TECHNICAL MEMORANDUM

Tenmile Lakes Toxic Algae Monitoring, November 12, 2009

Prepared for: **Tenmile Lakes Basin Partnership**

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November 12th, 2009 toxic algal cell count results for Tenmile Lakes are as follows (see Figure 1 below for sample station location):

Table 1. Cell density of potentially toxigenic cyanobacteria in Tenmile Lakes, November 12, 2009.

Station	Date	*Microcystis* (cells/ml)	*Gloeotrichia* (cells/ml)	Total *Microcystis*+ *Gloeotrichia*	Total *Anabaena* (cells/ml)
S3	11/12/2009	516	0	516	144
S8	11/12/2009	535	0	535	51
N11	11/12/2009	199	0	199	42.4
N16	11/12/2009	1377	0	1377	134.3

***Exceeds World Health Organization Alert Level 1 increased vigilance guideline level of 500 cells ml^{-1} for potentially toxigenic species in drinking water systems.**

Samples from November 12th show that M*icrocystis aeruginosa* (MSAE) and total *Anabaena* cell densities at all standard South and North Lake stations were below the Alert Level 2 guideline of 2000 cells/ml (at which time DHS and local health services typically issue a public alert for drinking water lakes and reservoirs) (Table 1; Figure 2). Moreover, levels of both MSAE and total *Anabaena* were well below recreational guidelines (State of Oregon posting guidelines for recreational water bodies are 40,000 cells/ml for *Microcystis* and 100,000 cells/ml for *Anabaena).* However, low levels of MSAE continued to persist at all stations, thus home-owners should ensure that treatment systems are operating effectively.

Patchy concentrations of blue-green algae noted in previous algal memos were not evident during the November 12th sampling event.

Blue-green algae (cyanobacteria) continued to comprise the majority of algal biomass at S3 and S8, with A*phanizomenon flos-aquae (APFA)* comprising the majority of biovolume (Appendix I). At N11 the green alga *Chlamydomonas* was dominant with APFA second; while at N16 MSAE, APFA, and *Anabaena* comprised 50.6% of the biovolume (Appendix I).

Due to the patchy nature of blue-green algal blooms it is possible for higher Microcystis aeruginosa and Anabaena flos-aquae densities (and therefore higher microcystin toxin and anatoxin concentrations to be present in areas not sampled in this survey, particularly along shorelines or during calm conditions of little to no wind. Given the lakes' demonstrated history of toxic blooms, and the fact that all areas of the lake cannot be tested at all times, those utilizing the lake for drinking water should always follow Oregon Health Division recommendations for purification (attached). In addition, recreational users should always avoid contact with *water whenever noticeable surface concentrations of algae are evident or when the lake has an obvious green to blue-green appearance. Moreover, because pets or other domestic animals are the most likely to ingest contaminated water, these animals should not be allowed access to the lakeshore whenever either noticeable surface concentrations of algae or an obvious green to blue-green appearance is evident.*

References for Alert Levels

Carey, C.C., and J.F. Haney, and K.L. Cottingham. 2007. First report of microcystin-LR in the cyanobacterium *Gloeotrichia echinulata.* Environmental toxicology 22:337-339.

Kann, J. 2007. Tenmile Lakes Toxic Algal Sampling Program: 2006 Data Summary Report. Tenmile Lakes Basin Partnership, Lakeside OR 97520

Falconer et al. 1999. Safe levels and safe practices. Pages 155-177 *in*: I. Chorus and J. Bartram, editors. *Toxic Cyanobacteria in water: a guide to their public health consequences*. World Health Organization Report. E & FN Spon, London and New York.

Stone, D., and W. Bress. 2007. Addressing Public Health Risks for Cyanobacteria in Recreational Freshwaters: The Oregon and Vermont Framework. Integrated Environmental Assessment and Management; 3(1): 137 -143 (2007). http://www.oregon.gov/DHS/ph/hab/docs/Stone_cyano_rec.pdf

Yoo, S.R., W.W. Carmichael, R.C. Hoehn, and S.E. Hrudy. 1995. Cyanobacterial (blue-green algal) toxins: a resource guide. AWWA Research Foundation and American Water Works Association. Denver, CO. 229 p. (ISBN 0-89867-824-2)

