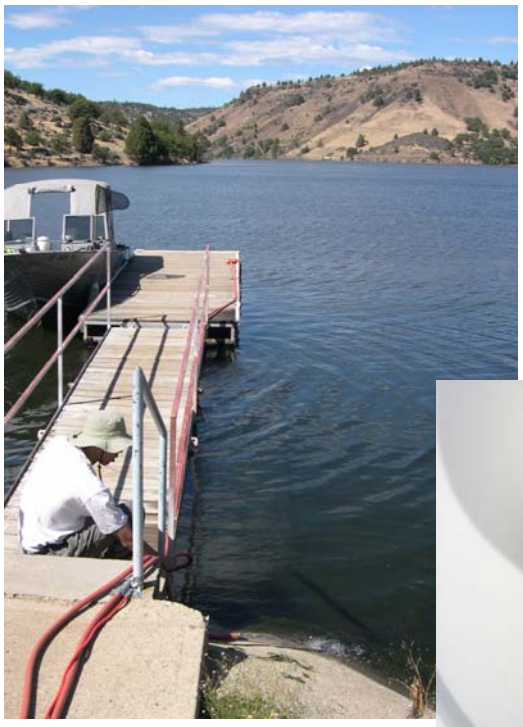
ALGAECIDE PILOT STUDY: COPCO RESERVOIR 2008



A Report for PacifiCorp

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November 30, 2009

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Executive Summary

As part of PacifiCorp's ongoing reservoir management planning efforts, Watercourse Engineering, Inc. (Watercourse) undertook a brief review of algaecide applications and conducted a small-scale bench-top algaecide experiment completed in 2008. The objective of this work was to provide background information on the use of algaecides in managing water quality in reservoirs and lakes and carry out a small bench-top test with waters from Copco Reservoir to gather information on algaecide efficacy in Iron Gate and Copco Reservoirs.

Although algae are a key component of aquatic ecosystems, playing a vital role in food webs and producing oxygen through photosynthesis, excessive and/or persistent phytoplankton blooms can be both a nuisance and an environmental problem. Algae can cause taste and odor problems in drinking water reservoirs; produce toxins that affect wildlife, livestock, and/or humans via contact or ingestion; present filter clogging challenges; and lower the aesthetic appeal and recreational use of surface waters.

Algaecide application has been identified as a tool to control nuisance algae (Holdren et al., 2001). Earlier algaecides specifically target plants using copper-based treatment methods. More recently, oxidizer algaecides that utilize hydrogen peroxide to rupture the cell walls of the algae have been developed (Wagner, 2004). Algaecides can provide a rapid removal of algae from the water column, sometimes resulting in dramatic short-term changes in water clarity. As with any form of pesticide, there are procedures and guidelines that must be followed prior to application of a product on a reservoir or lake.

To assess the efficacy of three types of algaecides (one copper-based and two hydrogen peroxide-based), a small-scale bench-top experiment was developed and implemented in 2008. Water samples from Copco reservoir were obtained and treated with algaecides to determine the impacts on various physical water conditions (e.g., alkalinity, hardness, copper) and algal species and toxin concentration (chlorophyll-a, phaeophytin, microcystin, and algae speciation). A triplicate study was developed using 5-gallon water samples, which were treated and sample during a 20-hour period.

While the small-scale algaecide test did provide some insights into the physical condition of Copco Reservoir in August 2008, the determination of the efficacy of different algaecide treatments was inconclusive. The results from the water quality parameters analyzed were mixed. The physical water condition parameters indicated that Copco Reservoir had soft, weakly buffered water, which may not be suitable for copper-based algaecide treatments (due to the impacts that the copper may have on sensitive aquatic species). Likewise, the copper concentrations indicated that the reservoir had naturally low ambient copper concentrations. Alkalinity, TOC, and copper concentrations did not provide insights into the efficacy of the algaecide treatments during the small scale study because the efficiency of the algaecides used in the test are not affected by those parameters. The chlorophyll-a, phaeophytin, microcystin, and algal species concentrations did not provide any clear insights into the efficacy of the algaecide treatments since these concentrations were variable.

Overall, the small-scale algaecide study conducted in 2008 developed a preliminary approach to assessing algaecide efficacy. A method of sample collection was identified and a range of parameters to monitor were determined. The results from the 2008 study provided limited insight in the efficacy of the algaecides used, but did provide guidance on how to improve the overall study design and implementation.

Algaecide Pilot Study: Copco Reservoir 2008

1. Introduction

As part of PacifiCorp's ongoing reservoir management planning efforts, Watercourse Engineering, Inc. (Watercourse) undertook a brief review of algaecide applications and conducted a small-scale bench-top algaecide experiment completed in 2008. The objective of this work was to provide background information on the use of algaecides in managing water quality in reservoirs and lakes and carry out a small bench-top test with waters from Copco Reservoir to gather information on potential algaecide efficacy in project reservoirs.

1.1. Report Organization

This report is divided into seven sections listed below. Sections 2 through 4 provide the reader with background information on the impacts of algal blooms in reservoirs and lakes, historic treatment methods, and brief primer on algaecide applications and procedures. Sections 5 and 6 discuss the results from a small-scale algaecide experiment on Copco Reservoir. Section 7 includes references.

- Section 1: Introduction;
- Section 2: A brief review of algae as a nuisance in reservoirs and lakes, with examples of commonly encountered problems;
- Section 3: A primer on common types of algaecides, historic algaecide use in reservoir management, and a proposed application procedure;
- Section 4: A discussion on the use of algaecides in California, with specific focus on usage in 2006 and 2007;
- Section 5: A review and discussion of results from a small-scale pilot study of algaecide application in water samples from Copco Reservoir;
- Section 6: The overall summary and conclusions from the study; and
- Section 7: References to works cited.

In addition, there are four appendices associated with this report. The appendices provide supplemental information.

- Appendix A: Example algaecide product information and labels;
- Appendix B: Tabular volumes of various algaecide use in California in 2006 and 2007, example application methods, and general application procedures in California;
- Appendix C: The 2008 field study plan; and
- Appendix D: Phytoplankton results from the 2008 field study.

2. Background: Algae Nuisance

Although algae are a key component of aquatic ecosystems, playing a vital role in food webs and producing oxygen through photosynthesis, excessive and/or persistent phytoplankton blooms can be both a nuisance and an environmental problem. Algae can cause taste and odor problems in drinking water reservoirs; produce toxins that affect wildlife, livestock, and/or humans via contact or ingestion; present filter clogging challenges; and lower the aesthetic appeal and recreational use of surface waters. Algal blooms typically becomes more of a nuisance in eutrophic environments. The issues of taste and odor, toxins, filter and screen impediment (clogging), and aesthetics are briefly discussed below.

2.1. Taste and Odor

Algae-borne taste and odor problems largely impact drinking water supplies (lake-side odors are usually termed an aesthetic problem). The most common causes of taste and odor problems in drinking water are due to algae byproducts (or metabolites). The most common kinds of algae in lakes (e.g., blue-green algae (cyanobacteria), diatoms, green algae, chrysophytes, and dinoflagellates) can produce a wide range of compounds that can be detected by humans as definable tastes and odors (e.g., moldy, musty, fishy, flowery, etc.) (see Table 1).

Two most common taste and odor byproducts are 2-methylisoborneol (MIB) and geosmin. At least two dozen other organic compounds released by algae have undesirable taste and odor (Jenkins *et al.*, 1967; Izaguirre *et al.*, 1983; Mohren and Juttner, 1983; Slater and Blok, 1983; and Hayes and Burch, 1989). Geosmin can be detected in water at approximately 10 ng/L by the average person (Izaguirre *et al.*, 1983) and some more sensitive individuals can detect geosmin at less than 5 ng/L. Geosmin concentrations range from 2 ng/L to 200 ng/L in typical waters and have been recorded as high as 8,200 ng/L. Likewise, most people can detect MIB at approximately 30 ng/L and more sensitive individuals can detected it at approximately 5 ng/L (Izaguirre *et al.*, 1983). Attached algae species, as well as fungi and bacteria, can also produce odor causing compounds.

2.1.1. Toxins

Cyanobacteria produce toxins as secondary metabolites (Thajuddin and Subramanian, 2005) (i.e., they are not directly involved in the typical growth, development, or reproduction of organisms). Toxin production may be a means to reduce grazing pressure (from zooplankton) or serve some other function to reduce competition by other planktonic species (Carmichael, 1994); however, the specific physiological or biochemical function of toxins for the cyanobacteria are the subject of continued research (WHO, 2003). Regardless of the reason, toxin production by algae can pose health risks for humans, stock animals, pets, and wildlife.

Table 1. Taste and odor in lakes and reservoirs due to common phytoplankton species (modified from MSC (2002), Izaguirre *et al.* (1983), and Tchobanoglous and Schroeder (1985)).

Taxonomy	Taste and Odor Compound(s)*	Taste and Odor Effect Resulting From Algal Density		Other Odors
		Medium	High	
Blue-green algae				
Anabaena	Geosmin	Mold, Grass	Septic	-
Pseudoanabaena	MIB	-	Musty	Camphor
Aphanizomenon	Geosmin	Mold, Grass	Septic	-
Oscillatoria	Geosmin, MIB, Hep	Mold	Musty	Cabbage, Grass
Lyngbia	Geosmin, MIB	-	-	Aldehyde-Ketone, Cabbage, Muddy
Microcystis	Hex, Cyc	Grass, Tobacco	Septic	-
Microcystis (old)	Merc	-	Rotten	-
Diatoms				
Asterionella	Tri-Meth, Ott	Geranium	Fishy	-
Fragilaria	-	Geranium	Musty	-
Melosira	-	Geranium	Musty	-
Stephanodiscus	Tri-Meth	Geranium	Fishy	-
Synedra	Geosmin	Earthy	Musty	-
Green Algae				
Closterium	Hex	-	Grassy	-
Dictyospherium	Tri-Meth	Grassy, Nasturtium	Fishy	-
Eudorina	Tri-Meth	-	Fishy	-
Gleocystis	-	-	Septic	-
Pandorina	Tri-Meth	-	Fishy	-
Scenedesmus	Hex	-	Grassy	-
Staurastrum	Hex	-	Grassy	-
Chrysophytes				
Dinobryon	Tri-Meth, Htd	Aromatic, Fishy, Violets	-	-
Synura	Nonenal, Tri-Meth	Cucumber, Fishy-Bitter	-	-
Dinoflagellates				
Ceratium	Tri-meth	Fishy, Septic-Bitter	-	-
Glenodinium	Tri-meth	Fishy	-	-

*Key to define taste and odor compound abbreviations:

Cyc = b-cyclocitral
Geosmin = trans1, 10-dimethyl trans9-alpha-decal
Hep = heptadec-cis-ene
Htd = hepta-trans, cis 2,4,dienal
Hex = cis-3-hexane-1-ol
Merc = isopropyl mercaptan
MIB = methylisoborneal or 2-exohydroxy-2-methylboranane
Nonenal = trans-2-nonenol
Ott = Octa-trans, cis 1,3,5-triene
Tri-Meth = trimethylamine

There are three primary classes of cyanotoxins:

- Hepatotoxins, which affect the liver,
- Neurotoxins, which affect the nervous system, and
- Dermatotoxins, which affect the skin.

Cyanotoxins are found in a wide range of algae species (Table 2) (NALMS, 2007). Different organizations and agencies use different terminology for classes of toxins. The World Health Organization (WHO) (2003) identified that at least 46 species of cyanobacteria have shown to produce toxins that can affect vertebrates.

Table 2. Potential toxin producing cyanobacteria and associated toxin.

Cyanobacterial Genera	Dermatoxins			Hepatotoxins			Neurotoxins			
	LYN	APL	LPS	CYL	MC	NOD	ANA	BMAA	NEO	SAX
Colonial/Filamentous										
Anabaena	-	-	X	X	X	-	X	X	X	X
Anabaenopsis	-	-	X	-	X	-	-	-	-	-
Aphanizomenon	-	-	X	X	-	-	X	X	X	X
Aphanocapsa	-	-	X	-	X	-	-	-	-	-
Cylindrospermopsis	-	-	X	X	-	-	-	X	-	X
Fischerella	-	-	X	-	-	-	-	X	-	-
Gloeotrichia	-	-	-	-	X	-	-	-	-	-
Haplosiphon	-	-	X	-	X	-	-	-	-	-
Hyella	-	-	X	-	-	-	-	-	-	-
Lyngbya (Plectonema)	X	X	X	X	-	-	-	X	-	X
Microcystis	-	-	X	-	X	-	-	X	-	-
Nodularia	-	-	X	-	-	X	-	X	-	-
Nostoc	-	-	X	-	X	-	-	X	-	-
Oscillatoria (Planktothrix)	X	X	X	-	X	-	X	X	-	X
Phormidium	-	-	X	-	-	-	X	X	-	-
Pseudanabaena	-	-	X	-	X	-	-	-	-	-
Raphidiopsis	-	-	X	X	-	-	X	-	-	-
Schizothrix	X	X	X	-	-	-	-	-	-	-
Umezakia	-	-	X	X	-	-	-	-	-	-
Unicellular										
Synechococcus	-	-	X	-	X	-	-	X	-	-
Synechocystis	-	-	X	-	X	-	-	X	-	-

[LYN, lyngbyatoxin-a; APL, aplysiatoxins; LPS, lipopolysaccharides; CYL, cylindrospermopsins; MC, microcystins; NOD, nodularins; ANA, anatoxins; BMAA, β-N-methylamino-L-alanine; NEO, neosaxitoxins; SAX, saxitoxinsl]

Table adapted from NALMS (2007) : http://www.nalms.org/nalmsnew/nalms.aspx?subcatid=65&Sid=3

2.2. Filter and Screen Impediment

Filter run times in water treatment facilities can be directly affected by the level of primary production in water bodies. The clogging of treatment plant filters increases the cost of treatment by reducing productivity and increasing equipment costs (e.g., filter replacement). Algae can also impede flow through fish screens on irrigation intakes and conveyance through canals where mat-forming algae are entrained into diversion works.

2.3. Water Quality and Aquatic Habitat

Extensive algal growth can affect water quality and aquatic habitats. Algal blooms may reduce water clarity, increase turbidity, deplete dissolved oxygen concentrations, lead to elevated pH (in weakly buffered systems), and other undesirable water quality conditions. Algal growth can also affect aquatic habitats by inhibiting the growth of aquatic plants, providing conditions for undesirable (e.g., non-native) fish species, detrimentally impacting aquatic food webs, producing undesirable organic sediment deposition, and other factors. Water quality conditions may have direct implication on aquatic system management as well as regulatory requirements including cultural and recreational uses, navigation, endangered species, and other uses.

2.4. Aesthetics

Algae blooms can reduce aesthetic appeal of reservoirs, lakes, and rivers. Extensive algal growth can form mats or shoreline scum that are unsightly, cover the water surface, and prevent swimming and impede boating. Likewise, large algal blooms may produce offensive odors as they decompose along shorelines.

3. Algaecide in Reservoir Management

Early lake and reservoir management focused on filamentous algae, mat-forming algae, and other weeds and unwanted aquatic plants that could be readily removed from water bodies by hand. While mechanical removal is still used for certain applications, a wide range of algae control strategies have developed over the last several decades. Some examples of reservoir and lake algae management strategies are listed below (SFPUC, 2002) and include approaches such as: limiting available nutrients, providing conditions that are not favorable for algae, reducing algal populations through grazing, and direct removal or treatment.

- Hypolimnetic Aeration
- Hypolimnetic Oxygenation
- Continuous Destratification
- Extended Winter Mixing
- Fall Destratification
- Intermittent Destratification
- Hypolimnetic Mixing/Circulation
- Biomanipulation
- Wetlands/Riparian Buffer
- Watershed management
- Algae Harvesting
- Alum Treatment
- Algaecide
- Hypolimnetic Flushing
- Hypolimnetic Release
- Selective Withdrawal
- Dilution
- Blending
- Reservoir Operation Restriction

Although comprehensive lake management strategies to reduce algal populations or manage algae for specific more desirable species usually include a suite of prescriptions, the rest of this report will focus on algaecides.

3.1. Algaecide Types

Algaecide application has been identified as a tool to control nuisance algae (Holdren *et al.*, 2001). In the 1900s, algaecides were developed that used chemicals (usually some form of copper) and were intended to specifically target plants. More recently, oxidizer algaecides that utilize hydrogen peroxide to rupture the cell walls of the algae have been developed.

Algaecides can provide a rapid removal of algae from the water column, sometimes resulting in dramatic short-term changes in water clarity. In certain cases, algaecides are applied at least once annually, but usually are reapplied in response to weather, operations, and algal conditions to prevent or reduce algal blooms throughout the growth season. Algaecides kill algae either by direct toxicity or through metabolic interference (Wagner, 2004). Algaecides fall into four major categories: natural, copper-based, synthetic organic, and oxidizers. The four types of algaecides discussed below are summarized in Table 3, including their mode of actions, advantages and disadvantages, and example products.

3.1.1. Natural Algaecides

Natural algaecides are allelopathic chemicals (i.e., chemicals that inhibit the growth of a plant that are naturally released by a different plant). The efficacy for natural algaecides is typically more gradual than other types of algaecides, allowing the system to accommodate increased oxygen demand associated with algal mortality upon application.

An example of a natural algaecide is barley straw. For small, shallow systems (e.g., farm ponds and similar sized reservoirs and lakes), barley straw is relatively inexpensive, but the successful use of barley straw as an algaecide may be linked with uncontrollable water chemistry factors (Wagner, 2004). There has not been extensive, consistent, or conclusive tests using barley straw as an algal management technique. Barley straw is not amenable to large scale applications, due to cost, maintenance, potential stratification, and other factors.

3.1.2. Copper Based Algaecides

Copper has been a known biocide of marine and freshwater organisms for hundreds, even thousands, of years. Egyptians recognized copper could control marine encrustations on ship hulls over 2,000 years ago, and as early as the 1600's, copper sheathing of marine vessels was a common way to prevent or decrease fouling of ship hulls (Richardson, 1997).

Copper-based algaecides affect algae in a variety of ways; as a cellular toxicant that may affect photosynthesis, nitrogen metabolism, and membrane transport (Wagner, 2004). Copper-based algaecides have been approved for a wide range of water bodies (including drinking water sources) and are effective for rapid control of many algae species. Copper based treatments also tend to inhibit rapid repopulation of algae, particularly chelated forms, which tend to contain less copper than copper sulfate. However, copper-based algaecides can be toxic to aquatic fauna, such as zooplankton, depending on the concentration of algaecide and the species in question. Further, copper-based algaecides

can be less effective in alkaline waters or at colder temperatures, although chelated forms perform better. Long-term use of copper-based algaecides may allow the accumulation of copper within aquatic systems and some algae have been shown to become resistant to copper-based algaecides (Wagner, 2004; García-Villada *et al.*, 2004). Copper treatment can be species specific at selected dosages, meaning that application of these algaecides will kill only certain algae species within the treatment area if applied properly.

3.1.3. Synthetic Organic Algaecides

Synthetic organic algaecides are absorbed by algae and contain "membrane active" chemicals that disrupt algae metabolism. These treatments are typically fast acting and are useful when copper based algaecides are ineffective. Limitations of synthetic organic algaecides include extended periods of restricted water use after application and the fact that they are non-selective (and possibly toxic to other desirable aquatic fauna) (Wagner, 2004). This can make synthetic organic algaecides inappropriate for some situations. Toxicity to zooplankton or other grazers reduces or removes an effective natural control method of algae loss in aquatic systems.

3.1.4. Oxidizer Algaecides

Oxidizer algaecides kill algae by rupturing the cell membranes; however, oxidizers can also disrupt other cellular functions. Oxidizer algaecides (typically in the form of sodium carbonate peroxyhydrate) can be applied in a selective manner to only affect blue-green algae, leaving other forms of algae in the system to produce oxygen via photosynthesis. Oxidizer algaecides can be used in conjunction with copper-based algaecides, especially in locally targeted areas such as algae mats. Oxidizer algaecides work quickly and are non-persistent in the system (Solvay Chemicals, 2005). However, oxidizer algaecides are relatively new and do not have the extensive application histories that copper-based algaecides have.

Table 3. Types of algaecides and the associated advantages and disadvantages.

Algaecide Type		Natural	Copper-Based	Synthetic Organic	Oxidizer
Mode of Action		Allelopathic	Inhibits photosynthesis, nitrogen metabolism and membrane transport	Disrupts algae metabolism	Ruptures the cell membranes and disrupts most cell functions
General Advantages	Low Cost	X	-	-	-
	Gradual effect	X	-	-	-
	Effective when Copper is not effective	-	-	X	-
	Fast acting	-	X	X	X
	Controls wide range of algae	-	X	-	-
	Approved for differing water bodies	-	X	-	X
	Can be used with copper based algaecide	-	-	-	X
	Non persistent	-	-	-	X
	Selective	-	-	-	X
General Disadvantages	Inconsistent results	X	-	-	X
	Limited to small bodies of water	X			X
	Not registered in CA as algaecide	-	-	-	-
	Restricts water body use after application	-	-	X	-
	Non-selective	-	-	X	-
	Not affective on all algae types	-	-	X	-
	Can be toxic to aquatic fauna	-	X	X	-
	Can be ineffective at cold temperatures	-	X	-	-
	Long-term use results in accumulation	-	X	-	-
	Some algae show resistance	-	X	-	-
	Limited testing/history	-	-	-	X
Example Products		Barley Straw	Algimycin PWF; Captain; Copper Sulfate Crystals; Cutrine Plus; Cutrine Ultra	Hydrothol 191	GreenClean PRO; PAK-27; Phycomycin

3.2. Potential Algaecide Effects

Use of any algaecide may cause several after- treatment effects. The initial effect is decreased algal productivity due to treatment. Depending on the chemical and application methodology, effects may occur rapidly or over a longer period of time. For

example, oxidizer treatments work rapidly (e.g., minutes), while copper will produce a toxic effect over a period of hours and even days.

Following a treatment, increased algal mortality leads to increased organic matter within the water body and can impart a dissolved oxygen demand on the system that, if not carefully considered, can lead to an undesirable depression in dissolved oxygen. This can affect surface waters as well as contribute to near-sediment anoxia, which can lead to nutrient release and other non-desirable effects. For example, as algae die and their cells rupture, nutrients contained within the algae may be released into the water column. The result could be an increase in nutrient concentrations, which can lead to additional algal growth (AERF, 2005). Similarly, as algae die and their cells rupture, toxins contained within the algae can be released into the water, leading to higher concentrations of toxins in the water body.

As noted previously, long-term application of certain algaecides can result in a build-up of product ingredients. Some products are inert, but others, such as copper-based products, can result in a long-term accumulation of copper in the treated system. Treatments are generally carefully designed to minimize undesirable effects. Strategies include treating different areas of a reservoir or lake at different times, location specific treatments that target blooms, implementing a seasonal program that is aimed at managing bloom conditions throughout the growth season, using different algaecides depending on conditions (e.g., targeting specific species), and using algaecides in combination with different reservoir prescriptions to attain desired results.

3.3. Algaecide Product Information

Algaecide products generally come with comprehensive instruction on handling, application, storage, and disposal. Material safety sheets and appropriate and inappropriate uses are provided. Important details to note for any algaecide application are the active ingredient, the target algae species (i.e., which type of algae it should be used on), the appropriate dose, the response time that can be expected, and any restrictions on water use after application, including the amount of time before those restrictions are lifted. Other important information that can be found from the product label and accompanying information includes whether the algaecide can be used to selectively target algae types (planktonic (suspended), filamentous (mat forming), etc.) or species, if the algaecide can be used in a preventative manner, what the ideal application conditions are, the length of the reapplication waiting period, any undesirable effects the algaecide could have on the water system, any physical or chemical conditions of the water that can affect the effectiveness of the algaecide, and if there are any byproducts created from the use of the algaecide. The types of information given above are necessary to determine if an algaecide is appropriate for use in a particulate water system, in a particulate situation, or as part of a specific algae management plan.

Example algaecide product information and example product labels are presented in Appendix A.

3.4. Proposed Application Procedure for Algaecide Use

Prior to algaecide application a planned procedure and approach should be developed. The manufacturer or other lake management professional can provide guidance on developing an application plan that will be cost effective, safe, and provide the desired result. Some elements of a plan should include a pre-application survey, defining the application method, and completing a post application survey to determine efficacy. These elements are outlined below.

3.4.1. Pre-Application Survey

A pre-application survey by staff ecologists or limnologists should be completed to identify the type of algae present and locations of accumulations. Blooms can be mapped using GPS with GIS integrated technology. Mapped areas are prioritized for treatment based on the needs/direction of the reservoir manager or similar entity. The largest, densest, and most recreationally utilized areas are generally selected for treatment. Algae and water quality sampling occur to quantify conditions and calculate appropriate pesticide dose and preferred method of application. Meteorological conditions are noted to determine if conditions for application are consistent with manufacturer recommendations.

3.4.2. Application Method

Following the detailed instructions given for the various algaecides on their labels, a general procedure for application of algaecides is formed. Algaecides should be applied to water bodies on warm or hot days. (The hydrogen peroxide based algaecides should be applied, preferably during an earlier part of the day, to allow for the remaining plants in the system to produce oxygen and decrease the impact of the dead algae oxygen demand on the system.) To prevent an excessive oxygen demand on the system, the entire water body should not be treated at once.

