Guidelines for the Management of Blooms of Blue-Green Algae in Freshwaters in Tasmania.

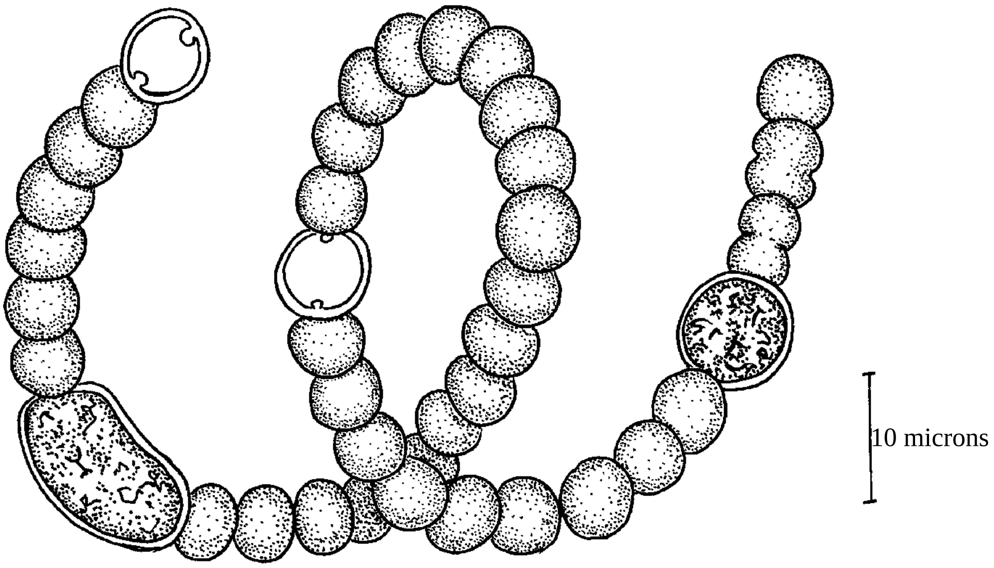

Diagram of *Anabaena*, a genera of blue-green algae which is potentially toxic and has formed significant blooms in Tasmanian waterways.

This document has been developed by the Department of Primary Industries, Water & Environment to assist with decision making during the occurrence of blooms of potentially toxic algae.

Other authorities which have had input to this are;
Department of Health and Human Services
North West Regional Water Authority
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Department of Environment and Land Management
Local Government Association of Tasmania
Hydro Electric Corporation

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Executive Summary

These guidelines aim to provide support to agencies involved in coping with major blue-green algal blooms. The strategy is based on 3 Alert Levels proposed as Australian National standards and establishes standard practices relating to monitoring, bloom management and public communication.

An algal 'bloom' is generally defined as any congregation of algae which are present in sufficient concentrations to produce visual and/or other effects on water quality. Toxic or potentially toxic algal blooms in fresh waters are most commonly caused by two or three genus' of blue-green algae. These are *Microcystis*, *Anabaena*, and in more saline waters by *Nodularia*.

This document covers the impacts on various users of blue-green algal blooms, the broad roles and responsibilities of various interest agencies and proposes an alert level framework based upon research at a national level. The proposed national framework upon which this bloom response strategy is based centres around three categories of algal concentrations. These are briefly presented below;

Algal Response Categories

ALERT LEVEL	Cell Concentrations	Response Actions
Alert Level 1	500 - 2000 cells/mL	– Identify the algal type – Establish early bloom conditions. – Initiate low level monitoring.
Alert Level 2	2000 - 15000 cells/mL	– Progression of bloom into potentially hazardous category. – Comprehensive monitoring. – Media releases, public notices. – Storage operation alterations.
Alert Level 3A (Toxic)	> 15000 cells/mL	– Bloom established as toxic. – Frequent toxicity testing. – Water supply alternatives may be required. – Higher level of public awareness.
Alert Level 3B (Non-toxic)	> 15000 cells/mL	– Bloom established as non-toxic. – Operations aimed at minimising taste and odour problems. – Continued medium level monitoring.

(Alert Level 3 has been divided on the basis of algal toxicity, the response strategy for a toxic bloom being different to that for a non-toxic bloom).

These categories are aimed mainly at establishing standard procedures for water supply storages. In the case of non-water supply water bodies, actions are aimed more towards increased public awareness and risk management (in accordance with ARMCANZ, 1995).

From these are developed contingency plans which will help to guide actions following the detection of a significant and potentially harmful blue-green algal bloom, from monitoring protocols through to the release of public information and the development of longer term management plans.

This document is aimed at water supply and other storage operators who may at some time have to deal with problems associated with algal blooms. As well as increasing their awareness of the hazards of blue-green algae, it should assist them in responding to blooms and bring about better coordination with other interest groups and organisations.

Attached are appendices which include a list of people and agencies which should be contacted upon detection of a bloom, an example of a typical Press Release, standard methods for the sampling and monitoring of blue-green algal blooms and sample preservation and cell counting procedures.

Introduction

The ‘Guidelines for Management of Blue-green Algae in Freshwaters’ has been prepared in response to the occurrence of the first recorded major blue-green algal bloom outbreak in freshwater in Tasmania (Craigbourne Dam,1997) as well as a recent study investigating the potential for blue-green and nuisance algal blooms across a large portion of the State by the Department of Primary Industries and Fisheries (Seamer, 1997).

It is clear that there is a significant potential for algal blooms in Tasmania and that the relevant State Agencies and water management authorities need to have a comprehensive and agreed set of guidelines for detecting early warning signs of algal outbreaks and for managing outbreaks in an effective manner. These guidelines also provide a range of standard protocols for algal sampling, toxicity testing, and pathways of communication.

Algae - What Are They ?

Algae are simple plants that vary considerably in size, shape and colour, and are found in a range of habitats. Algae are a natural part of the surface water ecosystem and are encountered in every water body that is exposed to sunlight. While a few algae are found in soils and in surfaces exposed to air, the great majority are truly aquatic and grow submerged in ponds, lakes, water supply storages, streams, estuaries and oceans. In water storages the phytoplankton, or floating microscopic plants, are of major importance, and are the basic food source of small aquatic animals. Phytoplankton includes the true algae and blue-green algae (cyanobacteria).

