

## 2012 Warner Park Rhythm and Booms Fireworks Environmental Impacts Study

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February 15, 2013

### Summary

This study of the environmental impacts of the annual Rhythm and Booms firework display was requested by the City of Madison Committee on the Environment. The purpose of the study was to determine the presence of firework impacts to surface water, plants, and soils in Warner Park. The study concluded that the annual display does have measureable impacts to the environment. The most discernable impact is the temporary spike in perchlorate, a commonly used rocket propellant, in lagoon surface water just after the display. It is not clear, however, if aquatic organisms living in and around the lagoon are affected at these concentrations. With the exception of chloride, trace metal concentrations in lagoon surface water showed no discernible change after the event. *Insert a sentence or two about the plant and soil results. Briefly discuss the COE's recommendations*

### Introduction

This study of environmental impacts from the annual Rhythm and Booms fireworks display at Warner Park was conducted at the request of the City of Madison Committee on the Environment (COE). Funding for the study came from the following sources: \$25,000 from the City of Madison Common Council, \$2,000 from the Yahara Fishing Club, and \$2,000 from the Golf Effect. With these funds, the COE directed City staff to investigate potential environmental impacts to plants, soil, and surface water in Warner Park from the annual fireworks display. Sediment samples from the lagoon were also taken to establish a baseline. Impacts to air quality or groundwater were not included in this scope of work.

### Site Characterization

Warner Park is an urban park in Madison, WI, containing large flat open areas, a lagoon area with two islands, an off-leash dog park, a beach, and a frequented boat launch (**Figure 1**). The lagoon area is hydrologically connected to Lake Mendota by a small inlet that passes under Woodward Drive. While this connection exists, the main hydrological influence is believed to be from stormwater runoff from the surrounding area into the lagoons and out into the lake. Since 1993, the park has hosted an annual Independence Day fireworks show called Rhythm and Booms. The event is primarily privately funded and claims to be the largest fireworks display in the Midwest. The fireworks are detonated from a small island located in the Warner Park lagoon, identified on **Figure 1**. Spectators for the event sit to the north, east, and south of the launch island.

A summary of environmental sampling funded through this study are as follows:

- February 28, 2012 – Lagoon sediment sampling
- June 22, 2012 – Pre-event plant and soil sampling
- June 29, 2012 – Pre-event lagoon surface water sampling
- June 30, 2012 – Rhythm and Booms fireworks display
- July 1, 2012 – Post-event lagoon surface water sampling

- July 9, 2012 – Post-event lagoon surface water sampling
- July 23, 2012 – Post-event plant and soil sampling
- July 30, 2012 – Post-event lagoon surface water sampling

## Background

This environmental study focused primarily on two classes of contaminants: perchlorate used as propellant and trace metals associated with fireworks coloring agents. While the composition of fireworks varies, most fireworks are believed to contain potassium perchlorate, an inorganic salt used as a propellant. Perchlorate is both a naturally-occurring and man-made chemical that is highly soluble, mobile in surface water and groundwater, and persistent in the environment. Detection of perchlorate in surface water and groundwater has recently fueled studies around the United States, and there has been particular interest in its potential threat to drinking water. Perchlorate may have adverse health effects because ingestion of the chemical can interfere with iodide uptake into the thyroid gland in mammals and aquatic vertebrates, such as fish.

In 2011, the USEPA issued a “regulatory determination” that perchlorate meets the Safe Drinking Water Act criteria for regulation as a contaminant. While the USEPA continues to evaluate the science on perchlorate to develop a national primary drinking water regulation (NPDWR), it has established an Interim Drinking Water Health Advisory of 15 µg/L in water. Numerous states, such as Massachusetts and California have also promulgated enforceable standards for perchlorate in drinking water. In Wisconsin, NR 140 of the Wisconsin Administrative Code has set the enforcement standard (ES) for perchlorate in groundwater at 1 µg/L.

Regarding plant uptake, the USEPA’s perchlorate toxicology fact webpage states:

*There is experimental evidence that perchlorates are taken up by leafy plants such as lettuce, tobacco plants, and poplar. However, the studies do not record any toxic effects. It has been suggested that plant uptake of perchlorates could be used to phytoremediate contaminated sites. Although plants may not be affected by perchlorate toxicity, plant uptake provides a point of entry into the food chain for herbivorous animals.*

In addition to perchlorate, the study evaluated the presence of trace metals used in firework displays to produce different colors and sparks. A previous study of the impacts of fireworks on the Warner Park lagoon by Public Health Madison Dane County tested for the following trace metals:

- aluminum (Al) – fuel, color producer (silver)
- barium (Ba) – color producer (green)
- calcium (Ca) – color producer (orange)
- chloride (Cl) – chlorinated rubber binder
- copper (Cu) – color producer (blue)
- iron (Fe) – color producer
- ammonia (NH<sub>3</sub>) – oxygen producer
- potassium – oxygen producer
- sodium – color producer (yellow)
- strontium – color producer (purple)
- zinc – fuel
- magnesium (Mg) – color producer (white)

In addition to the above list, this study included titanium (color producer – silver), cobalt (color producer), and chromium (color producer). Ammonia testing was not included with this study. Most academic studies on trace metal impacts from fireworks focus on their presence in particulates and the threat to human health through inhalation or

ingestion. Air quality monitoring was outside the scope of this study and no particulate sampling was conducted.

Sediment sampling of the Warner Park lagoon was the fourth area funded by this study. However, because the Warner Park lagoon is heavily impacted by stormwater runoff from the adjacent roadways and parking lots, it is not possible to separate the potential impacts from fireworks from overall stormwater contamination. Therefore, the sediment sampling was conducted to establish a baseline health status for the lagoon.

