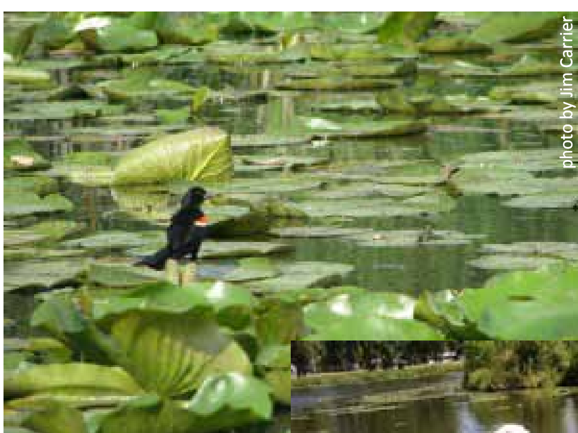
Warner Park

Fireworks Environmental Impact Baseline Study, 2012

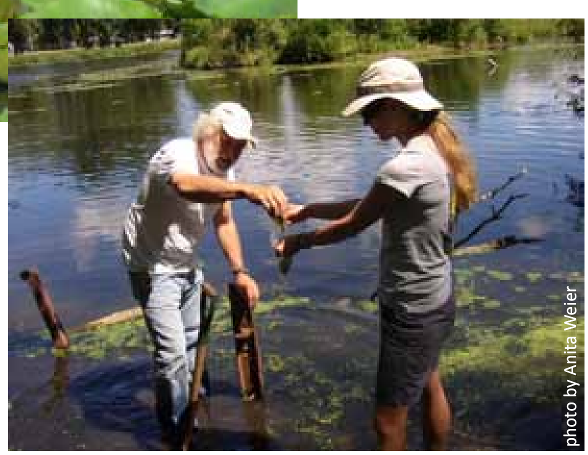
Water, sediment, soil, & plant analysis

Reports & Recommendations



Red-winged Blackbird

Rick Wenta, Public Health



Jim Carrier, Wild Warner and Brynn Bemis, City Engineering

Jim Bennett, UW & Committee on the Environment

Warner Park
Fireworks Environmental Impact Baseline Study
2012

Submitted to:
City of Madison
Common Council

Report from:
City of Madison
Committee on the Environment
Steve Fix, chair
James Bennett, vice chair
Anita Weier, alder
Mike DePue
Patricia Lasky
Patricia Gadow
Reginald Weide
Timothy Baker
Jennifer Giegerich

Compiled by:
City Engineering Division
March 26, 2013

This document is a result of field data collected in 2012 and the subsequent analyses in the form of two reports. Brynn Bemis, City Engineering, analyzes surface water and sediment data in her report (pg. 3-20). Dr. James P. Bennett, Committee on the Environment, analyzes soil and plant data in his report (pg 21-46). The Committee on the Environment reviewed both reports and heard public comment. The Committees recommendations are included on page 2.

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OVERVIEW

The City of Madison 2012 Operating Budget included an amendment to add in $50,000 for testing of sediment, soil, vegetation and water at Warner Park in, under and near the lagoon. The funding was contingent upon the City's Committee on the Environment obtaining matching funds for the study ($25,000 City Funds, $25,000 Contributions / Donations). This budget amendment assigned the study and the funding to Public Health Madison Dane County.

By early 2012, the City's Committee on the Environment determined that it would be unable to obtain a great amount of matching funding. Additionally, Public Health Madison Dane County had determined that the funding was inadequate for their staff to perform the study. It was then decided to seek an amendment to scale back the study to perform sampling and testing sufficient to produce a meaningful baseline assessment of the level of contamination in and around Warner Park and the Lagoons. The City's $25,000 was committed with no match restrictions, the Committee on the Environment was free to seek supplementary funding from outside sources, and the study was assigned to the Engineering Division in place of Public Health Madison Dane County.

Ultimately, the Engineering Division sought a DNR Planning Grant in the amount of $3,000, but was unsuccessful. Outside contributions totaling $4,000 were secured by Wild Warner and the Northside Planning Council, to supplement the City's funding. The Yahara Fishing Club contributed $2,000 of this total and The Golf Affect donated the other $2,000.

To save costs and meet the goal of the study, COE member James P. Bennett volunteered his time to handle the vegetation portion of the study. Dr. Bennett is a retired professor from the University of Wisconsin with a background in Botany. City Engineering staff Brynn Bemis, Hydrogeologist, managed the other portions of the study. They prepared separate summaries, including their recommendations. Those summaries are part of this report. Additionally, the Committee on the Environment made their recommendations separate from those of Bemis or Dr. Bennett.

Copies of all resolutions are attached at the end of this report.

COMMITTEE ON THE ENVIRONMENT - RECOMMENDATIONS

FIREWORKS ENVIRONMENTAL IMPACT STUDY, 2012

At their meeting of 3/18/13, the City of Madison Committee on the Environment unanimously recommended the following:

- Area is cleaned in its entirety following the event
- Duds are disposed of properly
- Request that low or no perchlorate fireworks be used
- Request that research be completed regarding what the most environmentally-ideal fireworks display would be with regards to height of detonation, location, etc.

WARNER PARK

FIREWORKS ENVIRONMENTAL IMPACT BASELINE STUDY 2012

SURFACE WATER & SEDIMENT ANALYSIS

Drafted by Brynn Bemis, City Engineering

2012 Warner Park Rhythm and Booms Fireworks Environmental Impacts Study

Drafted by: Brynn Bemis, City of Madison Engineering

March 21, 2013

Overview

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. A discernable impact is the temporary spike in perchlorate, a commonly used solid propellant, in wetland 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.

Based on the results of this study, the City of Madison and Public Health staff team recommends the following:

- 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
- Request low or no perchlorate-containing fireworks
- Additional monitoring of surface water, sediments, or air quality is *not* recommended

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 (donated through Wild Warner), and $2,000 from the Golf Affect (donated through Wild Warner). With these funds, the COE directed City of Madison staff to investigate potential environmental impacts to plants, soil, and surface water in Warner Park from the annual fireworks display. Sediment samples from the wetland lagoon were also taken to establish a baseline. While firework impacts to air quality were not included in this scope of work, a brief literature review for these impacts has been included at the end of this report.

Site Characterization

Warner Park is an urban park in Madison, WI, containing large flat open areas, a wetland area with two islands, an off-leash dog park, a beach, and a frequented boat launch (**Figure 1**). The wetland 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 wetland, 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 rocket propellant and metals associated with fireworks coloring agents. While the composition of fireworks varies, most fireworks are believed to contain inorganic perchlorate salts used as a solid propellant. Perchlorate is both a naturally-occurring and man-made chemical that is highly soluble, mobile in surface water and groundwater, and can be 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. At elevated levels, 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. However, the dose / response relationship has not yet been adequately assessed.

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 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 constituents:

- 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_3) – 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. While air quality monitoring was outside the scope of this study and no particulate sampling was conducted, a summary of published studies on this subject is included below.

Sediment sampling of the Warner Park wetland 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 wetland.

Methods

Wetland 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 µm pore size on June 29 and prior to 0.2 µm pore size filtering, samples were prefiltered through 0.8 µm 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 and 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.

Wetland 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

Wetland 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 affect 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, plant uptake, 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. Perchlorate salts are highly soluble, making abiotic attenuation to organic surfaces 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). Perchlorate is used as an electron acceptor by some microbes for cellular respiration and is degraded completely to chloride ion and oxygen. It is hypothesized that microbial perchlorate reduction 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 wetland surface water 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, 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 ($KClO_4 \Rightarrow KCl + 2O_2 \Rightarrow K^+ + Cl^- + 2O_2$) 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 July 30 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 United States Geological Survey (USGS), 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 adsorb 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 by Prof. Jim Bennett of the University of Wisconsin-Madison for a summary of the plant and soils results and discussion.

Literature Review of Air Impacts from Fireworks

Although the potential impacts to the ambient air from the Rhythm and Booms fireworks display was not included in the design of the current study, this issue has been thoroughly investigated by previously published research efforts. A literature review indicates a significant short-term increase in particulate matter—PM 10, PM 2.5, and total suspended particulates—following the use of fireworks (Illinois EPA, 2009; Joly et al., 2010; Majumdar et al., 2011; Moreno et al., 2007; Ravindra et al., 2003; Sarkar et al., 2010; Thakur et al., 2010; WI DNR, 2012; Zhang et al., 2010). This increase in particulate matter can temporarily, but severely, degrade air quality at the launch site and the surrounding areas. However, this short-term increase in particulates has also been observed to rapidly decline toward background levels, depending upon weather and environmental conditions (Illinois EPA, 2009; Sarkar et al., 2010; Thakur et al. 2010).

Inhalation of the smoke and fine particulate matter is considered the largest and most immediate threat to human health caused by fireworks. Exposure has led to reported increases in arrhythmias and various respiratory illnesses, such as exacerbation asthma, acute bronchitis, respiratory irritation and increased susceptibility to respiratory infection (Becker et al., 2000; Ravindra et al., 2003; WI DNR, 2012 and 2013). Susceptible populations, including elderly adults and individuals with respiratory or cardiac conditions, are the most severely impacted by exposure (Ravindra et al., 2003; WI DNR, 2012). No long-term impact is expected in the general population.