Algaecides should be applied in a uniform manner. There are several methods of application which attempt to provide uniform distribution of the algaecide, but not all are applicable to all forms or types of algaecide. For example, oxidizer algaecides should not be mixed with water prior to application. The more common methods of algaecide application include:

- Surface Application[1]: Spraying a diluted mixture of algaecide from the shore or a boat evenly across the surface of the water.
- Subsurface Application: In deeper water, the algaecide is applied through a weighted hose or other sub-surface delivery system to concentrate application where the greatest concentration of algae is present.

[1] Surface application is the most likely method to be used in treating reservoirs like Iron Gate and Copco. Additional information regarding two types of surface application methods are presented in Appendix B.2.

- Polymer Application: A polymer may be added to certain algaecides to improve sinking and deposition and minimize loss (e.g., due to spraying). Prior to using a polymer, consult the manufacturer's recommendations regarding the use of a polymer for improved algae control.
- Aircraft Application: Algaecide is applied as a spray from aircraft (e.g., plane or helicopter). Prior to application of an algaecide using aircraft, consult the manufacturer to determine desired rates given drift control or sinking agents. When treating moving water, apply the spray solution counter to the direction of flow.
- Drip System Application: For application of algaecide in irrigation conveyance systems and other moving water.

3.4.3. Post Application Survey

Ecologists or limnologists revisit the sites previously recorded and implement the same algae and water quality sampling protocols as the pre-application monitoring. Data are recorded for each plant species present and later analyzed for management effectiveness. If new, resistant, and/or re-colonized areas of filamentous algae are found during this survey, application specialists perform additional applications (subject to the restrictions listed on the product labels).

4. Algaecide Usage in California

4.1. 2006 and 2007 California Algaecide Usage

The California Department of Pesticide Regulation's California Pesticide Information Portal (CalPIP) retains the records of all reported pesticide use (including algaecides) in the state of California by county. A search of the CalPIP database for algaecides usage in different types of aquatic areas in 2006 and 2007 found several registered algaecide products. A total of four types of aquatic areas were identified, but only two areas yielded registered projects that were appropriate for use in a lake or reservoir.

A review of registered algaecides indicates that copper sulfate is the most prevalent in terms of pounds of product applied, with well over 200,000 pounds of chemical applied in both years (Table 4). Product name, active ingredient, pounds of product used, and pounds of chemical (i.e., active ingredient) applied by county in each year are presented in Appendix B.

Some of these algaecides have other registered uses, such as a herbicide, and many are used for other aquatic plant growth control in other types of sites. Other algaecides were also found in the database, but they were not appropriate for use in lakes and reservoirs with wildlife because either their active ingredient was chlorine, which is detrimental to fish and other wildlife, or because the environmental hazards listed for the algaecide were unacceptable for use in lakes and reservoirs with wildlife.

Some of the algaecide usage reported was for some inactive algaecides. Active and inactive registered algaecides can be used in California, but there are important

differences in the extent of their use. Active status refers to products that are currently registered for sale in California. Products must be "actively registered" for the registrant (seller) to ship the product to California, to sell the product in the state, or to distribute the product to retailers in California. An inactive registration status indicates that the registrant has let the registration lapse and as a result the registrant is not allowed to bring additional product into California after the inactivation date. However, retailers and distributors who still have the product in stock and that purchased the product while it was still active may still sell the product for 24-months after the last date of registration (the inactivation date). Also, any person or business that purchased the product while it was actively registered or while it was being sold for the 24-months after the inactivation date may still use the product until their inventory has been exhausted (pers. comm. E. Mahoney, California Department of Pesticide Regulation).

Table 4. Pounds of chemicals that are appropriate for lakes and reservoirs with wildlife usage, as applied in California in 2006 and 2007.

Active Ingredient	Year 2006		Year 2007	
	lbs./year	Percent	lbs./year	Percent
Copper Carbonate, Basic	4,312	2.0%	291	0.1%
Copper Ethanolamine Complexes (Mixed)	1,979	0.9%	2,135	0.9%
Copper Sulfate (Basic)	1,036	0.5%	1,755	0.8%
Copper Sulfate (Pentahydrate)	210,001	96.4%	223,199	96.0%
Endothall, Mono [N,N-Dimethyl Alkylamine] Salt	549	0.3%	1,228	0.5%
Sodium Carbonate Peroxyhydrate (Oxidixer)	14	0.0%	3,841	1.7%
Annual Total	217,891	-	232,449	-

4.2. Application in California

Any algaecide considered for use in reservoirs in California must be registered with the State of California as an algaecide. The California department of Pesticide Regulation keeps detailed records of algaecides registered within the state (CALPIP).

Two types of pesticides (which include algaecides) are classified by California: restricted use pesticides and non-restricted use pesticides. The algaecides reviewed herein are not classified as restricted use pesticides and therefore can be applied without hiring a certified pesticide applicator or obtaining a pesticide application permit[2]. Additional information regarding the pesticide classification system can be found in Appendix B.

Pest control in California is also classified into two groups: non-agricultural and agricultural use. Non-agricultural use includes home, industrial, institutional, and structural vector control and veterinarian pest control. Agricultural use is broken into two types: production and non-production use. While production agricultural pest control is any use of pest control to produce an agricultural animal or plant product, non-production agricultural pest control is defined as the use of pest control on any area not specifically listed in the non-agricultural class. For California, this includes watersheds, parks,

[2] Certification classifications for algaecides may change over time and prior to application; the status of the algaecide to be used should be verified prior to application.

recreation areas, and landscaped areas that are not covered by the specific definitions of home and institutional pest control.

Additional information regarding pesticide (e.g., algaecide) application in California is presented in Appendix B. Please note that prior to any algaecide application, the status of the algaecide, permit requirements, and application procedures should be reviewed. The information included in Appendix B is meant to serve as an example only and not as a definitive guide on the requirements and procedures.

5. Copco Reservoir Algaecide Field Test

5.1. Introduction

Copco Reservoir is located near the California-Oregon border (about one mile south of the border) and 15 miles west of Interstate 5. Copco Dam is approximately 9 river miles upstream of Iron Gate Dam and 25 river miles downstream of JC Boyle Dam. The reservoir is approximately 5 river miles long (Figure 1), with an east-to-west flow direction. Klamath River inflows to Copco reservoir are on the order of 1,000 cfs in the summer (tributary inflows are minor during this time). Copco Reservoir has a capacity of approximately 40,450 acre-feet (~13,180 million gallons) (Eiler, 2005). During peak stratification, surface water temperatures are in the mid-20°C range, while waters at the bottom of the reservoir range from approximately 10 to 14°C.

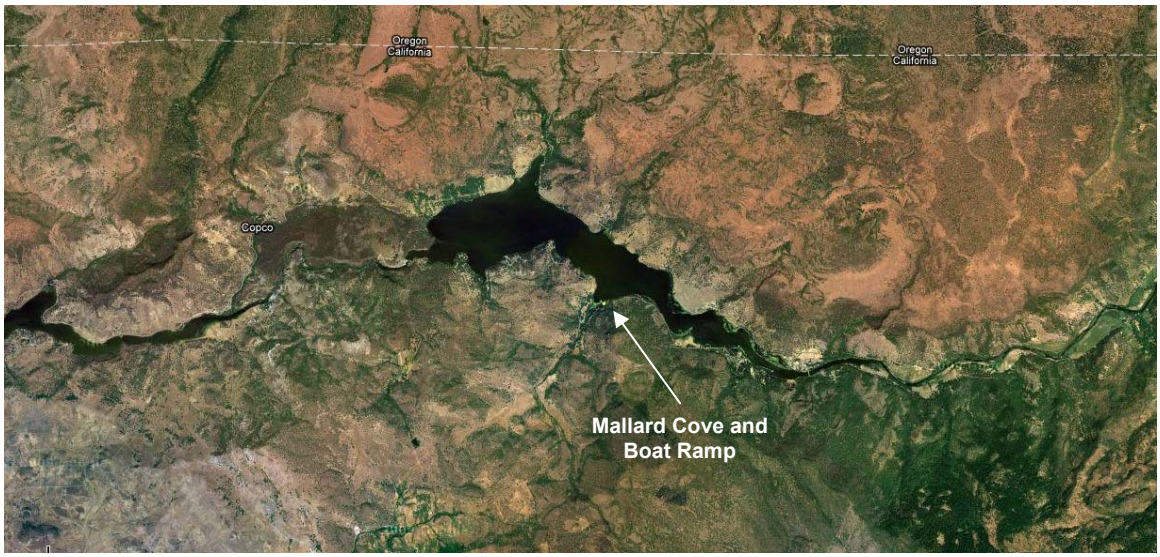

Figure 1. Copco Reservoir (from Google Maps).

Copco Reservoir experience seasonal stratification and summer period algal blooms. The inflow into the reservoir from the Klamath River has a considerable nutrient load (nitrogen and phosphorus) throughout the summer period, contributing to algae bloom conditions. Typical dominant summer season algae species present in the reservoir include *Aphanizomenon flos-aquae* (not a toxin producing form) and toxin-producing *Microcystis aeruginosa* (Moisander, 2008) and *Anabaena flos aquae* (Raymond, 2009). Other prevalent species include *Cryptomonas erosa*, *Rhodomonas minuta*, *Chlamydomonas sp.*, *Ankistrodesmus falcatus*, *Nitzschia palea*, *Chromulina sp.*,

Cocconeis placentula, *Melosira granulate*, *Cyclotella meneghiniana*, *Glenodinium sp*., *Sphaerocystis schroeteri*, *Fragilaria construens*, and *Nitzschia frustulum,* (Raymond 2009). While not all of the prevalent species are discussed in Table 1, some of the species listed above are known to produce noticeable odors that range from grassy to fishy to musty or rotten/septic. In addition to the aesthetic issues associated with algal blooms, the reservoir has been posted with public health warnings. One potential algal management strategy is to treat the reservoir with an algaecide. Algaecide treatments have been previously used in California (see previous section), but have not been used in Copco Reservoir specifically. Prior to implementing a treatment program, a bench top study was designed to assess the efficacy of three types of algaecides on target algal species.

5.2. Study Purpose and Methodology

The purpose of the algaecide test was to determine the effectiveness, on a small scale, of the newer hydrogen peroxide-based algaecides compared to a copper-based algaecide. One copper algaecide (Algimycin PWF) and two hydrogen peroxide algaecides (GreenClean PRO and PAK-27) were used for the study. The study was conducted in August of 2008, using water samples obtained from boat dock in Mallard Cove (water depth near the boat dock is approximately 1.5 meters of water). Water was pumped from 0.5 meter depth (about 1/3rd of the water column) into a 55-gallon drum located onshore. Water was continuously circulated within the drum using a small submersible pump while filling four 5-gallon containers to ensure a mixed sample. This process was repeated for each of the three sample sets (i.e., the experiment was carried out in triplicate) and samples transported to an off-site facility for processing over a two-day period. The samples were drawn from the reservoir on August 24, 2008 and the study occurred on August 24, 2008 and August 25, 2008.

Physical measurements and water samples for different constituents were collected from each test containers at different times in during the experiments to determine the change in water quality and algae status over time after product application. Each replicate consisted of four containers. One container each was designated Control, Algimycin PWF, PAK-27, or GreenClean PRO. The water samples were analyzed for alkalinity, hardness, total organic carbon (TOC), copper, microcystin, chlorophyll-a, phaeophytin[3], and algal species (note that not all tests were performed on all water samples). A total of 29 water samples were collected during the experiment.

The first water samples were collected prior to algaecide application. Three water samples (one from each of the control containers) were collected and analyzed for alkalinity, hardness, total organic carbon (TOC), copper, microcystin, chlorophyll-a, phaeophytin, and algal species. Then, the appropriate dosage/application rate for Algimycin PWF, GreenClean PRO, and PAK-27 (Table 5) were added to the appropriate containers. Approximately two hours after treatment, samples were collected from each container (including the control containers) to measure microcystin, chlorophyll-a, phaeophytin, and algal species. Approximately 19-hours after treatment, the containers

[3] Phaeophytin is also referred to as pheophytin or pheophytin-a or pheo.

were again sampled for analysis of TOC, copper, microcystin, chlorophyll-a, phaeophytin, and algal species.

A sub-experiment was conducted on one set of the GreenClean PRO and PAK-27 containers. After the second post-treatment samples were obtained, a second application of GreenClean PRO and PAK-27 occurred. This occurred approximately 20-hours after the initial algaecide application. One hour after the second application (approximately 21 hours after the initial algaecide application), microcystin samples were collected from those two containers. See Table 6 and Table 7 for the treatment and sampling schedule, respectively. The field study plan is presented in Appendix C.

Table 5. Dosage and application rates for Algimycin PWF, GreenClean PRO, and PAK-27.

Product	Active Ingredient Concentration	Recommended Application Rate	Application Rate per Gallon	Application Rate per Container
Algimycin PWF	0.25 ppm Cu	1.33 gal / acre-ft	0.54 drops*	3 drops*
GreenCleanPRO	5 ppm H2O2	50 lb / acre-ft	69.6 mg	348 mg
PAK-27	5 ppm H2O2	50 lb / acre-ft	69.6 mg	348 mg

*Algimycin PWF was measured using an 1.6 mL plastic dropper (35 drops). The application rate was approximately 0.0155 mL per gallon, which is approximately 0.54 drops per gallon or 3 drops per 5 gallons.

Table 6. Treatment method and schedule.

Treatment Method	Treatment Time, Hours	
	t = 0	*t* = 20
Control	-	-
Algimycin PWF	x	-
GreenClean PRO	x	x
PAK-27	x	x

Table 7. Sample collection and analysis schedule.

	Control				Algimycin PWF				GreenClean Pro				PAK-27			
	Time, hours				Time, hours				Time, hours				Time, hours			
	0	2	19	21	0	2	19	21	0	2	19	21	0	2	19	21
Alkalinity	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hardness	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOC	x	-	x	-	-	-	x	-	-	-	x	-	-	-	x	-
Copper	x	-	x	-	-	x	x	-	-	-	x	-	-	-	x	-
Microcystin	x	x	x	-	-	x	x	-	-	x	x	x	-	x	x	X
Chloraphyll-a	x	x	x	-	-	x	x	-	-	x	x	-	-	x	x	-
Phaeophytin	x	x	x	-	-	x	x	-	-	x	x	-	-	x	x	-
Algae Species	x	-	x	-	-	-	x	-	-	-	x	-	-	-	x	-

5.3. Results

The containers were sampled up to four times ($t = 0$, $t = 2$ hours, $t = 19$ hours, and $t = 21$ hours). The $t = 0$ sampling represents the pre-treatment or initial water conditions. Only the control containers were sampled at $t = 0$. For the $t = 2$ hours (immediately after treatment) and $t = 19$ hours (post-treatment), all twelve containers were sampled. The final sampling occurred at $t = 21$ hours and only the GreenClean PRO and PAK-27 containers were sampled.

A total of twenty-nine water sample sets were collected. The water samples were analyzed for alkalinity, hardness, total organic carbon, copper, microcystin, chlorophyll-a, phaeophytin, and algae species or some combination thereof. All water samples were analyzed for microcystin, chlorophyll-a, and phaeophytin. Alkalinity, hardness, total organic carbon, and copper were only collected during selected periods (e.g., pre-treatment and/or post-treatment) as noted below.

Alkalinity and hardness water analysis for control containers prior to treatment ($t = 0$) are presented in Table 8. The results represent the milligrams of calcium carbonate present per liter of sample water.

TOC, copper, chlorophyll-a, phaeophytin, and microcystin analyses are presented in Table 9. TOC was only analyzed in the pre-treatment control containers and in all twelve containers at the post-treatment ($t = 19$ hours) samples. Copper was analyzed in the pre-treatment control containers, the immediately post-treatment ($t = 2$ hours) Algimycin PWF containers and in twelve post-treatment ($t = 19$ hours) containers to ensure no contamination.

Average TOC, copper, microcystin, chlorophyll-a, and phaeophytin concentrations for each water sample (i.e., the three control container results for the immediately post-treatment ($t = 2$ hours) were averaged) are presented in Table 10.

Average density (number of cells per milliliter of water sample) of algae species are presented in Table 11. The water samples were analyzed prior to treatment ($t = 0$) (control containers only) and post-treatment ($t = 19$ hours) (all containers). The results are averaged (e.g., the three GreenClean PRO container results were averaged) and then presented based on six different algae species groups (blue-green, chrysophyte, cryptophytes, diatom, dinoflagellate, and green). Three specific types of blue-green algae were present (*Aphanizomenon flos-squae, Microcystis aeruginosa,* and *Anabaena flos-aquae*).

Figure 2 through Figure 4 present the measured chlorophyll-a, phaeophytin, and microcystin concentrations for each treatment method and control during the course of the experiment.

Table 8. Alkalinity and hardness in the control containers prior to treatment (*t* = 0).

Sample ID	Sample Date	Sample Time	Algaecide	Alkalinity (mg CaCO3/L)	Hardness (mg CaCO3/L)
CRA8001	8/24/2008	17:25	Control	61	46.6
CRA8002	8/24/2008	17:30	Control	61	49.1
CRA8003	8/24/2008	17:35	Control	61	48.2
			Average	61	48.0

Table 9. TOC, copper, microcystin, chlorophyll-a, and phaeophytin results.

Sample ID	Sample Date	Sample Time	Algaecide	*t*	TOC (mg/L)	Copper (µg/L)	Microcystin (µg/L)	Chlorphyll-a (µg/L)	Phaeophytin (µg/L)
CRA8001	8/24/2008	17:25	Control	0	7.5	*	20.3	25.83	6.41
CRA8002	8/24/2008	17:30	Control	0	6.8	*	18.55	15.55	3.83
CRA8003	8/24/2008	17:35	Control	0	7.1	*	13.34	10.28	2.01
CRA8004	8/24/2008	19:30	Control	2	-	-	17	12.08	1.38
CRA8005	8/24/2008	19:30	Control	2	-	-	20.76	23.73	6.44
CRA8016	8/24/2008	19:30	Control	2	-	-	14.53	8.01	1.75
CRA8013	8/24/2008	20:30	Algimycin PWF	2	-	368	24.55	15.45	3.65
CRA8025	8/24/2008	21:00	Algimycin PWF	2	-	401	19.75	32.68	11.66
CRA8014	8/24/2008	21:30	Algimycin PWF	2	-	394	20.39	29.79	8.32
CRA8010	8/24/2008	20:30	GreenClean PRO	2	-	-	19.13	52.74	11.29
CRA8022	8/24/2008	21:00	GreenClean PRO	2	-	-	23.69	33.03	8.21
CRA8011	8/24/2008	21:30	GreenClean PRO	2	-	-	2.28	27.28	6.91
CRA8007	8/24/2008	20:30	PAK-27	2	-	-	17.62	8.11	2.49
CRA8019	8/24/2008	21:00	PAK-27	2	-	-	17.6	23.41	5.96
CRA8008	8/24/2008	21:30	PAK-27	2	-	-	2.38	16.41	4.91
CRA8017	8/25/2008	12:15	Control	19	7.1	*	21.95	47.05	11.03
CRA8006	8/25/2008	12:45	Control	19	7.2	*	17.86	46.5	11.29
CRA8018	8/25/2008	13:15	Control	19	7.7	*	15.39	31.72	7.42
CRA8026	8/25/2008	12:20	Algimycin PWF	19	9.6	374	19.22	65.86	15.57
CRA8015	8/25/2008	12:45	Algimycin PWF	19	7.9	378	21.06	23.65	6.37
CRA8027	8/25/2008	13:15	Algimycin PWF	19	9	416	12.59	14.74	6.61
CRA8023	8/25/2008	12:20	GreenClean PRO	19	7.1	*	2.45	27.91	4.89
CRA8012	8/25/2008	12:45	GreenClean PRO	19	7.2	*	23.47	43.32	9.64
CRA8024	8/25/2008	13:15	GreenClean PRO	19	7	*	2.29	31.87	9.23
CRA8020	8/25/2008	12:20	PAK-27	19	7.1	*	18.59	41.22	8.98
CRA8009	8/25/2008	12:45	PAK-27	19	7.3	*	2.06	11.9	3.22
CRA8021	8/25/2008	13:15	PAK-27	19	7.1	*	2.27	19.19	4.32
CRA8031	8/25/2008	14:00	GreenClean PRO	21	-	-	35.59	-	-
CRA8028	8/25/2008	14:00	PAK-27	21	-	-	24.99	-	-

* Copper concentrations were reported by CH2MHill Laboratories, but the reported values are below the reporting limit (RL) and therefore are not reported herein.

A dash (-) indicates that water samples were not analyzed for that constituent/parameter.

Table 10. Average TOC, copper, microcystin, chlorophyll-a, and phaeophytin results by sampling period (t = 0, 2, 19, and 21).

Sample Date	Sample Time	Algaecide	*t*	TOC (mg/L)	Copper (µg/L)	Microcystin (µg/L)	Chlorphyll-a (µg/L)	Phaeophytin (µg/L)
8/24/2008	17:35	Control	0	7.1	*	17.4	17.2	4.1
8/24/2008	19:30	Control	2	-	-	17.4	14.6	3.2
8/24/2008	21:30	Algimycin PWF	2	-	-	21.6	26.0	7.9
8/24/2008	20:30	GreenClean PRO	2	-	-	15.0	37.7	8.8
8/24/2008	21:30	PAK-27	2	-	-	12.5	16.0	4.5
8/25/2008	12:15	Control	19	7.3	*	18.4	41.8	9.9
8/25/2008	13:15	Algimycin PWF	19	8.8	389.3	17.6	34.8	9.5
8/25/2008	12:20	GreenClean PRO	19	7.1	*	9.4	34.4	7.9
8/25/2008	13:15	PAK-27	19	7.2	*	7.6	24.1	5.5
8/25/2008	14:00	GreenClean PRO	21	-	-	35.6	-	-
8/25/2008	14:00	PAK-27	21	-	-	25.0	-	-

* Copper concentrations were reported by CH2MHill Laboratories, but the reported values are below the method detection limit (MDL) and therefore are not reported herein.

A dash (-) indicates that water samples were not analyzed for that constituent/parameter.

Table 11. Algal speciation results, averaged by treatment type.

	Average Density at Sampling Time				
	***t* = 0 hours**	***t* = 19 hours**			
	Control	**Control**	**Copper**	**GreenCleanPRO**	**PAK-27**
Total Density (#/mL):	**1671**	**1738**	**1344**	**1295**	**1319**
Trophic State Index:	47.0	48.3	46.1	46.7	49.5
# of species	13	14	13	17	12
Blue-green density, #ml	**295**	**486**	**176**	**230**	**303**
Aphanizomenon flos-aquae	140	273	62	111	107
Microcystis aeruginosa	137	171	114	119	196
Anabaena flos-aquae	18	43	0	0	0
Total other algal groups, density, #/ml	**1364**	**1200**	**1164**	**1050**	**1014**
Chrysophyte Density, #ml	168	199	97	52	53
Cryptophyte Density, #ml	164	197	25	64	40
Diatom Density, #ml	724	684	905	801	790
Dinoflagellate Density, #ml	0	18	8	0	3
Green Density, #ml	307	103	130	134	128

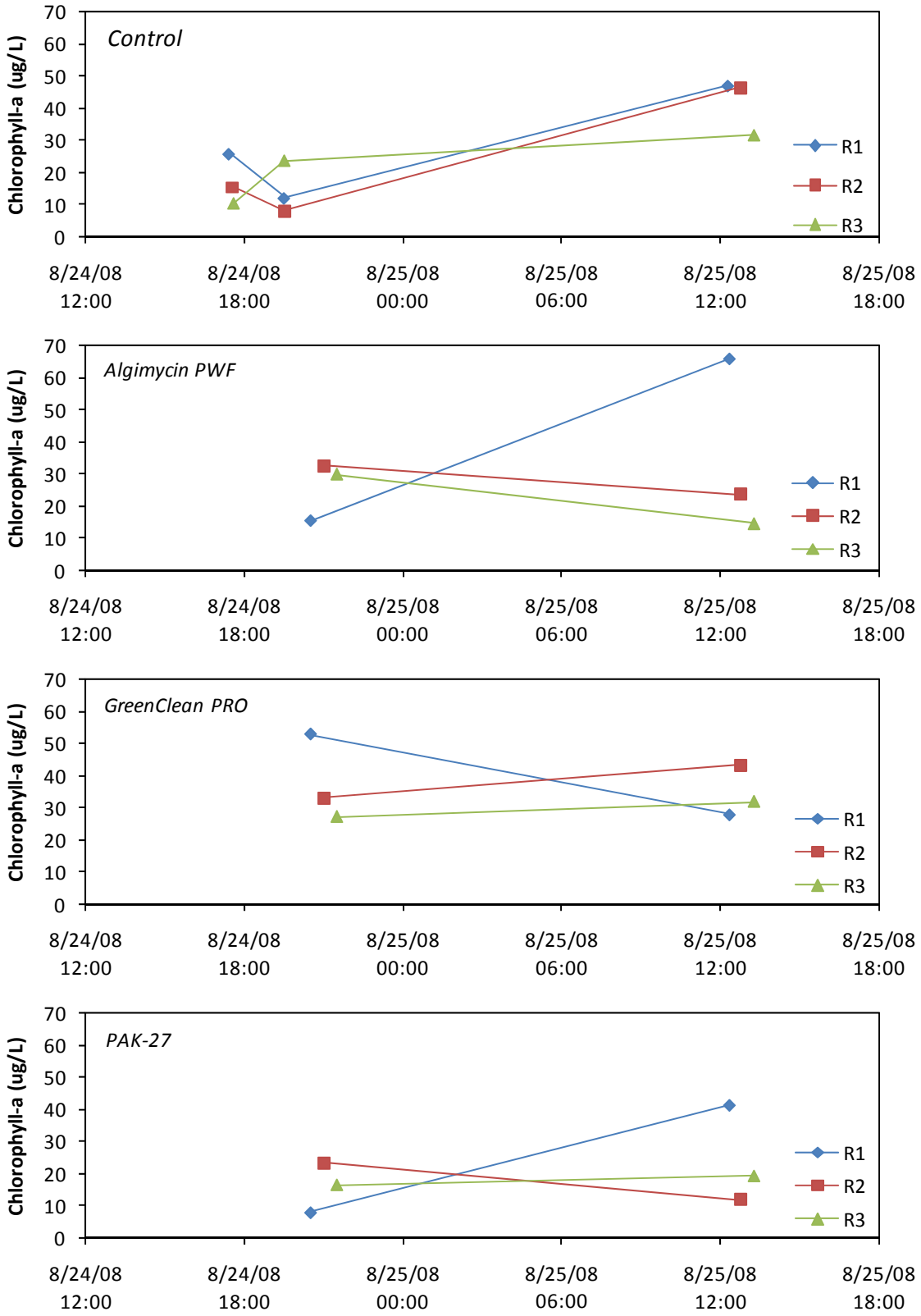

Figure 2. Chlorphyll-a concentrations for different algaecide tests over time. Each line represents the results from one of the replicate containers (i.e., R1 is the first container, R2 is the second container, and R3 is the third container for that algaecide treatment or control).

