TECHNICAL MEMORANDUM

Tenmile Lakes Toxic Algae Monitoring, September 8, 2009

Prepared for: **Tenmile Lakes Basin Partnership**

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September 8th, 2009 toxic algal cell count results for Tenmile Lakes are as follows (see Figure 1 below for sample station location):

Station	Date	*Microcystis* (cells/ml)	*Gloeotrichia* (cells/ml)	Total *Microcystis*+ *Gloeotrichia*	Total *Anabaena* (cells/ml)
S3	9/8/2009	2,497	0	2,497**	0
S8	9/8/2009	2,689	0	2,689**	440
N11	9/8/2009	1,222	0	1,222*	50
X	9/8/2009	300,940	0	300,940***	605,160***
N16	9/8/2009	2,158	0	2,158**	672

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

**Exceeds World Health Organization Alert Level 2 public health posting guideline level of 2000 cells ml^{-1} for potentially toxigenic species in drinking water systems

***Exceeds State of Oregon Recreational Guideline Levels of 40,000 cells/ml for *Microcystis* or 1000,000 cell/ml for *Anabaena*

Samples form September 8th show that M*icrocystis aeruginosa* (MSAE) at the standard stations (S3, S8, N11, and N16) generally increased with all stations except N11 exceeding the WHO 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) by approximately 2 times (Table 1; Figure 2). In past years such levels have been associated with microcystin toxin levels exceeding the WHO 1 µg/L drinking water level in Tenmile Lakes, thus, home-owners should ensure that treatment systems are operating effectively. Total *Anabaena* declined overall, and continued to be below Alert Level 2 at all stations (Figure 2); *h*owever, as noted in previous Algal Memos, the predominant *Anabaena* species identified was *Anabaena planctonica* (Appendix I), a species less commonly associated with toxin production.

During the course of sampling at the standard stations, it became apparent that patchy concentrations of blue-green algae were occurring in other areas of the lake (see photo in Figure 2 below). Thus, an additional sample was collected from the area shown in the picture and is shown as sample station "X" above in Table 1 and in the map in Figure 1. Results from this station clearly show not only a high concentration of *Anabaena planctonica* (605,160 cell/ml; Table 1 and Appendix 1), but that MSAE, while only comprising 1.6% of the biovolume, showed a cell density of 300,940 cells/ml (Appendix 1). Such MSAE levels can be associated with microcystin toxin levels that constitute a high probability of adverse health effects for recreational users of the lake. State of Oregon posting guidelines for recreational water bodies are 40,000 cells/ml for *Microcystis* and 100,000 cells/ml for *Anabaena*.

These results confirm statements in past reports "that although reported levels for non-dominant species (such as MSAE) indicate the general trend, they do not guarantee that levels of potentially toxigenic species at a particular location do not exceed guideline values". Thus, not only does this spatial variability (bloom patchiness) and the fact that cyanobacterial cells have been reported in home-owner drinking water treatment systems (see Kann 2007), make it prudent that all drinking water protection efforts should be in place, but it also shows that recreational exposure guidelines can be exceeded as well. Such was the case during the September 8th sampling date.

A sample form station "X" was collected and is being sent to a laboratory for analysis of the algal toxins microcystin and anatoxin-a.

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 Assesment and Managment; 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)