Although air quality following the Rhythm and Booms event was not measured, reasonable assumptions can be derived from other published studies. The Illinois EPA attributed an average concentration increase for particulate matter of 14.2 $\mu g/m^3$ (11.4 to 17.0 $\mu g/m^3$) associated with the Granite City, Illinois fireworks display on July 5, 2008 (Illinois EPA, 2009). In Dane County, the mean daily level for particulate matter in July 2011 was 11.2 ug/m^3 (5.3 to 22.9 ug/m^3). By adding the mean particulate matter increase reported in Illinois, average exposure levels resulting from Rhythm and Booms could increase to a range of 19.5 to 37.1 $\mu g/m^3$. The top of this range would exceed the National Ambient Air Quality Standard (NAAQS) of 35 $\mu g/m^3$ for particulate matter. For context, in 2009 and 2010 there were a total of nine days where fine particulate matter exceeded 35 $\mu g/m^3$ in Dane County. In addition, despite the potential exceedance of the NAAQS, the temporary increase in particulate concentration would be excluded by the USEPA under the Code of Federal Regulations at 40 CFR Part 50.14(b)(2) when caused by fireworks (Illinois EPA, 2009).

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. A discernable impact is the temporary spike in perchlorate, a commonly used solid propellant, in wetland 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.

Based on the results of this study, the City of Madison and Public Health staff team recommends the following:

- 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
- Request low or no perchlorate-containing fireworks
- Due to the potential exposure to smoke and particulate matter produced during fireworks displays, individuals with respiratory and/or cardiovascular diseases should be urged to take appropriate precautions when attending the Rhythm and Booms event, or view from a safe distance to reduce exposure.

In addition, the staff team *does not* recommend additional environmental monitoring for the following reasons:

- Surface Water - Monitoring results reflect concentrations and attenuation rates measured in other studies. No additional monitoring is recommended.
- Sediments - Sediment results are typical of stormwater-impacted lagoons. No additional monitoring is recommended.
- Air Quality - The consistent observation of the short-term impacts of fireworks to outdoor air quality and the rapid reduction of the contamination toward background levels is well established by published studies. Therefore, no additional monitoring is recommended.

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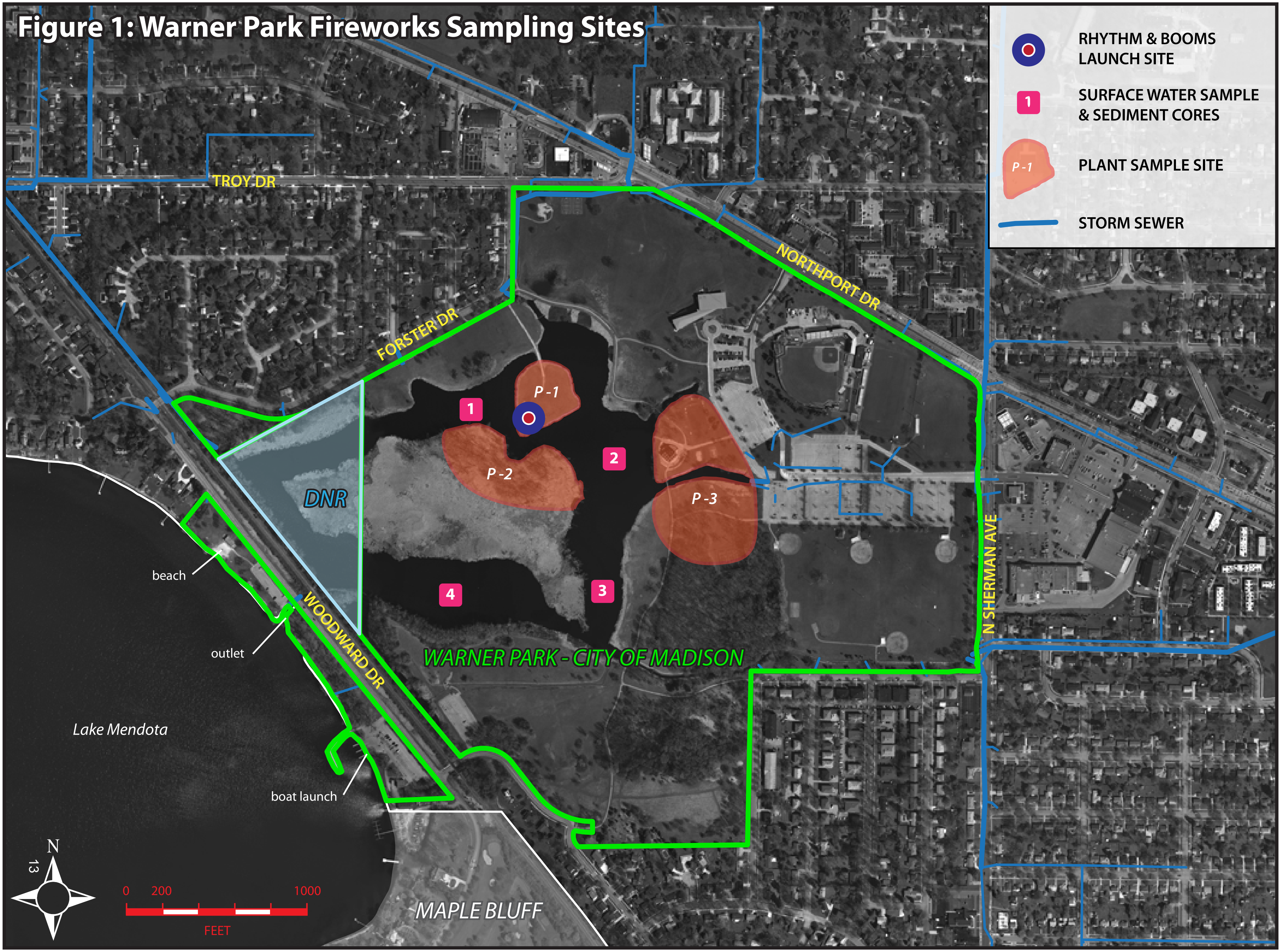