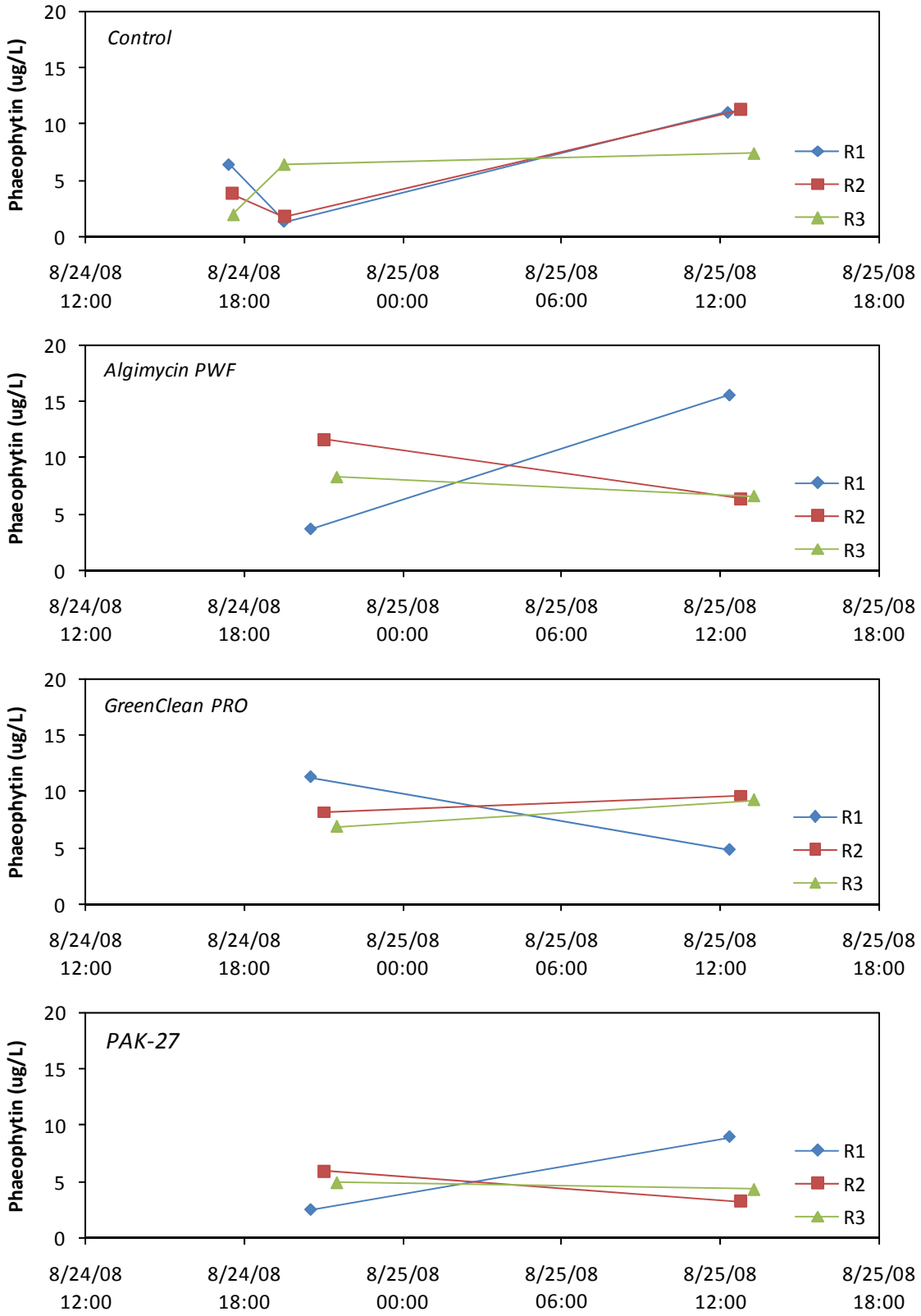

Figure 3. Phaeophytin concentrations for different algaecide tests over time. Each line represents the results from one of the replicate containers (i.e., R1 is the first container, R2 is the second container, and R3 is the third container for that algaecide treatment or control).

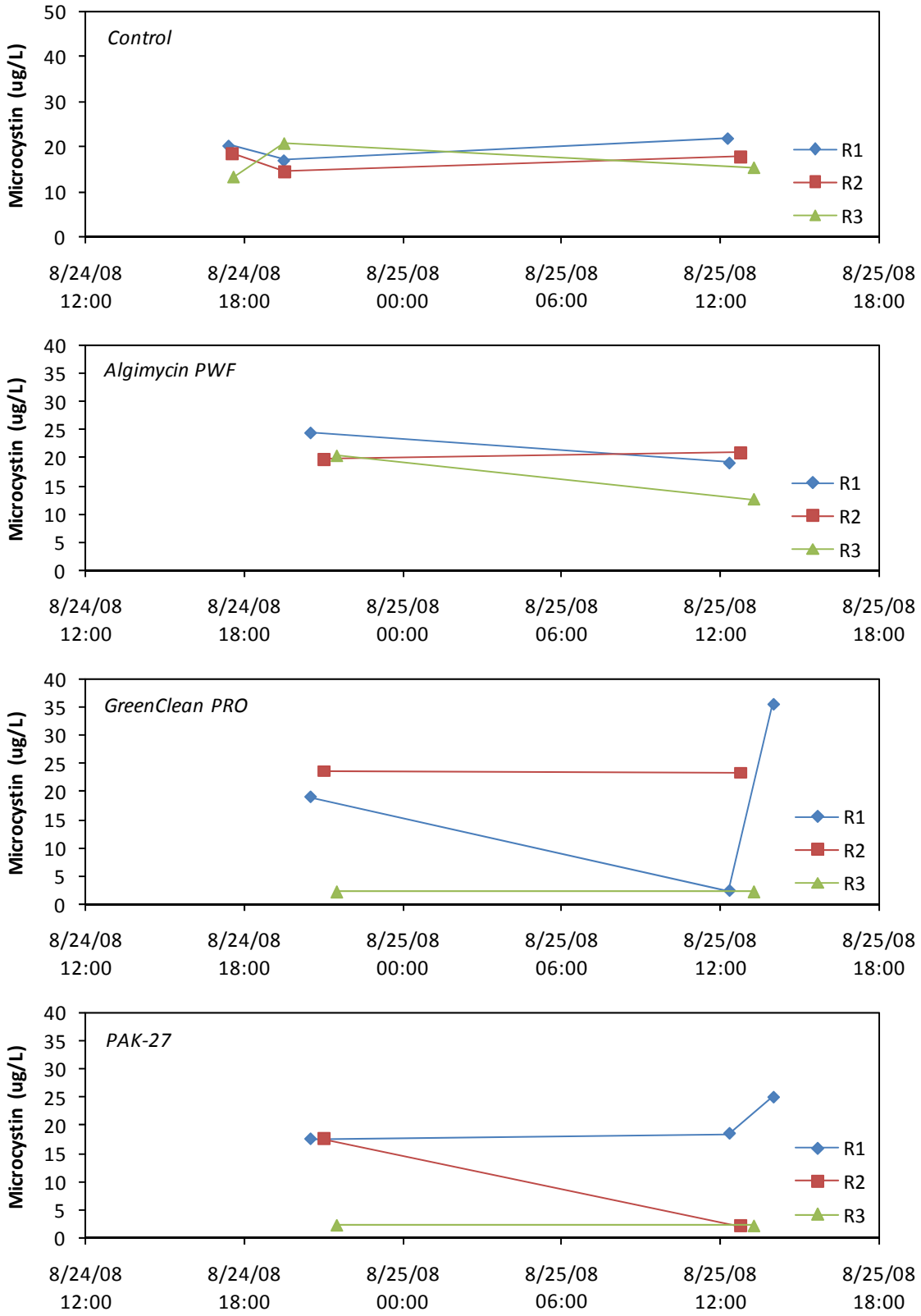

Figure 4. Microcystin concentrations for different algaecide tests over time. Each line represents the results from one of the replicate containers (i.e., R1 is the first container, R2 is the second container, and R3 is the third container for that algaecide treatment or control).

5.4. Discussion

The control containers were sampled prior to treatment as a means of determining the initial water quality. The control containers were assumed to be representative of all water samples and as such the other containers were not sampled prior to treatment. The reservoir water sampling procedure (see Appendix C) was designed to yield 12 similar water samples.

5.4.1. Alkalinity and Hardness

Alkalinity and hardness were only measured once during the study period (prior to treatment in the three control containers). The alkalinity was the same within the three containers, while hardness exhibited minor variations. As stated previously, the hardness and alkalinity values indicate that Copco Reservoir had soft, weakly buffered waters (Table 8). The type of water (e.g., soft, hard, etc.) can impact which types of algaecide treatments can or should be used. For example, Algimycin PWF (copper) is designed to be used on waters with hardness values of greater than 50 mg/L to avoid potential toxicity to sensitive fish species (e.g., trout, goldfish, koi); because Copco Reservoir waters had hardness values at the 50 mg/L lower limit, additional sampling would be required to determine if the hardness changed with time, depth, and/or location. Additionally, assessment of presence or absence of sensitive fish species within the treatment areas (both spatially and within the water column) would be appropriate.

5.4.2. Total Organic Carbon

Total organic carbon (TOC) is the amount of carbon bound to organic matter within the water and it generally comes from growth and decaying of organic matter in the water. TOC was measured in the pre-treatment control containers ($t = 0$) and in the post-treatment ($t = 19$) containers. Between the replicates, there was variability in the TOC values (i.e., no three containers of the same type had the same TOC concentrations), but overall the control, GreenClean PRO, and PAK-27 containers had similar TOC concentrations both among themselves (i.e., comparing the three replicates) and between the treatment methods (e.g., comparing the control containers with the GreenClean PRO containers). In general, the TOC values were within 1 mg/L of each other (ranging from 6.8 mg/L to 7.7 mg/L). The Algimycin PWF containers had more variability in the results; the TOC values were 7.9, 9.0, and 9.6 mg/L. The 7.9 mg/L concentration is similar to those of the control, GreenClean PRO, and PAK-27, but the 9.0 and 9.6 mg/L concentrations are markedly higher.

Based on the average concentrations, it would appear that the hydrogen peroxide based algaecides applied in this test had little impact on TOC (when compared to the control), whereas the copper treatments increased TOC by one or two milligrams per liter after 19-hours.

5.4.3. Copper

Copper testing occurred in the three control containers prior to any treatment, in the Algimycin PWF containers after treatment, and again in all containers when the $t = 19$ water samples were obtained. In the pre-treatment ($t = 0$) control contains and all water samples obtained from the non-Algimycin PWF treatment containers, the measured

copper concentrations were below the reporting limit (RL). The containers that received the Algimycin PWF treatments all had copper concentrations that were 30 times the RL. While there was some variability in copper concentrations between containers and the sampling times, the variability was minor. The results from the copper analysis indicated that copper contamination did not occur.

5.4.4. Chlorophyll-a and Phaeophytin

Chlorophyll-a and phaeophytin are both photosynthetic pigments (blue-green and grey, respectively) that are used by algae to "absorb light energy for photosynthetic cell reproduction and cell maintenance" (Tchobanoglous and Schroeder, 1985, pg. 136). Concentrations of both were measured in all water samples. Regardless of the sample time or treatment method, the concentrations were variable (Figure 5 and Figure 6)[4]. Chlorophyll-a concentrations ranged from 8.0 µg/L to 65.9 µg/L over the course of the study. Phaeophytin concentrations ranged from 1.4 µg/L to 15.6 µg/L. The concentrations within each container tended to have the same pattern between chlorophyll-a and phaeophytin (e.g., in the first control container, the concentrations of chlorophyll-a decreased from $t = 0$ to $t = 2$ hours and then increased from $t = 2$ hours to $t = 19$ hours; the concentrations of phaeophytin exhibited the same pattern).

Despite the similarity in behavior, both chlorophyll-a and phaeophytin concentrations were highly variable (over time and between containers) and did not appear to have any consistent trends related to treatment.

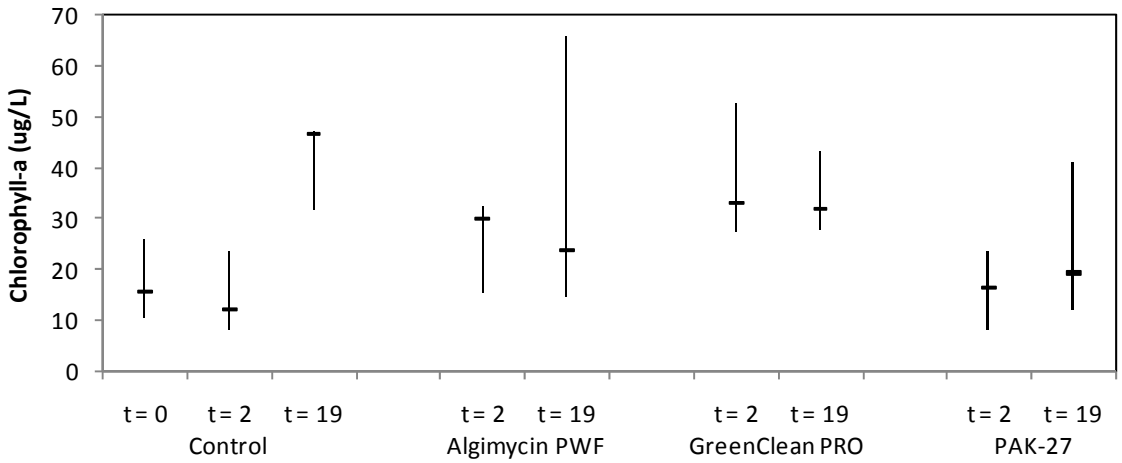

Figure 5. Chlorophyll-a concentrations for each water sample analyzed during the study period.

[4] In Figure 5 and Figure 6 the vertical bar represents the range of concentrations observed between the three replicates for each treatment type and control. The top of the bar is the highest observed value, while the bottom of the bar corresponds to the lowest observed value. The horizontal dash represents the third observed concentration (it is not the average value).

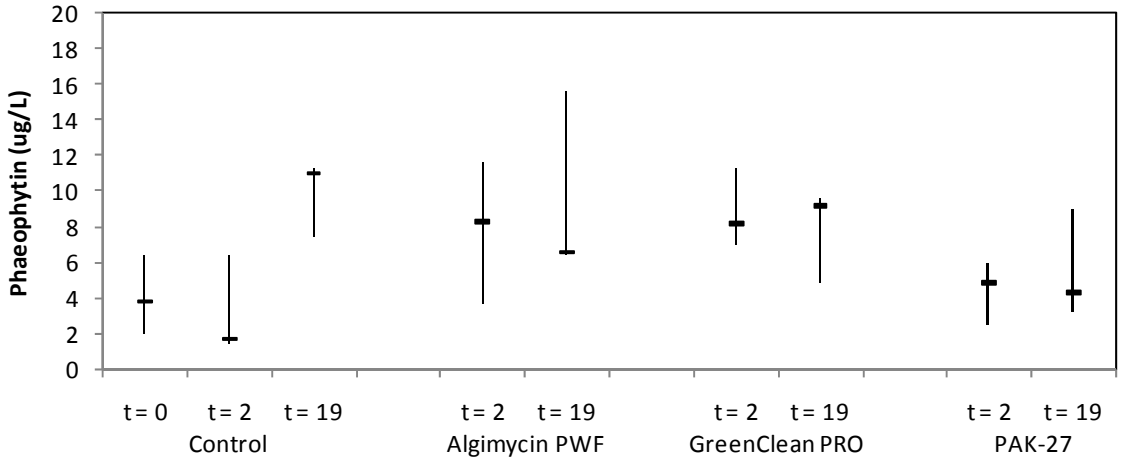

Figure 6. Phaeophytin concentrations for each water sample analyzed during the study period.

5.4.5. Algae Species

Six types of algae species groups were identified within the water samples: blue-green, chrysophyte, cryptophytes, diatom, dinoflagellate, and green[5]. Within the blue-green algae group, three species are of particular interest: *Anabaena flos-aquae*, *Aphanizomenon flos-aquae*, , and *Microcystis aeruginosa*. The algae species groups are provided by density (number of cells per milliliter) and biovolume (cubic micro-meters per milliliter) in Figure 7 and Figure 8, respectively. As with the chlorophyll-a and phaeophytin concentrations, the density and biovolume values were variable. *Aphanizomenon flos-aquae* and *Microcystis aeruginosa* were present in almost all of the samples, but *Anabaena flos-aquae* was only observed in the control samples (both before treatment, $t = 0$, and post-treatment, $t = 19$ hours).

The algal species results are presented in Appendix D.

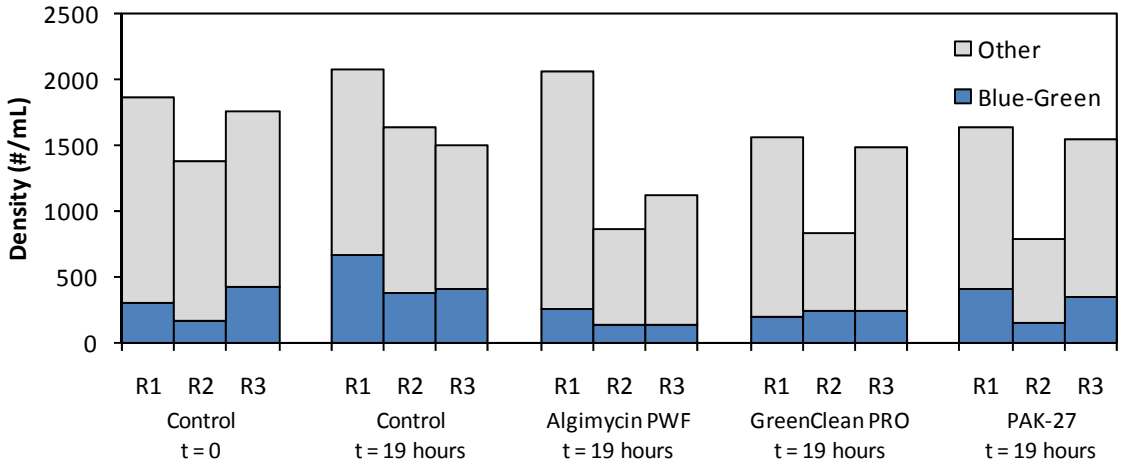

Figure 7. Blue-green and all other algae species group density (number of cells per milliliter). The sum of the blue-green and other group densities yields the total algae species density.

[5] A seventh category, unidentified, consolidated the results for those algae present in the water samples that could not be identified.

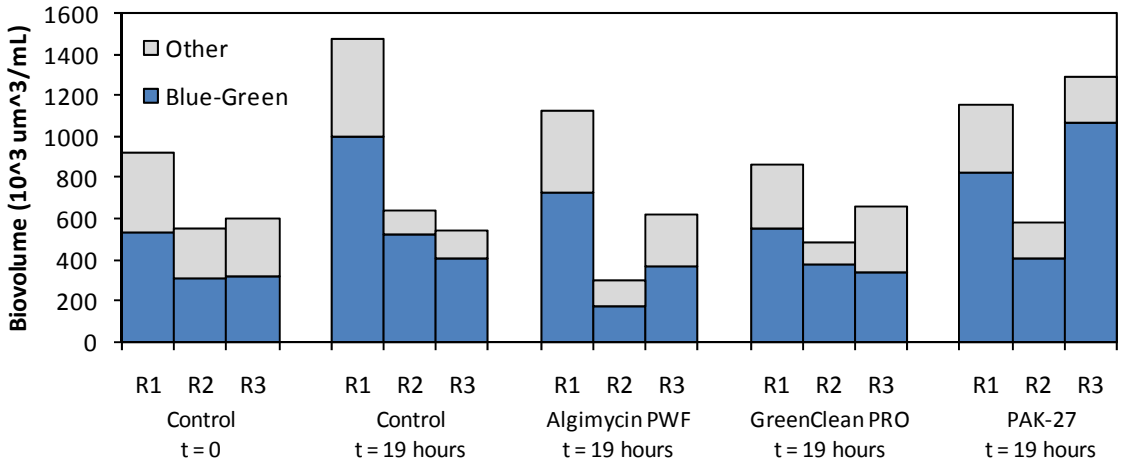

Figure 8. Blue-green and all other algae species group biovolume (cubic micro-meters per milliliter). The sum of the blue-green and other group biovolume yields the total algae species biovolume.

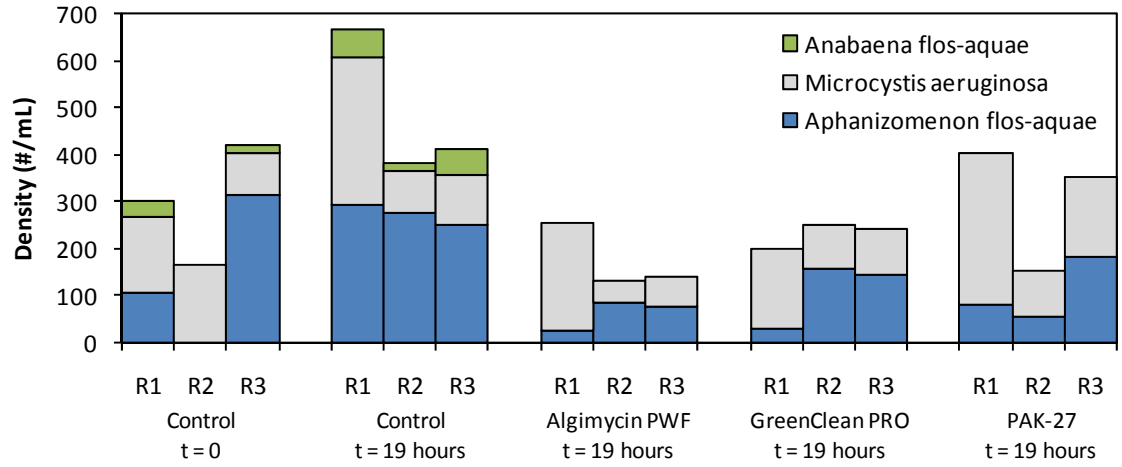

Figure 9. *Anabaena flos-aquae, Microcystis aeruginosa, and Aphanizomenon flow-aquae* densities (number of cells per milliliter) in the pre-treatment control and post-treatment water samples.

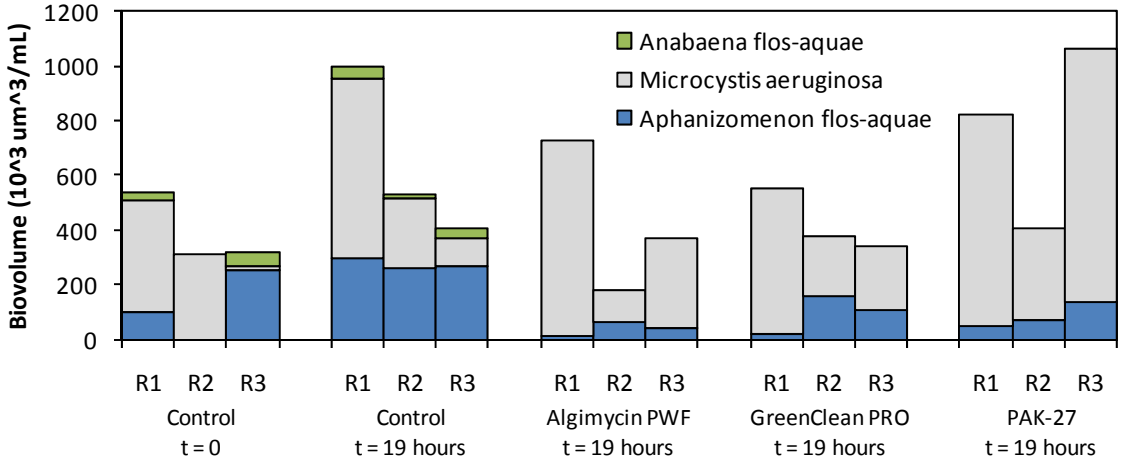

Figure 10. *Anabaena flos-aquae, Microcystis aeruginosa,* and *Aphanizomenon flow-aquae* biovolume (cubic micro-meters per milliliter) in the pre-treatment control and post-treatment water samples.