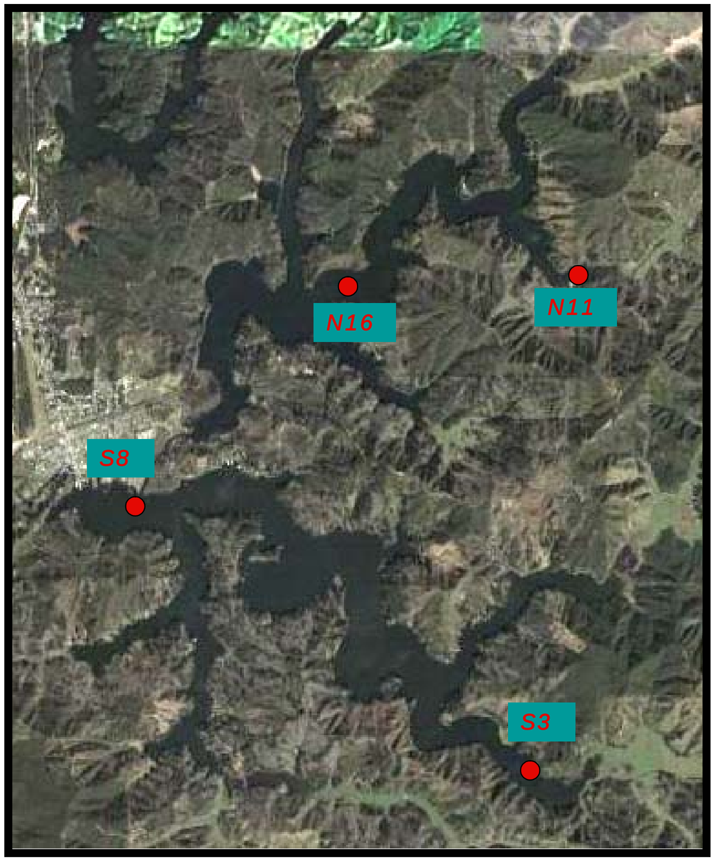

Figure1. Sample station location for potentially toxigenic cyanobacteria in Tenmile Lakes, 2009.

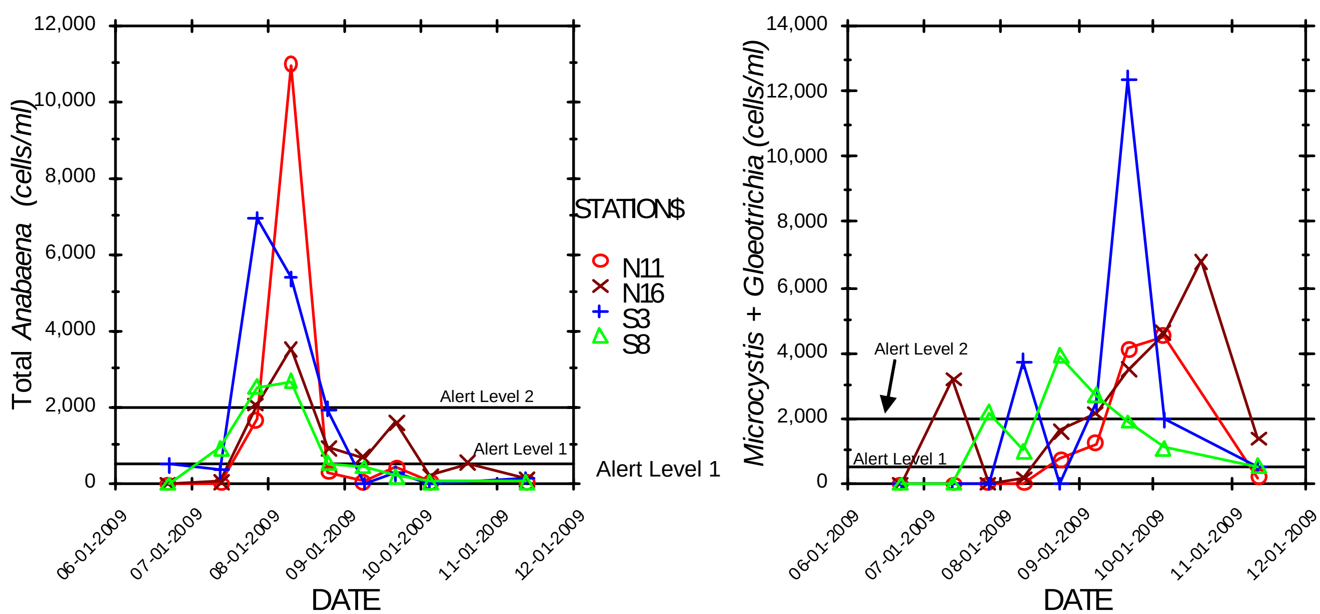

Figure 2. Trend of potentially toxigenic cyanobacteria (blue-green algae) in Tenmile Lakes, 2009..