Figure 1: Warner Park Fireworks Sampling Sites

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

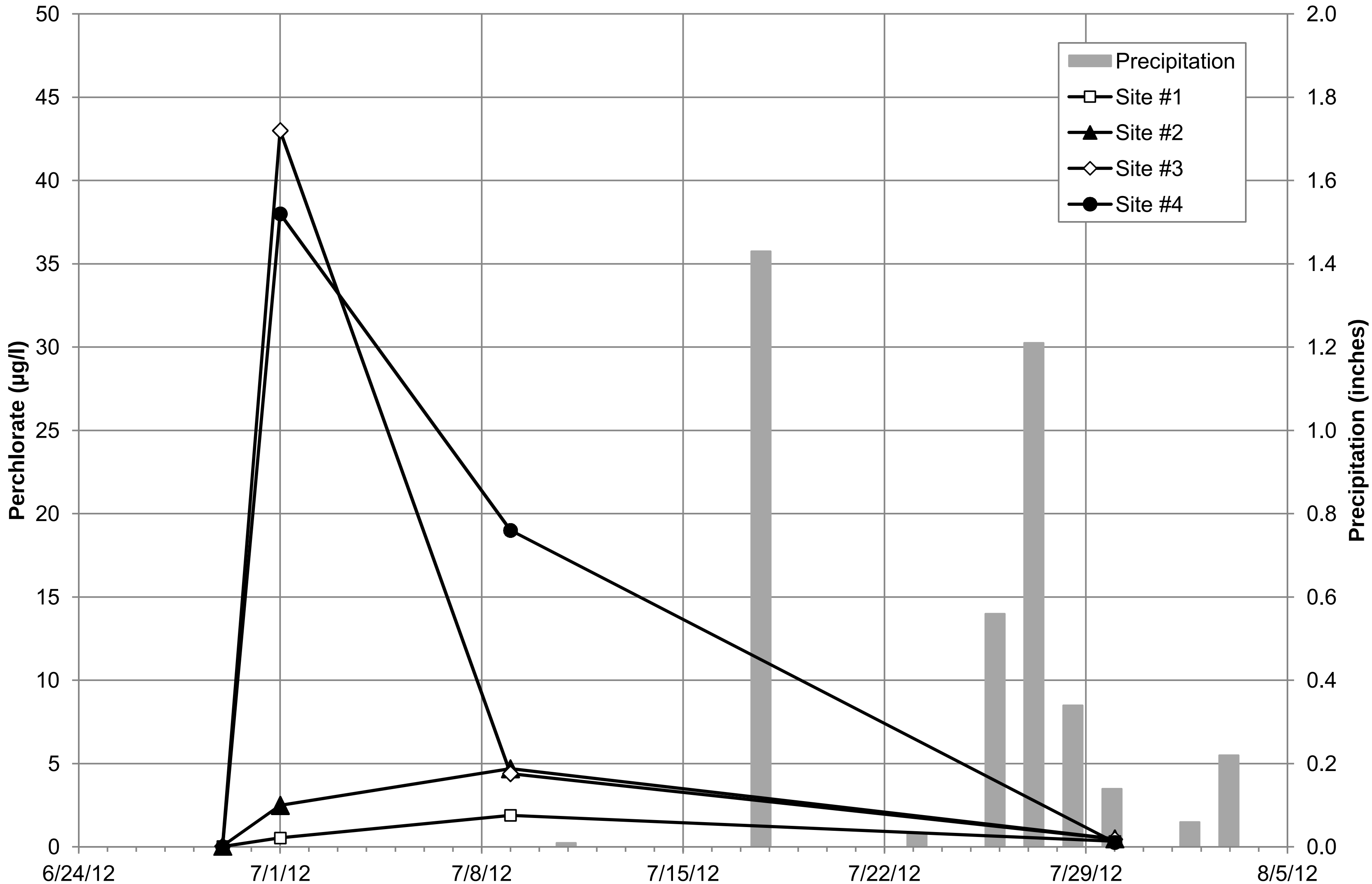
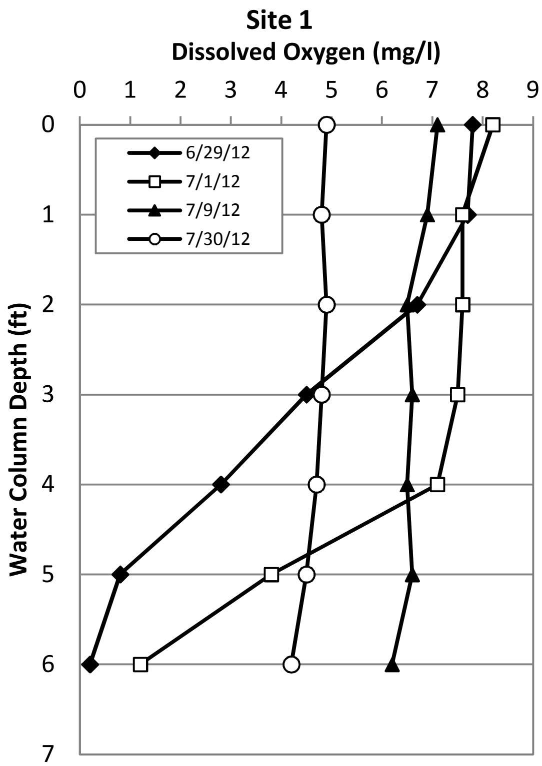
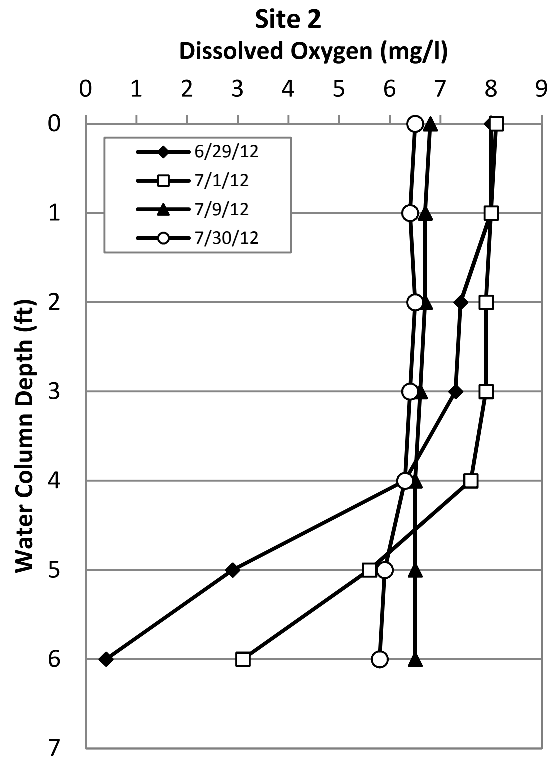
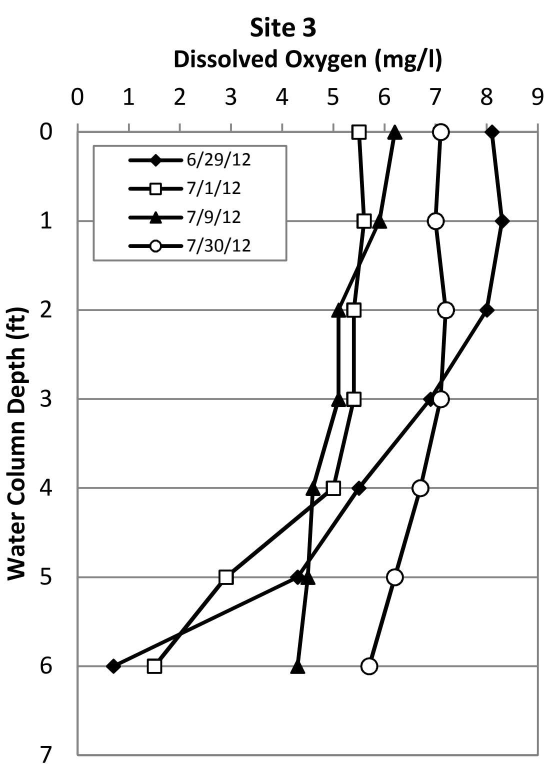


Figure 3
Surface Water Dissolved Oxygen Profiles
Warner Park Fireworks Study







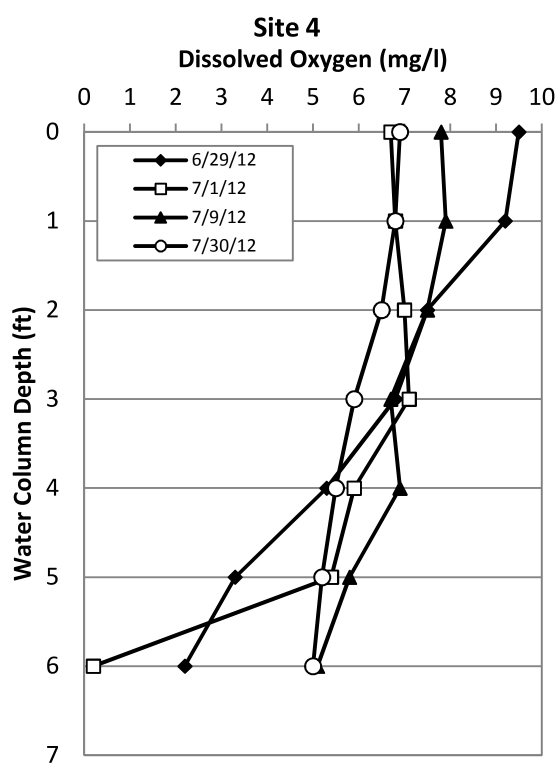


Table 1

Lagoon Surface Water Analytical Results

Warner Park Fireworks Study, Madison, WI

		Site #1				Site #2				Site #3				Site #4			
Date	Units	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)		
Depth	ft	**7-7.25**	**6-6.25**	**5-5.25**	**5-5.25**		Concentrations normalized by %TOC				**TEC**	**MEC**	**PEC**
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	**10.6**	7.0 J	**8.1 J**	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-Methylnapthalene	mg/kg	<0.117	<0.0856	<0.835	<0.145	--	--	--	--	--	--	--	--
2-Methylnapthalene	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	**0.205 J**	<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	**2.76**	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	**4.17**	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	**3.93**	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	**6.27**	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	**1.13**	<0.258	--	--	--	0.073	--	0.033	0.084	0.135
Fluoranthene	mg/kg	1.16	2.16	**13.9**	<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)		
Depth	ft	**7-7.25**	**6-6.25**	**5-5.25**	**5-5.25**		**Concentrations normalized by %TOC**				**TEC**	**MEC**	**PEC**
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	**3.37**	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	**4.54**	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	**8.34**	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 wieght 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)

WARNER PARK

FIREWORKS ENVIRONMENTAL IMPACT BASELINE STUDY 2012

VEGETATION & SOIL ANALYSIS

Drafted by James P. Bennett, Committee on the Environment

2012 Vegetation and Soil Analyses from Warner Park

James P. Bennett

Madison Committee on the Environment

March 19, 2013

Summary

This report contains the results of chemical analyses of plant and soil samples from Warner Park sampled in June and July, 2012, before and after the Rhythm and Booms fireworks event. Leaf samples of sixteen plant species and grab samples of surface soils were collected at three sites and analyzed for chemical elements. Most of the plant species showed elevated concentrations of elements associated with pyrotechnics 23 days following the Rhythm and Booms event. Perchlorate, in spite of small samples sizes, increased the most, followed by Ba, Sr and Mg, all important compounds in pyrotechnics. The launch pad showed the highest number of element increases after the event, followed by the viewing area site, and then the island south of the launch pad, although the differences were minor. Foliage of woody plants increased in pyrotechnics associated elements more than herbaceous species. The most correlated elements across species and sites were those that co-occur in pyrotechnics: Ba, K, Mg, Sr, chloride and perchlorate. Maximum concentrations of Al, Ba, Co, Fe, Mg, S, and some of the perchlorate values were considered either at critical levels or nearing toxicity levels for plants.