5.4.6. Microcystin

Microcystin (the toxin produced by *Microcystis aeruginosa,* as well as certain other cyanobacteria) was found in all of the water samples, with concentrations ranging from 2.1 µg/L to 35.6 µg/L. As with chlorophyll-a and phaeophytin, the microcystin concentrations were variable regardless of the sample time. The concentrations of microcystin in the all of the containers tended to either decrease with time or remain relatively unaffected, except in the after re-treatment containers. Two of the containers were re-treated with the algaecide after the t = 19 hours samples. GreenClean PRO and PAK-27 was re-applied to the first replicate container and a third microcystin sample was obtained from both containers. In both cases, the concentrations of microcystin increased from t = 19 hours to t = 21 hours (after re-treatment).

Observed microcystin concentration values did not produce consistent trends or patterns, but the ranges associated with each time and treatment method were relatively stable (except for the Algimycin PWF treated containers). The control containers had an average range of 6.6 µg/L, while the GreenClean PRO containers had an average range of 21.3 µg/L and the PAK-27 containers had an average range of 15.9 µg/L (Figure 11). In these two treatment cases, the range of microcystin concentrations increased after treatment, but the average concentration decreased. While the higher concentration values remained fairly similar (between the control and both treatment methods), the lower concentration values were notably reduced after treatment. Treatment with the hydrogen peroxide products (GreenClean PRO and PAK-27) may result in cell lyses, thus leading to increased microcystin to the water column – a general concern with algaecide treatment. While no clear conclusions or trends can be drawn from these results due to the small sample size, this does indicate that additional testing of the GreenClean PRO and/or PAK-27 may be warranted.

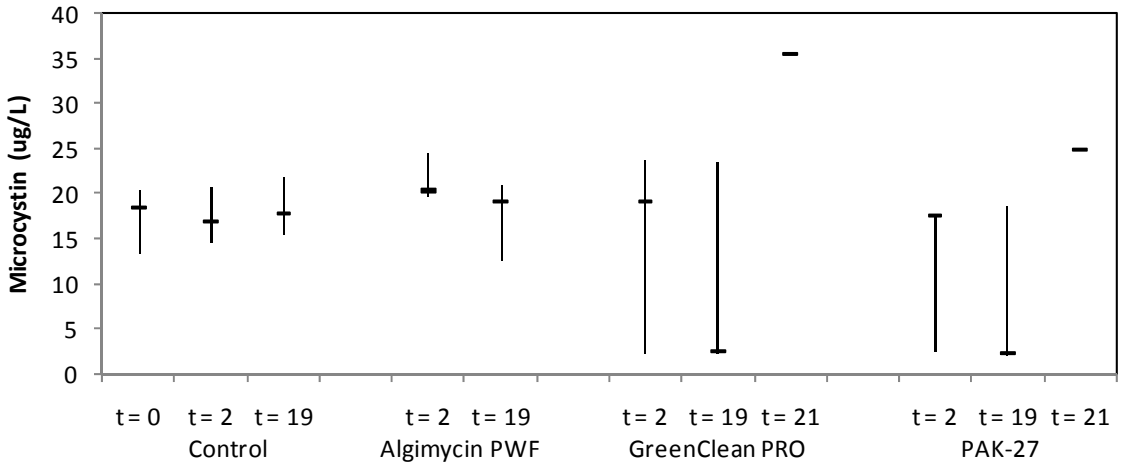

Figure 11. Microcystin concentrations for each water sample analyzed during the study period.

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5.4.7. Discussion Summary

While the small-scale algaecide test did provide insights into methods of algaecide application and potential algae response to treatment, the determination of the efficacy of different algaecide treatments were unclear at the dosages applied.

Basic chemical analysis indicates that ambient waters had very little copper present. The relatively low hardness values suggested that the water in Copco Reservoir could be of concern for the use copper-based algaecides if there are trout or other sensitive species of fish present as low water hardness can preclude the use of copper based algaecides in waters with sensitive fish species. Depending on the algaecide treatment being used, hardness could be an essential parameter to determine prior to the implementation of an algae management plan.

The chlorophyll-a, phaeophytin, microcystin, and algal species concentrations also did not provide clear insights into the efficacy of the algaecide treatments. The concentrations were variable. Some generalized trends could be identified (e.g., chlorophyll-a and phaeophytin concentrations tended to exhibit the same general pattern), but overall the individual replicates did not follow similar trends. Based on results, there appeared to be inherent variability of the water between the three replicates. While some parameters, such as alkalinity and copper, were fairly constant between the replicates, others, such as the total density of algae species, were highly variable between the replicates. It is unclear if the variability in concentrations of chlorophyll-a, phaeophytin, microcystin, and algal species was due to differences in the pre-treatment water samples, conditions within the replicates, sampling procedures, testing procedures, or some other factor(s). Likewise, there was some concern about the application of the algaecide on a small scale in a laboratory setting. Selected test volumes and depths utilized resulted in small volumes or doses of algaecide being applied to each water sample. Uncertainty could have been introduced when attempting to treat with a physically uniform application of the algaecide to the test water. The small depth associated with the tests in the laboratory setting did not allow for adequate exploration of the settling rates of the granular products (i.e., GreenClean PRO and PAK-27). There was also some concern that the test conditions did not provide the same sunlight conditions that would be present during the treatment of the reservoir itself and may have limited both the growth of any algae present as well as the effectiveness of the hydrogen peroxide based algaecide. Finally, it was determined that a longer test duration would be more useful to demonstrate the effectiveness of the copper-based algaecide, which requires more than one day to complete treatment.

6. Summary and Recommendations

The results from the 2008 study provided useful information on study design and technique, and insight into the efficacy of the algaecides used. It was determined that a longer study period was required for the small-scale algaecide test to assess the differences between copper-based and hydrogen peroxide based algaecide. Also, a larger scale algaecide test (i.e., larger sample volumes) would be preferable to allow for greater amounts of chemicals to be applied, which would minimize the variability in the results due to small variations in the measured amounts of products applied. The resolution of

the laboratory data and the natural variability of water quality parameters of Copco Reservoir made the results difficult to interpret. Triplicate samples were invaluable in ascertaining potential variations of the water and therefore provided insight into the limitations of the study.

In summary, a systematic approach to assessing algaecide use as a method of algae control was developed. A method of sample collection was identified, treatment with algaecide completed, and samples collected from discrete volumes of water. A range of parameters that provide insight into the efficacy of certain algaecide treatments were assessed. Although variability water quality parameter values presented challenges to interpretation, triplicate samples were invaluable in ascertaining the natural variations and provided greater insight into the limitations of the study. In addition to the experimental element of the project, details regarding general algal nuisance, treatment technologies and approaches, application procedures, and algaecide use in California are presented.

The limitations of the small scale algaecide treatment test were also determined, which included limitations of the sample size, duration of test, application period, dose-response relationships, resolution of analytical methods, and scale issues. Based on the 2008 findings, recommendations for future work include modifying methods to include the following attributes:

- Increase volume: Incorporate larger sample volumes (hypothesis or issue: bench test requires sufficient depth to address settling rates of hydrogen peroxide granules, and increased volumes will reduce uncertainty associated with variability among smaller volumes).
- Extend Analysis: Extend analysis for longer periods (hypothesis or issue: for certain treatments, particularly copper, a 24 hour period may be insufficient to ascertain efficacy of treatment, recommend two to three day period or longer).
- Daytime Application: Apply chemical in full sunlight conditions during active photosynthesis (hypothesis or issue, for certain species, application during photosynthesis leads to greater efficacy of treatment).
- Dose-Response: cover range of application quantities and repeated applications (hypothesis or issue: different species and waters may respond to different treatment rates, identify levels of treatment that may be effective in Project reservoirs).
- Analytical Resolution: in cooperation with analytical laboratories assess variability in microcystin and phytoplankton species to better interpret results (hypothesis or issue: seek to quantify uncertainty in analytical results).
- Scale Issues: address scale issues and treatment options for Project reservoirs (full scale, spot or local treatment, costs, etc.) (hypothesis or issue: identify potential costs of implementing a program that would provide reductions in algal standing crop either locally or at the reservoir scale).

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Appendices

A. Appendix A: Example Algaecide Product Information

Appendix A contains a partial description of nine algaecide product. Note that these are not complete descriptions of the products and additional information is available and should be obtained prior to use. The described products are (in alphabetical order): Algimycin PWF, Captain, Copper Sulfate Crystals, Curine Plus and Curine Ultra, GreenClean PRO, Hydrothol 191, PAK-27, and Phycomycin. In addition, the scanned product labels for Algimycin PWF, GreenClean PRO, and PAK-27 are presented in Appendix A.3.

A.1. Example Product Information

A.1.1. Algimycin PWF

Algimycin PWF is a copper citrate and copper gluconate chelates based algaecide made by Applied Biochemists. The algaecide is a solution with 62 grams per liter of copper.

Table A-1. Selected label information for Algimycin PWF

Information Type	Units	Details			
Active Ingredient	-	Copper citrate and copper gluconate chelates			
Federal Restricted Use	-	No			
California Restricted Use	-	No			
Recommended Algaecide Dose of Product	Gallons/ acre-ft	0.32 – 5.31			
Recommended Algaecide Dose of Active Ingredient	ppm	0.06 – 1.00			
Response Time	Days	1 – 10			
Target Type or Species	-	Planktoic, filamentous, chara / nitella			
Selectivity	-	0.06 to 0.12 ppm	0.12 to 0.25 pm	0.25 to 0.4 ppm	0.4 tp 0.5 ppm
		Anabaena	Ceratium	Chlorella	Ankistrodemus
		Microcystis	Euglena	Cymbella	Pithophora
		Aphanizomenon	Microspora	Desmidium	Chara
		Fragilaria	Oscillatoria	Hawmatococcus*	Eudorina
		Spirogyra	Synedra	Nostoc	Nitella
		Ulothrix	Tabellaria	Palmella	Pandorina
		Uroglena	Zygnema	Phormidium	Scenedesmus
				Cladophora	Hydrodictyon
Preventative	-	Not specified			
Restrictions	-	None			
Ideal Application Conditions	-	The ideal application time is specified as early in the day under calm bright conditions with the water temperature at least 60 °F, and when the algal growth as first appeared and created a nuisance. It is recommended to avoid treatment of more than one-half of lake or pond at one time to avoid depletion of oxygen levels due to decaying vegetation.			
Reapplication Delay Period	Weeks	1 – 2			

Undesirable Effects	-	Toxic to fish and aquatic organisms
Physical Conditions that affect product	-	Cold water makes the product less effective.
Chemical Conditions that affect product	-	Soft water (carbonate hardness less than 50 ppm) or acidic water makes the product more toxic to trout and other fish, do not use in water with carbonate hardness less than 50 ppm when trout or other sensitive species are present
Byproducts	-	None
Product Label Location	-	http://www.appliedbiochemists.com/labels/algimycinsl.pdf

A.1.2. Captain

Captain is a copper carbonate product made by SePro. It is a solution with 15.9% copper carbonate (9.1% elemental copper).

Table A-2. Selected label information for Captain

Information Type	Units	Details		
Active Ingredient	-	Copper carbonate		
Federal Restricted Use	-	No		
California Restricted Use	-	No		
Recommended Algaecide Dose of Product	Gallons/ acre-ft	0.6 – 2.4		
Recommended Algaecide Dose of Active Ingredient	ppm	0.2 – 0.8		
Response Time	Days	7 – 10		
Target Type or Species	-	Planktonic, filamentous and chara / nitella		
Selectivity	-		Copper, ppm	Product Dose, gallons/acre-ft
		Planktonic	0.2	0.6 - 1.5
		Filamentous	0.2 - 0.6	0.6 - 1.8
		Chara/Nitella	0.4 - 0.8	1.2 - 2.4
Preventative	-	Not specified		
Restrictions	-	Potable water may not exceed 1.00 ppm of copper.		
Ideal Application Conditions	-	It is recommended that Captain is applied early in the day under calm sunny conditions when water temperatures are at least 60 °F and when growth has first begun to appear or create a nuisance. Even distribution of Captain in the treatment area is desired. The use of high-pressure surface spray application to break up dense floating algal mats is recommended. Do not treat more than one-half of lake or pond at one time to avoid depletion of oxygen levels due to decaying vegetation.		
Reapplication Delay Period	Week	1 – 2		
Undesirable Effects	-	None		
Physical Conditions that affect product	-	Cold water temperature decrease the effectiveness of product.		
Chemical Conditions that affect product	-	In soft water (carbonate hardness less than 50 ppm), trout or other fish may be killed. Do not use in water with less than 50 pm carbonate hardness when trout or other sensitive species are present		
Byproducts	-	None		
Product Label Location	-	http://www.sepro.com/documents/Captain_Label.pdf		

A.1.3. Copper Sulfate Crystals

Copper Sulfate Crystals are made by many manufacturers, including Chem One. The crystals are 99% copper sulfate pentahydrate and 25% elemental copper.

Table A-3. Selected label information for Copper Sulfate Crystals

Information Type	Units	Details
Active Ingredient	-	Copper sulfate pentahydrate
Federal Restricted Use	-	No
California Restricted Use	-	No
Recommended Algaecide Dose of Product	Pounds/ acre-ft	0.67 – 5.32
Recommended Algaecide Dose of Active Ingredient	ppm	0.25 – 2.0
Response Time	Days	3
Target Type or Species	-	Blue-green, green, diatoms and protozoa
Selectivity	-	ORGANISM / ¼ to ½ ppm* / ½ to 1 ppm* / 1 to 1½ ppm* / 1½ to 2 ppm* Cyanophyceae (Blue-green): Anabaena, Anacystis, Aphanizomenon, Gloeotrichia, Gomphosphaeria, Polycystis, Rivularia / Cylindrospermum, Oscillatoria, Plectonema / Nostoc, Phormidium / Calothrix, Symploca Chlorophyceae (Green): Closterium, Hydrodictyon, Spirogyra, Ulothrix / Botryococcus, Cladophora, Coelastrum, Draparnaldia, Enteromorpha, Gloeocystis, Microspora, Tribonema, Zygnema / Chlorella, Crucigenia, Desmidium, Golenkinia, Oocystis, Palmella, Pithophora, Staurastrum, Tetraedron / Ankistrodesmus, Chara, Nitella, Scenedesmus Diatomaceae (Diatoms): Asterionella, Fragilaria, Melosira, Navicula / Gomphonema, Nitzschia, Stephanodiscus, Synedra, Tabellaria / Achnanthes, Cymbella, Neidium Protozoa (Flagellates): Dinobryon, Synura, Uroglena, Volvox / Ceratium, Cryptomonas, Euglena, Glenodinium, Mallomonas / Chlamydomonas, Hawmatococcus, Peridinium / Eudorina, Pandorina
Preventative	-	Not specified
Restrictions	-	Potable water must not exceed 1 ppm of copper (4 ppm copper sulfate pentahydrate
Ideal Application Conditions	-	Treatment should begin soon after plant growth has started. Treat algae on a sunny day when the heavy mats of filamentous algae are most likely to be floating on the surface where it can be sprayed directly. Treat one-third to one-half of the water area in a single operation. Begin along the shore and proceed outward in bands to allow fish to move into untreated water
Reapplication Delay Period	Day	10 – 14
Undesirable Effects	-	Trout and other species of fish may be killed at application rates recommended on this label, especially in soft or acid waters. However, fish toxicity generally decreases when the hardness of water increases.
Physical Conditions that affect product	-	Cold water temperatures reduce the effectiveness of the product. Flowing water reduces the effectiveness of the product.
Chemical Conditions that affect product	-	Hard water reduces the effectiveness of the product. Do not use in water with less than 50 pm carbonate hardness when trout or other sensitive species are present.
Byproducts	-	None
Product Label Location	-	http://www.chemone.com/default/other/copper%20sulfate%20label.pdf

A.1.4. Cutrine Plus and Cutrine Ultra

Both Cutrine Plus and Cutrine Ultra are solutions made by Applied Biochemists. Cutrine plus contains mixed copper-ethanolamine complexes and Cutrine Ultra contains mixed copper ethanolamine complexes in an emulsified formulation. Both products contain 9% elemental copper.

Table A-4. Selected label information for Cutrine Plus and Cutrine Ultra

Information Type	Units	Details
Active Ingredient	-	Copper – ethanolamine complexes (Cutrine Plus); copper – ethanolamine complexes in emulsified formulation (Cutrine Ultra)
Federal Restricted Use	-	No (both)
California Restricted Use	-	No (Both)
Recommended Algaecide Dose of Product	Gallons/ acre-ft	0.6 – 1.2 (Cultrine Plus) 0.6 – 3.0 (Cutrine Ultra)
Recommended Algaecide Dose of Active Ingredient	ppm	0.2 – 0.4 (Cutrine Plus) 0.2 – 1.0 (Cutrine Ultra)
Response Time	Days	7 - 10
Target Type or Species	-	Planktonic, filamentous, Chara / Nitella (both products)
Selectivity	-	Cutrine Plus:

		gallons per surface acre Depth In Feet			
Alage Type	Copper, ppm	1	2	3	4
Planktonic	0.2	0.6	1.2	1.8	2.4
Filamentous	0.2	0.6	1.2	1.8	2.4
Chara/Nitella	0.4	1.2	2.4	3.6	4.8

Cutrine Ultra:

		gallons per surface acre Depth In Feet			
Algae Type	Copper, ppm	1	2	3	4
Planktonic	0.2 - 0.6	0.6 - 1.8	1.2 - 3.6	1.8 - 5.4	2.4 - 7.2
Filamentous	0.2 - 0.8	0.6 - 2.4	1.2 - 4.8	1.8 - 7.2	2.4 - 9.6
Chara/Nitella	0.4 - 1.0	1.2 - 3.0	2.4 - 6.0	3.6 - 9.0	4.8 - 12.0

Preventative	-	Not specified (both)
Restrictions	-	Cutrine Plus is not for use in drinking water systems; Cutrine Ulltra has no restrictions
Ideal Application Conditions	-	For either product, the dosing chemical concentration should be maintained for a minimum of three hours contact time. Before applying either product dilute the required amount of algaecide with enough water to ensure even distribution with the type of equipment being used. Apply under calm and sunny conditions when water temperature is at least 60°F. Break up floating algae mats before spraying or while application is being made. Use hand or power sprayer adjusted to rain-sized droplets. Spray shoreline areas first to avoid trapping fish.
Reapplication Delay Period	Week	1 – 2
Undesirable Effects	-	Both products may be toxic to trout and other species of fish
Physical Conditions that affect product	-	Cold temperatures decrease the effectiveness of both products
Chemical Conditions that affect product	-	Fish toxicity increases with decreased water hardness; do not use either product in water containing trout or other sensitive species if the carbonate hardness of water does not exceed 50 ppm
Byproducts	-	Not specified
Product Label Location	-	http://www.appliedbiochemists.com/labels/CutrinePLUS.pdf (Cutrine Plus) http://www.appliedbiochemists.com/labels/CutrineUltra.pdf (Cutrine Ultra)

A.1.5. GreenClean PRO

GreenClean PRO is an algaecide producted by Bio Safe Systems, LLC. It consists of granules containing 85% sodium carbonate peroxyhydrate (27.6% hydrogen peroxide).

Table A-5. Selected label information for GreenClean PRO.

Information Type	Units	Details
Active Ingredient	-	sodium carbonate peroxyhydrate / hydrogen peroxide
Federal Restricted Use	-	No
California Restricted Use	-	No
Recommended Algaecide Dose of Product	Pounds/ acre-ft	2.0 – 9.0
Recommended Algaecide Dose of Active Ingredient	ppm	0.2 – 0.9 (hydrogen peroxide)
Response Time	Hours	24
Target Type or Species	-	Not specified
Selectivity	-	Not specified
Preventative	-	Yes
Restrictions	-	None
Ideal Application Conditions	-	Product application is recommended early in the day under calm, sunny conditions, and when water temperatures are warm as sunlight and higher temperatures both increase product effectiveness. Apply the product in a manner that will ensure even distribution to treatment area. Break up any heavy floating algae mats before or during application. Skimming any dead algae and organic matter that rises to the water's surface after treatment is recommended to avoid allowing dead organics to sink and decay which will provide a food source and additional nutrients that stimulate algae re-growth and further blooms. If there are algae mats, it is likely that a secondary treatment will be necessary.
Reapplication Delay Period	Hours	48
Undesirable Effects	-	Non-target plans will suffer contact burns if undiluted granules are spilled onto them Toxic to birds, bees and other beneficial insects
Physical Conditions that affect product	-	Cold water temperatures reduce effectiveness of product
Chemical Conditions that affect product	-	Not specified
Byproducts	-	Hydrogen peroxide (non-persistent)
Product Label Location	-	http://www.cdms.net/LDat/ld8JQ002.pdf

A.2.

A.2.1. Hydrothol 191

Hydrothol is produced by United Phosphorus, Inc. It is a solution with an active ingredient of endothall (23.6%).

Table A-6. Selected label information for Hydrothol 191

Information Type	Units	Details
Active Ingredient	-	Endothall (23.6%)
Federal Restricted Use	-	No
California Restricted Use	-	No
Recommended Algaecide Dose of Product	Pints/ acre-ft	0.6 – 18.0
Recommended Algaecide Dose of Active Ingredient	ppm	0.05 – 1.5
Response Time	-	Unclear
Target Type or Species	-	Planktonic, filamentous and branched algae
Selectivity	-	Unclear
Preventative Algaecide (yes/ no)	-	Not specified
Restrictions	-	7 to 25 day delay period before using treated water for watering livestock, agricultural sprays for food crops, irrigation or domestic purposes
Ideal Application Conditions	-	Not specified
Reapplication Delay Period		Not specified
Undesirable Effects	-	Fish may be killed by doses above 0.3 ppm of endothall Can injure desirable plants or crops
Physical Conditions that affect product	-	Not for use in brackish or salt water
Chemical Conditions that affect product	-	Not specified
Byproducts	-	None given
Product Label Location	-	http://www.cdms.net/LDat/ld7CR008.pdf

A.2.2. PAK-27

PAK-27 is a granular algaecide made by Solvay Chemicals containing 85% of sodium carbonate peroxyhydrate (27.6% hydrogen peroxide).