Blue-green algae contain within them a characteristic pigment and vary in size from 5 microns diameter (1 micron = 1/1000 mm) to large cell colonies which may be many millimetres across. Blue-green algae are relatively slow growing in comparison with true algae, but may dominate a water body’s biomass (ie bloom) when :

- Nutrient levels, particularly Phosphorus, are high
- There is low turbidity (good sunlight penetration into the water body
- Weather conditions are stable for a long time
- Water is still and turbulence is low

A bloom can reduce the recreational and aesthetic appeal of the water body, trap sediment and litter, produce unpleasant tastes and odours, reduce oxygen and adversely affect fish populations, and form scums which limit light availability for other aquatic vegetation. In addition, some blue-green algae produce toxins and other substances which can cause lethal and sub-lethal effects on aquatic organisms and stock. While no human deaths have been attributed to algal toxicity, they can cause illness in humans. It is not clear what mechanisms trigger algae to produce toxins, but experience has shown that, if conditions are right, a bloom may go from a non-toxic state to a toxic state in a few days. Similarly one part of the bloom may be toxic while another section may not.

For this reason, negative toxicity tests are not reliable guides to toxicity. They only measure the toxicity of a sample taken from a particular location at a particular time. Many scientists claim it is safer to work on the premise that if the presence of a species of blue-green algae which can produce toxins is detected, then it is safest to proceed with management options under the assumption that the bloom is toxic. Algal types which can produce toxins include *Microcystis*, *Anabaena*, *Nodularia*, *Oscillatoria*, *Anabaenopsis* and *Cylindrospermopsis*.

Toxins are contained within algal cells and are released as cells die and are ruptured. Death of the algae can result from natural dieback, treatment with algicides or following ingestion. Two main types of toxins have been identified - hepatotoxins which have chronic and acute effects, and neurotoxins which affect the neuro-muscular system and may cause death in mammals from respiratory failure. Hepatotoxins are produced in *Anabaena, Microcystis, Nodularia, Cylindrospermopsis* and *Oscillatoria;* while neurotoxins are produced by *Anabaena, Oscillatoria* and *Aphanizomenon.*

Many of the blue-green algae may also cause skin and eye conditions as a result of irritation or allergic responses. It is believed that these effects are caused by lipopolysaccharides that are present in the cell walls.

Impacts of Blue-green Algal Blooms

Blue-green algal blooms have a wide range of social, economic and environmental impacts. They can impact on the operation of water supplies, human health, agriculture (livestock), fish, native flora and fauna, recreation and tourism.

Public Water Supplies

In addition to the production of toxins, blue-green algal blooms alter the physical and chemical characteristics of water which may influence water supply operations.

Physical and Chemical effects

Dense algal blooms cause increased suspended solid loads which increases turbidity, reducing the efficiency of disinfection and can block filters and sprinklers. In addition, increased water pH due to photosynthesis can further reduce the acceptability of water for drinking and industrial uses. It also increases maintenance costs for treatment and distribution systems (A wide range of blue-green algae produce the chemicals geosmin and methyl-isoborneol which impart a disagreeable earthy taste and odour to the water. While these may not be a health risk they may make the water unpalatable). This can alter the form and toxicity of heavy metals and ammonia and change the chemical reactions in water treatment.

As the algae decay, they increase the dissolved organic carbon load and the biochemical oxygen demand. This increases the demand for flocculants in treatment. It also increases the chlorine required for treatment and the potential for trihalomethane production, which have possible health effects (Australian Water Resources Council, 1991).

Stock Watering

There are numerous reports from both the mainland and within Tasmania of stock deaths associated with algal blooms. The most common genera involved in cases of stock death have been *Microcystis, ,Anabaena*, *Nodularia* and *Aphanizomenon.* All cases of stock deaths relate to dense blooms with accumulation of scum on the water surface and shore. However there is no detailed information on the concentration of cells in the water which cause stock deaths.

Irrigation

In storages where water is only used for irrigation purposes, concern is generally focussed on protection of recreational users. There is little evidence that toxins from blue-green algae affect irrigation use and plant productivity, and it is much more likely that agricultural produce from irrigation areas using affected water will be subject to scrutiny from the human health perspective. Although storages which are primarily established for agricultural purposes may require minimal management, it is often the case that the rural community uses this water for domestic needs and this should be kept in mind when dealing with a potentially toxic bloom.

Recreation and Tourism

Toxic blue-green algae constitute a hazard to water users only if the user comes into contact with the blue-green algae. The scale of a hazard, or risk of injury, is likely to increase with the duration of contact. Ingestion of concentrated algal cells in the form of scum constitutes the greatest hazard. The potential risk from various water based activities depends on the likelihood of that activity bringing the individual into contact with the scum. Pleasure cruising, for example would constitute a low risk activity, and swimming particularly from the shore, a high risk activity. The use of wetsuits for water sports may also result in the greater risk of rashes, because algal material in the water trapped inside the wetsuit will be in close contact with the skin for long periods of time. Table 1 gives an indication of categories of risk for different water based activities

Table 1. Categories of Risk for Water Based Activities

LEVEL OF RISK FROM CONTACT		
HIGH	**MEDIUM**	**LOW**
Paddling Swimming Sailboarding Diving Water-skiing Livestock Watering Domestic consumption	Canoeing Sailing Rowing General Public Amenity	Fishing Irrigation of Crops Pleasure Cruising

There are a small number of reports of severe illness in people who have been in contact with water containing high concentrations of blue-green algae. Effects can include influenza like symptoms, sore throats, blistering in and around the mouth, vomiting, diarrhoea and fever.

Blue-green algae will have an obvious impact on local tourism and recreation and particularly on the economy of communities adjacent to dams and storages used for these purposes. Economic costs can include losses associated with activities supporting recreation and tourism (accomodation, transport, food) and losses incurred by commercial recreation facilities such as caravan parks and tourist parks.

Shellfish

Research into the toxicity of edible mussels from Peel Harvey Estuary in Western Australia during a *Nodularia* bloom has clearly shown a consumer hazard (Falconer and Choice, 1992). The mussels ingest the toxic blue-green algae and accumulate toxins in the digestive system of the mussel. The toxins are retained even after freezing and boiling the mussels and their detrimental effects can be demonstrated by death of mice receiving extracts of the mussels. It is unclear what effects freshwater algal blooms may have particularly in terms of downstream transport on estuarine aquaculture activities.

Fish

Algal Blooms in general can have direct and indirect impacts on fish populations and their habitats. The best understood impacts are those associated with the collapse of algal blooms and the decay of algal cells leading to oxygen depletion in the water body. The toxicity or particular algal species, especially that of blue-green algae to native fish species, is not known (Verhoevan, 1992). Little is also known about the toxicity of fish flesh for humans after exposure of fish to toxic blue-green algae. No studies at present have demonstrated toxicity in fish tissue. As a working procedure, however, it may be assumed that the liver and gastrointestinal tract of fish taken from waters containing toxic blue-green algae are likely to be poisonous to human consumers. The muscle tissues of fish is far less likely to be poisonous, but may well taste muddy or earthy due to chemicals arising from the algae which are not themselves toxic (QLD, 1992).