Introduction

The Madison Committee on the Environment received funding in 2012 to conduct a study of fireworks residues in plants, soils, sediments and water in Warner Park before and after the June 30th Rhythm and Booms fireworks event. The committee received $25,000 from the City of Madison and $4000 from Wild Warner for a total of $29,000 for the study. It is known from the scientific literature that trace elements of barium, strontium, magnesium as well as perchlorate and other elements have been found in these organisms and media following fireworks events. These elements and others are found in the chemicals that cause the various colors in fireworks (http://chemistry.about.com/od/fireworkspyrotechnics/a/fireworkcolors.htm). The purpose of this study was to determine if traces of fireworks chemicals existed in these organisms and soil at Warner Park.

Methods

Plants and soils in Warner Park were collected on June 22 and July 23, 2012 by J. Bennett, J. Carrier, A. Weir, B. Bemis and T. Nelson. The June samples were taken before the fireworks event, and the July samples were taken after the first large rainfall event following the fireworks. On both dates samples were taken from the fireworks launch mound (Site 1), the island directly south of the launch mound (Site 2), and the spectator areas east of the launch mound (Site 3)(map in Bemis report). Only leaves of the plant species were sampled, generally at breast height. Soils were sampled from the top layer. All samples were bulked. No replicates were taken as this was a pilot study.

Sixteen plant species were sampled:

- Alfalfa (*Medicago sativa*)
- Arrowwood (*Viburnum acerifolium*)
- **Black willow** (*Salix nigra*)
- Box elder (*Acer negundo*)
- Buckthorn (*Rhamnus carthatica*)
- **Cat tail** (*Typha latifolia*)
- **Cottonwood** (*Populus deltoids*)
- Creeping Charlie (*Glechoma hederacea*)
- Dandelion (*Taraxacum officinale*)
- Dogbane (*Apocynum androsaemifolium*)
- Duckweed (*Lemna minor*)
- Honeysuckle (*Lonicera tartarica*)
- Plantain (*Plantago major*)
- **Smartweed** (*Polygonum lapathifolium*)
- **Vervain** (*Verbena hastata*)
- Water lily (*Nymphaea odorata*)

The five species in bold font were collected on both dates at all three sites. Alfalfa was only sampled in June as no specimens could be located in July. The leaves were oven dried at 38^{o}C for 48 hours and stored until chemical analyses. After grinding, the 67 leaf and 9 soil samples were acid extracted and analyzed at the UW Soil and Plant Analysis Laboratory by means of ICP/OES, ICP/MS, and ion chromatography (Ellington & Evans 2000) for aluminum (Al), barium (Ba), cobalt (Co), chromium (Cr), iron (Fe), potassium (K), magnesium (Mg), sulfur (S), strontium (Sr), chloride, and perchlorate. These elements and ions were selected because of their known occurrences in fireworks and pyrotechnic emissions (Barman et al 2009; Li et al 2013; Munster et al 2009; Steinhauser et al 2008). Included with the plant and soil samples were spikes of Standard Reference Material 1575, tomato leaves from the National Bureau of Standards to perform data quality assurance results. Recoveries ranged from 59% to 140% and averaged 98%, with aluminum being low and barium being high due to the extraction methods. 62 of the 67 plant samples had no measurable chromium and this element will not be presented in this report. All remaining chemicals had acceptable measurable amounts, resulting in 688 data points (Appendix 1). No statistical analyses of the data have been performed because of the lack of within site replication, the small number of samples, and possible confounding of variables by interacting factors (e.g. site x sampling date).

Results

A complete tabulation of all the data is presented in Appendix 1, followed by a summary in Appendix 2, that was presented at the January 28th COE meeting.

The results are presented in five sections providing data to answer the following questions:

- Were there differences in concentrations before and after the fireworks?
- Were there differences in concentrations among the three sites?
- Were there differences in concentrations among species?
- Were there correlations among the elements that mean anything?
- How high were the concentrations?

Each section contains 10 tables presenting element data by sampling date and the other variable of interest for each question. Rows of data that are in bold font are those showing an increase in concentrations on the July sampling date compared to the June date. Soil data are presented in each table as well.

Recoveries of certified elements from the SRM ranged from 59% (Al) to 140%(Ba) and averaged 98%. The low and high recoveries mentioned were due to the acid extraction method used by SPAL differing from the one used by the certifying organization.

Differences in concentrations before and after the fireworks event

These tables show the concentrations of each element and compound for each plant species and soil on the two sampling dates, averaged across sites. The sample sizes for each average therefore range from one to three.

Average of Al (ppm)	Sampling Date	
Species	June (before)	July (after)
alfalfa	12.88	
arrowwood	**28.75**	**31.77**
black willow	**11.43**	**12.42**
boxelder	**40.69**	**52.61**
buckthorn	**27.89**	**37.62**
cat tail	12.90	9.91
cottonwood	**7.94**	**16.86**
creeping charlie	**144.41**	**387.42**
dandelion	**31.74**	**54.98**
dogbane	**15.89**	**16.82**
duckweed	**214.18**	**785.69**
honeysuckle	**38.29**	**46.11**
plantain	**40.70**	**400.82**
smartweed	42.61	12.95

soil	7936.11	6191.18
vervain	**14.94**	**47.11**
waterlily	35.95	34.74
Grand Average	1173.97	868.75

Average of Ba (ppm)	**Sampling Date**	
Species	**June (before)**	**July (after)**
alfalfa	25.79	
arrowwood	**125.70**	**136.33**
black willow	**6.10**	**10.56**
boxelder	**23.27**	**41.83**
buckthorn	**47.68**	**61.03**
cat tail	**10.49**	**16.74**
cottonwood	**32.52**	**41.11**
creeping charlie	**79.88**	**91.23**
dandelion	40.30	36.10
dogbane	20.42	19.64
duckweed	160.09	136.08
honeysuckle	**62.44**	**103.27**
plantain	103.73	87.65
smartweed	**106.70**	**157.72**
soil	162.53	115.31
vervain	**35.45**	**92.14**
waterlily	11.16	8.80
Grand Average	**69.51**	**74.49**

Average of Chloride (ppm)	**Sampling Date**	
Species	**June (before)**	**July (after)**
alfalfa	1562.00	
arrowwood	**656.75**	**745.50**
black willow	**1248.42**	**1313.50**
boxelder	**1286.88**	**1917.00**
buckthorn	**2680.25**	**4396.08**
cat tail	**10312.75**	**14762.08**
cottonwood	360.92	331.33
creeping charlie	4588.38	3266.00
dandelion	16844.75	12984.13
dogbane	5999.50	4881.25
duckweed	**16702.75**	**19782.38**
honeysuckle	**115.38**	**195.25**
plantain	23190.38	10561.25
smartweed	7987.50	7389.92
soil	27.45	21.15
vervain	**2402.17**	**5455.17**
waterlily	**17022.25**	**17501.50**
Grand Average	**5926.10**	**5988.35**

Average of Co (ppm)	Sampling Date	
Species	June (before)	July (after)
alfalfa	0.14	
arrowwood	**0.01**	**0.07**
black willow	0.32	0.22
boxelder	**0.01**	**0.15**
buckthorn	**0.04**	**0.08**
cat tail		0.12
cottonwood	**0.82**	**1.11**
creeping charlie	**0.06**	**0.26**
dandelion	**0.06**	**0.28**
dogbane		0.04
duckweed	**0.68**	**1.00**
honeysuckle	0.09	0.09
plantain	**0.10**	**0.31**
smartweed	0.69	0.34
soil	4.57	3.54
vervain	0.12	0.04
waterlily	**0.06**	**0.07**
Grand Average	1.00	0.72

Average of Fe (ppm)	Sampling Date	
Species	June (before)	July (after)
alfalfa	72.80	
arrowwood	56.77	56.02
black willow	**63.30**	**69.18**
boxelder	**65.75**	**106.05**
buckthorn	81.90	68.81
cat tail	**53.40**	**71.14**
cottonwood	**57.51**	**82.41**
creeping charlie	**177.61**	**441.15**
dandelion	**74.34**	**105.76**
dogbane	57.29	54.64
duckweed	**660.06**	**2148.11**
honeysuckle	**66.17**	**77.73**
plantain	**125.25**	**411.63**
smartweed	125.31	66.09
soil	9711.14	8384.79
vervain	**48.78**	**71.06**
waterlily	171.92	165.09
Grand Average	1348.38	1126.54

Average of K (%)	Sampling Date	
Species	June (before)	July (after)
alfalfa	1.23	
arrowwood	**0.71**	**0.73**

black willow	1.13	0.87
boxelder	1.79	1.02
buckthorn	1.88	1.50
cat tail	**1.59**	**1.67**
cottonwood	**1.14**	**1.22**
creeping charlie	**2.15**	**2.34**
dandelion	3.26	3.11
dogbane	1.30	1.05
duckweed	3.07	2.77
honeysuckle	0.91	0.76
plantain	2.10	1.73
smartweed	**1.44**	**1.61**
soil	0.13	0.11
vervain	0.87	0.80
waterlily	1.80	1.75
Grand Average	1.44	1.36