Appendix I: Aquatic Analysts Phytoplankton Lab Sheets

Phytoplankton Sample Analysis

Sample:	Tenmile Lake
Sample Site:	S3
Sample Depth:	
Sample Date:	12-Nov-09
Total Density (#/mL):	79
Total Biovolume (um^3/mL):	92,816
Trophic State Index:	32.8

	Species	**Density #/mL**	**Density Percent**	**Biovolume um^3/mL**	**Biovolume Percent**	**Group**
1	Aphanizomenon flos-aquae	36.1	45.5	45,469	49.0	bluegreen
2	Mallomonas sp.	5.7	7.2	2,165	2.3	chrysophyte
3	Cryptomonas erosa	5.3	6.7	2,765	3.0	cryptophyte
4	Dinobryon sertularia	5.3	6.7	3,893	4.2	dinoflagellate
5	Asterionella formosa	4.6	5.7	3,209	3.5	diatom
6	Anabaena flos-aquae	4.2	5.3	7,279	7.8	bluegreen
7	Microcystis aeruginosa	3.4	4.3	4,130	4.4	bluegreen
8	Rhodomonas minuta	3.0	3.8	61	0.1	cryptophyte
9	Chlamydomonas sp.	2.3	2.9	741	0.8	green
10	Melosira italica	2.3	2.9	5,797	6.2	diatom
11	Anabaena planctonica	1.5	1.9	5,561	6.0	bluegreen
12	Melosira distans alpigena	1.5	1.9	2,526	2.7	diatom
13	Melosira granulata	1.1	1.4	4,575	4.9	diatom
14	Synedra radians	1.1	1.4	410	0.4	diatom
15	Ankistrodesmus falcatus	0.8	1.0	19	0.0	green
16	Melosira ambigua	0.4	0.5	447	0.5	diatom
17	Ceratium hirundinella	0.4	0.5	3,723	4.0	dinoflagellate
18	Stephanodiscus hantzschii	0.4	0.5	46	0.0	diatom

Note: 200 count.

Aphanizomenon flos-aquae cells/mL =	722
Aphanizomenon flos-aquae heterocysts/mL =	7
Anabaena flos-aquae cells/mL =	109
Anabaena flos-aquae heterocysts/mL =	3
Anabaena flos-aquae akinetes/mL =	0
Microcystis aeruginosa cells/mL =	516
Anabaena planctonica cells/mL =	30
Anabaena planctonica heterocysts/mL =	1
Anabaena planctonica akinetes/mL =	1

Aquatic Analysts **Sample ID:** MV35

Phytoplankton Sample Analysis

Sample: Tenmile Lake
Sample Site: S8
Sample Depth:
Sample Date: 12-Nov-09

Total Density (#/mL): 54
Total Biovolume (um^3/mL): 71,204
Trophic State Index: 30.9

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Aphanizomenon flos-aquae	35.2	65.0	53,175	74.7	bluegreen
2	Microcystis aeruginosa	3.5	6.5	4,276	6.0	bluegreen
3	Anabaena flos-aquae	2.4	4.5	3,263	4.6	bluegreen
4	Synedra radians	1.9	3.5	682	1.0	diatom
5	Melosira ambigua	1.9	3.5	4,462	6.3	diatom
6	Dinobryon sertularia	1.4	2.5	552	0.8	dinoflagellate
7	Chlamydomonas sp.	1.4	2.5	440	0.6	green
8	Mallomonas sp.	1.4	2.5	514	0.7	chrysophyte
9	Cryptomonas erosa	1.1	2.0	563	0.8	cryptophyte
10	Ankistrodesmus falcatus	0.8	1.5	20	0.0	green
11	Asterionella formosa	0.5	1.0	357	0.5	diatom
12	Fragilaria crotonensis	0.5	1.0	2,272	3.2	diatom
13	Crucigenia quadrata	0.3	0.5	92	0.1	green
14	Achnanthes hauckiana	0.3	0.5	13	0.0	diatom
15	Gloeocystis ampla	0.3	0.5	69	0.1	green
16	Rhodomonas minuta	0.3	0.5	5	0.0	cryptophyte
17	Fragilaria vaucheriae	0.3	0.5	78	0.1	diatom
18	Eunotia incisa	0.3	0.5	155	0.2	diatom
19	Sphaerocystis schroeteri	0.3	0.5	151	0.2	green
20	Dictyosphaerium ehrenbergianum	0.3	0.5	65	0.1	green

Note: 200 count.

