around the world over the potential for bioaccumulation or surface contamination in plants and subsequent consumption when it is used for irrigation of food crops and pasture (Manning and Nobles, 2017; Xiang et al., 2020; Pindihama 2020).

Access to water has been identified as one of the most limiting factors to economic growth in the Worlds food crop production. Water reclaimed from wastewater (sewage) is being increasingly recognised as an important resource, and the agricultural sector is currently the largest consumer of this resource. The key to its ongoing use is to ensure that this resource is used in a sustainable manner without impacting adversely on human health or the environment.

Cyanobacterial blooms and their toxins are a common occurrence in wastewater storages that are being used to supply irrigation water for food crops. The forecasted increase in the occurrence and intensity of cyanobacteria blooms due to climate change and the projected increased use of this resource for agricultural purposes supports the need to investigate and understand toxin uptake by crops. This knowledge will be critical to develop and regulate this asset into the future.

The National Performance 2019/20: urban utilities reports that total recycled water supply across the major urban centres of Australia increased by 2 per cent from 2018–19 following an increase of 10 per cent from 2017–18 to 2018–19 with the majority of this water used for irrigation purposes.

To ensure the sustainability of this resource it is important to understand issues that could impact its use. Cyanobacterial toxin contamination from wastewater can occur on the external surfaces of the irrigated plants. Washing the product prior to consumption may reduce the risk of exposure to the consumer but this needs to be confirmed and understood before policy and guidelines can be developed.

Furthermore, over the last 10 years, cyanobacterial toxin uptake and internalisation by plants irrigated with wastewater containing cyanobacterial toxins has emerged as a health concern. **(**Pindihama and Gitari 2020, Zang et al. 2021)

Scientific research has shown that if cyanobacterial toxins are applied to growth media (soil, hydroponics) that food crops may bioconcentrate these compounds at levels that could pose a health risk to consumers. Furthermore, toxins may concentrate on the surface of food crops and provide another exposure route. Limited work has been conducted in Australia to assess the potential risks.

This highlights a significant risk for the Australian agriculture industry and the water authorities providing the product. A better understanding of the risk is needed so that policies and guidelines can be developed to guarantee the health of consumers and ensure that the use of recycled water into the future is safe and sustainable.

There is potential for toxin to either be present on the surface of the crop or internally taken up by roots. For example, toxins can be concentrated on the leaves of lettuces if they have been watered by spray irrigation or on the surface of root vegetables due to contact with soil irrigated with wastewater. Therefore, washing vegetables prior to consumption may have a major impact on the levels consumed and could be relevant to guideline development.

The fate of cyanobacterial toxins in soils will have a direct impact on how much will be potentially available for uptake by crops. Therefore, soil samples from wastewater irrigated areas will be included in the sampling program.

Faecal Coliforms

Faecal coliforms are bacteria found in the digestive tracts of warm-blooded animals, including humans, and their waste. Detecting these bacteria in water indicates faecal contamination. Monitoring faecal coliform levels assesses water quality and identifies potential public health risks.

Understanding Faecal Coliform

Faecal coliform bacteria are a subgroup within the larger coliform group. While many coliforms exist naturally in soil and vegetation, faecal coliforms specifically originate from the intestines of warm-blooded animals. Most types are not directly harmful to humans; instead, their importance lies in their role as indicators. If faecal coliforms are present, it suggests that other disease-causing microorganisms (bacteria, viruses, or parasites) shed in feces might also be present.

A well-known example is Escherichia coli (E. coli). While many strains of E. coli are harmless, certain types can cause severe illness. E. coli is often monitored more closely because its presence strongly indicates recent faecal contamination.

Sources of Faecal Coliform

Faecal coliforms enter the environment primarily through human and animal waste. Significant sources include human waste from failing sewage systems, leaking sewer pipes, or inadequate wastewater treatment plant discharges. Septic tank failures can also release contaminated water into groundwater and surface water bodies.

Animal waste contributes substantially to environmental faecal coliform levels. Runoff from agricultural lands, containing livestock manure, can carry these bacteria into streams and rivers. Urban areas also contribute through unmanaged pet waste, which rain can wash into storm drains and local waterways. Wild animals can also deposit faecal matter directly into natural water sources, especially during heavy rainfall.

Health and Environmental Implications

Elevated faecal coliform levels indicate potential waterborne pathogens that can cause health problems. Contact with or consumption of contaminated water can lead to gastrointestinal illnesses, including nausea, vomiting, diarrhea, and abdominal cramps. Other possible health effects include skin rashes, eye infections, and respiratory issues. Individuals with compromised immune systems, young children, and the elderly are particularly susceptible.