Average of Mg (%)	**Sampling Date**	
Species	**June (before)**	**July (after)**
alfalfa	0.61	
arrowwood	0.59	0.57
black willow	**0.27**	**0.36**
boxelder	**0.33**	**0.43**
buckthorn	**0.29**	**0.30**
cat tail	**0.14**	**0.20**
cottonwood	0.48	0.44
creeping charlie	0.58	0.56
dandelion	**0.51**	**0.59**
dogbane	0.85	0.60
duckweed	**0.41**	**0.48**
honeysuckle	**0.67**	**0.72**
plantain	**0.42**	**0.43**
smartweed	**0.61**	**0.63**
soil	**1.47**	**1.68**
vervain	**0.38**	**0.66**
waterlily	0.23	0.21
Grand Average	**0.57**	**0.60**

Average of Perchlorate (ppm)	**Sampling Date**	
Species	**June (before)**	**July (after)**
alfalfa		
arrowwood		
black willow		10.37
boxelder		16.46
buckthorn	8.72	
cat tail	25.42	

cottonwood	3.67	
creeping charlie		
dandelion		
dogbane		
duckweed	52.59	
honeysuckle		
plantain		41.52
smartweed		83.19
soil	12.41	
vervain		70.06
waterlily		
Grand Average	**20.56**	**44.32**

Average of S (%)	**Sampling Date**	
Species	**June (before)**	**July (after)**
alfalfa	0.53	
arrowwood	**0.14**	**0.17**
black willow	**0.31**	**0.32**
boxelder	0.18	0.18
buckthorn	0.15	0.14
cat tail	**0.23**	**0.28**
cottonwood	**0.76**	**0.95**
creeping charlie	0.32	0.30
dandelion	**0.37**	**0.43**
dogbane	0.82	0.41
duckweed	0.49	0.38
honeysuckle	**0.19**	**0.22**
plantain	0.50	0.35
smartweed	0.27	0.25
soil	0.09	0.08
vervain	**0.31**	**0.45**
waterlily	0.28	0.22
Grand Average	0.32	0.32

Average of Sr (ppm)	**Sampling Date**	
Species	**June (before)**	**July (after)**
alfalfa	30.17	
arrowwood	**27.95**	**28.77**
black willow	**9.08**	**11.96**
boxelder	**15.55**	**23.18**
buckthorn	**29.67**	**36.00**
cat tail	**6.11**	**9.12**
cottonwood	**23.68**	**26.18**
creeping charlie	**22.07**	**23.03**
dandelion	26.87	25.00
dogbane	11.73	10.34
duckweed	**27.94**	**38.04**
honeysuckle	**31.68**	**41.36**

plantain	36.52	31.92
smartweed	34.52	29.96
soil	33.35	27.17
vervain	**11.91**	**23.87**
waterlily	**4.18**	**5.06**
Grand Average	**23.38**	**25.11**

Differences in concentrations among the three sites

These tables show the concentrations of each element and compound for each site of the three sampling sites, averaged across plant species. The sample sizes for each are 16 or less depending on site.

Average of Al (ppm)	**Sampling Date**	
Site	**June (before)**	**July (after)**
1	1835.23	1241.53
2	688.72	301.20
3	1001.01	1078.35
Grand Average	1173.97	868.75

Average of Ba (ppm)	**Sampling Date**	
Site	**June (before)**	**July (after)**
1	**67.09**	**73.45**
2	66.05	54.51
3	**74.73**	**92.44**
Grand Average	**69.51**	**74.49**

Average of Chloride (ppm)	**Sampling Date**	
Site	**June (before)**	**July (after)**
1	**4223.86**	**4434.97**
2	**5204.60**	**7979.66**
3	8125.19	5502.04
Grand Average	**5926.10**	**5988.35**

Average of Co (ppm)	**Sampling Date**	
Site	**June (before)**	**July (after)**
1	1.29	0.98
2	0.95	0.43
3	0.77	0.77
Grand Average	1.00	0.72

Average of Fe (ppm)	**Sampling Date**	
Site	**June (before)**	**July (after)**

1	1855.55	1511.80
2	1028.49	532.17
3	**1151.63**	**1333.29**
Grand Average	1348.38	1126.54

Average of K (%)	Sampling Date	
Site	**June (before)**	**July (after)**
1	**1.20**	**1.29**
2	1.43	1.31
3	1.65	1.46
Grand Average	1.44	1.36

Average of Mg (%)	Sampling Date	
Site	**June (before)**	**July (after)**
1	**0.68**	**0.79**
2	0.50	0.50
3	**0.53**	**0.54**
Grand Average	**0.57**	**0.60**

Average of Perchlorate (ppm)	Sampling Date	
Site	**June (before)**	**July (after)**
1	3.67	
2	**10.57**	**54.54**
3	39.00	28.99
Grand Average	**20.56**	**44.32**

Average of S (%)	Sampling Date	
Site	**June (before)**	**July (after)**
1	**0.32**	**0.33**
2	0.35	0.31
3	**0.30**	**0.33**
Grand Average	0.32	0.32

Average of Sr (ppm)	Sampling Date	
Site	**June (before)**	**July (after)**
1	26.85	26.55
2	**18.19**	**22.54**
3	24.61	26.20
Grand Average	**23.38**	**25.11**

Differences among species types and soils

These tables show the concentrations of each element and compound for each of two types of plant species and soil on the two sampling dates, averaged across sites. The sample sizes for each average therefore range from nine to 21.

Average of Al (ppm)	**Sampling Date**	
Types	**June (before)**	**July (after)**
herbaceous	**58.39**	**217.91**
woody	**24.05**	**32.11**
soil	7936.11	6191.18

Average of Ba (ppm)	**Sampling Date**	
Types	**June (before)**	**July (after)**
herbaceous	**66.19**	**80.55**
woody	**39.10**	**54.62**
soil	162.53	115.31

Average of Chloride (ppm)	**Sampling Date**	
Types	**June (before)**	**July (after)**
herbaceous	**10349.10**	**10441.67**
woody	**1049.98**	**1649.48**
soil	27.45	21.15

Average of Co (ppm)	**Sampling Date**	
Types	**June (before)**	**July (after)**
herbaceous	0.33	0.32
woody	**0.30**	**0.34**
soil	4.57	3.54

Average of Fe ppm	**Sampling Date**	
Row Labels	**June (before)**	**July (after)**
herbaceous	**151.63**	**371.47**
woody	**65.14**	**77.49**
soil	9711.14	8384.79

Average of K (%)	**Sampling Date**	
Types	**June (before)**	**July (after)**
herbaceous	1.84	1.84
woody	1.28	1.07
soil	0.13	0.11

Average of Mg (%)	Sampling Date	
Types	**June (before)**	**July (after)**
herbaceous	**0.45**	**0.49**
woody	**0.42**	**0.44**
soil	**1.47**	**1.68**

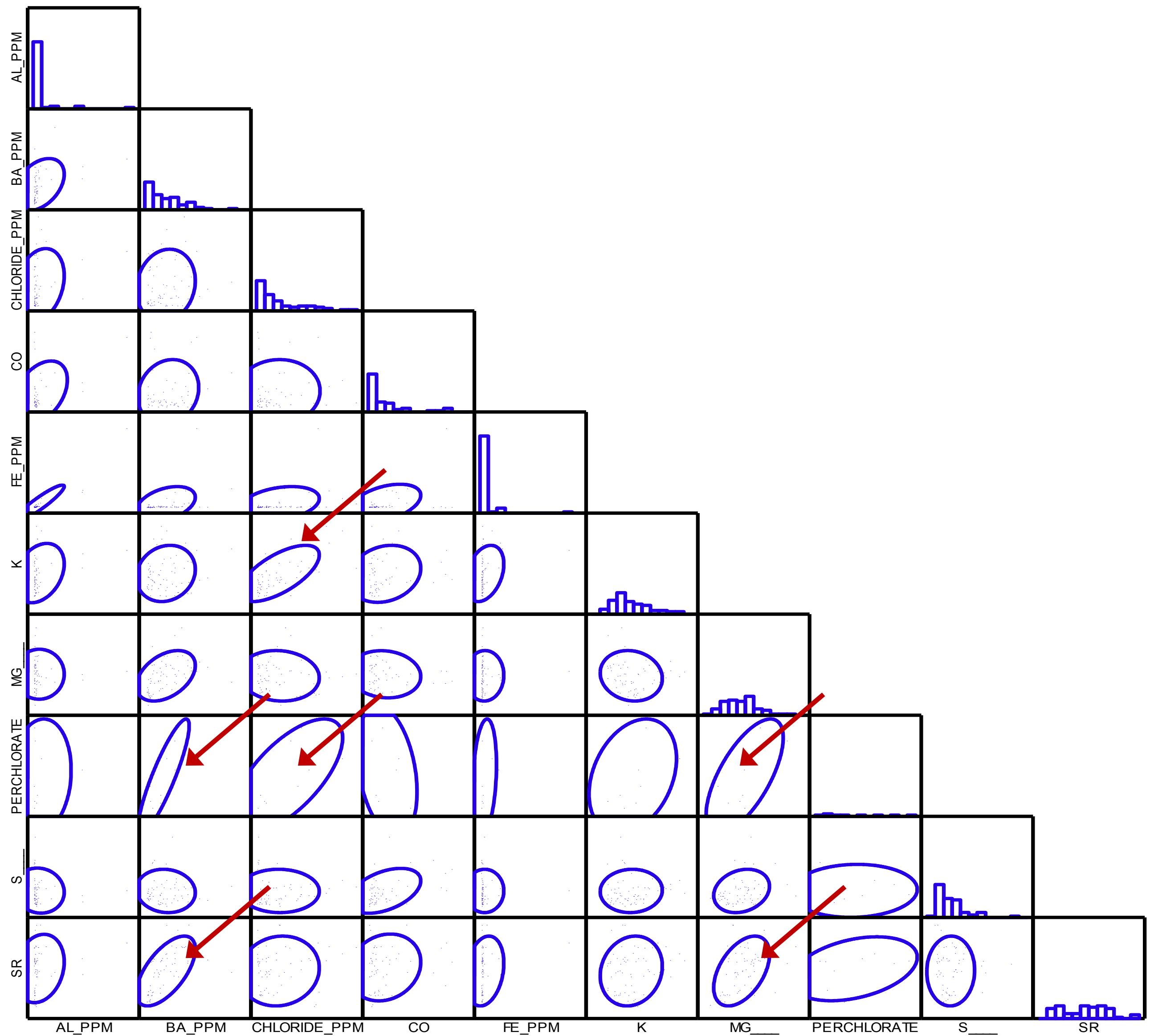
Average of Perchlorate (ppm)	Sampling Date	
Types	**June (before)**	**July (after)**
herbaceous	**39.00**	**64.92**
woody	**6.19**	**13.42**
soil	12.41	