Wildlife

Although not naturally inclined to do so, wildlife animals are known to drink from blue-green algal scums in periods of dry weather, when the moisture content of their forage grass is reduced and they are particularly thirsty.

The accumulation of these scums along shorelines present animals with highly concentrated doses of cells and possible toxins. If wildlife have no alternative but to drink from the water's edge occasional fatalities and illness are likely to occur (QLD, 1992). Death of wildlife due to toxic algal blooms are recorded (NHMRC, 1993) in other parts of the world, but information on the cause of deaths is not detailed.

It is difficult to assess the impact of chronic poisoning on wildlife populations because sporadic deaths frequently pass unnoticed and the long term effects of toxins on animals have not yet been established. Once a bloom occurs there is little that can be done to protect the wildlife from the danger.

The National Alert Level Framework

An alert level framework is in the process of being adopted nationally and provides a sensible and suitably cautious algal management framework. Basically there are three alert levels - *Alert Level 1* (500 - 2000 cells/ml); *Alert Level 2* (2000 - 15000 cells/ml) and *Alert Level 3* (> 15000 cells/ml). The alert level framework is a monitoring and action sequence which operators can use to respond to the onset and follow the progression of a particular bloom. The circumstances and operational options will vary depending upon the source of supply, its use and the resources available.

Alert Level 1 is used to identify the early stages of a bloom during which taste and odours may be detectable. If a routine monitoring program is not in place it is the point at which a sample is dispatched to a laboratory for identification and cell counts.

Alert Level 2 refers to an established bloom. At this level management action may be warranted for water supply storages. Toxicity testing of the bloom is important at this stage, as cell densities may reach levels where any toxins present could pose some risk. At this point there is also a need for public notification through press releases, signage, etc.

Alert Level 3 is reserved for toxic blooms of significant size. Serious management action is warranted at this stage; where the reservoir is used for water supply purposes an alternative water supply should be used; press releases are also required at this level.

In this management strategy, Alert Level 3 has been divided into Toxic (Level 3A) and Non-toxic (Level 3B) compartments, as some blue-green algae can reach high concentrations while remaining non-toxic. Contingency plans to cope with these non-toxic blooms will vary from those required to cope with toxic blooms.

At the national level the three Alert levels have been chosen based on blooms of *Microcystis*, which is essentially a single celled species which forms ‘colonies’ or clusters of cells. There is currently some debate over how these should be applied to genera of blue-green algae which form strands or filaments (such as *Anabaena*). Counting protocols for *Microcystis* are such that once average colony size has been determined (from counting numbers of cells in 15 - 20 colonies), cell concentrations can be derived from colony counts. In the case of *Anabaena*, some states are counting filaments after deriving the average number of cells per filament similarly. There is some debate as to the accuracy of this method for *Anabaena* as filament size can vary seasonally.

Once a national protocol for counting filamentous forms has been finalised, further additional information may need to be made to this document to cover filamentous forms.

Implementing a Response

Contingency Plan for Emergency Situations (Water Supply/ High Contact recreation)

When considering actions following the discovery of a significant algal bloom, a contingency plan can prove useful. An important part of any contingency plan should be a list of relevant organisations and people who should be contacted upon discovery of a bloom so that they can co-ordinate a response if one is necessary. Each organisation has a duty of care to have an effective hazard management plan which covers risk to workers and the public. This will normally include a clearly established pathway for communication in the case of an incident. The occurrence of a significant bloom of potentially toxic blue-green algae should be treated as a possible hazard. Appendix 1 is a draft for a protocol which addresses the issue of who to contact in the event of an incident or situation which could have the potential to be a hazard to human health.

The following section presents an contingency plan structure for blue-green algal blooms which is based upon monitoring blooms and initiating actions based on the alert levels discussed above. These alert levels relate to the supplied water. If the water is supplied direct from a storage, the water in the storage is the control. If the water is supplied after treatment (eg. a domestic supply), then the post treatment water is the control. The sequence of alert levels is based upon initial detection of blue-green algae at Level 1, through to moderate numbers at Level 2 where supply is still acceptable, followed by Level 3 where the water is unacceptable for supply as a result of high numbers of toxic blue green-algae. An outline of these alert levels is presented below.

ALERT LEVEL	Cell Concentrations	Response Actions
Alert Level 1	500 - 2000 cells/mL	– Identify the algal type – Establish early bloom conditions. – Initiate low level monitoring.
Alert Level 2	2000 - 15000 cells/mL	– Progression of bloom into potentially hazardous category. – Comprehensive monitoring. – Media releases, public notices. – Storage operation alterations.
Alert Level 3A (Toxic)	> 15000 cells/mL	– Bloom established as toxic. – Frequent toxicity testing. – Water supply alternatives may be required. – Higher level of public awareness.
Alert Level 3B (Non-toxic)	> 15000 cells/mL	– Bloom established as non-toxic. – Operations aimed at minimising taste and odour problems. – Continued medium level monitoring.

The progress through this sequence will vary depending upon whether the water source is a river or a storage and whether treatment options such as algicides and activated carbon are applicable or available.

The framework is developed from the perspective of the water supply operator, which can be a state or regional agency through to a local authority. The actions accompanying each level cover areas such as additional monitoring and testing, operational options, consultation with health authorities and media releases. An important part of the framework is consultation with other agencies and communication with the public during the various stages. This ensures a coordinated response to development of major algal blooms and timely transfer of information to the community.

Public information and media liaison is an important part of emergency contingency planning. Information must be prompt and concise with details about reasons for short term changes to supply and explanations for any differences in water quality that may result. It is important for all of the agencies involved to provide coordinated and consistent advice. This could be facilitated by the formation of coordinating committees.

There are several areas that need to be clearly examined when using this framework. These are; the health guidelines as they pertain to the various types of blue-green algae, the importance of species composition of blooms, the techniques for sampling and counting of blue-green algae, and media and community relations. Most of these issues are discussed later in this document.

Another factor which plays a pivotal role in determining the actions required at the various alert levels is algal species composition. While the majority of blooms of the blue-green algae *Microcystis* which have been tested have proved to be toxic, it has been shown that less than half of the tested blooms of *Anabaena* have been toxic. Algal identification and toxicity testing during the onset of major blooms is therefore of critical importance. To be confident of results, laboratories which have good quality assurance programs in place should be used. A list of nationally accredited laboratories which can carry out this testing can be found on the following website;

http://www.nata.asn.au/labaccred.htm

The following framework contains a number of points where media releases could be issued. These are presented as a guide only but they represent the levels at which consumers may experience changes in water quality. The comments made in the text in relation to media releases cover the sort of information that may be appropriate.