Table A-7. Selected label information for PAK-27

Information Type	Units	Details
Active Ingredient	-	sodium carbonate peroxyhydrate / hydrogen peroxide
Federal Restricted Use	-	No
California Restricted Use	-	No
Recommended Algaecide Dose of Product	Pounds/ acre-ft	3.0 – 100.0
Recommended Algaecide Dose of Active Ingredient	ppm	0.3 – 10.2
Response Time	Hours	24
Target Type or Species	-	Blue-green, green, diatoms, zooplankton
Selectivity	-	**Dosage rate in pounds per acre foot** / **Targeted Species** / **Types of Water Bodies** **3 – 16.9** (.3 – 1.7 ppm H_2O_2) / Selective for Blue –Green Algae (BGA) / Municipal Water Reservoirs **17 – 30** (1.7 – 3.0 ppm H_2O_2) / BGA Some Species of Green Algae / Recreational Lakes, Home Owner Ponds and Lakes, Aquaculture **31 – 50** (3.1 – 5.1 ppm H_2O_2) / BGA Some Species of Green Algae Some Species of Diatoms Zooplankton* / Farm Ponds Aquaculture **51 – 100** (5.1 – 10.2 ppm H_2O_2) / BGA and all of the above / Aerated Water Gardens, Impounded Water, Waste Water Ponds
Preventative	-	Yes
Restrictions	-	None
Ideal Application Conditions	-	It is recommended to apply with eight to ten hours of daylight remaining to allow for surviving algae to produce enough oxygen in the water to overcome the BOD introduced by the dead algae. It is also recommended to apply early in the growth season so that lower levels of treatment are required. To avoid low dissolved oxygen levels, if treating a large water body or a large algal bloom, treat one third to one half, wait 2 to 3 days and then treat the remaining water.
Reapplication Delay Period	Hours	48
Undesirable Effects	-	Un-dissolved product is corrosive to bird beaks
Physical Conditions that affect product	-	Not specified
Chemical Conditions that affect product	-	None
Byproducts	-	Hydrogen peroxide
Product Label Location	-	http://www.solvaychemicals.us/static/wma/pdf/1/0/6/2/9/PAK27.pdf (Technical Data Sheet) Dosage rates for different algae can be requested from Solvay Chemicals

A.2.3. Phycomycin

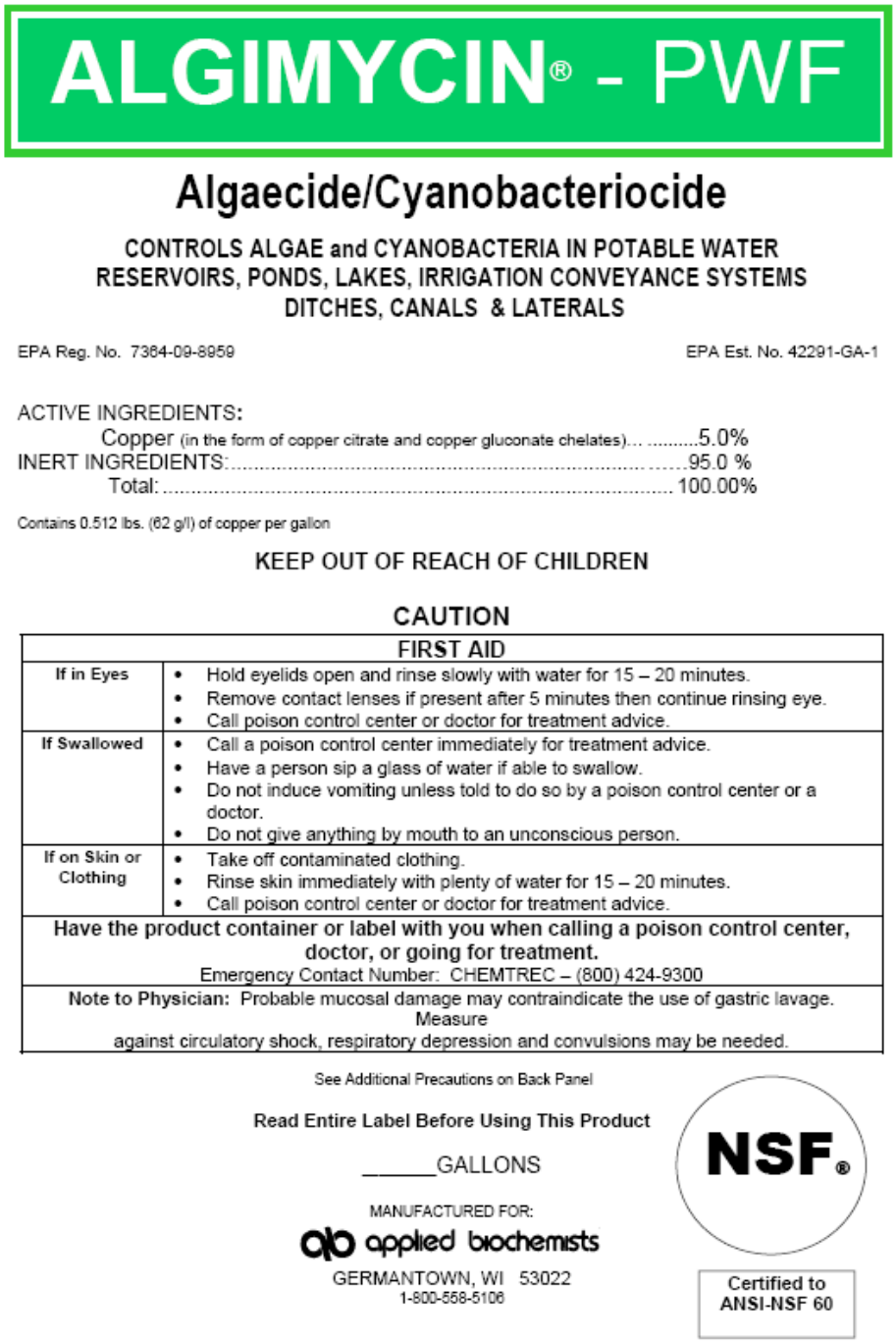
Phycomycin is a granular algaecide made by Applied Biochemists containing 85% sodium carbonate peroxyhydrate (percent hydrogen peroxide not specified on product label).

Table A-8. Selected label information for Phycomycin

Information Type	Units	Details
Active Ingredient	-	sodium carbonate peroxyhydrate / hydrogen peroxide
Federal Restricted Use	-	No
California Restricted Use	-	No
Recommended Algaecide Dose of Product	Pounds/ acre-ft	3.0 – 100.0
Recommended Algaecide Dose of Active Ingredient	ppm	0.3 – 10.2
Response Time	Hours	24
Target Type or Species	-	Blue-green algae
Selectivity	-	Not specified
Preventative	-	Yes
Restrictions	-	None
Ideal Application Conditions	-	It is recommended to apply with eight to ten hours of daylight remaining to allow for surviving algae to produce enough oxygen in the water to overcome the BOD introduced by the dead algae. It is also recommended to apply early in the growth season so that lower levels of treatment are required. To avoid low dissolved oxygen levels, if treating a large water body or a large algal bloom, treat one third to one half, wait 2 to 3 days and then treat the remaining water.
Reapplication Delay Period	Hours	48 – 36
Undesirable Effects	-	Un-dissolved product is corrosive to bird beaks
Physical Conditions that affect product	-	Not specified
Chemical Conditions that affect product	-	None
Byproducts	-	Hydrogen peroxide
Product Label Location	-	http://www.appliedbiochemists.com/labels/Phycomycin.pdf

A.3. Scanned Product Labels

A.3.1. Algimycin PWF



ALGIMYCIN® - PWF

Algaecide/Cyanobacteriocide

CONTROLS ALGAE and CYANOBACTERIA IN POTABLE WATER
RESERVOIRS, PONDS, LAKES, IRRIGATION CONVEYANCE SYSTEMS
DITCHES, CANALS & LATERALS

EPA Reg. No. 7364-09-8959 EPA Est. No. 42291-GA-1

ACTIVE INGREDIENTS:
Copper (in the form of copper citrate and copper gluconate chelates)... .....5.0%
INERT INGREDIENTS:.....95.0 %
Total:..... 100.00%

Contains 0.512 lbs. (62 g/l) of copper per gallon

KEEP OUT OF REACH OF CHILDREN

CAUTION

FIRST AID	
If in Eyes	• Hold eyelids open and rinse slowly with water for 15 – 20 minutes. • Remove contact lenses if present after 5 minutes then continue rinsing eye. • Call poison control center or doctor for treatment advice.
If Swallowed	• Call a poison control center immediately for treatment advice. • Have a person sip a glass of water if able to swallow. • Do not induce vomiting unless told to do so by a poison control center or a doctor. • Do not give anything by mouth to an unconscious person.
If on Skin or Clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15 – 20 minutes. • Call poison control center or doctor for treatment advice.
Have the product container or label with you when calling a poison control center, doctor, or going for treatment. Emergency Contact Number: CHEMTREC – (800) 424-9300	
Note to Physician: Probable mucosal damage may contraindicate the use of gastric lavage. Measure against circulatory shock, respiratory depression and convulsions may be needed.	

See Additional Precautions on Back Panel

Read Entire Label Before Using This Product

_____GALLONS

MANUFACTURED FOR:
applied biochemists
GERMANTOWN, WI 53022
1-800-558-5106

NSF®

Certified to ANSI-NSF 60

Figure A-1. Scanned product label for Algimycin PWF.

PRECAUTIONARY STATEMENTS

Hazards to Humans and Domestic Animals

CAUTION: Harmful if swallowed. Causes moderate eye irritation. Harmful if inhaled. Avoid breathing spray mist. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, or using tobacco. Avoid contact with the eyes, skin or clothing. Wear protective eyewear. Wear long-sleeved shirt and long pants, socks, shoes and gloves.

ENVIRONMENTAL HAZARDS: This pesticide is toxic to fish and aquatic organisms. Drift and runoff from treated areas may be hazardous to fish and aquatic organisms in adjacent sites. Direct application of this product to water may cause a significant reduction in the populations of aquatic invertebrates, plants, and fish. Do not treat more than one-half of lake or pond at one time to avoid depletion of oxygen levels due to decaying vegetation. Allow one to two weeks between treatments for oxygen levels to recover.

Trout and other species of fish may be killed at application rates recommended on this label, especially in soft or acid waters. Do not use in waters containing trout, goldfish, koi or other sensitive species if carbonate hardness is less than 50 ppm. Fish toxicity generally decreases when the hardness of the water increases. Do not contaminate water when disposing of equipment wastewaters. Consult your local state Fish and Game Agency before applying this product to public waters. Permits may be required before treating such water.

GENERAL INFORMATION

ALGIMYCIN PWF is a liquid, water soluble copper formulation designed to effectively control a broad range of algae and cyanobacteria growth in potable water sources including reservoirs, lakes, ponds and related water conveyance systems. Citric and gluconic acids in the formulation provide added chemical stability to the copper when used in alkaline waters. Control of certain forms of algae and cyanobacteria in these water sources can aid in the reduction of taste and odor problems associated with 2-methylisoborneol and geosmin production from these organisms. Dosage rates and frequency of treatment should be based upon the sensitivity of species present, the extent/biomass of the bloom and the depth of the growth present in the water column.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

Pre-Treatment Considerations: Consult your proper state authorities such as Dept. of Natural Resources, Fisheries Commission, Health Dept. or Environmental Agency to obtain necessary permits. Initial treatment with **ALGIMYCIN PWF** should be considered at the onset of nuisance bloom conditions as evidenced by initial taste and odor complaints; high cell counts or chlorophyll *a* concentrations; high MIB or geosmin concentrations; visible surface scum formations; low Secchi disk readings; significant daily fluctuations in dissolved oxygen; and/or sudden increases in pH. Monitoring of several of these parameters on a regular basis will assist in optimizing the timing of treatments and reducing the amounts of **ALGIMYCIN PWF** needed for seasonal control. Identification of primary nuisance species or genera may also be helpful in determining and refining dosage rates.

Identify Target Organism(s): If target species or genera are known, determine dosage from **Table 1** for the corresponding organism(s) and the level of growth present. If multiple target organisms are present, select the higher rate. If positive identification cannot be made, treatment rates should be determined based upon the algae growth form as indicated in **Table 2.**

TABLE 1

PPM COPPER REQUIRED FOR CONTROL OF SOME GENERA OF ALGAE AND CYANOBACTERIA WITH ALGIMYCIN PWF

(Use lower range concentrations in soft waters where algae growth is light to moderate. Use higher range concentrations in moderate to hard waters where algae growth is moderate to heavy.)

0.06 to 0.12 ppm	0.12 to 0.25 ppm	0.25 to .40 ppm	0.40 – 0.5 ppm
Anabaena	Ceratium	Chlorella	Ankistrodesmus
Microcystis	Euglena	Cymbella	Pithophora
Aphanizomenon	Microspora	Desmidium	Chara
Fragilaria	Oscillatoria	Hawmatococcus*	Eudorina
Spirogyra	Synedra	Nostoc	Nitella
Ulothrix	Tabellaria	Palmella	Pandorina
Uroglena	Zygnema	Phormidium	Scenedesmus
		Cladophora	Hydrodictyon

TABLE 2

PPM COPPER REQUIRED FOR CONTROL OF ALGAE GROWTH FORMS/BIOMASS (Abundance) WITH ALGIMYCIN PWF

(Use the following concentrations in areas where algae genera have not been positively identified. Use lower range concentrations in soft waters and higher range concentrations in moderate to hard waters.)

	Growth Form	
Abundance	Planktonic	Filamentous
Light	0.05 – 0.12	0.2 – 0.3
Moderate	0.12 – 0.25	0.3 – 0.5
Heavy	0.30 – 0.40	0.4 – 0.5
Severe	0.50 – 1.00	0.6 – 1.0

Calculate Volume of Water to be Treated: Treatment volume should be calculated based upon the surface area and depth of growth. Surface mats of filamentous algae often extend underwater and may be attached to bottom substrates. Similarly, planktonic cells are dispersed within the water column depending upon light or temperature conditions. Measure **Average Depth of Growth** at several locations within the targeted treatment area and calculate **Volume of Water to be Treated** as follows:

Avg. Length (ft.) x Avg. Width (ft.) x Avg. Depth of Growth = Cubic Feet of Water

$$\frac{\text{Cubic Feet of Water}}{43{,}560} = \text{Acre-Feet} \quad \text{-or-} \quad \frac{\text{Cubic Feet of Water}}{7.48} = \text{Gallons}$$

Note: 1 acre foot = 326,000 gallons

Figure A-2. Scanned product label for Algimycin PWF, continued.

Determine Dosage Rate: Use the **PPM Copper Concentration** selected from **Table 1** or **Table 2** to determine **Dosage Rate** from **Table 3.**

Table 3
ALGIMYCIN PWF Dosage Rate (Gallons)

ppm copper	0.05	0.10	0.12	0.20	0.25	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
Per Acre-Foot	0.32	0.53	0.64	1.06	1.33	1.59	2.13	2.66	3.19	3.72	4.25	4.78	5.31
Per Million Gallons	0.97	1.63	1.96	3.26	4.08	4.89	6.52	8.15	9.78	11.4	13.0	14.7	16.3

Total quantity of **ALGIMYCIN PWF** required can be determined by multiplying Dosage Rate times Total Volume of Water to be Treated. **Do not exceed 1.0 ppm copper dosage rate.**

METHOD OF APPLICATION:

For Potable Drinking Water Reservoirs, Lakes, Ponds:

If treated water is a source of potable water, the residue of copper must not exceed 1 ppm.

- For best results, begin applications early in the season when algae and/or cyanobacteria problems become evident and water temperature above 60°F or 15.6°C.
- Before applying, dilute **ALGIMYCIN PWF** with enough water to ensure even distribution with the type of equipment being used. Break up floating mats of filamentous algae or scum formations before spraying or while application is being made.
- Use rain-sized droplets for spraying surface algae mats and cyanobacterial scum formations. Subsurface injection should be used where growth extends into deeper water. **ALGIMYCIN PWF** will disperse within the water column, however, apply as evenly as possible throughout the target area.
- Spray shoreline areas first to avoid trapping fish. In areas of heavy infestation, treat only one-third to one-half of the water volume at one time to avoid fish suffocation caused by oxygen depletion from decaying algae. Allow sufficient time between treatments to allow for oxygen recovery as indicated by D.O. measurements in the water column. In regions where ponds freeze in winter, treatment should be done six (6) to eight (8) weeks before expected freeze time to prevent masses of decaying algae under an ice cover.

Irrigation Conveyance and Drainage Canal Systems:

- Prior to treatment it is important to accurately determine water flow rates. In the absence of weirs, orifices or similar devices which give accurate water flow measurements, volume of flow may be estimated by using the following formula:

Avg. Width (ft.) x Avg. Depth (ft.) x Velocity* (ft./sec) x 0.9 =
Cubic Feet per Second (C.F.S.)

*Velocity is the time it takes a floating object to travel a given distance downstream. Dividing the distance traveled (feet) by the time (seconds) will yield Velocity (ft./sec.). This measurement should be repeated at least three times at the intended application site and then averaged.

- After accurately determining the water flow rate in C.F.S. or gallons per minute, find the corresponding **ALGIMYCIN PWF** drip rate on the chart below:

Water Flow Rate		ALGIMYCIN PWF Drip Rate		
C.F.S.	Gal./Min	Qts/Hr	ml/min.	Fl. Oz./Min
•	450	1.75	28	0.9
•	900	3.50	56	1.8
•	1350	5.25	84	2.7
•	1800	7.00	112	3.6
•	2250	8.75	140	4.5

- Calculate the amount of **ALGIMYCIN PWF** needed to maintain the drip rate for a minimum of 3 hours by multiplying Qts./Hr. x 3; ml/min. x 180 or Fl. Oz./Min. x 180. Dosage will maintain 1.0 ppm Copper concentration in the treated water for a 3 hour contact period. Treatment should continue until waters at the downstream portion of the treatment area reach desired copper concentration. This can be determined by testing for total copper or by calculating turnover time for that section of the canal based upon its flow rates and volume. Introduction of **ALGIMYCIN PWF** should be made in the channel at weir or other turbulence-creating structures to promote chemical dispersion.
- Equip **ALGIMYCIN PWF** container with a vented, adjustable valve system constructed to maintain a constant drip or other suitable metering device. Use a stop watch and appropriate measuring container to set the desired drip rate. Readjust accordingly if channel flow rate changes during the treatment period.
- Distance of control down the waterway will vary depending upon density of growth. Treatments of longer duration or at more frequent intervals along the channel may be necessary. **Do not exceed 1.0 ppm copper in the water at any point along the treatment zone.** Periodic maintenance treatments may be required for seasonal control.

Figure A-3. Scanned product label for Algimycin PWF, continued.

GENERAL TREATMENT NOTES:
The following suggestions apply to the use of **ALGIMYCIN PWF** as an algaecide or cyanobacteriacide in all labeled sites:

For optimum effectiveness . . .

- Begin applications early in the day under calm, bright conditions when water temperatures are at least 60° F (15.5°C).
- Treat when growth first begins to appear and create a nuisance, if possible.
- Apply in a manner that will ensure even distribution of the chemical within the treatment area.
- Re-treat areas if regrowth begins to appear and seasonal control is desired. Allow dissolved oxygen levels to recover between consecutive treatments.
- Visible reduction in algae growth should be observed in 24 to 48 hours following application with full effects of treatments sometimes taking 7 – 10 days depending upon algae forms, weather, degree of infestation and water temperatures.

APPLICATION AND HANDLING EQUIPMENT

Application, handling or storage equipment must consist of either fiberglass, PVC's, polypropylenes, viton, most plastic, aluminum or stainless steel. Never use mild steel, nylon, brass or copper around full strength **ALGIMYCIN PWF**. Always rinse equipment free and clean of **ALGIMYCIN PWF** each night with plenty of fresh, clean water. Concentrate will destroy cotton and nylon materials. Always store **ALGIMYCIN PWF** above 32°F. Do not allow **ALGIMYCIN PWF** to freeze. Freezing may cause product separation. Seller makes no warranty for the performance of product that has been frozen.

STORAGE AND DISPOSAL:
Do not contaminate water, food or feed by storage or disposal.

Pesticide Storage: Store in a safe place away from pets and **KEEP OUT OF REACH OF CHILDREN.** Store in a cool, dry area. **ALGIMYCIN PWF** will freeze. Always keep container closed. Store in its original container only. Bulk **ALGIMYCIN PWF** shall be stored and handled in stainless steel, fiberglass, PVC's, polypropylenes or plastic equipment. Keep away from galvanized pipe and nylon storage handling equipment. If container is damaged, place the container in a plastic bag. In the event of a spill, neutralize with limestone or baking soda before disposal. Concentrate may deteriorate concrete.

Pesticide Disposal: Excess **ALGIMYCIN PWF** should be disposed of through label use. Do not contaminate lakes, rivers or streams as this may cause fish kill. Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide, spray mixture or rinsate is a violation of Federal law. If these wastes cannot be disposed of by used according to label instructions, contact your State Pesticide or Environmental Control Agency, or the hazardous waste representative at the nearest EPA Regional Office for guidance.

LIMITED WARRANTY AND LIMITATION OF REMEDIES
Seller warrants that the product conforms to the chemical description and is reasonably fit for the purpose stated on the label for use under normal conditions, but makes no other warranties of Fitness or Merchantability expressed or implied, or any other warranty if the product is used contrary to the label instructions or under abnormal conditions or under conditions not foreseeable to the seller. In no case shall the seller be liable for more than the cost of this product to the buyer, and will in no event be liable for any consequential special or indirect damages connected with the use or handling of this product. This product is offered and the buyer or user accepts it subject to the foregoing terms, which may not be varied.

Figure A-4. Scanned product label for Algimycin PWF, continued.

A.3.2. GreenClean PRO

GreenClean® PRO
Granular Algaecide
CALIFORNIA

SPECIMEN LABEL

For indoor or outdoor uses.

ACTIVE INGREDIENT:

Sodium Carbonate Peroxyhydrate*	85%
OTHER INGREDIENTS	15%
TOTAL	100%

*Contains 27.6% Hydrogen Dioxide by weight.

KEEP OUT OF REACH OF CHILDREN

DANGER – PELIGRO

Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle. (If you do not understand this label, find someone to explain it to you in detail.)

FIRST AID:

If in eyes
- Hold eye open and rinse slowly and gently with water for 15 – 20 minutes.
- Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.
- Call a poison control center or doctor for treatment advice.

If on skin or clothing
- Take off contaminated clothing.
- Rinse skin immediately with plenty of water for 15 – 20 minutes.
- Call a poison control center or doctor for treatment advice.

If swallowed
- Call poison control center or doctor immediately for treatment advice.
- Have person sip a glass of water if able to swallow.
- Do not induce vomiting unless told to do so by a poison control center or doctor.
- Do not give anything by mouth to an unconscious person.

If inhaled
- Move person to fresh air.
- If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably by mouth-to-mouth, if possible.
- Call a poison control center or doctor for treatment advice.

Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact **1-800-222-1222** for emergency medical treatment information.

NOTE TO PHYSICIAN:
Probable mucosal damage may contraindicate the use of gastric lavage.

Sold By:
BioSafe Systems, LLC • East Hartford, CT 06108
EPA Registration No. 70299-6 • EPA Establishment No. 68660-TX-001

PRECAUTIONARY STATEMENTS:

HAZARDS TO HUMAN AND DOMESTIC ANIMALS – DANGER: Corrosive. Causes irreversible eye damage. Harmful if swallowed, inhaled or absorbed through skin. Do not get in eyes, on skin or on clothing. Wash thoroughly with soap and water after handling. Remove and wash contaminated clothing before reuse.

PERSONAL PROTECTIVE EQUIPMENT (PPE): When handling wear protective eyewear (goggles or face shield) and chemical resistant gloves. Applicators and handlers must wear coveralls over long-sleeved shirt, long pants, and chemical resistant footwear plus socks. Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions exist for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

USER SAFETY RECOMMENDATIONS: Users should wash hands thoroughly with soap and water before eating, drinking, chewing gum, using tobacco or using the toilet. Users should remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing. Remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

ENVIRONMENTAL HAZARDS: This pesticide is toxic to birds. Do not contaminate water when disposing of equipment washwaters or rinsate. This product is highly toxic to bees and other beneficial insects exposed to direct contact on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops or weeds while bees are actively visiting the treatment area. Do not apply this product or allow it to drift to crops where beneficials are part of an integrated pest management strategy.

PHYSICAL AND CHEMICAL HAZARDS: Strong oxidizing agent. Corrosive. Do not bring in contact with other pesticides, cleaners or oxidative agents.

DIRECTIONS FOR USE:

It is a violation of Federal law to use this product in a manner inconsistent with its labeling. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulation. Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application.

Avoid use near shallow waterbody margins during amphibian breeding seasons.

Agricultural Use Requirements
Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR Part 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and

Figure A-5. Scanned product label for GreenClean PRO.

emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE), notification to workers, and restricted entry intervals (REI). The requirements in this box apply to uses of this product that are covered by the Worker Protection Standard.

For enclosed environments: There is a restricted entry of one (1) hour for this product when applied via spraying or foaming on hard surfaces in enclosed environments. PPE requirement for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil or water, is coveralls, waterproof gloves and shoes plus socks.

There is a restricted entry of zero (0) hours for spreading, broadcasting, spot treatment, injection or other non-spraying or non-foaming application methods when used in enclosed environments.

For water treatment and applications in non-enclosed environments: Keep unprotected persons out of treated areas until sprays have dried or dusts have settled.

Non-Agricultural Use Requirements: The requirements in this box apply to uses of this product that are not within the scope of the Worker Protection Standard for agricultural pesticides (40 CFR Part 170). The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries or greenhouses.

Keep unprotected persons out of treated areas until sprays have dried or dusts have settled.

Apply GreenCleanPRO Granular Algaecide to any listed water site.

APPLICATION SITES INCLUDE:

Farms, Sod Farms, Aquaculture Production Facilities, Fisheries, Hatcheries, Greenhouses, Nurseries, Golf Courses, Amusement Parks, Water Parks, Aquariums, Zoos, Botanical Gardens, National Parks, Recreational Areas, Non-Chlorinated Swimming Areas, Raceways, Sports Facilities, Business Parks, Indoor/Interiors, Malls, Hotels, Kennels, Livestock Barns, Livestock Stalls and Holding Pens, Cemeteries, Carwashes, Marinas, Boats, Docks, Garden Centers, Power Washing, Water Gardens, Landscapes, Municipalities, Reservoirs, Waterways, Storm Waters, Drainage Systems, Impounded Waters, and Wastewater.

APPLICATION SURFACES INCLUDE:

WATER SURFACES:

Ponds, Lakes, Lagoons, Fish Ponds, Stock Tanks, Golf Course Ponds, Industrial/Commercial Ponds, Impounded Waters, Standing Water, Bilge Water, Reservoir Water, Waterways, Conveyance Ditches, Canals, Laterals, Drainage Systems, Irrigation Systems, Irrigation Ponds, Catch Basins, Flooded Areas, Sewage Systems, Drain Fields, Fire Ponds, Watering Tanks, Storage Tanks, Water Collectors and Domestic/Commercial Waters

WATER TREATMENT

Use GreenClean PRO Granular Algaecide to treat, control, and prevent a broad spectrum of filamentous and planktonic blue-green algae. Effects of treatment are immediately apparent (bubbling, bleaching/discoloration of algae, floating of dead organic matter). Waters treated with GreenClean PRO Granular Algaecide are permissible to be used without interruption.