Year 2009 Tenmile Lakes Sample Site Locations

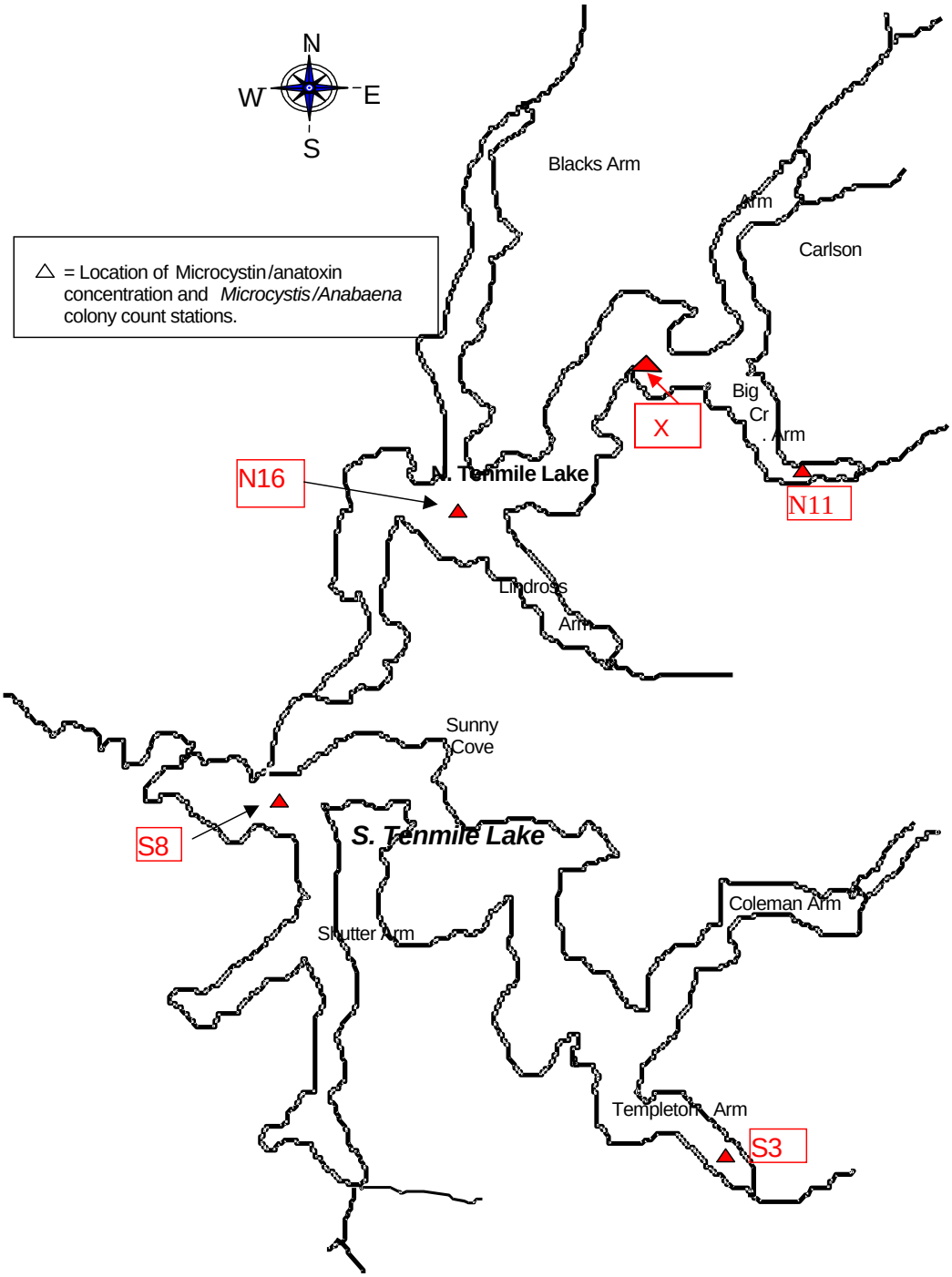
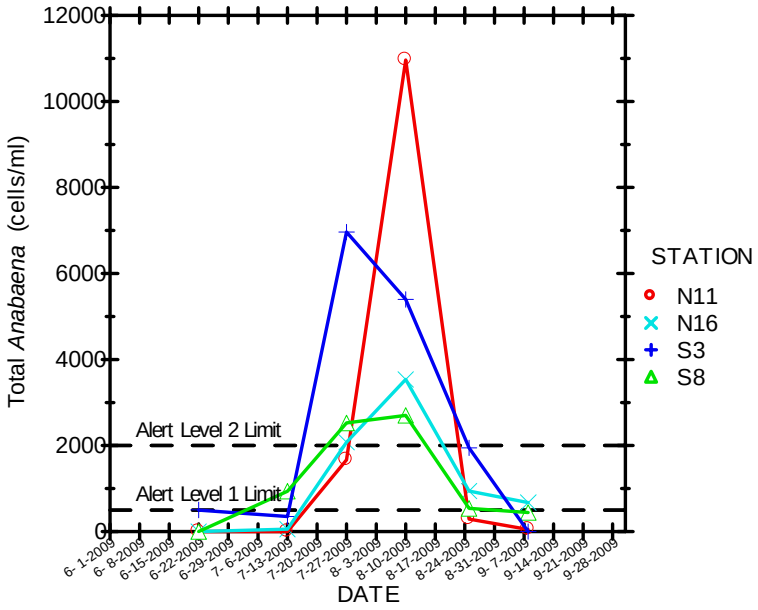


Figure1. Sample station location for potentially toxigenic cyanobacteria, Tenmile Lakes, 2009.