ALERT LEVEL 1

[500-2000 cells/ml]

This level encompasses the early development stages of population growth when taste and odours become detectable in the supply. Water may still be free of visible colour. It constitutes early warning and if a routine monitoring program is not in place, a sample should be taken and dispatched to a laboratory for examination. The presence of these low numbers would still indicate the potential in the storage for the formation of localised surface scums, and operators should begin to regularly inspect raw water off takes for scums or discoloured water.

- if counts are found to be within or above this range, a monitoring program should be initiated immediately.
- if scums are seen to occur at this alert level, a low level media release should be made to inform the public to its presence and condition and activities which are being undertaken to identify any potential dangers.

ALERT LEVEL 2

[2000-15000 cells/mL]

This level refers to an established bloom with moderately high numbers which may or may not be showing a trend upwards over successive samples. The population will have developed to the extent of forming localised surface scums and as such may pose a health risk (human and stock).

This level may warrant operational actions such as treatment with algicides, filtration with activated carbon or other measures to avoid contamination of the supply. In some circumstances the use of algicides may be unacceptable owing to adverse environmental impacts, and operators should obtain advice or clearance from the relevant environmental authority or department. The bloom population should be sampled to establish the extent of its spread and variability. Special samples (concentrated scums) should be collected and despatched for toxicity testing.

Toxicity testing at this stage will establish the potential for further escalation of the alert level. The toxicity test should preferably be quantitative rather than qualitative to allow for the relative toxicity of the bloom. This requires a dry weight based estimate of MLD_{100} (minimum lethal dose, mg dry weight of algae/kg mouse) in the case of mouse bioassay, or an estimate of microcystin content if an analytical method for peptide hepatotoxins is available.

Level 2 should involve consultation with the relevant health authority for ongoing assessment of the status of the bloom. This consultation should be done as early as possible and also after the results of toxicity tests become available

It may be appropriate to issue a press release at this stage to indicate the cause of any taste/odour problems in the storage/river and actions which are currently being taken. If the source water is used for recreational purposes statements may be issued to avoid swimming in discoloured water or patches of scum due to possible skin and eye irritation.

ALERT LEVEL 3A Toxic Bloom

[> 15000 cells/mL]
The threshold definition encompasses an establish toxic bloom with high and variable numbers due to localised scums. The sampling program will have indicated that the bloom is widespread with no indication of a population decline in the short term.

Level 3A is the point at which the water has become contaminated with toxins and is unacceptable for supply based on an assessment by the health authority. At present there is some difficulty in defining acceptable levels of toxins in drinking water due to the presence of blue-green algae. As a result, each positive result will require consideration in light of most up-to-date information.

If activated carbon treatment (powdered or granular) is available, it should be used in the treatment process. The treated water can be monitored for microcystin hepatotoxin using gas chromatography to confirm its removal. However, this technique is not applicable for the neurotoxins produced by *Anabaena circinalis* as not all the toxins produced by this species have been identified. If water quality has changed under these circumstances a media release may be warranted and warnings about recreational use of the source should be reinforced if that is appropriate.

If water treatment with activated carbon is not available, Level 3A will result in the activation of a contingency plan which is appropriate for the operator. This may involve switching to an alternative supply and even delivery of water to consumers by a tanker in some circumstances.

More extensive media releases and letterbox drops of leaflets with appropriate advice to householders may be necessary. The bloom must continue to be monitored twice per week to determine when it is in decline so that normal supply can be resumed as soon as possible. Toxicity testing is probably only warranted at 1-2 week intervals. Experience suggests that the degree of toxicity can change but it is unlikely to become completely non-toxic or decline in a short space of time (ie. days).

ALERT LEVEL 3B Non-toxic

[> 15000 cells/mL]
The actions following identification of a bloom as non-toxic will be different to those required for a toxic bloom. It is well known that non-toxic blooms can reach quite high concentrations without severely limiting the use of water (especially for agricultural use). Species such as *Anabaena*, which may remain non-toxic, will require frequent population monitoring, but less frequent toxicity testing.

In terms of operational changes, the water supply should basically be treated so as to avoid taste and odour contamination. Such operations may mean altered pumping routines, modification of off-take levels, physical barriers to filter algae or use of activated carbon. Use of algicides in this case may be warranted, although only after an assessment of the environmental implications of its use.

A bloom at this level should continue to be monitored bi-weekly to both assist operators in management of the supply and to allow early detection of a decline in the bloom.

In both cases, the sequence at Level 3 follows through to deactivation of an emergency with media releases to confirm this. It is possible that the collapse of a bloom could mean a rapid decline from Level 3 back to Level 1 or beyond. Likewise the sequence might escalate rapidly, by-passing Level 1 and 2 straight to emergency mode if early warning information is not available.

Contingency Plan for River and storages (non water supply)

In the case of rivers or storages which are not subject to use for water supply or high recreational use, modification to the actions required at each of the alert levels may be chosen. While the alert level framework outlined above for water supply storages can be retained, lower levels of monitoring and public communication may be deemed adequate, depending on the location and activities occurring in or on the water body. In the case of downstream users abstracting water for domestic use, storage operators may be required to implement more strict management strategies.

In areas where no authority extracts water for domestic or industrial use (eg irrigation supply) it is not likely that routine inspection of the water body occurs. Any indication that a bloom exists is therefore likely to come from public concern, at which stage the bloom will most likely have entered at least Alert Level 2 (presence of visual surface scums). While monitoring of the bloom (identification and enumeration) may be required, unless the bloom occurs in a much frequented area, monitoring may be kept at a low level.

National guidelines for the management of recreational waters potentially containing blue-green algae have been published by ARMCANZ (1995). The need to ensure that individuals are not exposed to risks associated with algal blooms is paramount. Ways to minimise the risk of exposure include temporary or permanent signs, media releases and closures of affected waters. Longer term management of affected water bodies may require local strategic plans incorporating; assessment of status, routine monitoring, characterisation of activities and uses of the water body, coordination with the public and longer term management goals. Stake-holders in such a plan would include State and Local government, resource managers, recreational clubs and other interested public groups.

Artificial Dispersal of algal blooms

Potential algal management mechanisms that could be used for the State’s waterways are categorised into physical, chemical and biological controls. Feasible physical control measures include flow regulation, artificial de-stratification, light restriction, variation of storage off-take, aeration, alterations of turbidity levels, floating booms and deepening and dredging. Chemical control options include algicides (in off river water supply storages) and various nutrient controls. It is not recommended that algicides be used in the non-water supply storages as they impact on other aquatic organisms.