## Methods

### *Lagoon Surface Water*

Surface water samples were collected around the Warner Park lagoon on four separate days. There are no known sources of natural or anthropogenic perchlorate in the park, with the exception of firework displays. Samples were collected on June 29, July 1, July 9, and July 30, 2012. The June 29 samples were taken prior to the Rhythm and Booms annual fireworks display and the remaining 3 sampling events were taken post-event. **Figure 1** shows the sampling locations and the location of the fireworks launch site.

Samples were collected by boat into a large plastic bottle that was inverted below the water surface, and aliquots were distributed to plastic sample bottles. Samples for perchlorate were field-filtered (0.2  $\mu\text{m}$  pore size on June 29 and prior to 0.2  $\mu\text{m}$  pore size filtering, samples were prefiltered through 0.8  $\mu\text{m}$  pore size filters for subsequent samplings), and samples for metals were field-preserved with nitric acid. All samples were kept refrigerated at 4 °C or iced until analysis. At each sample location, measurements in the field were made for pH and conductivity just beneath the water surface. Temperature and dissolved oxygen profiles, in one-foot increments were also determined at each site. Unfiltered samples were analyzed for aluminum (Al), barium (Ba), calcium (Ca), chloride (Cl), copper (Cu), iron (Fe), magnesium (Mg), phosphorus (P), potassium (K), sodium (Na), strontium (Sr), titanium (Ti), and zinc (Zn) by Public Health Madison Dane County (PHMDC), using an ICP/OES. Filtered samples were analyzed for perchlorate by TestAmerica, using an IC/MS/MS.

### *Plants and Soils*

Plants and soils samples were collected on June 22 and July 23, 2012 for trace metals and perchlorate analysis. Sampling occurred just prior to the June 30 Rhythm and Booms fireworks event and 3 weeks afterward. **Figure 1** shows an aerial photograph of the park, locations of sampling sites, and the location of the fireworks launch site. On both dates, samples were collected from the fireworks launch site (P-1), the island south of the launch site (P-2), and the spectator areas east of the launch site (P-3). For plant samples, only leaves were collected, generally at chest height. Soil samples were collected by compositing surface soil samples collected at each corner of a one-meter quadrant.

Sixteen plant species were sampled: alfalfa, arrowwood, black willow, boxelder, buckthorn, cattail, cottonwood, creeping charlie, dandelion, dogbane, duckweed, honeysuckle, plantain, smartweed, vervain, and water lily. Plant samples were dried for 48 hours and homogenized prior to analysis by the University of Wisconsin Soil Plant Analysis Laboratory (SPAL). Samples were analyzed for Al, Ba, cobalt

(Co), chromium (Cr), Fe, K, Mg, sulfide (S), Sr, chloride, and perchlorate, using an ICP/OES, ICP/MS, and ion chromatography.

#### *Lagoon Sediment*

Sediment samples were collected from four locations around the Warner Park lagoon on February 28, 2012. After a hole was augured through the lagoon ice, a bucket auger was used to collect the top of sediment. Sediments samples were then portioned into sampling containers for the analysis of polycyclic aromatic hydrocarbons (PAHs), nutrients (total phosphorus, nitrate plus nitrite, and total Kjeldahl nitrogen), pH, total organic carbon (TOC), cyanide, sulfide, metals (Al, As, Ba, cadmium (Cd), Cr, Cu, Fe, K, manganese (Mn), nickel (Ni), lead (Pb), antimony (Sb), selenium (Se), Sr, and Zn). Sample containers were refrigerated at 4 °C until analysis by Pace Analytical Laboratories in Green Bay, WI.

### **Results and Discussion**

#### *Lagoon Surface Water*

Perchlorate sample concentrations preceding the June 30, 2012 fireworks display ranged from nondetectable to 0.049 µg/L, with a mean value of 0.032 µg/L (**Table 1** and **Figure 2**). The July 1, 2012 sampling event within 12 hours after the fireworks showed spikes in perchlorate values ranging from 17 to 1329x the mean baseline perchlorate concentration (0.54 to 43 µg/L). The maximum concentration of 43 µg/L was taken at Site #3, at the southeast corner of the lagoon. Concentrations decreased to 59 to 587x the mean baseline perchlorate concentration within 9 days of the fireworks display. Note that there was no measurable precipitation between June 30 and July 9, 2012. Concentrations further decreased to just 8 to 15x the mean baseline perchlorate concentration by July 30, 2012. Between July 9 and July 30, 2012, a cumulative total of 4.0 inches of precipitation fell, as measured at the City of Madison Fire Station #11 (4011 Morgan Way).

These trends show significant increases in perchlorate levels that can be reasonably attributed to the June 30, 2012 fireworks display. Perchlorate salts of potassium and ammonium are the most commonly used oxidizers in modern fireworks, and presumably unreacted perchlorate salts are the cause of the spikes measured. Factors that potentially impact the increase in perchlorate in lagoon surface water include the quantity of ignited fireworks, the efficiency of perchlorate oxidation (which controls the mass of perchlorate release), wind direction and velocity (which controls the dispersion and fallout of particulates), and the sampling locations relative to the fireworks launch site.

After the fireworks display, perchlorate concentrations decreased to almost background levels within 30 days. The attenuation of perchlorate may be due to variety of pathways, including the reduction of perchlorate by naturally-occurring microbes, abiotic adsorption, and dilution. Based on the rapid attenuation between July 1 and July 9 (in the absence of rain) dilution with either rain or lake water is not considered the dominant attenuation pathway for the first two weeks following the display. Likewise, perchlorate salts are highly soluble, making abiotic attenuation to organic surfaces also unlikely. A 2007 study determined that microbial degradation of perchlorate matched the observed attenuation of this chemical in a municipal lake in Oklahoma following a fireworks displays (Wilkin, 2007). It is hypothesized that microbial degradation along with dilution during the second half of July explains the attenuation of perchlorate in the Warner Park lagoon.