High faecal coliform levels also affect aquatic ecosystems. Increased bacterial loads deplete oxygen as bacteria decompose organic matter, harming aquatic organisms. Contaminated water can impact recreational activities, making swimming, fishing, and boating unsafe. Public health advisories or beach closures may be issued to prevent exposure and limit access to natural resources.

Animal manure is an important and valuable fertiliser source. However, animal manure may also be a potential source of pathogens (harmful viruses, bacteria and protozoa). Coliforms are one type of bacteria found in all animal faeces. When found in waterbodies, coliforms indicate that the water has been contaminated by faecal material.

Applying the most appropriate beneficial manure and grazing management practices is critically important for reducing environmental and water quality impacts and ensuring agricultural sustainability. Some of the consequences of water contamination by coliforms include increased water treatment costs, loss of use of recreational waters, constraints on the expansion of the livestock industry, and potentially food safety and human health effects.

It is important to understand which agricultural lands and waters are at risk of contamination by coliforms, and to understand what land-use practices can reduce or mitigate contamination.

What determines the risk of water contamination by coliforms?

The risk of water contamination by coliforms is determined by the estimating the amount of coliforms present in soil and the likelihood that they will move into surface waters.

Bacteria make up a large part of all types of manure. The species of bacteria vary by the type of livestock (for example, poultry, pigs and cattle), manure storage and treatment, and herd health. Coliforms are found in all animal faeces. They are most abundant where there is high livestock manure production. Since 1981, livestock production has become more concentrated: livestock numbers have generally increased while the number of farms has decreased to one third.

The risk of coliforms moving into waterways is highest where manure use coincides with dense water drainage networks, high surface runoff, preferential flow and soil erosion. Risk is also increased where shallow groundwater or shallow soils occur over fractured bedrock.

When spreading manure as fertiliser on cropland, weather conditions impact the risk of water contamination by coliforms. Colder weather increases coliform mortality and thus reduces coliform numbers in the soil. The risk of movement to waterbodies (and therefore risk of coliform contamination) strongly depends on how intense rainfall is during and following spreading manure.

Coliform abundance on grazing land varies throughout the year based on when livestock are on pasture.

The risk of water contamination by coliforms is determined by estimating both the potential numbers of coliforms on agricultural land (coliform source) and the likelihood of their movement to surface waters (transport).

Coliform sources consider manure from four livestock types: cattle, pigs, poultry and other livestock. Coliform populations are determined for pastured and confined animals by estimating the amount of manure produced, the amount of coliform growth and the amount of coliform decay.

Coliforms from pastured-animal manure are considered to be available for transport on the same day they are produced. Coliforms from confined-animal manure are assumed to be available when spread onto fields based on the first and last day of soil freezing and on typical seeding and harvest dates.

Coliforms tend to be filtered out by soil so transport of coliforms to waterways is assumed to occur by surface flow or rapid tile drainage. The potential for coliforms to be transported to waterways considers topography, soil texture, daily precipitation, soil erosion risk and the density of surface waterbodies on the landscape.

How can the risk of water contamination by coliforms be reduced?

For high-risk areas, the risk of water contamination by coliforms can be reduced using a number of beneficial management practices:

- Reduce the amount of manure per animal by increasing feed quality.
- Minimize the potential for soil water erosion on lands receiving manure.
- Use manure-handling practices that stabilize the waste and reduce pathogen load (for example, composting).
- Consider slope, soil moisture and climate conditions at the time of manure application.
- Establish suitable manure spreading setback distances from water bodies or streams.
- Incorporate manure into soil immediately or shortly after application.
- Discourage pastured animals from accessing streams by using fencing or providing off-site watering.
- Establish buffer strips around waterways.

Areas of further work

The impacts on livestock health and performance are generally well understood for many of the specific chemical ions. Less well known however, are the impacts of many biological parameters – two of which are the subject of this brief report.

Given the large broadacre nature of Australian grazing systems, it seems unreasonable that there is this lack of information about the impacts on livestock health, welfare and performance on many of these biological parameters. As anecdotally the incidence of blue green algae events seemingly become more prevalent, it would be prudent for agency's and producers to identify the risks these biological parameters pose.

In addition, there may be implications on the use of biologically contaminated waters on human health. Potentially, may there be risks to human health if animal products are consumed, where there has been ingestion (at some point) of the animal with some of these biological pollutants?

As such, in the opinion of the author, the following could be considered to further advance our knowledge of the impacts of biological contaminants on components of the food chain.