Biological control options are generally aimed at longer term management of affected water bodies, and include the promotion of macrophyte growth, wetland creation and preservation to absorb nutrients from runoff and re-establishing bankside vegetation. Implementation of catchment management programs will also assist in long term management of algal bloom occurrence.

Long term Management

The quality of water in a river or storage is a direct result of activities within the catchment. If we seek to avoid algal problems rather than just manage them, then we must look at catchment management.

The catchment contributes nutrients from point sources such as sewage treatment plants, and from run off from land. When water runs off land it transports sediment and a variety of other contaminants like nutrients to the receiving waters. The sediment load from the catchment will determine the turbidity, and hence light environment in the water; the nutrients directly stimulate plant growth.

There are several basic strategies for managing a catchment to minimise non point-source pollution

- Retain buffer strips (at least 10m each side) with natural vegetation along both major waterways and tributaries.
- Prevent stock from having access to stream or storage banks to avoid bank damage and direct faecal and nutrient contamination of streams.
- Encourage land holders to adopt basic soil conservation management and ensure the maintenance of vegetative cover on the land. This is especially important under drought conditions.
- Control the use of agricultural chemicals and ensure they are not applied directly to streams and buffer areas and they are applied where they will be retained on site rather than washed into waterways.
- require animal wastes from dairies or other intensive congregation zones to be treated using wetland pollution control ponds or other appropriate technologies.

Public Information and Consultation

Recommended Signage

In most cases, warning signs as well as media releases are sufficient to alert the public to the presence of algal blooms and deter them from using water affected by blue-green algae. In some instances, responsible agencies may need to close storages or river reaches where the risk to human health is higher.

Warning signs should include words or symbols indicating that swimming, drinking and stock watering is not recommended. The signs should include information as to what the cause is and what the symptoms might be if the water is consumed eg;

CAUTION!

BLUE-GREEN ALGAE MAY BE PRESENT IN THIS WATER.
CONTACT MAY CAUSE SICKNESS IN HUMANS AND ANIMALS.
CONTACT MAY CAUSE SKIN AND EYE IRRITATION.

It is also important that signs be placed in locations that are prominent, such as at boat ramps or swimming areas, and that they are of adequate size so as to be easily read at some distance.

Press Releases

Press releases should be issued when a bloom is confirmed at Alert level 2 and above. At Alert Level 3 media releases with the latest information may be warranted at weekly intervals. Media reports should include;

- site identification
- a clear explanation of the potential risks and dangers
- an outline of users, activities and services that are or may be curtailed, withdrawn, unwise to use or unaffected
- provision of a contact name for people wanting more information

and should be issued to those media outlets that have the potential to reach as great a proportion of the affected and potentially affected section of the population of the region.

Upon two consecutive weekly samples showing counts less than 2000 cells per ml, a press release should be issued informing the public that the alert is over. The release should contain;

- an explanation of the spatial extent of the bloom
- the duration of the bloom
- an outline of any services, supplies, recreational activities etc that were affected by the bloom, and
- an assurance that any such activities outlined above are now safe.

A sample press release is given in Appendix II.

Information Sheets

The widespread distribution of public pamphlets or information sheets appear to have been successful in other parts of the world. There are now many publications and pamphlets available which outline the causes and health effects of blue-green algal blooms in Australia (AWRC, 1991; NH&MRC, 1993; ARMCANZ, 1995).

In addition to these, a public information sheet should be prepared on blue-green algae. This should be readily available easily understood by the public and should be distributed to areas which have previously experienced blooms.

References

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APPENDIX I

Algal Bloom Incident Communication Protocol

AIM

The aim of the Algal Bloom Incident Communication Protocol (ABICP) is to provide a process for ensuring the notification of incidents which have the potential to be a hazard to human health, animal health or the environment.

SCOPE

The ABICP applies to the following hazards or incidents occurring within Tasmania:

1. Any significant blue-green algal (cyanobacteria) bloom in any body of fresh water;

2. Any bloom in fresh water that could directly or indirectly result in the contamination of any foods or sources of food, including animals, crops, animal feeds, fish stocks, shellfish or other agricultural produce.

COMMUNICATION RESPONSE PROCEDURE

Preamble
It is implicit that there be a timely response to any incident which has the potential to be a . threat to public health, animal health, food supply or the environment. For this to proceed smoothly, it is essential that the lists of contact people and numbers are kept current. Please advise of any changes as soon as practicable. In addition, people designated as contacts should be available; if this is not always possible, a deputy should be nominated.

The lead Agency in the management of fresh water algal blooms is the Department of Primary Industries, Water and Environment. However, other Agencies will have responsibilities for minimising or preventing effects on human health or the environment.

A Department of Primary Industries, Water and Environment

On becoming aware of any bloom falling within the scope of this response protocol, the Department of Primary Industries, Water and Environment undertakes to:

1. Immediately, or as soon as practicable, inform the Public and Environmental Health Service (Department of Health and Human Services).

2. Inform the Environmental Health Officer, or in his/her absence a responsible officer, of the local Council of the municipal area where the bloom is occurring. If the bloom crosses, or produces effects that cross municipal boundaries, inform the EHO's of the relevant Councils involved.

B State Government Agencies and Authorities

When a State Government Agency or Authority discovers or is informed of an algal bloom in freshwater it should immediately contact the nominated person in the Department of Primary Industries, Water and Environment.

C Environment and Land Management

On becoming aware of any bloom listed above being reported by either a member of the public or a government agency, the Council Environmental Health Officer (EHO), or in his/her absence a responsible officer, undertakes to immediately, or as soon as practicable, to:

1. Inform the Public and Environmental Health Service (PEHS), Department of Health and Human Services.
2. Inform the Department of Primary Industries, Water and Environment (DPIWE).
3. Advise the Environment and Planning Division of the Department of Primary Industries, Water and Environment (DPIWE) Incident Response/Duty Officer, or in his/her absence the Executive Officer.

CONTACT PERSONS

A <u>Department of Primary Industries, Water and Environment</u>

1) Land and Water Management Branch

Regional Management Officers

Arthur Pieman	**David Krushka**	**Office Telephone**	03 6452 1233
		Mobile	018 142 357
Inglis Cam	**Martin Huzzey**	**Office Telephone**	03 6430 5420
		Mobile	0417 305 648
Mersey Forth	**Terry Leary**	**Office Telephone**	03 6421 7628
		Mobile	0418 547 846
Meander	**Robyn Wilson**	**Office Telephone**	03 6421 7628
		Mobile	015 871 087
North East Rivers	**Julian Johnston**	**Office Telephone**	03 6336 5377
		Mobile	041 937 504
South Esk / Macquarie			
	Ken Bailey	**Office Telephone**	03 6336 2513
		Mobile	018 144 352
South East and East Coast Rivers			
	Andrew Dix	**Office Telephone**	03 6233 6157
		Mobile	018 123 355

2) Environment & Planning Division

Lands Building
134 Macquarie Street
GPO Box 44A
Hobart

Facsimile: (03) 6233 3800

Incidents occurring in all regions initially should be reported on the **1800 005 171** incident number 24hrs/7 days a week.