It is unclear if aquatic organisms are affected at the perchlorate concentrations detected during this study. Previous work indicates thyroid impacts in fish at perchlorate concentrations as low as 100 µg/l and exposure times of 30 days (Bradford, 2005). However, the concentrations detected in the lagoon were lower and of shorter duration than this threshold.

Spikes of trace metals used as coloring agents in the fireworks display were not detected in the Warner Park lagoon (**Table 1**). These results are similar to those from the 2005 study by PHMDC, where no clear trend in trace metal levels was detected. It is unclear why changes in the concentrations of these analytes were not detected. It may be related to the affinity of metals to solid surfaces, the more limited sensitivity of the analytical technique used for these elements (ICP-OES), combined in some cases with relatively high background of the mineral components (Al, Ca, Na, K, Mg). In contrast, perchlorate is highly soluble and thus present in a dissolved form, and in addition, it may also be present as a higher mass abundance compared to these coloring agents.

Profiles of dissolved oxygen and temperature were collected at each sampling location for all four events (**Table 2** and **Figure 3**). They show that the lagoon was vertically stratified for the first two sampling events on June 29 and July 1, 2012. Oxidation reaction of the propellant ( $\text{KClO}_4 \Rightarrow \text{KCl} + 2\text{O}_2 \Rightarrow \text{K}^+ + \text{Cl}^- + 2\text{O}_2$ ) impacts dissolved oxygen levels. Perchlorate oxidation evidently caused the dissolved oxygen profile to move deeper at the closest sites 1 and 2 for the launch site during the sampling event following fireworks. By July 9 and July 30, 2012, however, the lagoon was vertically well-mixed, perhaps a reflection of mixing by wind or incoming precipitation and stormwater. This mixing may have impacted the July 9 and 30<sup>th</sup> sampling results by diluting surface concentrations of perchlorate and trace metals.

### *Sediment*

Sediment sample results from the Warner Park lagoon reflect both impacts from incoming stormwater and potentially impacts from firework residue. However, due to the large stormwater signature, the City did not attempt to separate the two signals. Rather, the February 2012 sampling is a reflection of the overall sediment quality of the lagoon. Results presented in **Table 3** show that the lagoon sediments are impacted by the typical suite of stormwater contaminants, including phosphorus, Cd, Cr, Cu, Pb, and Zn (Bannerman 1993). The only analyte detected above Wisconsin Department of Natural Resources Administrative Code Chapter NR 528 ceiling level was arsenic (8 mg As/kg). However, according to the USGS (United States Geological Survey), naturally occurring background concentrations of arsenic in Dane County range from 1.05 to 12.19 mg/kg (USGS, 2001-2002).

**Table 3** compares detected concentrations to the WDNR's Consensus-Based Sediment Quality Guidelines (CBSQG), which identify concentrations at which the toxicity impact to benthic-dwelling macroinvertebrate species is considered probable (the "probable effect concentration" or PEC). (Examples of benthic organisms include insect larvae, leeches, worms, crayfish, mollusks, and snails.) According to these guidelines, concentrations of organic contaminants are divided by the percent total organic carbon (%TOC) prior to comparison. This is because organic compounds tend to sorb and

concentrate on finer-grained and organic sediments. Inorganic contaminants such as trace metals, however, are compared on a bulk chemistry basis, and are not normalized by %TOC.

Using these guidelines, there were no measured sediment concentrations from the Warner Park lagoon that exceeded the WDNR's probable effect concentration guidelines. While several PAH's exceeded the respective PEC when compared in bulk, once these concentrations were normalized by the %TOC, the concentrations were below the PEC guidelines.

#### *Plants and Soils*

Soil sample results are included as **Table 4**. Please refer to the 2012 Vegetation and Soil Analyses from Warner Park report drafted by Prof. Jim Bennett of the University of Wisconsin-Madison for a summary of the plant and soils results and discussion.

### **Conclusions and Recommendations**

While the scope of this environmental study was narrow, it does conclude that the annual Rhythm and Booms fireworks display has measurable impact to the environment. The most discernable impact is the spike in perchlorate, a commonly used rocket propellant, in lagoon surface water just after the display. It is not clear, however, if aquatic organisms living in and around the lagoon are affected at these levels. It is also likely that the fireworks display results in a temporary increase in the concentration of chloride in the lagoon. *Insert a sentence or two about the plant and soil results.*

*Recommendations should be agreed upon by the COE. Based on best management practices published by other states, potential recommendations include:*

- *Require that all fireworks display debris and unburned shell fragments be cleaned up in entirety the following day to ensure debris does not leach contamination.*
- *Require that any "misfires" or "duds" be located and disposed of properly.*
- *Possibly request low (or no) perchlorate-containing fireworks.*