Average of S (%)	Sampling Date	
Types	**June (before)**	**July (after)**
herbaceous	0.36	0.34
woody	**0.34**	**0.37**
soil	0.09	0.08

Average of Sr	Sampling Date	
Row Labels	**June (before)**	**July (after)**
herbaceous	**22.14**	**23.17**
woody	**21.54**	**27.16**
soil	33.35	27.17

Correlations among elements (plants only)

This graph shows a group of 2-way plots pairing each element with each other. The data are points and an ellipse is drawn around the points showing how they vary together. Ellipses that are highly slanted and narrow indicate high correlations. Highly correlated variables (across all plant samples, sites and sampling dates) are indicated with red arrows.



How high were the concentrations?

These tables show the highest concentrations (max) of each element by species and sampling dates. The sample sizes for these values are one.

Max of Al (ppm)	Sampling Dates	
Species	**June (before)**	**July (after)**
alfalfa	12.88	
arrowwood	**28.75**	**31.77**
black willow	13.90	13.91
boxelder	**40.69**	**52.71**
buckthorn	41.85	40.61

cat tail	17.87	9.91
cottonwood	**9.93**	**21.80**
creeping charlie	**261.03**	**729.19**
dandelion	**38.71**	**57.57**
dogbane	**15.89**	**16.82**
duckweed	**313.98**	**1386.77**
honeysuckle	**50.72**	**69.34**
plantain	**67.49**	**722.08**
smartweed	100.05	13.99
soil	13355.79	9788.93
vervain	**16.95**	**80.72**
waterlily	35.95	34.74

Max of Ba (ppm)	**Sampling Dates**	
Species	**June (before)**	**July (after)**
alfalfa	25.79	
arrowwood	**125.70**	**136.33**
black willow	**7.72**	**15.01**
boxelder	**38.46**	**45.27**
buckthorn	**50.82**	**78.62**
cat tail	**13.36**	**23.06**
cottonwood	**61.47**	**80.01**
creeping charlie	**84.82**	**127.19**
dandelion	47.00	48.19
dogbane	20.42	19.64
duckweed	256.87	152.59
honeysuckle	**64.27**	**110.06**
plantain	115.67	88.07
smartweed	**136.30**	**185.44**
soil	217.41	166.67
vervain	**44.39**	**97.97**
waterlily	11.16	8.80

Max of Chloride (ppm)	**Sampling Dates**	
Species	**June (before)**	**July (after)**
alfalfa	1562.00	
arrowwood	**656.75**	**745.50**
black willow	**1597.50**	**2147.75**
boxelder	**1402.25**	**2857.75**
buckthorn	**2698.00**	**6798.25**
cat tail	**12105.50**	**18406.75**
cottonwood	**426.00**	**479.25**
creeping charlie	6496.50	4047.00
dandelion	20590.00	15850.75
dogbane	5999.50	4881.25
duckweed	25347.00	21424.25
honeysuckle	**159.75**	**248.50**
plantain	29518.25	15407.00
smartweed	**9709.25**	**13152.75**

soil	63.90	30.18
vervain	**3354.75**	**9975.50**
waterlily	**17022.25**	**17501.50**

Max of Co (ppm)	Sampling Dates	
Species	June (before)	July (after)
alfalfa	0.14	
arrowwood	**0.01**	**0.07**
black willow	0.46	0.27
boxelder	**0.01**	**0.15**
buckthorn	**0.04**	**0.12**
cat tail	**0.00**	**0.12**
cottonwood	**1.52**	**1.65**
creeping charlie	**0.06**	**0.35**
dandelion	**0.06**	**0.28**
dogbane	**0.00**	**0.04**
duckweed	**0.77**	**1.54**
honeysuckle	0.14	0.15
plantain	**0.11**	**0.54**
smartweed	1.44	0.41
soil	6.68	5.29
vervain	0.13	0.06
waterlily	0.06	0.07

Max of Fe (ppm)	Sampling Dates	
Species	June (before)	July (after)
alfalfa	72.80	
arrowwood	56.77	56.02
black willow	93.46	79.56
boxelder	**78.94**	**118.91**
buckthorn	97.58	81.63
cat tail	**61.22**	**77.04**
cottonwood	**91.01**	**147.41**
creeping charlie	**286.21**	**801.10**
dandelion	**76.22**	**106.83**
dogbane	57.29	54.64
duckweed	**869.95**	**3514.84**
honeysuckle	**77.38**	**94.46**
plantain	**204.16**	**720.63**
smartweed	247.52	69.99
soil	14484.37	12778.76
vervain	**53.11**	**80.68**
waterlily	171.92	165.09

Max of K (%)	Sampling Dates	
Species	June (before)	July (after)
alfalfa	1.23	
arrowwood	0.71	0.73

black willow	1.44	1.10
boxelder	2.04	1.10
buckthorn	2.03	1.68
cat tail	1.92	1.70
cottonwood	1.56	1.33
creeping charlie	**2.27**	**2.46**
dandelion	3.67	3.11
dogbane	1.30	1.05
duckweed	3.47	2.93
honeysuckle	0.98	0.76
plantain	2.38	1.83
smartweed	**2.09**	**2.13**
soil	0.19	0.17
vervain	1.11	1.02
waterlily	1.80	1.75

Max of Mg (%)	**Sampling Dates**	
Species	**June (before)**	**July (after)**
alfalfa	0.61	
arrowwood	0.59	0.57
black willow	**0.30**	**0.43**
boxelder	**0.38**	**0.46**
buckthorn	**0.30**	**0.35**
cat tail	**0.19**	**0.22**
cottonwood	0.59	0.56
creeping charlie	0.60	0.72
dandelion	0.51	0.65
dogbane	0.85	0.60
duckweed	0.45	0.52
honeysuckle	0.72	0.73
plantain	0.49	0.48
smartweed	1.09	0.67
soil	**2.67**	**2.74**
vervain	**0.56**	**0.99**
waterlily	0.23	0.21

Max of Perchlorate (ppm)	**Sampling Dates**	
Species	**June (before)**	**July (after)**
alfalfa		
arrowwood		
black willow		10.37
boxelder		16.46
buckthorn	8.72	
cat tail	25.42	
cottonwood	3.67	
creeping charlie		
dandelion		
dogbane		

duckweed	52.59	
honeysuckle		
plantain		41.52
smartweed		83.19
soil	12.41	
vervain		70.06
waterlily		

Max of S (%)	Sampling Dates	
Species	June (before)	July (after)
alfalfa	0.53	
arrowwood	**0.14**	**0.17**
black willow	**0.36**	**0.39**
boxelder	0.22	0.20
buckthorn	0.16	0.17
cat tail	**0.24**	**0.30**
cottonwood	**0.83**	**1.25**
creeping charlie	**0.40**	**0.42**
dandelion	**0.42**	**0.47**
dogbane	0.82	0.41
duckweed	0.54	0.40
honeysuckle	0.23	0.24
plantain	0.56	0.41
smartweed	0.42	0.30
soil	0.21	0.10
vervain	**0.33**	**0.51**
waterlily	0.28	0.22

Max of Sr (ppm)	Sampling Dates	
Species	June (before)	July (after)
alfalfa	30.17	
arrowwood	**27.95**	**28.77**
black willow	**10.39**	**13.04**
boxelder	**20.46**	**23.75**
buckthorn	**30.61**	**48.79**
cat tail	**6.99**	**12.02**
cottonwood	29.04	28.52
creeping charlie	**23.32**	**24.37**
dandelion	**29.30**	**29.56**
dogbane	11.73	10.34
duckweed	**33.07**	**39.01**
honeysuckle	**32.79**	**46.14**
plantain	36.59	33.34
smartweed	48.92	31.15
soil	42.43	36.12
vervain	**14.16**	**27.76**
waterlily	**4.18**	**5.06**