All calls to this number are processed through the Environment & Planning Hobart Office, 134 Macquarie Street, Hobart.

Incident Response/Duty Officer Mr John Dobson	**Telephone**	**B/H** 03 6233 6127 **FAX** 03 6233 3800 **A/H Mobile** 0418 125 859
Executive Officer Mr Chris Eden	**Telephone**	**B/H** 03 6233 2776 **FAX** 03 6233 3800

Regional Contacts

Northern Region

Senior Environmental Officer	**Telephone**	**B/H** 03 636 2894 **FAX** 03 63362803
Mr Robert Trimble	**Mobile**	0417 301 282
Henty House 1 Civic Square LAUNCESTON TAS 7250		

North West Region/ Western Region

Environmental Officer Rosmary Holness Ulverstone	**Telephone**	03 6429 8760

B **Public and Environmental Health Service**

Department of Health and Human Services

34 Davey Street
Hobart

Free Call Number: 1800 671 738
All hours – toll free number

FAX: (03) 6233 6620
(03) 6223 1163

Senior Environmental Health Officer
Scott Burton

Telephone B/H (03) 6233 3772
Mobile 0408 338 133

Director of Public and Environmental Health
Dr Mark Jacobs

Telephone B/H 6233 3768
Mobile 0418 123 265

C Regional Water Authorities

North West Regional Water Authority
162 Pumping Station Rd.
Forth. 7310
Neville Dance - Technical Services Manager

Telephone 03 6428 2339
Fax 03 6428 2835

Esk Water Authority
323 George Town Road
ROCHERLEA 7248
Barry Cash - Engineer Manager

Telephone (03) 6336 2571
Mobile 0419 524 812
Fax 03 6336 2567

Hobart Water Authority
2-4 Negara Cres.
GOODWOOD 7010
Russel Fox - Manager Water Supply

Telephone (03) 6233 3303
Fax (03) 6273 9205

South East Irrigation Scheme - Craigbourne Dam

Mauri Costa - Administration Officer (DPIWE)
Telephone 03 6233 3658
Mobile 041 9344 070

Rodney Beven - Overseer
Telephone (03) 6260 2376

Robert Byrne - Operator
Mobile 018 122 785
Fax (03) 6260 2376

Winnaleah Irrigation Scheme - Cascade Reservoir
C/o Post Office

DERBY 7264

Stephen Pryor - Senior Technical Officer (DPIF)	**Telephone**	(03) 6233 3658
	Mobile	041 9344 070
Danny LeFevre - Operator	**Telephone**	(03) 6354 2455
	Fax	(03) 6354 2587

E Municipal Councils

Contact	**Phone**		**Fax**
	B/H	**Mobile**	
BREAK O'DAY Senior EHO Break O'Day Council PO Box 21 ST HELENS TAS 7216	03 63761281		03 63761551
BRIGHTON Senior EHO Brighton Council PO Box 105 BRIDGEWATER 7030	03 62630332	018 125617	03 62630313
BURNIE Chief EHO City of Burnie PO Box 973 BURNIE TAS 7320	03 64305765		03 64313896
CENTRAL COAST Environmental Service Manager Central Coast Council PO Box 220 ULVERSTONE TAS 7315	03 64298900		03 64251224
CENTRAL HIGHLANDS Senior EHO Central Highlands Council Tarleton Street HAMILTON TAS 7140	03 62595503	041 9302670	03 62595722
CIRCULAR HEAD Senior EHO Circular Head Council PO Box 348 SMITHTON TAS 7330	03 64521265	0418144155	03 64522610

Contact	Phone		Fax
	B/H	Mobile	
CLARENCE Senior EHO City of Clarence PO Box 96 ROSNY PARK 7018	0362458658		0362458700
DERWENT VALLEY EHO New Norfolk Council Circle Street NEW NORFOLK TAS 7140	03 6261 0725		03 6261 3136
DEVONPORT Chief EHO City of Devonport PO Box 604 DEVONPORT 7310	03 6424 0551	0418 140 781	03 6424 9649
DORSET Senior EHO Dorset Council PO Box 21 SCOTTSDALE TAS 7260	03 6352 2444	0417 322 267	03 6352 3309
FLINDERS ISLAND Environmental Health Officer Flinders Council PO Box 40 WHITE MARK FLINDERS ISLAND 7255	03 6336 2220	0419 340 226	03 6334 3057
GLAMORGAN/SPRING BAY Senior EHO Glamorgan/Spring Bay Council Council Chambers TRIABUNNA TAS 7190	03 6257 4056		03 6257 3367

Contact	Phone		Fax
	B/H	**Mobile**	
GLENORCHY City of Glenorchy PO Box 103 GLENORCHY 7010	03 6274 0796	0414 495 440	03 6273 1056
GEORGE TOWN Senior EHO George Town Council PO Box 161 GEORGE TOWN TAS 7253	03 6382 1211	03 6356 1426	03 6382 3240
HOBART **After Hours Emergency Number** Chief EHO City of Hobart GPO Box 503E HOBART TAS 7001	03 6238 2737 03 6234 3066	0418 138 805	03 6224 4344
HUON VALLEY Environmental Health Officer Huon Valley Council PO Box 210 HUONVILLE TAS 7109	03 6264 0282		03 6264 1185
KENTISH Mr Rob Pollock Senior EHO Kentish Council PO Box 63 SHEFFIELD TAS 7306	03 6426 1041	03 6491 2264	03 6491 1659
KING ISLAND Senior EHO King Island Council PO Box 147 CURRIE KING ISLAND 7256	03 6462 1177		03 6462 1313
KINGBOROUGH Senior EHO Kingborough Council Council Chambers 15 Channel Highway KINGSTON TAS 7050	03 6229 5555	015 872 518	03 6229 2851