### Literature Cited

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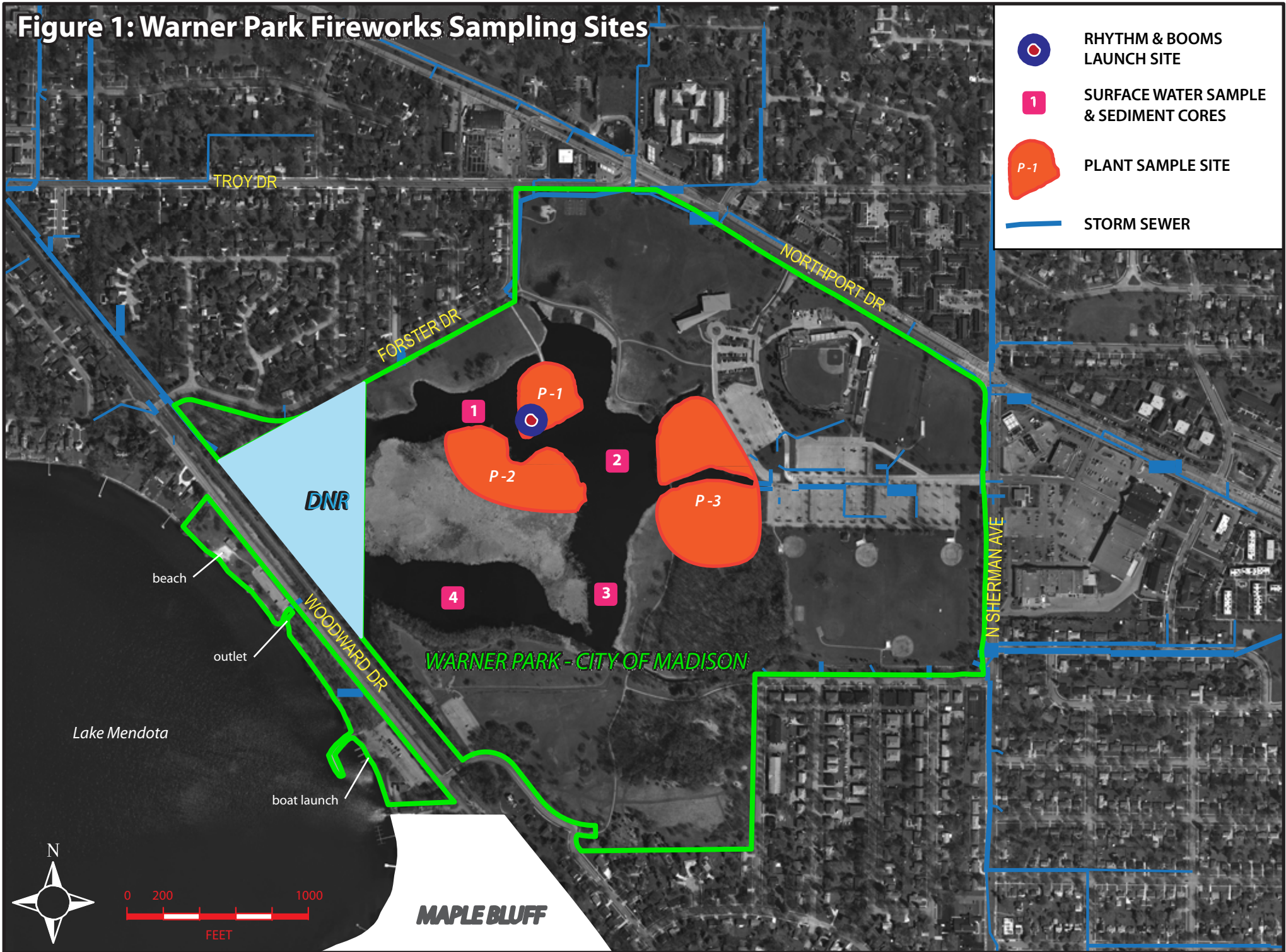
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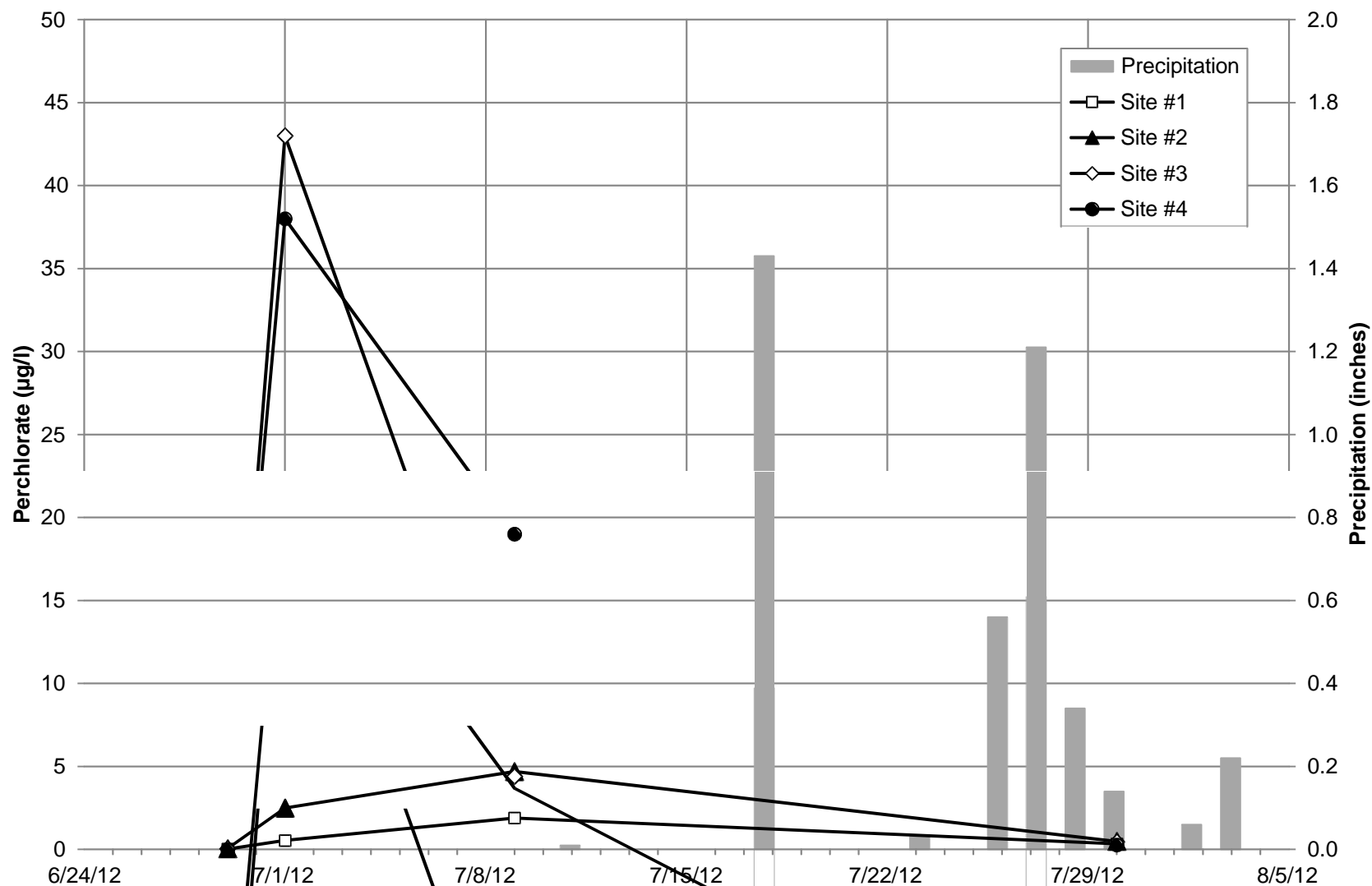
United States Protection Agency Perchlorate Toxicology website:  
<http://clu.in.org/contaminantfocus/default.focus/sec/perchlorate/cat/Toxicology/>