DETERMINING WATER VOLUME:

Measure length (L), width (W), and average depth (D) in feet (ft) or meters (m) and calculate volume using one of the following formulas:

Square/Rectangular:	Circular/Elliptical:
L(ft) x W(ft) x D(ft) x 7.5 = Gallons	L(ft) x W(ft) x D(ft) x 5.9 = Gallons
L(m) x W(m) x D(m) x 1000 = Liters	L(m) x W(m) x D(m) x 786 = Liters

1 acre-foot of water =

- water measuring 208.7 ft long x 208.7 ft wide x 1 ft deep
- 43,560 cubic feet
- 325,851 gallons
- 2,780,000 pounds

$$\frac{\text{Avg. Length (ft) x Avg. Width (ft) x Avg. Depth (ft)}}{43{,}560} = \text{acre-feet of water}$$

$$\frac{\text{Avg. Length (ft) x Avg. Width (ft)}}{43{,}560} = \text{acres}$$

APPLICATION RATES:

Full Water Volume Rates:

	HEAVY ALGAE GROWTH	LOW ALGAE GROWTH - MAINTENANCE
GRANULAR: Lg. Volume	50-250 pounds of GreenClean PRO Granular Algaecide per million gallons of water - OR - 20-90 pounds of GreenClean PRO Granular Algaecide per acre-foot of water.	5-25 pounds of GreenClean PRO Granular Algaecide per million gallons of water. - OR - 2-9 pounds of GreenClean PRO Granular Algaecide per acre-foot of water.
	For example: Lakes, ponds, lagoons	
GRANULAR: Sm. Volume	2-10 tablespoons of GreenClean PRO Granular Algaecide per 1000 gallons of water.	1-3 teaspoons of GreenClean PRO Granular Algaecide per 1000 gallons of water.
	(16 Tbs. = 1 Cup) (2 Cups = 1 lb.)	(3 tsp. = 1 Tbs.)
	For example: Indoor or outdoor water gardens, fountains, ornamental waterfalls	

Surface Water Volume Only Rates:

Use a "surface only" treatment for suspended algae and free-floating algae mats.

	HEAVY ALGAE GROWTH	LOW ALGAE GROWTH - MAINTENANCE
GRANULAR:	20-90 pounds of GreenClean PRO Granular Algaecide per acre-foot of water.	2-9 pounds of GreenClean PRO Granular Algaecide per acre-foot of water.
LIQUID:	**Solution Preparation:** Due to solubility limitations, use at least 1 gallon of water to fully dissolve each 0.5 pounds of GreenClean PRO Granular Algaecide. Dissolution of GreenClean PRO Granular Algaecide in cold water takes approximately 5 minutes. **Treatment Rates:** Use the same rates as the granular application given above.	

Figure A-6. Scanned product label for GreenClean PRO, continued.

GENERAL TREATMENT NOTES:

- Control is most easily achieved when algae are not yet well established. Treat when growth first begins to appear. This is especially important in the prevention of clogged irrigation systems, pumps, filters etc.
- Apply early in the day under calm, sunny conditions, and when water temperatures are warm. Sunlight and higher temperatures both enhance GreenClean PRO Granular Algaecide activity.
- Apply in a manner that will insure even distribution of GreenClean PRO Granular Algaecide within the treatment area.
- Break up any heavy floating algae mats before or during application.
- Skim any dead algae and organic matter that rises to the water's surface after treatment. Allowing dead organics to sink and decay will provide a food source and additional nutrients that stimulate algae re-growth and further blooms.
- Use GreenClean PRO Granular Algaecide as an integral part of your water management system. If using in conjunction with other water additives (such as bacteria or enzymes), always apply GreenClean PRO Granular Algaecide first and wait several hours before adding any other products.
- Re-treat areas if re-growth begins to appear. Allow 48 hours between consecutive treatments.
- Maintain an algae free pond with GreenClean PRO Granular Algaecide maintenance rates at a frequency appropriate for your environmental conditions.
- In regions where water freezes in the winter, treatment with GreenClean PRO Granular Algaecide (including skimming) 6-8 weeks before expected freeze will help prevent masses of decaying algae under the ice cover.
- After application, do not allow undiluted granules to remain in an area where humans or animals are exposed.
- Non-target plants will suffer contact burn if undiluted granules are accidentally spilled on them. Do not apply in such a way that the concentrated product comes in contact with grass, ornamentals and other foliage.
- Do not tank mix with aquatic herbicides or algaecides containing copper or bromides. Always apply GreenClean PRO Granular Algaecide at least one day prior to the application of these products.
- 100 pounds of GreenClean PRO Granular Algaecide per million gallons of water = 4ppm of sodium.

EFFECTIVENESS FACTORS:

- Effects of GreenClean PRO Granular Algaecide treatment are immediately apparent (bubbling, bleaching/discoloration of algae, floating dead organic matter).
- GreenClean PRO Granular Algaecide treatments are successful when contact of the pesticide is made with the algae.
- Liquid applications will not sink through the water column as readily as a granular application.
- When treating surface mats and blooms, it is possible that GreenClean PRO Granular Algaecide will not penetrate the water column below the infested area, and a second application is then required for treating any bottom growing algae.
- Apply more frequently during the summer months when water consumption and temperatures are high.

APPLICATION METHODS:

In bodies of water where an aerator is available, and when treating the entire water volume, dose GreenClean PRO Granular Algaecide at the edges, or in the turbulence created while the aerator runs to facilitate rapid and adequate mixing.

SPREADING / BROADCASTING:

Broadcast GreenClean PRO Granular Algaecide with a mechanical spreader or by hand, directly on the water surface, from shore or from a properly equipped boat.

SPOT TREATMENT:

Apply GreenClean PRO Granular Algaecide directly over the infested area. Re-treatment is required when heavy growth occurs.

LIQUID:

Make a solution with GreenClean PRO Granular Algaecide (refer to liquid application rates). Spray this solution on the water surface from shore or a properly equipped boat. When using this method, the wind direction is important as well as the operation of the boat. If using a slurry, agitate constantly.

INJECTION:

Make a solution with GreenClean PRO Granular Algaecide (refer to liquid application rates). Inject this solution into the water via a piping system.

SUBSURFACE:

Place GreenClean PRO Granular Algaecide in burlap bags and drag through the water by means of a boat. Use granular application rates. Begin treatment along the shoreline, and proceed outward. The path of the boat shall insure an even distribution. Continue dragging until all GreenClean PRO Granular Algaecide is dissolved.

STORAGE AND DISPOSAL:

Do not contaminate water, food, or feed by storage or disposal.

PESTICIDE STORAGE: Store in original containers in a cool, well-vented area, away from direct sunlight. Do not allow product to become over-heated in storage. This may cause increased degradation of the product, which will decrease product effectiveness. In case of spill, flood area with large quantities of water. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur.

PESTICIDE DISPOSAL: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility. Open dumping is prohibited. If wastes cannot be disposed of according to label directions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste Representative at the nearest EPA Regional Office for guidance.

CONTAINER DISPOSAL: Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.

WARRANTY:

This material conforms to the description on the label and is reasonably fit for the purposes referred to in the directions for use. Timing, unfavorable temperatures, water conditions, presence of other materials, method of application, weather, watering practices, nature of soil, disease problem, condition of crop, incompatibility with other chemicals, pre-existing conditions and other conditions influencing the use of this product are beyond the control of the seller. Buyer assumes all risks associated with the use, storage, or handling of this material not in strict accordance with directions given herewith. NO OTHER EXPRESS OR IMPLIED WARRANTY OF FITNESS OR MERCHANTABILITY IS MADE.

4.2007

Figure A-7. Scanned product label for GreenClean PRO, continued.

GreenClean PRO Granular Algaecide CALIFORNIA

MATERIAL SAFETY DATA SHEET

1. IDENTIFICATION:

Product Name: GreenCleanPRO California Granular Algaecide
Product Type: Algaecide
Manufacturer: BioSafe Systems LLC
22 Meadow Street
East Hartford, CT 06108
US Patent Number: 5723406
Office Telephone Number: (888) 273-3088
Emergency: CHEMTREC: 800-424-9300
(24 HOURS EVERY DAY)
Creation Date: 4/2007
NOTE: NOT VALID TWO YEARS AFTER CREATION DATE.

2. COMPONENTS:

Sodium Carbonate Peroxyhydrate: CAS 15630-89-4

3. HEALTH HAZARDS DATA:

Inhalation: Slight nose and throat irritation
Eye contact: Severe eye irritation, risk of serious eye lesions
Skin contact: Slight irritation
Ingestion: Severe irritation of the mouth, throat, esophagus and stomach

4. FIRST AID:

If in eyes: Hold eye open and rinse slowly,and gently with water for 15 – 20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.
If on skin or clothing: Take off contaminated clothing. Rinse skin immediately with plenty of water for 15 – 20 minutes. Call a poison control center or doctor for treatment advice.
If swallowed: Call poison control center or doctor immediately for treatment advice. Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a poison control center or doctor. Do not give anything by mouth to an unconscious person.
If inhaled: Move person to fresh air. If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth if possible. Call poison control center or doctor for treatment advice.

Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact 1-800-222-1222 for emergency medical treatment information.

NOTE TO PHYSICIAN: Probable mucosal damage may contraindicate the use of gastric lavage.

5. FIRE AND EXPLOSION DATA:

Special fire hazards: Oxidizing substance that causes exothermic reactions with organic materials.
Fire fighting methods: Product is not flammable and can be quickly diluted with clean water.
Specific Hazards: Reacts with strong reducing agents – decomposition may support combustion.

6. SPILL OR LEAK PROCEDURES:

Cleanup: Collect the product with suitable means, shovel, and sweep, avoiding dust formation.
Waste Disposal: Do not return spilled or contaminated material to inventory. Clean the area with large quantities of clean, cold water.

7. HANDLING AND STORAGE:

- Never return unused product to the original container
- Keep concentrate away from reactive substances
- Prevent contact with organic materials
- Keep product in original container
- Store in cool, dry area
- Keep out of direct sunlight and away from heat sources

8. EXPOSURE CONTROLS / PERSONAL PROTECTION:

Respiratory: For most conditions, no respiratory protection should be needed.
Eyes: Use dust proof chemical goggles
Hands: Protective gloves – chemical resistant
Skin: Body-covering clothing

9. PHYSICAL AND CHEMICAL PROPERTIES:

Appearance: White, granular, solid
Odor: None
Bulk Density: 1.0 – 1.2 g/cm3
Solubility: 140 g/L @ 24° C (75° F)
pH: 1% solution: 10.4 – 10.6

10. STABILITY AND REACTIVITY:

Stability: Stable under normal conditions
Avoid: Heat/Sources of Heat • Water/Moisture • Acids • Bases • Reducing Agents • Organic Materials

11. TOXICOLOGICAL INFORMATION:

Acute Toxicity:

- Dermal = LD Lo rabbit > 2000 mg/kg
- Inhalation = LC 0 1 hour, rat > 4580 mg /m
- Oral = LD 50 rat 1034 mg/kg

12. ECOLOGICAL INFORMATION:

Toxic to simple cell organisms
Danger to the environment is limited - due to product properties.

- No bioaccumulation
- Soil degradation = 99% in 20 minutes
- Considerable abiotic and biotic degradability
- Sediments = Non-significant adsorption
- Weak persistence of degradation products
- Degradation products = sodium carbonate, carbon dioxide, bicarbonate carbonate, hydrogen dioxide.

13. DISPOSAL CONSIDERATIONS:

Packing Treatment: Rinse empty containers with clean water. Clean and empty containers are to be recycled or disposed oin accordance with local regulations.

14. TRANSPORT INFORMATION:

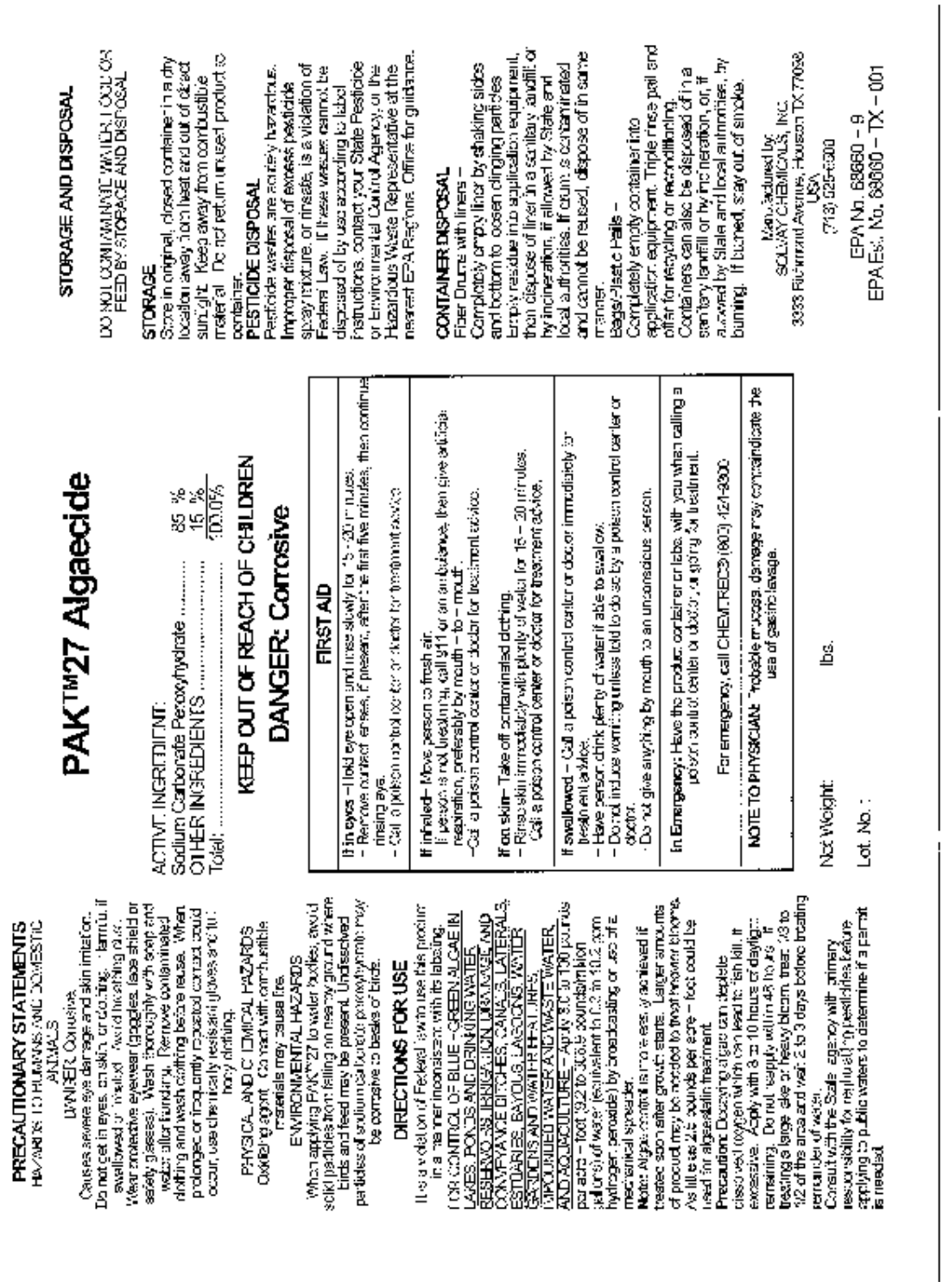
D.O.T. Shipping Name: Sodium Carbonate Peroxhydrate
UN Number: UN # 3378
Hazard Class: 5.1
Primary Hazard Label: Oxidizer
Subsidiary Risk Label: None
Packing Group: III
WHMIS Classification: C – oxidizing material

To the extent of our knowledge, the information herein is accurate as of the date of this document. However, neither BioSafe Systems nor any of its affiliates make any warranty, expressed or implied, or accept any liability in connection with the information or its use. The information is for use by technically skilled persons at their own discretion and risk. This is not a license or a patent. The user alone must finally determine suitability of any information or material for any contemplated use, the manner or use and whether any patents are infringed.

For additional information on GreenCleanPRO California Granular Algaecide, call us toll-free at 1.888.273.3088.

Figure A-8. Scanned product label for GreenClean PRO, continued.

A.3.3. PAK-27



PAK™27 Algaecide

KEEP OUT OF REACH OF CHILDREN

DANGER: Corrosive

ACTIVE INGREDIENT:

Sodium Carbonate Peroxyhydrate	85 %
OTHER INGREDIENTS	15 %
Total:	100.0%

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

DANGER. Corrosive.

Causes severe eye damage and skin irritation. Do not get in eyes, on skin or on clothing. Harmful if swallowed or inhaled. Avoid breathing dust. Wear protective eyewear (goggles, face shield or safety glasses). Wash thoroughly with soap and water after handling. Remove contaminated clothing and wash clothing before reuse. When prolonged or frequently repeated contact could occur, use chemically resistant gloves and/or body clothing.

PHYSICAL AND CHEMICAL HAZARDS

Oxidizing agent. Contact with combustible materials may cause fire.

ENVIRONMENTAL HAZARDS

When applying PAK™27 to water bodies, avoid solid pesticide application falling on nearby ground where birds and feed may be present. Undissolved particles of sodium carbonate peroxyhydrate may be corrosive to beaks of birds.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

FOR CONTROL OF BLUE-GREEN ALGAE IN LAKES, PONDS AND DRINKING WATER RESERVOIRS, IRRIGATION LATERALS AND CONVEYANCE DITCHES, CANALS, LATERALS, ESTUARIES, BAYOUS, LAGOONS, WATER TREATMENT PONDS AND WITHIN HEADWORKS, IMPOUNDED WATER AND WASTE WATER AND AQUACULTURE – Apply 50 to 100 pounds per acre – foot (92 to 369 pounds per million gallons of water (equivalent to 8.3 to 16.2 ppm hydrogen peroxide) by broadcasting or use of a mechanical spreader.

Note: Algae control is more easily achieved if treated soon after growth starts. Larger amounts of product may be needed to treat heavier blooms. As little as 25 pounds per acre – foot could be used for algaestatin treatment.

Precautions: Dosaging algae can deplete dissolved oxygen in which can lead to fish kill. If excessive. Apply with 8 to 10 hours of daylight remaining. Do not supply within 48 hours if treating a large algae or heavy bloom treat 1/3 to 1/2 of the area and wait 2 to 3 days before treating remainder of water.

Consult with the State agency with primary responsibility for pesticides before applying to public waters to determine if a permit is needed.

FIRST AID

If in eyes – Hold eye open and rinse slowly for 15 – 20 minutes.
- Remove contact lenses, if present, after the first five minutes, then continue rinsing eye.
- Call a poison control center or doctor for treatment advice.

If inhaled– Move person to fresh air.
If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably by mouth – to – mouth.
–Call a poison control center or doctor for treatment advice.

If on skin– Take off contaminated clothing.
- Rinse skin immediately with plenty of water for 15 – 20 minutes.
- Call a poison control center or doctor for treatment advice.

If swallowed – Call a poison control center or doctor immediately for treatment advice.
- Have person drink plenty of water if able to swallow.
- Do not induce vomiting unless told to do so by a poison control center or doctor.
- Do not give anything by mouth to an unconscious person.

In Emergency: Have the product container or label with you when calling a poison control center or doctor, or going for treatment.

For emergency, call CHEMTREC® (800) 424-9300

NOTE TO PHYSICIAN: Probable mucosal damage may contraindicate the use of gastric lavage.

Net Weight: lbs.

Lot. No. :

STORAGE AND DISPOSAL

DO NOT CONTAMINATE WATER, FOOD OR FEED BY STORAGE AND DISPOSAL

STORAGE

Store in original, closed container in a dry location away from heat and out of direct sunlight. Keep away from combustible material. Do not return unused product to container.

PESTICIDE DISPOSAL

Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide, spray mixture, or rinsate, is a violation of Federal Law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste Representative at the nearest EPA Regional Office for guidance.

CONTAINER DISPOSAL

Fiber Drums with liners –
Completely empty liner by shaking sides and bottom to loosen clinging particles. Empty residue into application equipment, then dispose of liner in a sanitary landfill or by incineration, if allowed by State and local authorities. If drum is contaminated and cannot be reused, dispose of in same manner.

Bags/Plastic Pails –
Completely empty container into application equipment. Triple rinse pail and offer for recycling or reconditioning. Containers can also be disposed of in a sanitary landfill or by incineration, or, if allowed by State and local authorities, by burning. If burned, stay out of smoke.

Manufactured by:
SOLVAY CHEMICALS, Inc.
3333 Richmond Avenue, Houston TX 77098
USA
(713) 525-6300

EPA No. 68660 – 9
EPA Est. No. 68660 – TX – 001

Figure A-9. Scanned product label for PAK-27.

B. Appendix B. Algaecide Usage in California

Included herein is additional information regarding pesticide (e.g., algaecide) application in California. As stated previously, please note that prior to any algaecide application, the status of the algaecide, permit requirements, and application procedures should be reviewed. The information presented below is meant to serve as an example only and not as a definitive guide on the requirements and procedures.

B.1. Algaecide Application in 2006 and 2007

This appendix contains the algaecide usage in California in 2006 and 2007 by type (Table B-1 and

Table B-2, respectively), by county (Table B-3 through Table B-5), and finally by chemical (Table B-6 and Table B-7).

Table B-1. 2006 use of California registered algaecides appropriate for lakes and reservoirs with wildlife.

Algaecides Used in 2006	Active Ingredient	Status	2006 Total State Reported Usage, lbs	
			Product	Active Ingredient
Agritec	Copper Sulfate (Pentahydrate)	Active	4,457	883
Agritec Algicide/Bactericide	Copper Sulfate (Pentahydrate)	Active	5,047	999
Blue Viking Copper Sulfate Star Shine Crystal	Copper Sulfate (Pentahydrate)	Inactive	5,350	5,297
Captain Liquid Copper Algaecide	Copper Carbonate, Basic	Active	4,731	752
Chipco Copper Sulfate Crystals	Copper Sulfate (Pentahydrate)	Inactive	59,266	58,674
Copper Sulfate Ag Crystals	Copper Sulfate (Pentahydrate)	Inactive	337	333
Copper Sulfate Crystal	Copper Sulfate (Pentahydrate)	Active	30,753	30,445
Copper Sulfate Crystals	Copper Sulfate (Pentahydrate)	Active	9,962	9,862
Copper Sulfate Large Crystals	Copper Sulfate (Pentahydrate)	Inactive	6,600	6,534
Cutrine Ultra	Copper Ethanolamine Complexes, Mixed	Active	103	9
Cutrine-Plus	Copper Ethanolamine Complexes, Mixed	Active	20,870	1,878
Cutrine-Plus Granular Algaecide	Copper Ethanolamine Complexes, Mixed	Active	2,225	82
Formula 30	Copper Sulfate (Basic)	Active	18,417	1,036
Hydrothol 191	Endothall, Mono [N,N-Dimethyl Alkylamine] Salt	Active	1,035	549
Kocide Copper Sulfate Pentahydrate Crystals	Copper Sulfate (Pentahydrate)	Inactive	4,900	4,851
Lesco Lescocide - Plus Algaecide	Copper Ethanolamine Complexes, Mixed	Inactive	100	9
Nautique Aquatic Herbicide	Copper Carbonate, Basic	Active	22,386	3,559
Phycomycin-Scp Algaecide And Oxidizer	Sodium Carbonate Peroxyhydrate	Active	17	14
Pristine Blue	Copper Sulfate (Pentahydrate)	Active	4,147	821
Triangle Brand Copper Sulfate Algicide-Herbicide	Copper Sulfate (Pentahydrate)	Inactive	85,070	84,219
Triangle Brand Copper Sulfate Crystal	Copper Sulfate (Pentahydrate)	Active	7,154	7,083

Table B-2. 2007 use of California registered algaecides appropriate for lakes and reservoirs with wildlife.