Contact	Phone B/H	Phone Mobile	Fax
LATROBE Senior EHO Latrobe Council PO Box 63 LATROBE TAS 7307	03 6426 1041		03 6426 2121
LAUNCESTON Chief EHO City of Launceston PO Box 396 LAUNCESTON 7250	03 6337 1203		03 6337 1395 03 6337 1117
MEANDER VALLEY Senior EHO Meander Valley Council PO Box 102 WESTBURY TAS 7303	03 6393 5300	018 134 070	03 6393 1474
NORTHERN MIDLANDS **After Hours Emergency No:** Senior EHO Northern Midlands Council PO Box 156 LONGFORD TAS 7301	0363911303	0419 399 274 016 181 598 (pager)	0363911741
SORELL Senior EHO Sorell Council 12 Sommerville Street SORELL TAS 7172	03 6265 2464	0418 378 786	03 6265 1127
SOUTHERN MIDLANDS **After Hours Emergency No** Senior EHO Southern Midlands Council PO Box 21 OATLANDS TAS 7120	0362593011	018 126 686 018 120 539	0362591327

Contact	Phone		Fax
	B/H	Mobile	
TASMAN Senior EHO .Tasman Council Main Road NUBEENA TAS 7184	03 6250 2200		03 6250 2568
WARATAH/WYNYARD Senior EHO Waratah/Wynyard Council PO Box 168 WYNYARD TAS 7325	03 6442 0333	018142659	03 6442 1299
WEST COAST Senior EHO West Coast Council PO Box 40 ZEEHAN TAS 7469	03 6471 1404	0419 390 912	03 6471 1078
WEST TAMAR **After Hours Emergency No** Environmental Health Officer West Tamar Council PO Box 59 BEACONSFIELD TAS 7270	03 6383 1106 03 6398 2281		03 6383 1540

APPENDIX II SAMPLE PRESS RELEASE

MEDIA RELEASE

Department of Primary Industry and Fisheries

Hobart

Date…

Blue-green Algal Bloom in Craigbourne Dam

- An algal bloom was reported in Craigbourne Dam early Thursday morning 5th June 1997. DPIF's Land and Water Assessment Branch responded immediately and identified the principal algae as *Anabaena circinalis* a blue-green algae, this was later confirmed by CSIRO scientists. *A. circinalis* was responsible for the algal blooms in the Murray-Darling river system in 1991 which killed 1600 farm animals.

- Since some subspecies of *A. circinalis* can produce toxins harmful to stock and humans, DPIF and the Department of Community and Health Services advised the public to avoid contact with water in the dam and in the Coal River. Samples have been submitted for toxicity testing.

- The main driving forces producing the bloom are unknown. Algal blooms are often linked to the concentration of nutrients and thermal stratification (layering) of lakes. However, it is rare that an algal bloom can be attributed to any single factor.

Contact: David Fuller 6233 2578

APPENDIX III STANDARD PRACTICES

Routine visual monitoring

Routine monitoring should include visual inspection. The storage supervisor should inspect the water in the vicinity of offtake areas and recreational areas, for surface scums and/or high turbidity resulting from algae. The visual inspection should be undertaken weekly during spring and summer, unless algae are noticed in which case daily inspections should be commenced. The results of the inspections should be recorded, together with the weather conditions including air temperature, wind and rain. All reservoir operators should be provide with a format on which to record information to make the task simpler. In the absence of an appropriate algal monitoring programme, a visual change such as colour and odour should be followed up immediately with a proper microscopic analysis.

Algal Sampling

A recent national workshop on monitoring blue-green algae and other phytoplankton recommended the following monitoring protocol as a benchmark for rivers. It is expected that this will be adopted for standing waters as well in the future. Sampling frequency and methodology is linked to national alert levels. The workshop advocated that monitoring should be a routine procedure. In many states, however monitoring of algal blooms is reactive and this is certainly the case in Tasmania. It is likely that storages will only be monitored at the onset of an algal bloom or in storages that have previously experienced an algal bloom. All other storages should at least be visually inspected from time to time. Some water supplies do currently monitor for algae on a routine basis, though many of the smaller rural schemes extracting directly from smaller rivers do not. Sampling frequency should also be linked to water use eg. fortnightly in recreational water bodies as opposed to twice weekly for water supplies where these are experiencing major blooms. Upon discovery of a bloom, two sampling strategies may be adopted to gather information on bloom conditions and progression. These are outlined below:

1. Sampling-Strategy A

Method A is intended for a broader coverage, simpler sampling and counting methods. Sampling would take place midstream in rivers or greater than 50m from shore in lakes and reservoirs. Benchmarks for sampling would be an integrated hosepipe with the sample depth ranging anywhere from 2-5m (for large water bodies), or a composite sample from three sites, each greater than 100m apart (in smaller rivers).

2. Sampling-Strategy B

Method B is a more complex sampling method and includes algal counting which is aimed at more precise estimates of population size. Field methods including compositing of shore based samples from 3 sites >100m apart in rivers and depth integrated sampling (using Niskin Bottle or the like) in larger water bodies. Where sampling is shore based, immersion of the sample bottle should be greater than 20 cm below the water surface.

For Alert level 1 (500 cells/ml) Strategy A is an adequate benchmark. For greater than Alert level 1 Strategy B should be utilised.

Frequency and method of sampling will vary based on the current Alert Level of the algal bloom. For a bloom at or below Alert Level 1 (ie. >2000 cells/ml) sampling Strategy A and a frequency of once per fortnight is adequate. Strategy B should be undertaken once Alert Level 2 is reached (2000 - 15000 cells/ml). At this level and above, sampling should take place on at least a weekly basis (although twice per week is highly recommended). A greater number of sites should also be included once Alert Level 2 is reached, to gain greater information in bloom density and extent.

Physicochemical data recording

The following parameters should be measured when sampling takes place as physical and chemical measurements are important for correlation with cyanobacterial levels to establish trends. This will inform management agencies in terms of how to manage future blooms more effectively and to identify causal factors leading to cyanobacterial blooms. Some of the parameters which are normally measured simultaneously are;

- Water temperature
- pH
- electrical conductivity
- secchi depth and/or turbidity
- an estimate of windspeed
- dissolved oxygen
- flow (or storage volume)
- water depth at site

In addition to the above parameters, it is also preferable to collect samples for nutrient analysis as frequently as possible. This will provide information on the status of the water body and in what form nutrients are present.

Field data sheet

A standardised format for data recording should be agreed to at a State level. Preferably, a state field data sheet should be set up in accordance with the proposed national format as discussed at the national workshop. However, in the absence of such a standard, data sheets should be clear and logical in format, with the units of each parameter clearly denoted. In cases where multiple meters are used, identification of individual meters should be noted. It might also be advantageous to note calibration dates, where electronic instruments are used.

Algal Identification

There is a need to identify known toxic algae to species level. For other non-toxic algae, identification to at least genera level is recommended but identification to species level should be encouraged. Most states confirm identification of blue-green algae by more than 1 member of staff as a quality control measurement and this is suggested as the correct procedure for known toxic cyanobacteria in Tasmania. Identification to species level for all cyanobacteria at all times is particularly important in terms of setting different national alert levels for different species in the future.