# Figure 1: Warner Park Fireworks Sampling Sites

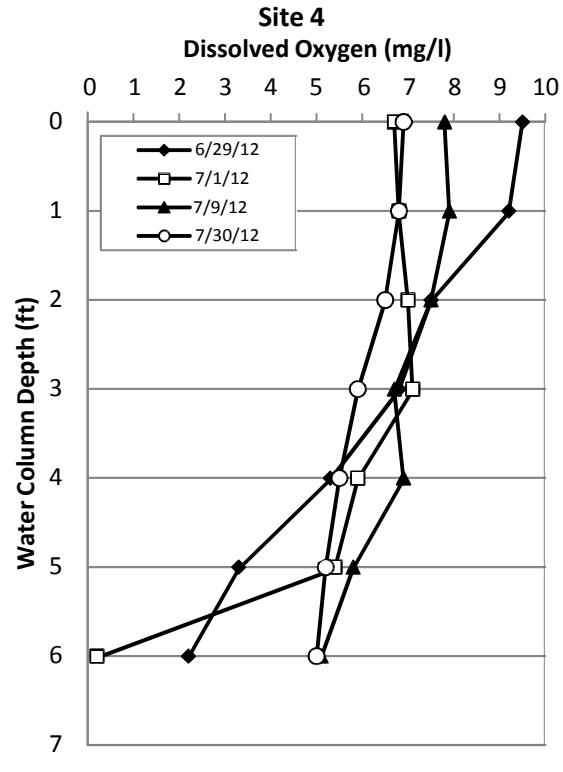
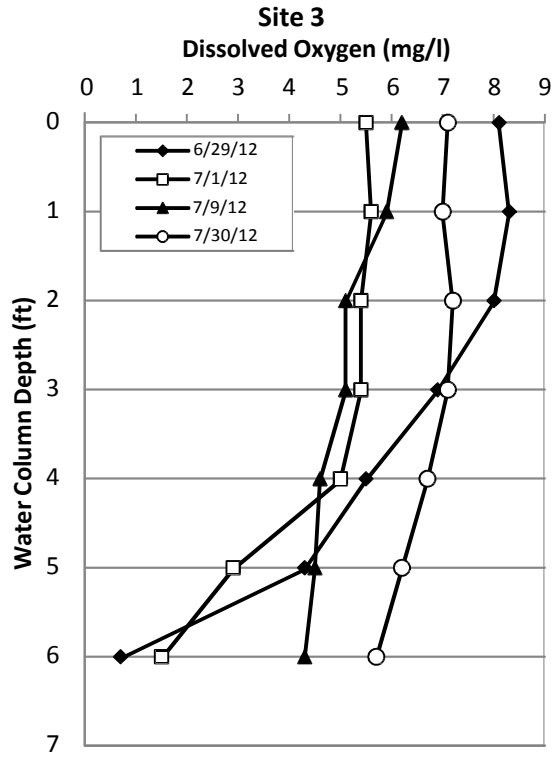
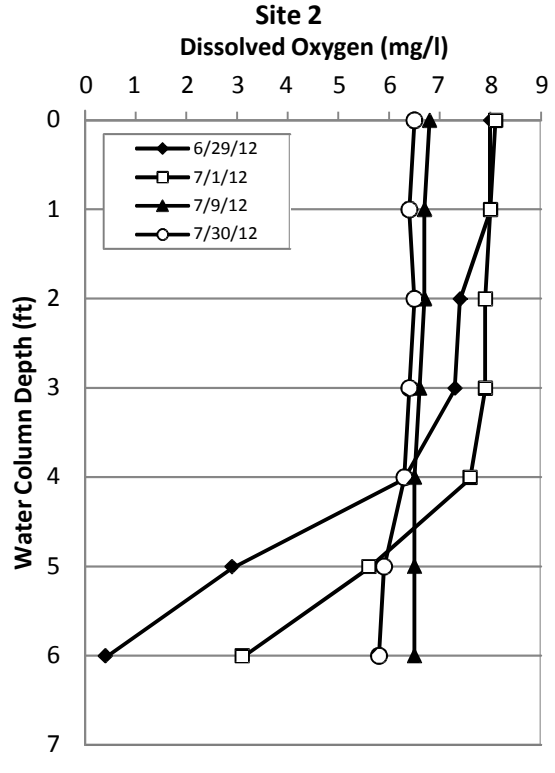
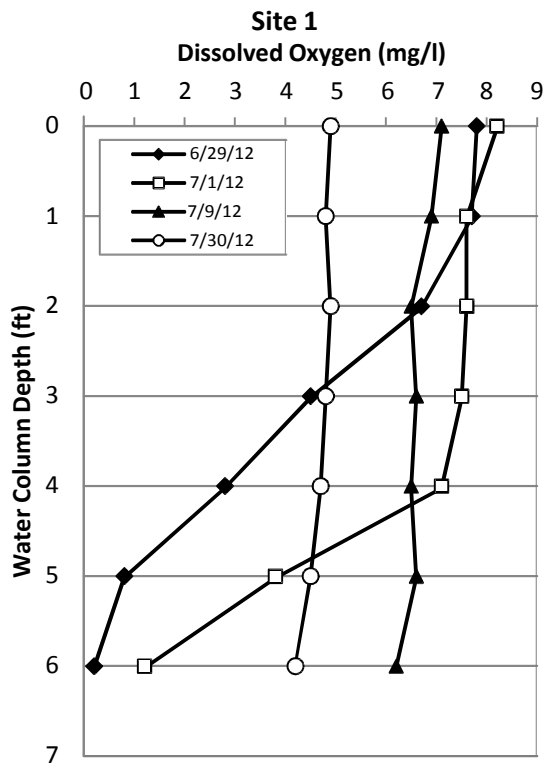