Algaecides Used in 2007	Active Ingredient	Status	2007 Total State Reported Usage, lbs	
			Product	Active Ingredient
AB Brand Copper Sulfate Crystal	Copper Sulfate (Pentahydrate)	Active	1,248	1,236
AB Brand Copper Sulfate Crystals	Copper Sulfate (Pentahydrate)	Active	65	64
Agritec	Copper Sulfate (Pentahydrate)	Inactive	12,234	2,422
Agritec Algicide/Bactericide	Copper Sulfate (Pentahydrate)	Inactive	1,334	264
Captain Liquid Copper Algaecide	Copper Carbonate, Basic	Active	1,753	279
Chipco Copper Sulfate Crystals	Copper Sulfate (Pentahydrate)	Inactive	63,474	62,840
Copper Sulfate Crystal	Copper Sulfate (Pentahydrate)	Inactive	4,656	4,609
Copper Sulfate Crystals	Copper Sulfate (Pentahydrate)	Inactive	11,088	10,977
Copper Sulfate Large Crystals	Copper Sulfate (Pentahydrate)	Inactive	11,775	11,657
Copper Sulfate Large Crystals (1-Inch)	Copper Sulfate (Pentahydrate)	Inactive	24	24
Crystal Blue Copper Sulfate Crystals	Copper Sulfate (Pentahydrate)	Active	213	211
Cutrine-Plus	Copper Ethanolamine Complexes, Mixed	Active	22,080	1,987
Cutrine-Plus Granular Algaecide	Copper Ethanolamine Complexes, Mixed	Active	3,897	144
Earthtec-Bactericide	Copper Sulfate (Pentahydrate)	Inactive	25	5
Formula 30	Copper Sulfate (Basic)	Inactive	31,203	1,755
Greenclean Pro Granular Algaecide	Sodium Carbonate Peroxyhydrate	Active	106	90
Hydrothol 191	Endothall, Mono [N,N-Dimethyl Alkylamine] Salt	Active	2,306	1,222
Hydrothol 191 Granular Aquatic Algicide And Herbicide	Endothall, Mono [N,N-Dimethyl Alkylamine] Salt	Active	50	6
Kocide Copper Sulfate Pentahydrate Crystals	Copper Sulfate (Pentahydrate)	Inactive	2,500	2,475
Lesco Lescocide - Plus Algaecide	Copper Ethanolamine Complexes, Mixed	Inactive	25	2
Lesco Lescocide-Plus Granular Algaecide	Copper Ethanolamine Complexes, Mixed	Inactive	30	1
Nautique Aquatic Herbicide	Copper Carbonate, Basic	Active	75	12
Pak 27 Algaecide (Oxidixer)	Sodium Carbonate Peroxyhydrate	Active	4,095	3,481
Phycomycin-Scp Algaecide And Oxidizer	Sodium Carbonate Peroxyhydrate	Active	318	270
Triangle Brand Copper Sulfate Algicide-Herbicide	Copper Sulfate (Pentahydrate)	Inactive	84,402	83,558
Triangle Brand Copper Sulfate Crystal	Copper Sulfate (Pentahydrate)	Active	43,290	42,857

Table B-3. 2006 California reported algaecide use - products appropriate for lakes and reservoirs with wildlife by county

	2006 Total Product Use, Lbs																				
County	Agritec	Agritec Algicide/Bactericide	Blue Viking Copper Sulfate Star Shine Crystal	Captain Liquid Copper Algaecide	Chipco Copper Sulfate Crystals	Copper Sulfate Ag Crystals	Copper Sulfate Crystal	Copper Sulfate Crystals	Copper Sulfate Large Crystals	Cutrine Ultra	Cutrine-Plus	Cutrine-Plus Granular Algaecide	Formula 30	Hydrothol 191	Kocide Copper Sulfate Pentahydrate Crystals	Lesco Lescocide - Plus Algaecide	Nautique Aquatic Herbicide	Phycomycin-Scp Algaecide And Oxidizer	Pristine Blue	Triangle Brand Copper Sulfate Algicide-Herbicide	Triangle Brand Copper Sulfate Crystal
Alameda				796							337	210									
Contra Costa					50						372	270	1445								
El Dorado											387										
Fresno					1750						924	20									
Kern	3				3741				6600		442				4900				3681	17459	
Kings																				813	
Lake																	122				
Los Angeles				158	3587						1281			6							
Madera	4454	5047	5350		29854		30200	4500			30									2027	
Marin											301							17			
Mariposa											1000										
Mendocino					288																
Merced					1150		250	2300									22256			542	
Monterey				748	32																5800
Napa				666	576	320	303				462	150								6800	
Orange					3507					103	1728	1026	1333	149						100	
Placer											981	155				100				214	54
Riverside					5775						2663	280	15181							32500	
Sacramento				221							1939		458	248					20	1385	
San Bernardino				1106	4370						3250										
San Diego					3550			2850													
San Joaquin											1070	24								1490	
San Luis Obispo																					1300
San Mateo				1022							1366	60		632							
Santa Barbara						17															
Solano											176	30									
Sonoma				13	716												8			50	
Stanislaus								312			372									390	
Tehama											1788									21250	
Tulare					320															50	
Ventura																			446		
Total	4457	5047	5350	4731	59266	337	30753	9962	6600	103	20870	2225	18417	1035	4900	100	22386	17	4147	85070	7154

Table B-4. 2007 California reported algaecide use - products appropriate for lakes and reservoirs with wildlife by county; Products A through F.

	2007 Total Product Use, Lbs														
County	AB Brand Copper Sulfate Crystal	AB Brand Copper Sulfate Crystals	Agritec	Agritec Algicide/Bactericide	Captain Liquid Copper Algaecide	Chipco Copper Sulfate Crystals	Copper Sulfate Crystal	Copper Sulfate Crystals	Copper Sulfate Large Crystals	Copper Sulfate Large Crystals (1-Inch)	Crystal Blue Copper Sulfate Crystals	Cutrine-Plus	Cutrine-Plus Granular Algaecide	Earthtec-Bactericide	Formula 30
Alameda	0	0	0	0	627	0	0	0	0	0	0	1432	480	0	0
Calaveras	0	0	0	297	0	0	0	0	0	0	0	13	0	0	0
Colusa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contra Costa	0	0	0	0	0	750	0	225	0	0	0	151	90	0	185
El Dorado	0	0	0	0	0	0	0	0	0	0	0	136	35	0	0
Fresno	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kern	0	0	0	594	0	3928	4450	1400	11775	0	0	1105	0	0	0
Kings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Los Angeles	0	0	0	0	0	2960	0	0	0	0	0	1869	0	0	0
Madera	0	0	12174	0	0	40850	0	4150	0	0	0	20	20	25	0
Marin	0	0	0	0	0	0	0	0	0	0	0	1507	300	0	0
Mariposa	0	0	0	0	0	0	0	0	0	0	0	567	0	0	0
Mendocino	0	0	0	0	0	70	46	0	0	0	0	20	0	0	0
Merced	1248	0	0	0	0	0	0	1850	0	0	0	0	0	0	0
Monterey	0	0	0	0	75	350	0	380	0	0	0	151	0	0	0
Napa	0	65	0	0	285	154	160	0	0	0	0	378	40	0	0
Nevada	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Orange	0	0	0	0	0	3660	0	0	0	0	0	3155	2118	0	1269
Placer	0	0	0	0	21	0	0	0	0	0	213	629	145	0	0
Riverside	0	0	0	0	395	4273	0	5	0	0	0	1221	161	0	29379
Sacramento	0	0	0	0	0	0	0	0	0	0	0	3198	21	0	326
San Bernardino	0	0	0	0	342	2965	0	0	0	0	0	1790	180	0	0
San Diego	0	0	0	0	0	2950	0	1700	0	0	0	1155	0	0	0
San Joaquin	0	0	0	0	0	0	0	0	0	0	0	2213	132	0	0
San Luis Obispo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
San Mateo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	44
Santa Barbara	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0
Santa Clara	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shasta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Siskiyou	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solano	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sonoma	0	0	0	0	8	565	0	50	0	0	0	573	121	0	0
Stanislaus	0	0	0	0	0	0	0	1228	0	0	0	377	54	0	0
Tehama	0	0	0	0	0	0	0	0	0	0	0	251	0	0	0
Tulare	0	0	59	443	0	0	0	0	0	24	0	20	0	0	0
Tuolumne	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ventura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yolo	0	0	0	0	0	0	0	0	0	0	0	151	0	0	0
Total	1248	65	12234	1334	1753	63474	4656	11088	11775	24	213	22080	3897	25	31203

Table B-5. 2007 California reported algaecide use - products appropriate for lakes and reservoirs with wildlife by county; Products G through Z.

	2007 Total Product Use, Lbs										
County	Greenclean Pro Granular Algaecide	Hydrothol 191	Hydrothol 191 Granular Aquatic Algicide And Herbicide	Kocide Copper Sulfate Pentahydrate Crystals	Lesco Lescocide - Plus Algaecide	Lesco Lescocide-Plus Granular Algaecide	Nautique Aquatic Herbicide	Pak 27 Algaecide	Phycomycin-Scp Algaecide And Oxidizer	Triangle Brand Copper Sulfate Algicide-Herbicide	Triangle Brand Copper Sulfate Crystal
Alameda	0	0	0	0	0	0	0	0	0	0	0
Calaveras	0	0	0	0	0	0	0	0	0	0	0
Colusa	0	0	0	0	0	0	0	0	0	0	0
Contra Costa	0	38	0	0	0	0	0	0	0	0	0
El Dorado	0	0	0	0	0	0	0	0	0	0	0
Fresno	0	0	0	0	0	0	0	0	0	20	0
Kern	0	0	0	2500	0	0	0	0	0	29271	10200
Kings	0	0	0	0	0	0	0	0	0	0	1800
Los Angeles	0	0	0	0	0	0	0	0	0	0	0
Madera	0	0	20	0	0	0	0	0	0	2000	25290
Marin	0	0	0	0	0	0	0	0	0	0	0
Mariposa	0	0	0	0	0	0	0	0	0	0	0
Mendocino	0	0	0	0	0	0	0	0	0	400	0
Merced	0	0	0	0	0	0	0	0	0	0	0
Monterey	0	27	0	0	0	0	0	0	0	0	6000
Napa	0	0	0	0	0	0	0	4095	318	2250	0
Nevada	0	0	0	0	0	0	32	0	0	0	0
Orange	0	158	0	0	0	0	0	0	0	215	0
Placer	0	0	0	0	0	30	35	0	0	38	0
Riverside	0	0	0	0	0	0	0	0	0	48000	0
Sacramento	0	34	0	0	0	0	0	0	0	640	0
San Bernardino	0	0	0	0	25	0	0	0	0	0	0
San Diego	0	0	0	0	0	0	0	0	0	0	0
San Joaquin	0	0	0	0	0	0	0	0	0	380	0
San Luis Obispo	0	0	0	0	0	0	0	0	0	0	0
San Mateo	0	2049	30	0	0	0	0	0	0	0	0
Santa Barbara	0	0	0	0	0	0	0	0	0	0	0
Santa Clara	0	0	0	0	0	0	0	0	0	0	0
Shasta	0	0	0	0	0	0	0	0	0	0	0
Siskiyou	0	0	0	0	0	0	0	0	0	0	0
Solano	0	0	0	0	0	0	0	0	0	0	0
Sonoma	106	0	0	0	0	0	8	0	0	0	0
Stanislaus	0	0	0	0	0	0	0	0	0	135	0
Tehama	0	0	0	0	0	0	0	0	0	950	0
Tulare	0	0	0	0	0	0	0	0	0	104	0
Tuolumne	0	0	0	0	0	0	0	0	0	0	0
Ventura	0	0	0	0	0	0	0	0	0	0	0
Yolo	0	0	0	0	0	0	0	0	0	0	0
Total	106	2306	50	2500	25	30	75	4095	318	84402	43290

Table B-6. 2006 California algaecide use - chemicals appropriate for lakes and reservoirs with wildlife by county.

County	Copper Carbonate, Basic	Copper Ethanolamine Complexes, Mixed	Copper Sulfate (Basic)	Copper Sulfate (Pentahydrate)	Endothall, Mono [N,N-Dimethyl Alkylamine] Salt	Sodium Carbonate Peroxyhydrate
Alameda	126	38	0	0	0	0
Contra Costa	0	43	81	50	0	0
El Dorado	0	35	0	0	0	0
Fresno	0	84	0	1733	0	0
Kern	0	40	0	33102	0	0
Kings	0	0	0	805	0	0
Lake	19	0	0	0	0	0
Los Angeles	25	115	0	3551	3	0
Madera	0	3	0	73093	0	
Marin	0	27	0	0	0	14
Mariposa	0	90	0	0	0	0
Mendocino	0	0	0	285	0	0
Merced	3539	0	0	4200	0	0
Monterey	119	0	0	5774	0	0
Napa	106	47	0	7919	0	0
Orange	0	203	75	3571	79	0
Placer	0	103	0	265	0	0
Riverside	0	250	854	37892	0	0
Sacramento	35	175	26	1375	131	0
San Bernardino	176	293	0	4326	0	0
San Diego	0	0	0	6336	0	0
San Joaquin	0	97	0	1475	0	0
San Luis Obispo	0	0	0	1287	0	0
San Mateo	163	125	0	0	335	0
Santa Barbara	0		0	16	0	0
Solano	0	17	0	0	0	0
Sonoma	3	0	0	758	0	0
Stanislaus	0	33	0	695	0	0
Tehama	0	161	0	21038	0	0
Tulare	0	0	0	366	0	0
Ventura	0	0	0	88	0	0
Total	4312	1979	1036	210001	549	14

Table B-7. 2007 California algaecide use - chemicals appropriate for lakes and reservoirs with wildlife by county.

County	Copper Carbonate, Basic	Copper Ethanolamine Complexes, Mixed	Copper Sulfate (Basic)	Copper Sulfate (Pentahydrate)	Endothall, Mono [N,N-Dimethyl Alkylamine] Salt	Sodium Carbonate Peroxyhydrate
Alameda	100	147	0	0	0	0
Calaveras	0	1	0	59	0	0
Colusa	0	0	0	0	0	0
Contra Costa	0	17	10	965	20	0
El Dorado	0	14	0	0	0	0
Fresno	0	0	0	20	0	0
Kern	0	99	0	63006	0	0
Kings	0	0	0	1782	0	0
Los Angeles	0	168	0	2930	0	0
Madera	0	3	0	73983	2	0
Marin	0	147	0	0	0	0
Mariposa	0	51	0	0	0	0
Mendocino	0	2	0	511	0	0
Merced	0	0	0	3067	0	0
Monterey	12	14	0	6663	14	0
Napa	45	35	0	2602	0	3751
Nevada	5	0	0	0	0	0
Orange	0	362	71	3836	84	0
Placer	9	63	0	248	0	0
Riverside	63	116	1653	51755	0	0
Sacramento	0	289	18	634	18	0
San Bernardino	54	170	0	2935	0	0
San Diego	0	104	0	4604	0	0
San Joaquin	0	204	0	376	0	0
San Luis Obispo	0	0	0	0	0	0
San Mateo	0	0	2	0	1089	0
Santa Barbara	0	0	0	99	0	0
Santa Clara	0	0	0	0	0	0
Shasta	0	0	0	0	0	0
Siskiyou	0	0	0	0	0	0
Solano	0	0	0	0	0	0
Sonoma	2	56	0	609	0	90
Stanislaus	0	36	0	1349	0	0
Tehama	0	23	0	941	0	0
Tulare	0	2	0	226	0	0
Tuolumne	0	0	0	0	0	0
Ventura	0	0	0	0	0	0
Yolo	0	14	0	0	0	0
Total	291	2135	1755	223199	1228	3841

B.2. Application Methods

When cyanobacteria blooms at near surface locations in small surface area reservoirs in canyon terrain with large river inflows, the most probable method of application would be surface application. There are many different types of surface application system, but two example surface application systems are presented below.

B.2.1. Aquatic Pesticide Application System

The first application system is the Aquatic Pesticide Application System (APAS) and methods (US Patent #6,778,887 B2; Patents Pending) by the Natural Resource Company, LLC (TNRC). The APAS is utilized to ensure precise application of herbicides within a lake and is capable of implementing variable application rate (VAR) technology, accounting for variations in specific lake attributes such as surface area, water quality parameters, plant species and densities as well as water depth and volume. The APAS includes a dispensing system, receiver on the vessel for receiving position data from a global positioning satellite (GPS) system, data storage devise for storing digital data, processor for receiving data, and processor which is continuously receiving position and attribute data to apply the appropriate amount of pesticide at specific locations. The software utilized within APAS system records the total amount of product applied as well as real-time geo-referenced application data, which is used to produce "as applied" results and maps for the herbicide treatment (TNRC, 2004).

B.2.2. Pro Applicator®

The second surface application system is the Pro Applicator® automated aquatic herbicide application system. The Pro Applicator® utilizes a Controller Area Network (CAN) system that is comprised of independent, intelligent modules connected by a single high speed cable, called a bus, over which all data in the system travels. In this system, there are three modules that each contain their own microprocessors and share a standard communication sequence that conforms to ISO 11898 standards: the Power Speed Module, the Switch Sense Module, and the Product Control Module. The modules are connected via an on board computer system to a Trimble sub meter GPS receiver beacon and a Swath XL Lightbar for system positioning and guidance (Clean Lakes, 2009).

B.3. Generalized Application Procedure for California Reservoirs

If an algaecide was applied to reservoirs in California, it would be considered non-production agricultural pest control, and therefore such algaecide application would need to follow the procedures determined by the California Code of Regulations, Title 3. Food and Agriculture, Division 6. Pesticides and Pest Control Operations, Sections 6660 through 6628.

To summarize the code of regulations, the administrative procedure for application of algaecide for non-production agricultural pest control would include:

- The property owner where the pesticide is applied must give consent for the application.

- Written notice must be given to the property owner with the scheduled date of application, the name of the pesticide to be used, and the precautions that need to be observed.
- The property operator must give notice of pesticide application to all persons who are on the property or who may enter the property during the application or during any time restrictions after application. (Signs and or barriers may be used.)
- Prior to the purchase and use of pesticides the operator of the property, or the authorized representative of the operator, needs to obtain an operator identification number from the commissioner of each county in which the operator intends to apply pesticides. (The operator of the property is not required to obtain an ID number if they are hiring a professional pest control person / company to apply the pesticides.) This number will be recorded on a restricted materials permit, or issued on an approved form, and will be valid for a specified period that cannot exceed 36 months.
- If an operator is required to obtain more than one operator identification number (one from each county where pesticide application will occur), they shall provide each county commissioner a list of the counties in which pest control will be performed and all valid operator identification numbers issued by other commissioners. The number(s) will be recorded by the commissioner on either the operator's restricted materials permit or on a form approved by the county director.
- In addition to obtaining the operator identification number, if a restricted materials permit is necessary, the restricted materials permit must be obtained as well.
- Persons who use pesticides for an agricultural use will maintain records of pesticide use which include the date of application, the name of the operator of the property treated, the location of the property treated, the site treated, the total acreage or unites treated at the site and the pesticide used, the EPA or California registration number and the amount of pesticide used.
- A monthly summary report of the monthly use of pesticides will be reported to the commissioner of the county in which the pesticide was applied. The report will be provided by the 10th day of the month following the month of application (postmark will be date of delivery if mailed). The report will be submitted on a department form or in a format approved by the county director, and needs to include the name and address of the person who or the business which applied the pesticide(s), the county where the pesticide was applied, the month and year of pesticide use, the site treated, the pesticide (with USEPA or CA registration number) and amount used, the number of applications made with each pesticide and the total number of applications made during the month and the total acres or units treated with each pesticide.
- If the county in which the pesticide was applied has no commissioner, the report will be provided to the county director.

Though the summary above provides a general administrative procedure of algaecide use in California, the California Code of Regulations should be referred to for further details.

C. Appendix C: Copco Reservoir Algaecide Field Test Study Plan

August 13, 2008

Algaecides to be tested include: PAK-27 (hydrogen peroxide), GreenClean PRO (hydrogen peroxide), and Algimycin PWF (copper)

Test Location: Copco Reservoir

C.1. Pre-Site Visit Procedure:

1. Mark one-gallon gradations on the outside of the five-gallon container.
    - Using a one-gallon vessel, pour one gallon of water into the five-gallon container and after water surface settles, mark the outside of the five-gallon container at the water line using a sharpie or similar water-proof marker.
    - Repeat process until all five-gallon increments are marked.
2. Using a ruler, measure the distance from the bottom of the container to each gradation mark. Record each gradation mark distance.
3. For the remaining five-gallon containers, using the recorded distances from the bottom, make one-gallon gradation marks on the outside of each container.

C.2. Water Collection Procedure:

1. Deploy large pump with reinforced PVC tubing into Copco Reservoir.
2. Place circulating pump into the 55-gallon drum, turn on, and begin to fill with Copco Reservoir water.
3. Remove large pump from the reservoir and place it in the 55-gallon drum.
4. Fill four (4) of the five-gallon containers with sample water, capping each container with a lid when completely filled.
5. Label each container and lid with correct experiment number (e.g., "Experiment 1").
6. Empty and clean the 55-gallon drum and the large and small pumps.
7. Repeat steps 1 through 6 until all containers have been filled.[6]

C.3. Algaecide Testing Procedure

Table C-1 contains the container test load rates for the three algaecides used in the test. Table C-2 contains the proposed sample collected and analysis schedule.

[6] For the small scale algaecide study performed a total of twelve 5-gallon containers were filled, requiring that steps 1 through 6 be repeated three times (i.e., Replicate 1, Replicate 2, and Replicate 3). Each container contained approximately 5-gallons of well-mixed sample waters from Copco Reservoir.

Table C-1. Dosage and application rates for Algimycin PWF, GreenClean PRO, and PAK-27.

Product	Active Ingredient Concentration	Recommended Application Rate	Application Rate per Gallon	Application Rate per Container
PAK-27	(5 ppm H2O2)	50 lb / acre-ft	69.6 mg	348 mg
GreenCleanPRO	(5 ppm H2O2)	50 lb / acre-ft	69.6 mg	348 mg
Algimycin PWF	(0.25 ppm Cu)	1.33 gal / acre-ft	0.54 drops	3 drops

Table C-2. Proposed sample collection and analysis schedule.

	Control			Initial Application									Second Application	
				Algimycin PWF			GreenClean Pro			PAK-27			GreenClean PRO	PAK-27
	Time, hours			Time, hours			Time, hours			Time, hours			Time, hours	Time, hours
Constituents	0	1	24	0	1	24	0	1	24	0	1	24	25	25
Alkalinity	x	-	-	-	-	-	-	-	-	-	-	-	-	-
Hardness	x	-	-	-	-	-	-	-	-	-	-	-	-	-
TOC	x	-	x	-	-	x	-	-	x	-	-	x	-	-
Copper	x	-	x	-	x	x	-	-	x	-	-	x	-	-
Microcystin	x	x	x	-	x	x	-	x	x	-	x	x	x	x
Chloraphyll-a	x	x	x	-	x	x	-	x	x	-	x	x	x	x
Phaeophytin	x	x	x	-	x	x	-	x	x	-	x	x	x	x
Algae Species	x	-	x	-	-	x	-	-	x	-	-	x	-	-

C.4. Container Test Set-Up

8. Place three utility trays onto the rubber matting.
9. Put four filled closed containers into each utility tray.
10. Label *both* the containers and lids: Control, Algimycin PWF, GreenClean PRO, and PAK-27.

C.4.1. Control

11. Remove lid to Control container.
12. Using handheld probe measure water temperature.
13. Collect appropriate samples for t = 0 hours.
14. Replace control lid.
15. Repeat process at t = 1 hour and t = 24 hours.
16. At the conclusion of the study, discard the sample.

C.4.2. Algimycin PWF

17. Remove lid to Algimycin PWF container.
18. Using handheld probe measure water temperature.
19. Using a plastic dropper, drop the appropriate number of drops of product onto the surface of the water. DO NOT STIR WATER.
20. Place the lid back onto the container.

21. When t = 1 hour, remove control lid and gently stir the sample using a glass stirring rod.
22. Measure water temperature and collect appropriate samples.
23. Place the lid back onto the container.
24. Repeat steps 5 and 6 when t = 24 hours.
25. Discard sample when finished.

C.4.3. GreenClean PRO and PAK-27:

26. Fold a sheet of paper in half (short way), crease, and then unfold the paper.
27. Place unfolded paper on scale and tare the scale.
28. Measure out required amount of product onto paper on scale.
29. Remove product from scale and carefully pour into open salt shaker.
30. Secure cap onto salt shaker.
31. Remove lid to test container.
32. Using handheld probe measure water temperature.
33. Using salt shaker, apply product evenly over surface of water in container. DO NOT STIR WATER.
34. Place the lid back onto the container.
35. When t = 1 hour, remove control lid and gently stir the sample using a glass stirring rod.
36. Measure water temperature and collect appropriate samples.
37. Place the lid back onto the container.
38. Repeat steps 5 and 6 when t = 24 hours.
39. Measure a second application load for bucket and place in salt shaker. If there is significantly less water in container, estimate new volume based on graduation marks on outside of container and recalculate new application load for container based on new volume of water.
40. Using salt shaker, apply product evenly over surface of water in container. DO NOT STIR WATER.
41. Place the lid back onto the container.
42. When t = 25 hours, remove test container lid and measure water temperature and collect the appropriate samples.
43. Discard remaining sample.

D. Appendix D. Copco Reservoir Algaecide Field Test Results

Appendix D contains phytoplankton results obtained the Copco Reservoir Algaecide Field Test.

Table D-1. Algal speciation results.