Algal Preservation, Storage and transport.

All samples should preferably be taken in 1L high density polyethylene (HDPE) containers and preserved with Lugols solution and stored in the dark. Samples should be transported back to the lab within 48 hours where possible. During initial formation of blooms, it is preferable to have live samples examined to aim taxonomic identification.

Algal Counting.

The time required to count each sample will vary greatly depending on cell density, ease with which cells can be identified, the desired level of precision (equal to the percentage of the chamber counted) and level of detritus/turbidity present in the sample.

The basic procedure for counting algae is to fill a counting chamber with a sub-sample of the preserved sample and then simultaneously identify and count the algal cells under a light microscope.

Sub-sampling preserved samples

Before sub-sampling gently shake the preserved sample so that it is well mixed, in order to avoid sub-sampling errors. The break up of filaments and colonies during shaking is often unavoidable. The sub-sample is either transferred into a counting chamber or a sedimentation vessel. The sub-sampling technique should be checked regularly by taking several successive sub-samples from the same bottle and comparing the counts of some species.

If the cell density is less than 10^5 cells per L^{-1}, the sample needs to be concentrated before counting by either sedimentation (for preserved samples) or filtration (for live samples). If cell density is too high, dilute the sample with distilled water. Dilution or concentration factors need to be taken into account for calculating the final results of cells/mL.

If samples require concentration, sedimentation by gravity should be used allowing for two hours per cm of height. While some Australian states use centrifugation in order to achieve quicker results some have expressed doubts about using this process as a benchmark but agreed that it could be used after comparison of counts with gravimetric methods.

Species containing gas vacuoles(cyanobacteria) are unlikely to fully sediment despite the iodine (Lugols) fixation. Two methods are available for collapsing vacuoles to assist sedimentation. Samples can either be exposed to brief ultrasonification (< 1 minute but may vary for different species) or alternatively, pressure can be applied to the sample: after placing the sample in a strong rigid bottle or syringe which are closed by stoppers, bang the stopper several times with a mallet or against a hard surface. This will collapse the vacuoles and the cells will then settle through gravity. Examine the surface within the settling chamber to ascertain whether or not other algae may be floating rather than sedimenting.

Choice of counting chamber

The Sedgewick-Rafter chamber will become the national benchmark for algal counting. Tasmania already uses Sedgwick-Rafter chambers for counting blue-green algae.

A Sedgewick-Rafter chamber is basically a 50mm by 20 mm microscope slide with a grid floor (1000 fields) and a rim in order to hold a volume of 1.0mL. The Sedgewick-Rafter chamber can be placed directly under the upright microscope, but can only be used with the 10x and 20x objective. The dimensions of each chamber can vary slightly and need to be measured and recorded as they are required for calculating concentrations from cell counts and for quality control.

Counting with the Sedgewick -Rafter chamber

A calibrated pipette is used to sub-sample 1mL of either the original sample or the concentrated sub-sample, the uncovered chamber is filled and the sample is randomised with several strokes of the pipette in both dimensions. The cover slip is applied and the sample is left to settle for about 5 minutes. To prevent formation of air bubbles from evaporation during counting, distilled water is added to the edge of the cover slip from time to time. The cells are counted on the bottom of the chamber. All cells within randomly selected fields are counted. A convention needs to be followed for cells or units lying on a boundary line or field eg. All cells or units overlapping the right hand and top boundary are counted, but those overlapping the bottom and left hand boundary are not. It is recommended that 30 fields be counted within the chamber so as to include 90-95% of the species present. Counting 25 fields will include 80%-90% of the species present. The number of units per millilitre for each taxon is calculated according to:

$$\text{(1)} \quad No./mL = \frac{Cx1000mm^3}{AxDxF}$$

where

C = number of cells counted,
A = area of field [mm^2]
D = depth of a field (S-R chamber depth) [mm]
F = no. of fields counted

For colonial taxa multiply the count of units by the average number of cells per unit and use the resulting value as C in equation 1. To adjust for sample concentration of dilution the result is divided or multiplied by the appropriate factor. To obtain total cell density per millilitre, sum all counts of individual taxa.

If cell density is low (< 10 units per field) counting of long transects to cover a large proportion of the chamber floor is more appropriate. Several transects with a width of a chamber field are counted. The number of strips depends on the required precision and the phytoplankton density. The number of cells per mm is calculated according to:

$$(2) \quad No./mL = \frac{C x 1000 mm^3}{L x D x W x S}$$

where

C = number of cells counted,
L = length of strip[mm]
D = depth of a field (S-R chamber depth) [mm]
W = width of strip [mm]
S = number of strips counted

Treat counts of units as above. To adjust for sample concentration or dilution the result is divided or multiplied by the appropriate factor.

Algal Toxicity Testing.

Sampling

Samples for toxicity testing should be taken at the same sites and using the same methods used as those samples collected for counting. A minimum volume of 1 litre should be collected for toxicity testing. Scums or net tows should only be used for confirmation of toxicity. Samples should be collected on a minimum fortnightly basis for bloom levels greater than Alert Level 2 with the exception of water treatment plants where testing should be more frequent. Any samples to be sent off for toxicity testing must be individually labelled with the precise site and date of sampling. An information sheet should be completed and sent with the samples in a waterproof bag.

Analysis

Samples should be stored on ice and arrive at the testing laboratory within 48 hours. Routine analysis should be by HPLC (High Performance Liquid Chromatography) for toxin concentration. Other methods such as ELIZA or Pphase may be used in the future depending on further testing by interstate laboratories.

Mouse bioassay should be used only for unusual blooms and for random toxicity testing (eg. 10% of samples). Toxin data should be reported as;

- toxin/cell

- toxin/dry weight (where possible)

- toxin/ L (standard reporting unit).

It is expected that all samples collected for toxicity testing will be sent away for analysis. Tasmania has neither the resources or the high incidence of algal blooms to warrant in house toxicity testing. In terms of national standards Tasmanian state agencies will expect standards as a client rather than as a service provider.

Staff Training

Some basic training may be required, where staff engaged in operating water supplies have little or no experience in identifying blue-green algae. Various texts are available which contain visual aids to the identification of blue-green algal blooms, and other features of blooms which help in their identification. Some training can also be gained through courses run by laboratories or colleges of advanced education.

Where greater expertise is sought (such as microscopic identification and counting techniques), staff should be enrolled in formal courses which provide training in this area. These courses will often also include basic information on the biology of blue-green algae, field sampling methods and standards, and coverage of issues such as quality control and quality assurance.