**Figure 2**  
**Lagoon Surface Water Perchlorate Concentrations**  
**Before and After the June 30, 2012 Rhythm and Booms Fireworks Display**  
**Warner Park Fireworks Study, Madison, WI**



**Figure 3**  
**Surface Water Dissolved Oxygen Profiles**  
**Warner Park Fireworks Study**



**Table 1**  
**Lagoon Surface Water Analytical Results**  
**Warner Park Fireworks Study, Madison, WI**

Date	Units	Site #1				Site #2				Site #3				Site #4			
		6/29/12	7/1/12	7/9/12	7/30/12	6/29/12	7/1/12	7/9/12	7/30/12	6/29/12	7/1/12	7/9/12	7/30/12	6/29/12	7/1/12	7/9/12	7/30/12
Al	µg/l	41.8	40.8	50.5	34.5	59.7	49.9	43.9	52.4	51.6	46.3	45.2	42.2	31.5	34	41.6	41
Ba	µg/l	50.9	52	57.8	54.7	47.5	51.9	46.2	33	48.4	58.4	85.7	33.3	64.2	67.3	61.3	41.7
Ca	µg/l	33.1	33.3	33.9	25	32.2	32.1	32.7	20.3	32.2	32.4	33	20.3	32.9	32.9	33.4	30
Cl	µg/l	na	115	113	85.6	na	121	125	64.1	na	120	126	64.5	na	117	114	99.1
Cu	µg/l	1.28	< 1.20	< 1.20	< 1.20	< 1.20	< 1.20	< 1.20	< 1.20	< 1.20	< 1.20	< 1.20	< 1.20	< 1.20	< 1.20	< 1.20	< 1.20
Fe	µg/l	0.24	0.194	0.297	0.316	0.339	0.228	0.251	0.276	0.302	0.242	0.371	0.252	0.284	0.301	0.324	0.318
Mg	µg/l	13.6	14.5	16.8	11.2	12.7	12.7	13.4	8.36	12.6	12.8	13.5	8.35	16.2	16.1	18.3	17.1
P	µg/l	0.238	0.214	0.239	0.225	0.41	0.225	0.222	0.187	0.269	0.236	0.252	0.169	0.201	0.184	0.222	0.212
K	µg/l	4.66	4.52	4.78	3.87	5.11	4.65	4.88	3.34	4.66	4.74	4.89	3.3	4.75	4.7	4.87	4.12
Na	µg/l	76.3	74.3	71.8	53.7	77.6	77.8	79.4	40.1	77.6	78.6	80.3	40.1	72.1	71.9	70.4	60.3
Sb	µg/l	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	2.1	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Sr	µg/l	76.8	76.8	80	61.4	75.9	77	80.4	52.1	76.2	77.8	81.7	52.1	72.5	73.4	77	70.9
Ti	µg/l	1.4	0.82	0.879	0.95	1.29	0.915	0.515	1.21	1.07	0.714	0.612	1.97	0.463	0.45	0.402	0.778
Zn	µg/l	1.78	0.654	2.43	1.34	2.92	1.14	2.12	2.28	1.55	1.02	1.01	1.87	1.07	0.645	1.22	1.22
Conductivity	µmhos/cm	677	689	675	497	656	688	693	389	655	678	693	387	651	668	675	602
pH	S.U.	8.16	8.1	8.1	7.62	8.17	8.33	8.24	8.08	8.16	7.88	8	8.15	8.18	7.88	8.31	7.85
Temp	°C	26.9	25.2	28	26.2	27.6	27.2	29	26.1	27.8	27.5	29.2	26.1	27.9	27.1	29.2	26.4
Perchlorate	µg/l	0.029 J	0.54	1.9	0.34	0.047 J	2.5	4.7	0.49	0.049 J	43	4.4	0.46	< 0.0088	38	19	0.27

na - Not analyzed.

J - Value is between the detection limit (DL) and the limit of quantitation (LOQ).

Data were collected by Public Health Madison Dane County.