Aphanizomenon flos-aquae cells/mL =	844
Aphanizomenon flos-aquae heterocysts/mL =	25
Anabaena flos-aquae cells/mL =	49
Anabaena flos-aquae heterocysts/mL =	2
Microcystis aeruginosa cells/mL =	535

Aquatic Analysts **Sample ID:** MV36

Phytoplankton Sample Analysis

Sample: Tenmile Lake
Sample Site: N11
Sample Depth:
Sample Date: 12-Nov-09

Total Density (#/mL): 104
Total Biovolume (um^3/mL): 55,757
Trophic State Index: 29.1

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Chlamydomonas sp.	63.1	61.0	20,511	36.8	green
2	Cocconeis placentula	14.3	13.8	6,581	11.8	diatom
3	Aphanizomenon flos-aquae	3.8	3.7	11,451	20.5	bluegreen
4	Achnanthes minutissima	2.9	2.8	147	0.3	diatom
5	Gomphonema angustatum	2.1	2.0	379	0.7	diatom
6	Microcystis aeruginosa	1.7	1.6	1,589	2.8	bluegreen
7	Navicula cryptocephala	1.3	1.2	304	0.5	diatom
8	Anabaena planctonica	1.3	1.2	5,313	9.5	bluegreen
9	Anabaena flos-aquae	1.3	1.2	846	1.5	bluegreen
10	Melosira granulata	1.3	1.2	2,291	4.1	diatom
11	Cryptomonas erosa	0.8	0.8	438	0.8	cryptophyte
12	Navicula viridula	0.8	0.8	379	0.7	diatom
13	Gomphonema subclavatum	0.8	0.8	505	0.9	diatom
14	Pinnularia sp.	0.8	0.8	337	0.6	diatom
15	Synedra rumpens	0.8	0.8	118	0.2	diatom
16	Achnanthes linearis	0.8	0.8	111	0.2	diatom
17	Asterionella formosa	0.8	0.8	278	0.5	diatom
18	Tabellaria flocculosa	0.4	0.4	248	0.4	diatom
19	Sphaerocystis schroeteri	0.4	0.4	236	0.4	green
20	Rhodomonas minuta	0.4	0.4	8	0.0	cryptophyte
21	Desmidium sp.	0.4	0.4	1,473	2.6	green
22	Achnanthes hauckiana	0.4	0.4	20	0.0	diatom
23	Nitzschia frustulum	0.4	0.4	50	0.1	diatom
24	Dinobryon sertularia	0.4	0.4	202	0.4	dinoflagellate
25	Ankistrodesmus falcatus	0.4	0.4	11	0.0	green
26	Synedra ulna	0.4	0.4	837	1.5	diatom
27	Eunotia pectinalis	0.4	0.4	303	0.5	diatom
28	Trachelomonas volvocina	0.4	0.4	793	1.4	euglenoid

Note: 200 count.

Aphanizomenon flos-aquae cells/mL =	182
Aphanizomenon flos-aquae heterocysts/mL =	0.4
Microcystis aeruginosa cells/mL =	199
Anabaena planctonica cells/mL =	29
Anabaena planctonica heterocysts/mL =	0.4
Anabaena flos-aquae cells/mL =	13

Aquatic Analysts — Sample ID: MV37

Phytoplankton Sample Analysis

Sample:	Tenmile Lake				
Sample Site:	N16				
Sample Depth:					
Sample Date:	12-Nov-09				
Total Density (#/mL):	32				
Total Biovolume (um^3/mL):	44,467				
Trophic State Index:	27.5				