Date	Time	Algaecide	Sample ID	Species	Group	Density (#/ml)	Density (%)	Biovolume (μm^3/mL)	Biovolume (%)
8/24/08	17:25	Control	KRA 8001	*Microcystis aeruginosa*	bluegreen	160	8.6	410389	44.5
8/24/08	17:25	Control	KRA 8001	*Aphanizomenon flos-aquae*	bluegreen	107	5.7	100994	11.0
8/24/08	17:25	Control	KRA 8001	*Anabaena flos-aquae*	bluegreen	36	1.9	23868	2.6
8/24/08	17:25	Control	KRA 8001	*Chromulina sp.*	chrysophyte	214	11.4	4275	0.5
8/24/08	17:25	Control	KRA 8001	*Rhodomonas minuta*	cryptophyte	178	9.5	3562	0.4
8/24/08	17:25	Control	KRA 8001	*Cryptomonas erosa*	cryptophyte	53	2.9	27787	3.0
8/24/08	17:25	Control	KRA 8001	*Nitzschia palea*	diatom	321	17.1	57711	6.3
8/24/08	17:25	Control	KRA 8001	*Cocconeis placentula*	diatom	178	9.5	81935	8.9
8/24/08	17:25	Control	KRA 8001	*Nitzschia frustulum*	diatom	36	1.9	4275	0.5
8/24/08	17:25	Control	KRA 8001	*Nitzschia amphibia*	diatom	18	1.0	1710	0.2
8/24/08	17:25	Control	KRA 8001	*Gomphonema subclavatum*	diatom	18	1.0	10687	1.2
8/24/08	17:25	Control	KRA 8001	*Rhoicosphenia curvata*	diatom	18	1.0	2084	0.2
8/24/08	17:25	Control	KRA 8001	*Synedra ulna*	diatom	18	1.0	35446	3.8
8/24/08	17:25	Control	KRA 8001	*Chlamydomonas sp.*	green	481	25.7	156300	17.0
8/24/08	17:25	Control	KRA 8001	*Ankistrodesmus falcatus*	green	18	1.0	445	0.0
8/24/08	17:25	Control	KRA 8001	*Unidentified flagellate*		18	1.0	356	0.0
8/24/08	17:30	Control	KRA 8002	*Microcystis aeruginosa*	bluegreen	165	11.9	313572	57.0
8/24/08	17:30	Control	KRA 8002	*Chromulina sp.*	chrysophyte	13	0.9	253	0.0
8/24/08	17:30	Control	KRA 8002	*Nitzschia palea*	diatom	1001	72.5	180147	32.8
8/24/08	17:30	Control	KRA 8002	*Cocconeis placentula*	diatom	101	7.3	46620	8.5
8/24/08	17:30	Control	KRA 8002	*Rhoicosphenia curvata*	diatom	25	1.8	2964	0.5
8/24/08	17:30	Control	KRA 8002	*Nitzschia microcephala*	diatom	25	1.8	2534	0.5

8/24/08	17:30	Control	KRA 8002	*Nitzschia amphibia*	diatom	13	0.9	2432	0.4
8/24/08	17:30	Control	KRA 8002	*Ankistrodesmus falcatus*	green	25	1.8	633	0.1
8/24/08	17:30	Control	KRA 8002	*Schroderia sp.*	green	13	0.9	570	0.1
8/24/08	17:35	Control	KRA 8003	*Aphanizomenon flos-aquae*	bluegreen	314	17.8	257101	42.7
8/24/08	17:35	Control	KRA 8003	*Microcystis aeruginosa*	bluegreen	87	5.0	15347	2.5
8/24/08	17:35	Control	KRA 8003	*Anabaena flos-aquae*	bluegreen	17	1.0	46739	7.8
8/24/08	17:35	Control	KRA 8003	*Chromulina sp.*	chrysophyte	279	15.8	5581	0.9
8/24/08	17:35	Control	KRA 8003	*Rhodomonas minuta*	cryptophyte	209	11.9	4186	0.7
8/24/08	17:35	Control	KRA 8003	*Cryptomonas erosa*	cryptophyte	52	3.0	27206	4.5
8/24/08	17:35	Control	KRA 8003	*Nitzschia palea*	diatom	279	15.8	50227	8.3
8/24/08	17:35	Control	KRA 8003	*Cocconeis placentula*	diatom	70	4.0	32090	5.3
8/24/08	17:35	Control	KRA 8003	*Gomphonema subclavatum*	diatom	35	2.0	20928	3.5
8/24/08	17:35	Control	KRA 8003	*Fragilaria vaucheriae*	diatom	17	1.0	10045	1.7
8/24/08	17:35	Control	KRA 8003	*Chlamydomonas sp.*	green	331	18.8	107692	17.9
8/24/08	17:35	Control	KRA 8003	*Sphaerocystis schroeteri*	green	35	2.0	24416	4.1
8/24/08	17:35	Control	KRA 8003	*Ankistrodesmus falcatus*	green	17	1.0	436	0.1
8/24/08	17:35	Control	KRA 8003	*Unidentified flagellate*		17	1.0	349	0.1
8/25/08	12:45	Control	KRA 8006	*Aphanizomenon flos-aquae*	bluegreen	275	16.8	259875	40.3
8/25/08	12:45	Control	KRA 8006	*Microcystis aeruginosa*	bluegreen	92	5.6	257400	39.9
8/25/08	12:45	Control	KRA 8006	*Anabaena flos-aquae*	bluegreen	15	0.9	10236	1.6
8/25/08	12:45	Control	KRA 8006	*Chromulina sp.*	chrysophyte	397	24.3	7944	1.2
8/25/08	12:45	Control	KRA 8006	*Rhodomonas minuta*	cryptophyte	244	15.0	4889	0.8
8/25/08	12:45	Control	KRA 8006	*Cryptomonas erosa*	cryptophyte	15	0.9	7944	1.2
8/25/08	12:45	Control	KRA 8006	*Nitzschia palea*	diatom	382	23.4	68750	10.7
8/25/08	12:45	Control	KRA 8006	*Cocconeis placentula*	diatom	31	1.9	14056	2.2
8/25/08	12:45	Control	KRA 8006	*Nitzschia frustulum*	diatom	15	0.9	1833	0.3
8/25/08	12:45	Control	KRA 8006	*Navicula sp.*	diatom	15	0.9	2292	0.4
8/25/08	12:45	Control	KRA 8006	*Rhoicosphenia curvata*	diatom	15	0.9	1788	0.3

8/25/08	12:45	Control	KRA 8006	*Hemidinium sp.*	dinoflagellate	15	0.9	4583	0.7
8/25/08	12:45	Control	KRA 8006	*Ankistrodesmus falcatus*	green	61	3.7	1528	0.2
8/25/08	12:45	Control	KRA 8006	*Unidentified flagellate*		61	3.7	1222	0.2
8/25/08	12:45	PAK-27	KRA 8009	*Microcystis aeruginosa*	bluegreen	98	12.4	338152	58.2
8/25/08	12:45	PAK-27	KRA 8009	*Aphanizomenon flos-aquae*	bluegreen	57	7.2	71750	12.4
8/25/08	12:45	PAK-27	KRA 8009	*Chromulina sp.*	chrysophyte	65	8.2	1302	0.2
8/25/08	12:45	PAK-27	KRA 8009	*Rhodomonas minuta*	cryptophyte	16	2.1	325	0.1
8/25/08	12:45	PAK-27	KRA 8009	*Cryptomonas erosa*	cryptophyte	8	1.0	4230	0.7
8/25/08	12:45	PAK-27	KRA 8009	*Nitzschia palea*	diatom	374	47.4	67357	11.6
8/25/08	12:45	PAK-27	KRA 8009	*Cocconeis placentula*	diatom	24	3.1	11226	1.9
8/25/08	12:45	PAK-27	KRA 8009	*Gomphonema ventricosum*	diatom	8	1.0	55317	9.5
8/25/08	12:45	PAK-27	KRA 8009	*Nitzschia microcephala*	diatom	8	1.0	813	0.1
8/25/08	12:45	PAK-27	KRA 8009	*Glenodinium sp.*	dinoflagellate	8	1.0	5694	1.0
8/25/08	12:45	PAK-27	KRA 8009	*Chlamydomonas sp.*	green	65	8.2	21151	3.6
8/25/08	12:45	PAK-27	KRA 8009	*Ankistrodesmus falcatus*	green	33	4.1	813	0.1
8/25/08	12:45	PAK-27	KRA 8009	*Sphaerocystis schroeteri*	green	8	1.0	2278	0.4
8/25/08	12:45	PAK-27	KRA 8009	*Schroderia sp.*	green	8	1.0	366	0.1
8/25/08	12:45	PAK-27	KRA 8009	*Unidentified flagellate*		8	1.0	163	0.0
8/25/08	12:45	GreenClean PRO	KRA 8012	*Aphanizomenon flos-aquae*	bluegreen	157	18.9	158044	32.7
8/25/08	12:45	GreenClean PRO	KRA 8012	*Microcystis aeruginosa*	bluegreen	92	11.1	217661	45.1
8/25/08	12:45	GreenClean PRO	KRA 8012	*Chromulina sp.*	chrysophyte	74	8.9	1476	0.3
8/25/08	12:45	GreenClean PRO	KRA 8012	*Rhodomonas minuta*	cryptophyte	28	3.3	553	0.1
8/25/08	12:45	GreenClean PRO	KRA 8012	*Cryptomonas erosa*	cryptophyte	9	1.1	4796	1.0
8/25/08	12:45	GreenClean PRO	KRA 8012	*Nitzschia palea*	diatom	277	33.3	49804	10.3
8/25/08	12:45	GreenClean PRO	KRA 8012	*Cocconeis placentula*	diatom	65	7.8	29698	6.2
8/25/08	12:45	GreenClean PRO	KRA 8012	*Nitzschia frustulum*	diatom	18	2.2	3320	0.7
8/25/08	12:45	GreenClean PRO	KRA 8012	*Nitzschia microcephala*	diatom	9	1.1	922	0.2
8/25/08	12:45	GreenClean PRO	KRA 8012	*Gomphonema subclavatum*	diatom	9	1.1	5534	1.1

8/25/08	12:45	GreenClean PRO	KRA 8012	*Ankistrodesmus falcatus*	green	55	6.7	1383	0.3
8/25/08	12:45	GreenClean PRO	KRA 8012	*Chlamydomonas sp.*	green	28	3.3	8992	1.9
8/25/08	12:45	GreenClean PRO	KRA 8012	*Schroderia sp.*	green	9	1.1	415	0.1
8/25/08	12:45	Algimycin PWF	KRA 8015	*Aphanizomenon flos-aquae*	bluegreen	85	9.9	64158	21.0
8/25/08	12:45	Algimycin PWF	KRA 8015	*Microcystis aeruginosa*	bluegreen	48	5.6	114447	37.5
8/25/08	12:45	Algimycin PWF	KRA 8015	*Chromulina sp.*	chrysophyte	36	4.2	727	0.2
8/25/08	12:45	Algimycin PWF	KRA 8015	*Rhodomonas minuta*	cryptophyte	12	1.4	242	0.1
8/25/08	12:45	Algimycin PWF	KRA 8015	*Nitzschia palea*	diatom	436	50.7	78561	25.8
8/25/08	12:45	Algimycin PWF	KRA 8015	*Cocconeis placentula*	diatom	48	5.6	22308	7.3
8/25/08	12:45	Algimycin PWF	KRA 8015	*Fragilaria construens*	diatom	12	1.4	1358	0.4
8/25/08	12:45	Algimycin PWF	KRA 8015	*Rhoicosphenia curvata*	diatom	12	1.4	1418	0.5
8/25/08	12:45	Algimycin PWF	KRA 8015	*Nitzschia capitellata*	diatom	12	1.4	4365	1.4
8/25/08	12:45	Algimycin PWF	KRA 8015	*Fragilaria pinnata*	diatom	12	1.4	727	0.2
8/25/08	12:45	Algimycin PWF	KRA 8015	*Nitzschia frustulum*	diatom	12	1.4	1455	0.5
8/25/08	12:45	Algimycin PWF	KRA 8015	*Dinobryon sertularia*	dinoflagellate	12	1.4	1455	0.5
8/25/08	12:45	Algimycin PWF	KRA 8015	*Ankistrodesmus falcatus*	green	73	8.5	2182	0.7
8/25/08	12:45	Algimycin PWF	KRA 8015	*Chlamydomonas sp.*	green	24	2.8	7880	2.6
8/25/08	12:45	Algimycin PWF	KRA 8015	*Sphaerocystis schroeteri*	green	12	1.4	3395	1.1
8/25/08	12:45	Algimycin PWF	KRA 8015	*Unidentified flagellate*		12	1.4	242	0.1
8/25/08	12:15	Control	KRA 8017	*Microcystis aeruginosa*	bluegreen	313	15.1	658961	44.6
8/25/08	12:15	Control	KRA 8017	*Aphanizomenon flos-aquae*	bluegreen	294	14.2	295969	20.0
8/25/08	12:15	Control	KRA 8017	*Anabaena flos-aquae*	bluegreen	59	2.8	39345	2.7
8/25/08	12:15	Control	KRA 8017	*Chromulina sp.*	chrysophyte	39	1.9	783	0.1
8/25/08	12:15	Control	KRA 8017	*Rhodomonas minuta*	cryptophyte	98	4.7	1957	0.1
8/25/08	12:15	Control	KRA 8017	*Nitzschia palea*	diatom	959	46.2	379827	25.7
8/25/08	12:15	Control	KRA 8017	*Cocconeis placentula*	diatom	39	1.9	18009	1.2
8/25/08	12:15	Control	KRA 8017	*Nitzschia amphibia*	diatom	39	1.9	3758	0.3
8/25/08	12:15	Control	KRA 8017	*Glenodinium sp.*	dinoflagellate	20	0.9	13702	0.9

8/25/08	12:15	Control	KRA 8017	*Chlamydomonas sp.*	green	59	2.8	19085	1.3
8/25/08	12:15	Control	KRA 8017	*Ankistrodesmus falcatus*	green	59	2.8	1468	0.1
8/25/08	12:15	Control	KRA 8017	*Sphaerocystis schroeteri*	green	20	0.9	5481	0.4
8/25/08	12:15	Control	KRA 8017	*Dictyosphaerium ehrenbergianum*	green	20	0.9	18792	1.3
8/25/08	12:15	Control	KRA 8017	*Coelastrum microporum*	green	20	0.9	18792	1.3
8/25/08	12:15	Control	KRA 8017	*Unidentified flagellate*		39	1.9	783	0.1
8/25/08	13:15	Control	KRA 8018	*Aphanizomenon flos-aquae*	bluegreen	251	16.7	268345	49.2
8/25/08	13:15	Control	KRA 8018	*Microcystis aeruginosa*	bluegreen	107	7.1	101368	18.6
8/25/08	13:15	Control	KRA 8018	*Anabaena flos-aquae*	bluegreen	54	3.6	35973	6.6
8/25/08	13:15	Control	KRA 8018	*Chromulina sp.*	chrysophyte	161	10.7	3221	0.6
8/25/08	13:15	Control	KRA 8018	*Rhodomonas minuta*	cryptophyte	233	15.5	4653	0.9
8/25/08	13:15	Control	KRA 8018	*Nitzschia palea*	diatom	519	34.5	102764	18.8
8/25/08	13:15	Control	KRA 8018	*Cocconeis placentula*	diatom	36	2.4	16465	3.0
8/25/08	13:15	Control	KRA 8018	*Dinobryon sertularia*	dinoflagellate	18	1.2	2148	0.4
8/25/08	13:15	Control	KRA 8018	*Ankistrodesmus falcatus*	green	36	2.4	895	0.2
8/25/08	13:15	Control	KRA 8018	*Chlamydomonas sp.*	green	18	1.2	5816	1.1
8/25/08	13:15	Control	KRA 8018	*Sphaerocystis schroeteri*	green	18	1.2	2506	0.5
8/25/08	13:15	Control	KRA 8018	*Unidentified flagellate*		54	3.6	1074	0.2
8/25/08	12:20	PAK-27	KRA 8020	*Microcystis aeruginosa*	bluegreen	323	19.8	774249	67.3
8/25/08	12:20	PAK-27	KRA 8020	*Aphanizomenon flos-aquae*	bluegreen	81	5.0	50810	4.4
8/25/08	12:20	PAK-27	KRA 8020	*Chromulina sp.*	chrysophyte	32	2.0	645	0.1
8/25/08	12:20	PAK-27	KRA 8020	*Rhodomonas minuta*	cryptophyte	48	3.0	968	0.1
8/25/08	12:20	PAK-27	KRA 8020	*Nitzschia palea*	diatom	855	52.5	261599	22.8
8/25/08	12:20	PAK-27	KRA 8020	*Nitzschia amphibia*	diatom	48	3.0	4645	0.4
8/25/08	12:20	PAK-27	KRA 8020	*Fragilaria sp.*	diatom	16	1.0	3226	0.3
8/25/08	12:20	PAK-27	KRA 8020	*Ankistrodesmus falcatus*	green	97	5.9	2420	0.2
8/25/08	12:20	PAK-27	KRA 8020	*Chlamydomonas sp.*	green	97	5.9	31454	2.7
8/25/08	12:20	PAK-27	KRA 8020	*Dictyosphaerium ehrenbergianum*	green	16	1.0	15485	1.3

8/25/08	12:20	PAK-27	KRA 8020	*Scenedesmus quadricauda*	green	16	1.0	4194	0.4
8/25/08	13:15	PAK-27	KRA 8021	*Aphanizomenon flos-aquae*	bluegreen	183	11.9	138319	10.8
8/25/08	13:15	PAK-27	KRA 8021	*Microcystis aeruginosa*	bluegreen	168	10.9	927127	72.1
8/25/08	13:15	PAK-27	KRA 8021	*Chromulina sp.*	chrysophyte	61	4.0	1220	0.1
8/25/08	13:15	PAK-27	KRA 8021	*Rhodomonas minuta*	cryptophyte	46	3.0	915	0.1
8/25/08	13:15	PAK-27	KRA 8021	*Nitzschia palea*	diatom	1022	66.3	202264	15.7
8/25/08	13:15	PAK-27	KRA 8021	*Rhoicosphenia curvata*	diatom	15	1.0	1784	0.1
8/25/08	13:15	PAK-27	KRA 8021	*Sphaerocystis schroeteri*	green	15	1.0	8538	0.7
8/25/08	13:15	PAK-27	KRA 8021	*Chlamydomonas sp.*	green	15	1.0	4955	0.4
8/25/08	13:15	PAK-27	KRA 8021	*Ankistrodesmus falcatus*	green	15	1.0	381	0.0
8/25/08	12:20	GreenClean PRO	KRA 8023	*Microcystis aeruginosa*	bluegreen	167	10.7	534519	61.8
8/25/08	12:20	GreenClean PRO	KRA 8023	*Aphanizomenon flos-aquae*	bluegreen	30	1.9	19133	2.2
8/25/08	12:20	GreenClean PRO	KRA 8023	*Chromulina sp.*	chrysophyte	46	2.9	911	0.1
8/25/08	12:20	GreenClean PRO	KRA 8023	*Rhodomonas minuta*	cryptophyte	46	2.9	911	0.1
8/25/08	12:20	GreenClean PRO	KRA 8023	*Nitzschia palea*	diatom	805	51.5	144867	16.8
8/25/08	12:20	GreenClean PRO	KRA 8023	*Cocconeis placentula*	diatom	61	3.9	27941	3.2
8/25/08	12:20	GreenClean PRO	KRA 8023	*Nitzschia capitellata*	diatom	46	2.9	16400	1.9
8/25/08	12:20	GreenClean PRO	KRA 8023	*Navicula pupula*	diatom	30	1.9	8200	0.9
8/25/08	12:20	GreenClean PRO	KRA 8023	*Nitzschia amphibia*	diatom	30	1.9	2916	0.3
8/25/08	12:20	GreenClean PRO	KRA 8023	*Synedra ulna*	diatom	30	1.9	60437	7.0
8/25/08	12:20	GreenClean PRO	KRA 8023	*Nitzschia microcephala*	diatom	15	1.0	1519	0.2
8/25/08	12:20	GreenClean PRO	KRA 8023	*Cyclotella meneghiniana*	diatom	15	1.0	5770	0.7
8/25/08	12:20	GreenClean PRO	KRA 8023	*Synedra parasitica*	diatom	15	1.0	2126	0.2
8/25/08	12:20	GreenClean PRO	KRA 8023	*Fragilaria construens*	diatom	15	1.0	1701	0.2
8/25/08	12:20	GreenClean PRO	KRA 8023	*Nitzschia frustulum*	diatom	15	1.0	1822	0.2
8/25/08	12:20	GreenClean PRO	KRA 8023	*Chlamydomonas sp.*	green	91	5.8	29611	3.4
8/25/08	12:20	GreenClean PRO	KRA 8023	*Ankistrodesmus falcatus*	green	46	2.9	1139	0.1
8/25/08	12:20	GreenClean PRO	KRA 8023	*Gloeocystis ampla*	green	15	1.0	3887	0.4

8/25/08	12:20	GreenClean PRO	KRA 8023	*Unidentified flagellate*		46	2.9	911	0.1
8/25/08	13:15	GreenClean PRO	KRA 8024	*Aphanizomenon flos-aquae*	bluegreen	145	9.8	109986	16.7
8/25/08	13:15	GreenClean PRO	KRA 8024	*Microcystis aeruginosa*	bluegreen	97	6.5	232774	35.4
8/25/08	13:15	GreenClean PRO	KRA 8024	*Chromulina sp.*	chrysophyte	36	2.4	727	0.1
8/25/08	13:15	GreenClean PRO	KRA 8024	*Rhodomonas minuta*	cryptophyte	97	6.5	1940	0.3
8/25/08	13:15	GreenClean PRO	KRA 8024	*Cryptomonas erosa*	cryptophyte	12	0.8	6304	1.0
8/25/08	13:15	GreenClean PRO	KRA 8024	*Nitzschia palea*	diatom	752	50.4	135300	20.6
8/25/08	13:15	GreenClean PRO	KRA 8024	*Cocconeis placentula*	diatom	48	3.3	22308	3.4
8/25/08	13:15	GreenClean PRO	KRA 8024	*Synedra ulna*	diatom	48	3.3	96504	14.7
8/25/08	13:15	GreenClean PRO	KRA 8024	*Nitzschia amphibia*	diatom	24	1.6	2328	0.4
8/25/08	13:15	GreenClean PRO	KRA 8024	*Navicula anglica*	diatom	12	0.8	4365	0.7
8/25/08	13:15	GreenClean PRO	KRA 8024	*Melosira ambigua*	diatom	12	0.8	7141	1.1
8/25/08	13:15	GreenClean PRO	KRA 8024	*Fragilaria construens*	diatom	12	0.8	1358	0.2
8/25/08	13:15	GreenClean PRO	KRA 8024	*Nitzschia frustulum*	diatom	12	0.8	1455	0.2
8/25/08	13:15	GreenClean PRO	KRA 8024	*Nitzschia capitellata*	diatom	12	0.8	4365	0.7
8/25/08	13:15	GreenClean PRO	KRA 8024	*Amphora coffeiformes*	diatom	12	0.8	1152	0.2
8/25/08	13:15	GreenClean PRO	KRA 8024	*Chlamydomonas sp.*	green	85	5.7	27581	4.2
8/25/08	13:15	GreenClean PRO	KRA 8024	*Ankistrodesmus falcatus*	green	48	3.3	1212	0.2
8/25/08	13:15	GreenClean PRO	KRA 8024	*Schroderia sp.*	green	24	1.6	1091	0.2
8/25/08	12:20	Algimycin PWF	KRA 8026	*Microcystis aeruginosa*	bluegreen	229	11.1	711239	63.1
8/25/08	12:20	Algimycin PWF	KRA 8026	*Aphanizomenon flos-aquae*	bluegreen	25	1.2	15998	1.4
8/25/08	12:20	Algimycin PWF	KRA 8026	*Chromulina sp.*	chrysophyte	127	6.2	2539	0.2
8/25/08	12:20	Algimycin PWF	KRA 8026	*Rhodomonas minuta*	cryptophyte	51	2.5	1016	0.1
8/25/08	12:20	Algimycin PWF	KRA 8026	*Nitzschia palea*	diatom	1320	64.2	308996	27.4
8/25/08	12:20	Algimycin PWF	KRA 8026	*Cocconeis placentula*	diatom	76	3.7	35044	3.1
8/25/08	12:20	Algimycin PWF	KRA 8026	*Nitzschia amphibia*	diatom	25	1.2	2438	0.2
8/25/08	12:20	Algimycin PWF	KRA 8026	*Rhoicosphenia curvata*	diatom	25	1.2	2971	0.3
8/25/08	12:20	Algimycin PWF	KRA 8026	*Melosira granulata*	diatom	25	1.2	13967	1.2

8/25/08	12:20	Algimycin PWF	KRA 8026	*Chlamydomonas sp.*	green	76	3.7	24759	2.2
8/25/08	12:20	Algimycin PWF	KRA 8026	*Schroderia sp.*	green	25	1.2	1143	0.1
8/25/08	12:20	Algimycin PWF	KRA 8026	*Dictyosphaerium ehrenbergianum*	green	25	1.2	6095	0.5
8/25/08	12:20	Algimycin PWF	KRA 8026	*Ankistrodesmus falcatus*	green	25	1.2	635	0.1
8/25/08	13:15	Algimycin PWF	KRA 8027	*Aphanizomenon flos-aquae*	bluegreen	75	6.7	47243	7.6
8/25/08	13:15	Algimycin PWF	KRA 8027	*Microcystis aeruginosa*	bluegreen	64	5.8	325491	52.4
8/25/08	13:15	Algimycin PWF	KRA 8027	*Chromulina sp.*	chrysophyte	129	11.5	2571	0.4
8/25/08	13:15	Algimycin PWF	KRA 8027	*Rhodomonas minuta*	cryptophyte	11	1.0	214	0.0
8/25/08	13:15	Algimycin PWF	KRA 8027	*Nitzschia palea*	diatom	653	58.7	211724	34.1
8/25/08	13:15	Algimycin PWF	KRA 8027	*Cocconeis placentula*	diatom	32	2.9	14783	2.4
8/25/08	13:15	Algimycin PWF	KRA 8027	*Nitzschia amphibia*	diatom	11	1.0	1028	0.2
8/25/08	13:15	Algimycin PWF	KRA 8027	*Glenodinium sp.*	dinoflagellate	11	1.0	7499	1.2
8/25/08	13:15	Algimycin PWF	KRA 8027	*Ankistrodesmus falcatus*	green	86	7.7	2143	0.3
8/25/08	13:15	Algimycin PWF	KRA 8027	*Schroderia sp.*	green	21	1.9	964	0.2
8/25/08	13:15	Algimycin PWF	KRA 8027	*Chlamydomonas sp.*	green	21	1.9	6963	1.1