**Table 2**  
**Lagoon Surface Water Field Parameter Profiles**  
**Warner Park Fireworks Study, Madison, WI**

Site	Depth (ft)	6/29/12		7/1/12		7/9/12		7/30/12	
		Temp (°C)	Dissolved oxygen (mg/l)	Temp (°C)	Dissolved oxygen (mg/l)	Temp (°C)	Dissolved oxygen (mg/l)	Temp (°C)	Dissolved oxygen (mg/l)
1	0	26.9	7.8	25.2	8.2	28.0	7.1	26.2	4.9
	1	26.9	7.7	27.3	7.6	28.8	6.9	26.3	4.8
	2	26.9	6.7	27.4	7.6	28.8	6.5	26.3	4.9
	3	26.7	4.5	27.4	7.5	28.8	6.6	26.3	4.8
	4	26.6	2.8	27.4	7.1	28.8	6.5	26.3	4.7
	5	25.8	0.8	27.1	3.8	28.8	6.6	26.3	4.5
	6	25.1	0.2	26.6	1.2	28.8	6.2	26.2	4.2
2	0	27.6	8.0	27.2	8.1	29.0	6.8	26.1	6.5
	1	27.6	8.0	27.6	8.0	29.1	6.7	26.1	6.4
	2	27.4	7.4	27.6	7.9	29.2	6.7	26.1	6.5
	3	27.3	7.3	27.6	7.9	29.2	6.6	26.1	6.4
	4	27.1	6.3	27.6	7.6	29.2	6.5	26.1	6.3
	5	26.7	2.9	27.6	5.6	29.1	6.5	26.1	5.9
	6	26.1	0.4	27.3	3.1	29.1	6.5	26.1	5.8
3	0	27.8	8.1	27.5	5.5	29.2	6.2	26.1	7.1
	1	27.8	8.3	27.6	5.6	29.3	5.9	26.2	7.0
	2	27.7	8.0	27.6	5.4	29.3	5.1	26.2	7.2
	3	27.4	6.9	27.7	5.4	29.2	5.1	26.2	7.1
	4	27.2	5.5	27.7	5.0	29.2	4.6	26.2	6.7
	5	27.1	4.3	27.5	2.9	29.1	4.5	26.1	6.2
	6	26.7	0.7	27.3	1.5	29.0	4.3	26.0	5.7
4	0	27.9	9.5	27.1	6.7	29.2	7.8	26.4	6.9
	1	27.6	9.2	27.2	6.8	29.1	7.9	26.3	6.8
	2	27.2	7.5	27.2	7.0	29.0	7.5	26.2	6.5
	3	27.0	6.8	27.2	7.1	28.8	6.7	26.1	5.9
	4	26.8	5.3	27.2	5.9	28.8	6.9	26.0	5.5
	5	26.4	3.3	27.1	5.4	28.6	5.8	26.0	5.2
	6	26.1	2.2	26.9	0.2	28.5	5.1	25.9	5.0

Data were collected by Public Health Madison Dane County.

**Table 3  
Warner Park Lagoon Sediment Sample Results  
Warner Park Fireworks Study, Madison, WI**

	units	Site #1	Site #2	Site #3	Site #4	NR 528 Ceiling Levels	Site #1	Site #2	Site #3	Site #4	Consensus-Based Sediment Quality Guidelines (CBSQG)		
											TEC	MEC	PEC
Depth	ft	<b>7-7.25</b>	<b>6-6.25</b>	<b>5-5.25</b>	<b>5-5.25</b>		Concentrations normalized by %TOC						
Aluminum	mg/kg	12600	10700	10700	13100	--	--	--	--	--	--	--	--
Antimony	mg/kg	3.5 J	<2.0	3.1 J	<3.1	--	--	--	--	--	2	13.5	25
Arsenic	mg/kg	5.8 J	<b>10.6</b>	7.0 J	<b>8.1 J</b>	8	--	--	--	--	9.8	21.4	33
Barium	mg/kg	142	108	125	124	--	--	--	--	--	--	--	--
Cadmium, total	mg/kg	0.51 J	0.59 J	0.58 J	0.46 J	10	--	--	--	--	0.99	3.0	5.0
Chromium, total	mg/kg	24.8	25.6	41.0	30.1	100	--	--	--	--	43	76.5	110
Copper	mg/kg	38.4	38.4	65.1	45.7	--	--	--	--	--	32	91	150
Iron, total	mg/kg	16300	15600	15700	17200	--	--	--	--	--	20,000	30,000	40,000
Lead, total	mg/kg	47.9	77.7	72.7	72.3	250	--	--	--	--	36	83	130
Manganese, total	mg/kg	300	319	369	327	--	--	--	--	--	460	780	1100
Nickel, total	mg/kg	18.0	18.4	20.5	19.8	--	--	--	--	--	23	36	49
Potassium	mg/kg	1730	1540	1540	1650	--	--	--	--	--	--	--	--
Selenium, total	mg/kg	<3.4	<2.4	<2.4	<3.9	--	--	--	--	--	--	--	--
Strontium, total	mg/kg	27.2	29.2	39.6	28.9	--	--	--	--	--	--	--	--
Zinc, total	mg/kg	167	231	372	235	--	--	--	--	--	120	290	460
1-Methylnaphthalene	mg/kg	<0.117	<0.0856	<0.835	<0.145	--	--	--	--	--	--	--	--
2-Methylnaphthalene	mg/kg	<0.117	<0.0856	0.0921 J	<0.145	--	--	--	0.006	--	0.0202	0.111	0.201
Acenaphthene	mg/kg	<0.108	<0.0789	<b>0.205 J</b>	<0.133	--	--	--	0.013	--	0.0067	0.048	0.089
Acenaphthylene	mg/kg	<0.122	<0.0893	0.101 J	<0.151	--	--	--	0.007	--	0.0059	0.067	0.128
Anthracene	mg/kg	<0.178	0.137 J	0.653	<0.221	--	--	0.007	0.042	--	0.0257	0.451	0.845
Benzo(a)anthracene	mg/kg	0.254 J	0.421 J	<b>2.76</b>	0.310 J	--	0.022	0.021	0.178	0.015	0.108	0.579	1.05
Benzo(a)pyrene	mg/kg	0.282 J	0.540 J	<b>4.17</b>	0.349 J	--	0.024	0.027	0.269	0.017	0.15	0.8	1.45
Benzo(b)fluoranthene	mg/kg	0.440 J	1.07	6.25	0.642 J	--	0.037	0.053	0.403	0.032	0.24	6.82	13.4
Benzo(g,h,i)perylene	mg/kg	0.288 J	0.64	<b>3.93</b>	0.401 J	--	0.024	0.032	0.254	0.020	0.17	1.685	3.2
Benzo(k)fluoranthene	mg/kg	0.328 J	0.502 J	5.01	0.420 J	--	0.028	0.025	0.323	0.021	0.24	6.82	13.4
Chrysene	mg/kg	0.468 J	1	<b>6.27</b>	0.625 J	--	0.040	0.050	0.405	0.031	0.166	0.728	1.29
Dibenzo(a,h)anthracene	mg/kg	<0.208	<0.153	<b>1.13</b>	<0.258	--	--	--	0.073	--	0.033	0.084	0.135
Fluoranthene	mg/kg	1.16	2.16	<b>13.9</b>	<0.474	--	0.098	0.107	0.897	--	0.423	1.327	2.23