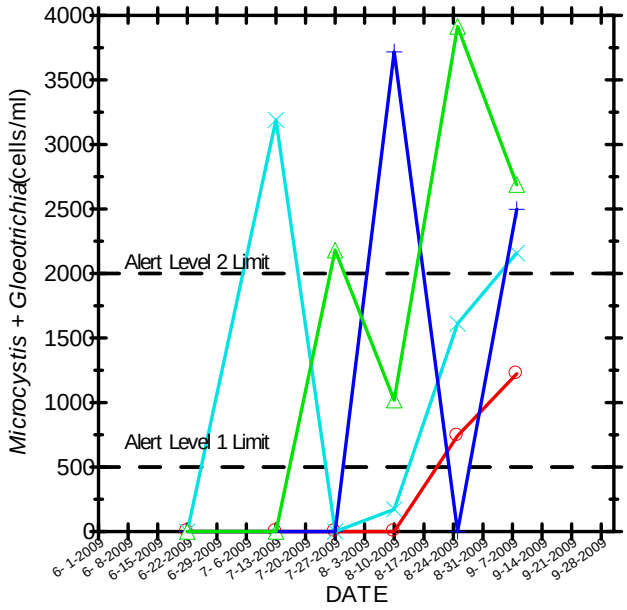


Figure 2. Trend of potentially toxic cyanobacteria in Tenmile Lakes, 2009.

Figure 3. September 8th bloom condition at Station "X" located in North Tenmile Lake (see map above).

Appendix I: Aquatic Analysts Phytoplankton Lab Sheets

Phytoplankton Sample Analysis

Sample:	Tenmile Lake
Sample Site:	S3
Sample Depth:	
Sample Date:	8-Sep-09
Total Density (#/mL):	182
Total Biovolume (um^3/mL):	255,333
Trophic State Index:	40.0

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Aphanizomenon flos-aquae	157	86.3	148,407	58.1	bluegreen
2	Melosira granulata	8	4.4	23,919	9.4	diatom
3	Microcystis aeruginosa	6	3.1	19,979	7.8	bluegreen
4	Ceratium hirundinella	4	2.2	39,463	15.5	dinoflagellate
5	Fragilaria crotonensis	2	0.9	20,295	7.9	diatom
6	Cryptomonas erosa	1	0.4	419	0.2	cryptophyte
7	Scenedesmus quadricauda	1	0.4	209	0.1	green
8	Cocconeis placentula	1	0.4	370	0.1	diatom
9	Mallomonas sp.	1	0.4	918	0.4	chrysophyte
10	Staurastrum gracile	1	0.4	435	0.2	green
11	Sphaerocystis schroeteri	1	0.4	902	0.4	green
12	Rhodomonas minuta	1	0.4	16	0.0	cryptophyte

Aphanizomenon flos-aquae cells/mL =	2,356
Microcystis aeruginosa cells/mL =	2,497

Note: 200 count

Aquatic Analysts	
Sample ID:	MB64

Phytoplankton Sample Analysis

Sample:	Tenmile Lake
Sample Site:	S8
Sample Depth:	
Sample Date:	8-Sep-09
Total Density (#/mL):	105
Total Biovolume (um^3/mL):	264,003
Trophic State Index:	40.3

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Melosira granulata	49.3	47.1	124,795	47.3	diatom
2	Anabaena planctonica	17.1	16.3	78,115	29.6	bluegreen
3	Microcystis aeruginosa	12.8	12.2	21,514	8.1	bluegreen
4	Melosira ambigua	6.6	6.3	18,382	7.0	diatom
5	Aphanizomenon flos-aquae	5.2	5.0	5,259	2.0	bluegreen
6	Dictyosphaerium ehrenbergianum	4.3	4.1	3,458	1.3	green
7	Asterionella formosa	2.8	2.7	3,130	1.2	diatom
8	Mallomonas sp.	1.4	1.4	1,244	0.5	chrysophyte
9	Melosira granulata angustissima	1.4	1.4	1,885	0.7	diatom
10	Cryptomonas erosa	0.9	0.9	493	0.2	cryptophyte
11	Rhodomonas minuta	0.5	0.5	9	0.0	cryptophyte
12	Glenodinium sp.	0.5	0.5	332	0.1	dinoflagellate
13	Staurastrum gracile	0.5	0.5	256	0.1	green
14	Sphaerocystis schroeteri	0.5	0.5	266	0.1	green
15	Cocconeis placentula	0.5	0.5	218	0.1	diatom
16	Ceratium hirundinella	0.5	0.5	4,648	1.8	dinoflagellate

Note: 200 count

Anabaena planctonica cells/mL =	427
Anabaena planctonica heterocysts/mL =	11
Anabaena planctonica akinetes/mL =	2
Microcystis aeruginosa cells/mL =	2,689
Aphanizomenon flos-aquae cells/mL =	83