These include:

1. A detailed review of the literature (both Australian and overseas) on risks to end users from toxins in water used for agricultural/horticulture crops, and their introduction into the human food chain. e.g. fruit and vegetables, cereal crops, pasture. What is currently understood and what further information is required. Specific areas for consideration include:
    - Spray irrigation vs drip irrigation vs flood irrigation
    - Exposure through consumption
    - Experiences of both Australian and overseas wastewater authorities.
    - What guidelines/standards currently exist in Australia or overseas.
2. Review the literature on the risks to livestock from consuming water with cyanbacteria toxins and from feeding on crops irrigated with toxins, including the risk to humans from consuming meat from stock exposed to toxins.
3. Design experiments to investigate the risks. Options could include:
    - Sampling of crops already being irrigated with recycled water to determine toxin uptake.
    - Sampling of soils for toxin at different depths over an irrigation season.
    - Determining whether soils seasonally exposed to toxin are capable of biodegradation
    - Breakdown of toxins following spray or surface irrigation(drip) e.g. in soil or exposed to sunlight
    - Experiments investigating mechanisms of toxin uptake and bioaccumulation.
4. Determine if there is evidence for the establishment of irrigation and watering limits and guidelines for the use of water with cynobacteria blooms.
5. Testing for presence of cyanobacterial toxin in food crops irrigated with recycled wastewater. This will include development of analytical techniques.
6. Conducting further sampling at the farm level to determine current levels of biological contamination, with an aim to identify those practices/classes of livestock which may be contributing to higher levels of biological contamination.
7. Identify ways to practically and realistic treat biologically contaminated waters at the farm level to minimise risk to livestock health and performance.
8. Assessment of cyanobacterial toxins in the irrigation pathway to crop production. Determine the fate of toxins from the point of release from recycled water storage systems, irrigation processes and losses from soil following irrigation.
9. Undertake some case study/benefit cost analysis on implementing systems at the farm level which would reduce the likelihood of contamination, and improve livestock health and performance.

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References

ANZECC and ARMCANZ 2000, Australian and New Zealand Guidelines for Fresh and Marine Water Quality, vol. 1, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, paper no. 4 in the National Water Quality Management Strategy, October 2000.

ANZECC and ARMCANZ 2023, Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Livestock Drinking Water Guidelines (Draft). Australian and New Zealand Governments and Australian state and territory governments, Canberra.

Levizou, E.; Papadimitriou, T.; Papavasileiou, E.; Papadimitriou, N.; Kormas, K.A. Root vegetables bioaccumulate microcystins-LR in a developmental stage-dependent manner under realistic exposure scenario: The case of carrot and radish. Agric. Water Manag. 2020, 240, 106274.

Manning S.R., Nobles D.R. Impact of global warming on water toxicity: cyanotoxins Curr. Opin. Food. Sci., 18 (2017), pp. 14-20 doi:10.1016/j.cofs.2017.09.013

Manubolu, M.; Lee, J.; Riedl, K.M.; Kua, Z.X.; Collart, L.P.; Ludsin, S.A. Optimization of extraction methods for quantification of microcystin-LR and microcystin-RR in fish, vegetable, and soil matrices using UPLC-MS/MS. Harmful Algae 2018, 76, 47–57.

Murray Local Land Services, 2024. Future Drought Fund – On-farm Water Management Waterways, Dam, and Trough water quality sampling protocols. Murray Local Land Services.

National performance report 2019–20: urban water utilities, part A, February 2021
Published by the Bureau of Meteorology, GPO Box 1289, Melbourne VIC 3001.

Pindihama, G.K., and Gitari, M.W. (2020). Cyanobacterial toxins: an emerging threat in South African irrigation water. Water Environ. J. 34, 506–516.

Radcliffe, J.C., Page, D., 2020. Water reuse and recycling in Australia- history, current situation and future perspectives. Water Cycle 1, 19–40. https://doi.org/10.1016/j. watcyc.2020.05.005.

Testai, E., Buratti, F. M., Funari, E., Manganelli, M., Vichi, S., Arnich, N., BirÈ, R., Fessard, V., and Sialehaamo, A. (2016). Review and analysis of occurrence, exposure and toxicity of cyanobacteria toxins in food. EFSA supporting publication, EN-998, 309 pp.

Xiang, L.; Li, Y.W.; Wang, Z.R.; Liu, B.L.; Zhao, H.M.; Li, H.; Cai, Q.Y.; Mo, C.H.; Li, Q.X. Bioaccumulation and Phytotoxicity and Human Health Risk from Microcystin-LR under Various Treatments: A Pot Study. Toxins 2020, 12, 523.

Zhang, Y.; Whalen, J.K.; Sauvé, S. Phytotoxicity and bioconcentration of microcystins in agricultural plants: Meta-analysis and risk assessment. Environ. Pollut. 2020, 115966.