**Table 3  
Warner Park Lagoon Sediment Sample Results  
Warner Park Fireworks Study, Madison, WI**

	units	Site #1	Site #2	Site #3	Site #4	NR 528 Ceiling Levels	Site #1	Site #2	Site #3	Site #4	Consensus-Based Sediment Quality Guidelines (CBSQG)		
											TEC	MEC	PEC
Depth	ft	<b>7-7.25</b>	<b>6-6.25</b>	<b>5-5.25</b>	<b>5-5.25</b>		Concentrations normalized by %TOC						
Fluorene	mg/kg	<0.190	<0.140	0.409 J	<0.236	--	--	--	0.026	--	0.0774	0.307	0.536
Indeno(1,2,3-cd)pyrene	mg/kg	0.228 J	0.454 J	<b>3.37</b>	0.303 J	--	0.019	0.022	0.217	0.015	0.2	1.7	3.2
Naphthalene	mg/kg	<0.134	<0.0982	0.208 J	<0.166	--	--	--	0.013	--	0.176	0.369	0.561
Phenanthrene	mg/kg	0.528 J	0.801	<b>4.54</b>	0.487 J	--	0.045	0.040	0.293	0.024	0.204	0.687	1.17
Pyrene	mg/kg	0.664 J	1.25	<b>8.34</b>	0.823 J	--	0.056	0.062	0.538	0.041	0.195	0.858	1.52
Cyanide, Reactive	mg/kg	<3.0	<2.1	<2.2	<3.5	--	--	--	--	--	--	--	--
Sulfide, Reactive	mg/kg	<74.0	309	174	<88.7	--	--	--	--	--	--	--	--
pH	SU	6.2	6.4	6.3	6.5	--	--	--	--	--	--	--	--
Nitrogen, Kjeldahl, Total	mg/kg	11800	8360	11400	18500	--	--	--	--	--	--	--	--
Nitrogen, NO2 plus NO3	mg/kg	<9.6	<7.0	<6.8	54.6	--	--	--	--	--	--	--	--
Phosphorus	mg/kg	1250	1170	1320	1230	--	--	--	--	--	--	--	--
TOC	mg/kg	118000	202000	155000	203000	--	--	--	--	--	--	--	--
TOC	%	11.8	20.2	15.5	20.3	--	--	--	--	--	--	--	--

J - Concentration is between the detection limit (DL) and the limit of quantitation (LOQ).  
NR 528 - Management of Accumulated Sediment from Storm Water Management Structures

WDNR 2003: Consensus-Based Sediment Quality Guidelines: Recommendations for Use and Application (WT-732 2003)  
TEC - Threshold Effect Concentration: Level at which toxicity to benthic-dwelling organisms is predicted to be unlikely.  
MEC - Midpoint Effect Concentration: Midpoint between the TEC and the PEC.  
PEC - Probable Effect Concentration: Level at which toxicity to benthic-dwelling organisms is predicted to be probable.

**Bold** - Concentration is above the NR 528 ceiling level

**Bold** - Concentration is above the level at which toxicity to benthic-dwelling organisms is predicted to be probable (PEC level).

**Notes:**

Samples were collected on February 28, 2012.

The CBSQCs for organic compounds are expressed on a dry weight concentration at 1% TOC in sediments. However, site metals are not adjusted to a 1% TOC basis

WDNR 1997: Soil cleanup levels for polycyclic aromatic hydrocarbons (PAHs). Interim Guidance Publication RR-519-97.  
USGS Average concentrations of elements in Dane County, Wisconsin

**Table 4**  
**Warner Park Soils Sample Results**  
**Warner Park Fireworks Study, Madison, WI**

Date		6/22/2012					7/23/2012			
Sample Location	Units	P1 - North	P1 - East	P1 - West	P2	P3	P1 - A	P1 - B	P2	P3
Al	mg/kg	9829	7719	2493	6395	13384	3097	9054	2909	9817
Ba	mg/kg	179.1	188.9	31.25	217.4	195.9	53.05	166.7	95.23	146.3
Cl	mg/kg	11.2	7.1	8.9	63.9	46.2	7.1	18.3	30.2	29.0
Co	mg/kg	5.26	4.60	2.04	4.26	6.68	2.16	4.68	2.04	5.29
Cr	mg/kg	17.7	13.5	4.97	11.1	25.9	7.51	16.0	4.68	20.1
Fe	mg/kg	10020	8811	4537	10705	14485	5845	10098	4819	12779
K	mg/kg	0.18	0.12	0.05	0.12	0.19	0.06	0.15	0.06	0.17
Mg	mg/kg	1.12	0.91	2.67	1.12	1.52	2.74	1.55	1.12	1.32
S	mg/kg	0.09	0.09	0.02	0.21	0.05	0.05	0.10	0.10	0.06
Sr	mg/kg	34.0	37.2	25.3	42.4	27.8	25.8	36.1	25.0	21.8
Perchlorate	mg/kg	ND	ND	ND	12.41	ND	ND	ND	ND	ND

**Notes**

Refer to Figure 1 for sampling locations.

Samples were collected by members of Wild Warner and the Committee on the Environment.

P1 - The fireworks launch island (see Figure 1)

P2 - The island to the south of the launch island (see Figure 1)

P3 - The spectator area to the east of the launch site (see Figure 1)