Maximum of Al (ppm)	Sampling Date	
Type	June (before)	July (after)
herbaceous	**313.98**	**1386.77**
woody	**50.72**	**69.34**
Grand Maximum	**313.98**	**1386.77**

Maximum of Ba (ppm)	Sampling Date	
Type	June (before)	July (after)
herbaceous	256.87	185.44
woody	**125.70**	**136.33**
Grand Maximum	256.87	185.44

Maximum of Chloride (ppm)	Sampling Date	
Type	June (before)	July (after)
herbaceous	29518.25	21424.25
woody	**2698.00**	**6798.25**
Grand Maximum	29518.25	21424.25

Maximum of Co (ppm)	Sampling Date	
Type	June (before)	July (after)
herbaceous	**1.437**	**1.542**
woody	**1.523**	**1.653**
Grand Maximum	**1.523**	**1.653**

Maximum of Fe (ppm)	Sampling Date	
Type	June (before)	July (after)
herbaceous	**869.95**	**3514.84**
woody	**97.58**	**147.41**
Grand Maximum	**869.95**	**3514.84**

Maximum of K (%)	Sampling Date	
Type	June (before)	July (after)
herbaceous	3.67	3.11
woody	2.04	1.68
Grand Maximum	3.67	3.11

Maximum of Mg (%)	Sampling Date	
Type	June (before)	July (after)
herbaceous	1.09	0.99
woody	0.72	0.73
Grand Maximum	1.09	0.99

Maximum of Perchlorate (ppm)	Sampling Date	
Type	June (before)	July (after)
herbaceous	**52.59**	**83.19**
woody	**8.72**	**16.46**
Grand Maximum	**52.59**	**83.19**

Maximum of S (%)	Sampling Date	
Type	June (before)	July (after)
herbaceous	0.82	0.51
woody	**0.83**	**1.25**
Grand Maximum	**0.83**	**1.25**

Maximum of Sr (ppm)	Sampling Date	
Type	June (before)	July (after)
herbaceous	48.92	39.01
woody	**32.79**	**48.79**
Grand Maximum	48.92	48.79

Discussion

When discussing results I refer to 15 plant species with changes from June to July because alfalfa is excluded.

Differences in concentrations before and after the fireworks event

Twelve of the fifteen plant species had increased levels of Al with plantain having the largest increase of about 100%. For Mg, 11 species increased, and for Ba, Fe and Sr, 10 species increased, 9 increased in chloride and Co, 7 increased in S, and 5 increased in K. The grand average across all species increased most for perchlorate at 109%, followed by Sr at 9%, Ba at 6%, Mg at 5% and chloride at 1%. All other grand averages of the elements decreased.

No species increased in all 10 elements, but cat tail increased in 9, arrowwood and black willow in 7, and creeping charlie in 6. Soil decreased in all elements except Mg, where there was a small increase, probably due to different sampling methods.

Differences in concentrations among the three sites

Site 1, the launch pad, had 5 increases in elements between June and July, followed 4 for Site 3, and 3 for Site 2. The largest increase was for perchlorate at Site 2, which increased almost 400%.

Differences among species types and soils

Differences among species were self-evident in the previous tables, so it was decided to group them by life form, i.e. woody vs. herbaceous. Herbaceous species increased concentrations of elements in July compared to June for Al, Ba, chloride, Fe, and perchlorate, with a small increase in Mg. Woody plants increased in Al, Ba, chloride, Co, Fe, perchlorate, S and Sr, with a small increase in Mg. While woody plants increased in more elements than herbaceous plants, they also increased the largest amount in perchlorate at 116% compared to 67% for herbaceous species. For Ba, woody plants increased 41% compared to 22% for herbaceous species.

Correlations among elements (plants only)

The most correlated elements across all plant species were K and chloride, Ba and Mg, Ba and Sr, and Ba, chloride and Mg with perchlorate. This indicates they vary together, and may be due to coming from the same sources.

How high were the concentrations?

The highest concentrations of each element in relation to the sampling dates were as follows:

Al: 1387 ppm in July in duckweed
Ba: 257 ppm in June in duckweed
Chloride: 29518 ppm in June in plantain
Co: 1.65 ppm in July in cottonwood
Fe: 3515 pm in July in duckweed
K: 3.67% in June in dandelion
Mg: 1.09% in June in smartweed
Perchlorate: 83 ppm in July in smartweed
S: 1.25% in July in cottonwood
Sr: 49 ppm in July in buckthorn and June in smartweed

In general the maxima occurred in July for Al, Fe, perchlorate and S. Although herbaceous species had higher perchlorate maxima than woody species, woody species outnumbered herbaceous species in number of maxima.

Comparisons to known levels and toxicity

This discussion compares the maximum values above with tabulated average values for plants, toxicity levels in plants (if known), and with those for a “reference plant” which is considered a normal set of values of plants in general (Whitehead 2000; Pais and Jones 1997). Maxima that are near toxicity levels or critical levels are highlighted. Critical levels are those that may approach toxicity levels for plants. There are no Environmental Protection Agency criteria for element concentrations in plant materials.

Al. The maximum value is almost 7 times higher than the average level of 200 ppm, and 17 times higher than the 80 ppm level for the reference plant. Levels above 500 ppm are considered very high.

Ba. The highest concentration (above) is more than 17 times higher than that of the average plant (15 ppm) and higher than the standard reference plant value of 40 ppm. However, some species of plants do concentrate Ba in high amounts, but it is unknown if smartweed is a Ba accumulator. The maximum value is close to the moderate toxicity level for some plant species.

Chloride. Chloride levels in plants are highly variable, ranging from 20 ppm to seveal percent concentrations. The maximum value of 29% is certainly at the high end of this range.

Co. The highest concentration is 10 times higher than that of the reference plant but is not at a toxicity level.

Fe. The maximum values above are 23 times higher than the reference plant level of 150 ppm, and at least 10 times higher than the 20-100 ppm range for most plant species. The critical level for most plants is 50 ppm.

K. The maximum value in dandelion is just barely over the usual range of K in plants of 1-3.5% so it would not be considered excessive or toxic.

Mg. The maximum value in smartweed is 10 times higher than the usual range of 0.1 – 0.3% in plants and it exceeds the critical levels for herbage plants.

Perchlorate. The perchlorate levels in the plant samples in this study exceed those of some species in the literature and are less than others. They exceed the 5 – 300 ppb levels in tamarisk (Urbansky et al 2000), 10 ppb in tobacco (Sundberg et al 2008), and the 2 ppm levels in tree species (Smith et al 2004). But they are less than higher levels in tobacco (Smith et al 2004; Sundberg et al 2003; Ellington et al 2001), and cucumber and lettuce (Yu et al 2004). It is possible the two high values of 70 & 83 ppm in duckweed and smartweed in July at Site 2 could be considered possible warning levels for those species. Duckweed is an aquatic species and smartweed grows right next to the water on banks, so both may have been exposed to water-born perchlorate.

S. The maximum value in cottonwood is 10 times higher than the normal range for plants of 0.15-0.6%. Critical levels of S in plants range from 0.1 – 0.3%.

Sr. The maximum values are within the normal range of 3-3000 ppm and agrees with the 50 ppm for the reference plant. No toxicity levels are known for Sr in plants. Concentrations of this element vary widely in plants.

Conclusions

Most of the plant species showed elevated concentrations of elements associated with pyrotechnics 23 days following the Rhythm and Booms event. Perchlorate, in spite of small samples sizes, increased the most, followed by Ba, Sr and Mg, all important compounds in pyrotechnics. The launch pad showed the highest number of element increases after the event, followed by the viewing area site, and then the island south of the launch pad, although the differences were minor. Foliage of woody plants increased in pyrotechnics associated elements more than herbaceous species. The most correlated elements across species and sites were those that co-occur in pyrotechnics: Ba, K, Mg, Sr, chloride and perchlorate. Maximum concentrations of Al, Ba, Co, Fe, Mg, S, and some of the perchlorate values were considered either at critical levels or nearing toxicity levels for plants.

Recommendations

- Fireworks events in Warner Park should be curtailed in some way until a replicated scientifically reviewed study is conducted to validate the above conclusions.
- The foliage of the same woody plant species in this study should be sampled again (2013 or 2014) at the launch site and the viewing site at a time earlier than 23 days following the fireworks event, providing there is a rainfall event in between.
- Sampling should be replicated at least three times.
- Analytes should include Ba, Fe, K, Mg, S, Sr and perchlorate.
- Soil need not be analyzed.
- Aquatic plant species need not be analyzed.
- If funding is available, samples of fruits and seeds of the selected species should be taken to determine the potential for food web transfers.