Aquatic Analysts **Sample ID:** MB65

Phytoplankton Sample Analysis

Sample:	Tenmile Lake
Sample Site:	N11
Sample Depth:	
Sample Date:	8-Sep-09
Total Density (#/mL):	16
Total Biovolume (um^3/mL):	36,016
Trophic State Index:	26.1

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Aphanizomenon flos-aquae	8.2	52.3	10,884	30.2	bluegreen
2	Anabaena planctonica	1.8	11.5	8,914	24.8	bluegreen
3	Microcystis aeruginosa	1.6	10.1	9,780	27.2	bluegreen
4	Melosira granulata	1.2	7.8	2,497	6.9	diatom
5	Cocconeis placentula	1.0	6.4	465	1.3	diatom
6	Melosira ambigua	0.4	2.8	1,581	4.4	diatom
7	Cryptomonas erosa	0.4	2.3	188	0.5	cryptophyte
8	Fragilaria crotonensis	0.1	0.9	1,091	3.0	diatom
9	Eunotia pectinalis	0.1	0.9	104	0.3	diatom
10	Scenedesmus quadricauda	0.1	0.9	38	0.1	green
11	Sphaerocystis schroeteri	0.1	0.9	121	0.3	green
12	Cosmarium sp.	0.1	0.5	15	0.0	green
13	Melosira granulata angustissima	0.1	0.5	72	0.2	diatom
14	Chlamydomonas sp.	0.1	0.5	23	0.1	green
15	Staurastrum gracile	0.1	0.5	39	0.1	green
16	Gomphonema angustatum	0.1	0.5	13	0.0	diatom
17	Gomphonema subclavatum	0.1	0.5	43	0.1	diatom
18	Gloeocystis ampla	0.1	0.5	148	0.4	green

Note: 200 count

Aphanizomenon flos-aquae cells/mL =	173
Aphanizomenon flos-aquae heterocysts/mL =	1
Anabaena planctonica cells/mL =	49
Anabaena planctonica heterocysts/mL =	1
Microcystis aeruginosa cells/mL =	1,222

Aquatic Analysts **Sample ID:** MB66

Phytoplankton Sample Analysis

Sample:	Tenmile Lake
Sample Site:	X
Sample Depth:	grab
Sample Date:	8-Sep-09
Total Density (#/mL):	59,040
Total Biovolume (um^3/mL):	147,296,053
Trophic State Index:	85.9

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Aphanizomenon flos-aquae	32,800	55.6	35,128,800	23.8	bluegreen
2	Anabaena planctonica	24,600	41.7	108,043,200	73.4	bluegreen
3	Microcystis aeruginosa	820	1.4	2,407,520	1.6	bluegreen
4	Botryococcus braunii	547	0.9	1,574,400	1.1	green
5	Cryptomonas erosa	273	0.5	142,133	0.1	cryptophyte

Aphanizomenon flos-aquae cells/mL =	557,600
Aphanizomenon flos-aquae heterocysts/mL =	3,280
Anabaena planctonica cells/mL =	590,400
Anabaena planctonica heterocysts/mL =	14,760
Microcystis aeruginosa cells/mL =	300,940

Note: 200 count

Aquatic Analysts **Sample ID:** MB68

Phytoplankton Sample Analysis

Sample:	Tenmile Lake
Sample Site:	N16
Sample Depth:	
Sample Date:	8-Sep-09
Total Density (#/mL):	669
Total Biovolume (um^3/mL):	1,434,689
Trophic State Index:	52.4

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Aphanizomenon flos-aquae	555	82.9	699,158	48.7	bluegreen
2	Ceratium hirundinella	25	3.7	241,684	16.8	dinoflagellate
3	Anabaena planctonica	22	3.2	110,571	7.7	bluegreen
4	Fragilaria crotonensis	18	2.8	264,126	18.4	diatom
5	Melosira ambigua	15	2.3	61,734	4.3	diatom
6	Melosira granulata angustissima	9	1.4	13,872	1.0	diatom
7	Microcystis aeruginosa	6	0.9	17,263	1.2	bluegreen
8	Melosira granulata	6	0.9	18,650	1.3	diatom
9	Anabaena circinalis	3	0.5	4,377	0.3	bluegreen
10	Chlamydomonas sp.	3	0.5	1,002	0.1	green
11	Navicula reinhartii	3	0.5	1,603	0.1	diatom
12	Cosmarium sp.	3	0.5	647	0.0	green

Aphanizomenon flos-aquae cells/mL =	11,098
Anabaena planctonica cells/mL =	604
Anabaena planctonica heterocysts/mL =	6
Microcystis aeruginosa cells/mL =	2,158
Anabaena circinalis cells/mL =	62

Note: 200 count

Aquatic Analysts **Sample ID:** MB67

O**regon 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