	Species	**Density #/mL**	**Density Percent**	**Biovolume um^3/mL**	**Biovolume Percent**	**Group**
1	Microcystis aeruginosa	7.9	24.6	11,017	24.8	bluegreen
2	Aphanizomenon flos-aquae	4.7	14.8	5,652	12.7	bluegreen
3	Anabaena flos-aquae	3.6	11.3	5,821	13.1	bluegreen
4	Asterionella formosa	2.8	8.9	2,431	5.5	diatom
5	Anabaena planctonica	2.0	6.4	7,863	17.7	bluegreen
6	Rhodomonas minuta	1.9	5.9	38	0.1	cryptophyte
7	Chlamydomonas sp.	1.6	4.9	511	1.2	green
8	Cryptomonas erosa	1.3	3.9	655	1.5	cryptophyte
9	Melosira ambigua	1.1	3.4	2,855	6.4	diatom
10	Dinobryon sertularia	0.9	3.0	986	2.2	dinoflagellate
11	Melosira granulata	0.8	2.5	1,904	4.3	diatom
12	Fragilaria crotonensis	0.6	2.0	3,437	7.7	diatom
13	Sphaerocystis schroeteri	0.5	1.5	264	0.6	green
14	Cyclotella stelligera	0.5	1.5	26	0.1	diatom
15	Melosira distans alpigena	0.3	1.0	386	0.9	diatom
16	Dictyosphaerium ehrenbergianum	0.3	1.0	227	0.5	green
17	Cocconeis placentula	0.3	1.0	145	0.3	diatom
18	Nitzschia acicularis	0.2	0.5	44	0.1	diatom
19	Ankistrodesmus falcatus	0.2	0.5	4	0.0	green
20	Oocystis pusilla	0.2	0.5	34	0.1	green
21	Mallomonas sp.	0.2	0.5	60	0.1	chrysophyte
22	Desmidium sp.	0.2	0.5	110	0.2	green

Note: 200 count

Anabaena planctonica cells/mL =	43
Anabaena planctonica heterocysts/mL =	1.3
Anabaena planctonica akinetes/mL =	0.2
Microcystis aeruginosa cells/mL =	1,377
Aphanizomenon flos-aquae cells/mL =	90
Aphanizomenon flos-aquae heterocysts/mL =	1.9
Aphanizomenon flos-aquae akinetes/mL =	0.2
Anabaena flos-aquae cells/mL =	87
Anabaena flos-aquae heterocysts/mL =	2.8

Aquatic Analysts — Sample ID: MV38

Oregon Health Division
Drinking water treatment guidance
August 31, 2001

DHS Contact Information:

Harmful Algae Program Coordinator: Laura Boswell at (971) 673 – 0438
If she is not available call the main line for the Office of Environmental Public Health at: (971) 673 – 0440 or
Toll Free: (877) 290 – 6767 and press 0. Ask for Laura Boswell

1. Treatment systems should consist of sand filtration followed by chlorination, followed by activated charcoal filtration. It is essential that sand filtration be done before disinfection to remove as many algal cells as possible without killing or rupturing them.

2. Chlorination systems should be capable of maintaining at least 1 ppm of chlorine residual for at least 20 minutes contact time before the water enters the activated charcoal system.

3. The final step in the process should be effective activated charcoal treatment to remove toxin remaining after the sand filtration and disinfection processes.

4. All treatment equipment used should meet NSF standard 53, and should be adequately sized to treat the maximum amount of water that you use. Treatment equipment needs regular monitoring and servicing to assure that it functions properly.

5. Ideally all water entering your home should be treated as recommended. It is possible to treat only water used in the kitchen, but this increases chances that animals or pets would inadvertently drink untreated water.

As more monitoring is done and toxin levels are measured this advisory may be altered. The advisory is to remain in effect until specifically changed or lifted by county and state health officials.

FACT SHEET

TOXIC *MICROCYSTIS* BLOOMS IN TENMILE LAKES

(information modified from Oregon Health Division Document: Hazards from *Microcystis aeruginosa* in Fresh Water – http://www.ohd.hr.state.or.us/esc/docs/mafact.htm)

➢ What is a toxic bloom of *Microcystis aeruginosa*?

Microcystis aeruginosa is a species of blue-green algae that grows naturally in many surface waters. In most bodies of fresh water and most weather conditions it does not pose a hazard to wildlife or human beings. However, under certain conditions (such as when the water is warm with abundant nutrients) *Microcystis aeruginosa* can grow more rapidly than normal. The result can be excessive numbers of large colonies that form floating masses on the water surface or that are dispersed within the water column. These occurrences are called "algal blooms". *Microcystis aeruginosa* can produce natural toxins (called microcystins) that are very potent, and these toxins are higher in concentration during bloom conditions. The microcystin toxins are produced and contained inside the *Microcystis* cells, and are released to the water when the cells die and disintegrate. Also, since the cells are very small, they can be ingested along with the water. Toxin levels in a water body tend to be higher near shorelines and at the surface of the water where animal and human contact is most likely.

➢ What are the primary toxic effects of these blooms?

The primary toxic effect of microcystins is on the liver. At very high doses, death of liver cells and destruction of blood vessels in the liver can result in serious injury and possibly death. Though less is known about the long-term effects of microcystin toxins, animal studies have shown these toxins can cause chronic liver damage and may promote the formation of liver tumors. These effects are more likely to occur if exposure is frequent over a long period of time.

The levels of toxin necessary to produce immediate or acute illness in humans and animals are much higher than levels that may cause chronic liver injury. Drinking water standards are usually based on chronic effects. Currently, there is no drinking water standard in the U.S. for microcystins. Canada, Australia, and Great Britain have developed a guideline level of 1 microgram toxin per liter of water, or 1 part per billion (1 ppb). During algal blooms, toxin levels can greatly exceed 1 ppb.

➢ How is it determined when the water becomes safe once a bloom is reported?

Changes in weather or in other conditions in a water body influence the growth of blue-green algae. Generally, cooler weather, rainfall, and reduced sunshine will lead to reductions in algal growth and toxin levels. Algal blooms generally peak and die off rapidly and toxin levels in the water decline over days or weeks. Only blue-green algae experts can distinguish visually between different kinds of algal growth, and are able to determine when blooms have disappeared. Testing of the water is the only way to be certain that toxin levels are no longer dangerous.

➢ When does the Oregon Health Division Issue Warnings?

Drinking Water -- When measured or estimated toxin levels reach 1 ug/l the Department of Human Services, Office of Public Health Systems issues public advisories or warnings. These will include warnings regarding the use of water for drinking or food preparation unless the water has been treated following specific guidelines for destroying and removing toxins. Animals should be kept away from water during periods when microcystin toxin levels exceed 1 ug/l, because drinking the water can cause serious or even fatal illness.

Contact Recreation -- If levels are high enough to pose hazards for swimming, water-skiing or other direct skin contact activities, the advisories will warn against water contact. Generally skin hazards occur where the water has a green or blue-green color or where there are visible clumps or mats of algae present in the water. When measured toxin levels reach 5 ug/L or cell counts reach 15,000 cells/ml, contact recreation is considered unsafe.

➢ Can testing ensure that all areas of the lake are safe?

No, due to the patchy nature of blue-green algal blooms it is possible for higher *Microcystis* densities (and therefore higher microcystin toxin concentrations) to be present in areas not sampled in a given survey, particularly along shorelines or during calm conditions of little to no wind. **Therefore, when a lake has a demonstrated history of algal toxicity or the presence of known toxin producing algal species, those utilizing the lake for drinking water should always follow Oregon Health Division recommendations for purification. In addition, recreational users should always avoid contact with water whenever noticeable surface concentrations of algae are evident or when the lake has an obvious green to blue-green appearance.**

➢ Are domestic animals at risk during blooms?

Yes, pets or other domestic animals are the most likely to ingest contaminated water, these animals should not be allowed access to the lakeshore whenever either noticeable surface concentrations of algae or an obvious green to blue-green appearance is evident.

➢ Is it safe to eat fish and other aquatic life?

Clams, mussels, snails and other shellfish should not be eaten during microcystin advisory periods, but it is believed that fish can be safely eaten if they are cleaned and all internal organs discarded. Internal organs of such fish may be toxic even to animals.

➢ How much does testing cost?

Samples must be shipped to qualified laboratories for analysis. A microscopic determination to quantify the number of Microcystis colonies and cells costs $90 per sample. A specialized test to analyze for the microcystin toxin concentration costs $100 per sample (overnight shipping costs not included), and for anatoxins the cost is $250/sample .

- NOTE: A fact sheet about microcystin toxin and its effects may be found on the Web at www.dhs.state.or.us/publichealth/esc/docs/mafact.cfm