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Appendix 1. Plant and soil chemical data

SPAL No	Date	Site	Species	Al ppm	Ba ppm	Chloride ppm	Co	Cr	Fe ppm	K	Mg (%)	Perchlorate	S (%)	Sr
1	June (before)	1	alfalfa	12.88	25.79	1562.0	0.142	<.001	72.80	1.23	0.61	ND*	0.53	30.17
2	June (before)	1	black willow	<5	5.87	834.3	0.185	<.001	46.55	0.95	0.30	ND	0.32	10.39
4	June (before)	1	cat tail	<5	10.60	11786.0	<.001	<.001	48.20	1.41	0.19	ND	0.20	6.99
5	June (before)	1	cottonwood	9.93	21.74	266.3	0.826	<.001	43.81	1.27	0.49	3.67	0.83	29.04
3	June (before)	1	creeping charlie	27.79	74.94	2680.3	0.061	<.001	69.00	2.27	0.60	ND	0.40	23.32
6	June (before)	1	dandelion	24.77	33.61	13099.5	<.001	<.001	76.22	2.86	0.50	ND	0.42	24.43
7	June (before)	1	honeysuckle	25.86	60.60	71.0	0.135	<.001	54.95	0.84	0.61	ND	0.15	32.79
8	June (before)	1	plantain	13.90	91.80	16862.5	0.098	<.001	46.34	2.38	0.36	ND	0.56	36.45
9	June (before)	1	smartweed	100.05	129.38	6638.5	0.752	<.001	247.52	1.20	0.34	ND	0.15	48.92
10	June (before)	1	vervain	14.96	18.49	1082.8	0.129	<.001	50.01	0.89	0.19	ND	0.33	10.05
11	July (after)	1	black willow	10.93	8.74	994.0	0.197	<.001	69.72	0.89	0.41	ND	0.39	12.31
13	July (after)	1	cat tail	<5	23.06	18406.8	0.117	<.001	68.32	1.66	0.22	ND	0.28	12.02
14	July (after)	1	cottonwood	13.94	16.54	159.8	1.653	<.001	54.61	1.33	0.39	ND	0.72	28.52
12	July (after)	1	creeping charlie	45.66	55.27	4047.0	0.172	<.001	81.20	2.22	0.72	ND	0.42	24.37
15	July (after)	1	dandelion	52.40	24.02	10117.5	0.283	<.001	106.83	3.11	0.53	ND	0.39	20.44
16	July (after)	1	honeysuckle	22.88	96.48	142.0	0.031	<.001	61.00	0.76	0.72	ND	0.20	46.14
17	July (after)	1	plantain	79.56	87.23	5715.5	0.080	<.001	102.64	1.62	0.38	ND	0.41	33.34
18	July (after)	1	smartweed	13.99	185.44	5715.5	0.413	<.001	63.11	1.40	0.57	ND	0.21	29.66
19	July (after)	1	vervain	80.72	91.48	3461.3	<.001	<.001	80.68	1.02	0.46	ND	0.51	23.39
22	June (before)	2	black willow	13.90	7.72	1597.5	0.456	<.001	93.46	1.44	0.25	ND	0.36	10.24
20	June (before)	2	boxelder	<5	8.09	1171.5	0.006	<.001	52.56	2.04	0.28	ND	0.22	10.64
21	June (before)	2	buckthorn	41.85	44.54	2698.0	<.001	<.001	97.58	1.73	0.29	8.72	0.14	28.73
23	June (before)	2	cat tail	17.87	7.50	7046.8	<.001	<.001	50.78	1.43	0.07	ND	0.24	4.82
24	June (before)	2	cottonwood	<5	14.34	426.0	1.523	<.001	37.70	1.56	0.36	ND	0.65	15.61
25	June (before)	2	dogbane	15.89	20.42	5999.5	<.001	<.001	57.29	1.30	0.85	ND	0.82	11.73
26	June (before)	2	duckweed	313.98	256.87	8058.5	0.765	0.316	869.95	2.68	0.38	ND	0.44	22.81
27	June (before)	2	smartweed	29.66	53.22	7188.8	0.339	<.001	77.53	1.32	0.48	ND	0.23	15.90
28	June (before)	2	smartweed	33.75	107.88	8413.5	0.240	<.001	85.24	1.16	1.09	ND	0.28	36.99
29	June (before)	2	vervain	16.95	43.47	2769.0	<.001	<.001	43.23	0.62	0.56	ND	0.30	14.16
30	June (before)	2	waterlily	35.95	11.16	17022.3	0.055	<.001	171.92	1.80	0.23	ND	0.28	4.18
34	July (after)	2	black willow	13.91	15.01	2147.8	0.191	<.001	58.27	0.61	0.43	10.37	0.23	13.04
31	July (after)	2	boxelder	52.71	38.40	2857.8	0.148	<.001	118.91	0.93	0.40	ND	0.20	22.62
32	July (after)	2	buckthorn	40.61	63.35	6798.3	0.012	<.001	60.47	1.30	0.35	ND	0.11	48.79
33	July (after)	2	buckthorn	40.61	41.13	3692.0	0.105	<.001	81.63	1.52	0.26	ND	0.13	21.76
35	July (after)	2	cat tail	<5	12.91	12815.5	<.001	<.001	68.06	1.65	0.20	ND	0.27	7.31
36	July (after)	2	cottonwood	14.83	26.78	479.3	1.283	<.001	45.20	1.19	0.36	ND	0.87	22.62
37	July (after)	2	dogbane	16.82	19.64	4881.3	0.037	<.001	54.64	1.05	0.60	ND	0.41	10.34
38	July (after)	2	duckweed	184.60	119.56	21424.3	0.462	0.329	781.38	2.93	0.43	ND	0.40	37.07
39	July (after)	2	smartweed	11.92	126.35	13152.8	0.271	<.001	69.99	2.13	0.67	83.19	0.30	29.08
40	July (after)	2	vervain	21.89	86.96	9975.5	0.061	<.001	63.68	0.62	0.99	70.06	0.47	27.76
41	July (after)	2	waterlily	34.74	8.80	17501.5	0.074	<.001	165.09	1.75	0.21	ND	0.22	5.06
42	June (before)	3	arrowwood	28.75	125.70	656.8	0.012	<.001	56.77	0.71	0.59	ND	0.14	27.95
45	June (before)	3	black willow	8.96	4.71	1313.5	<.001	<.001	49.89	1.01	0.25	ND	0.24	6.63
43	June (before)	3	boxelder	40.69	38.46	1402.3	0.012	<.001	78.94	1.54	0.38	ND	0.15	20.46
44	June (before)	3	buckthorn	13.93	50.82	2662.5	0.037	<.001	66.22	2.03	0.30	ND	0.16	30.61
47	June (before)	3	cat tail	7.93	13.36	12105.5	<.001	<.001	61.22	1.92	0.17	25.42	0.23	6.51

48	June (before)	3	cottonwood	5.95	61.47	390.5	0.111	<.001	91.01	0.59	0.59	ND	0.81	26.40
46	June (before)	3	creeping charlie	261.03	84.82	6496.5	0.049	<.001	286.21	2.04	0.55	ND	0.23	20.82
49	June (before)	3	dandelion	38.71	47.00	20590.0	0.055	<.001	72.46	3.67	0.51	ND	0.32	29.30
50	June (before)	3	duckweed	114.37	63.31	25347.0	0.592	<.001	450.17	3.47	0.45	52.59	0.54	33.07
51	June (before)	3	honeysuckle	50.72	64.27	159.8	0.037	<.001	77.38	0.98	0.72	ND	0.23	30.57
52	June (before)	3	plantain	67.49	115.67	29518.3	0.105	<.001	204.16	1.82	0.49	ND	0.43	36.59
53	June (before)	3	smartweed	6.97	136.30	9709.3	1.437	<.001	90.92	2.09	0.53	ND	0.42	36.29
54	June (before)	3	vervain	12.91	44.39	3354.8	0.111	<.001	53.11	1.11	0.40	ND	0.29	11.50
55	July (after)	3	arrowwood	31.77	136.33	745.5	0.067	<.001	56.02	0.73	0.57	ND	0.17	28.77
58	July (after)	3	black willow	<5	7.93	798.8	0.271	<.001	79.56	1.10	0.23	ND	0.32	10.55
56	July (after)	3	boxelder	52.50	45.27	976.3	0.142	<.001	93.18	1.10	0.46	16.46	0.17	23.75
57	July (after)	3	buckthorn	31.64	78.62	2698.0	0.117	<.001	64.34	1.68	0.28	ND	0.17	37.46
60	July (after)	3	cat tail	9.91	14.26	13064.0	<.001	<.001	77.04	1.70	0.18	ND	0.30	8.03
61	July (after)	3	cottonwood	21.80	80.01	355.0	0.407	<.001	147.41	1.12	0.56	ND	1.25	27.40
59	July (after)	3	creeping charlie	729.19	127.19	2485.0	0.351	0.417	801.10	2.46	0.40	ND	0.18	21.69
62	July (after)	3	dandelion	57.57	48.19	15850.8	<.001	<.001	104.70	3.10	0.65	ND	0.47	29.56
63	July (after)	3	duckweed	1386.77	152.59	18140.5	1.542	3.634	3514.84	2.60	0.52	ND	0.37	39.01
64	July (after)	3	honeysuckle	69.34	110.06	248.5	0.154	<.001	94.46	0.76	0.73	ND	0.24	36.59
65	July (after)	3	plantain	722.08	88.07	15407.0	0.543	0.312	720.63	1.83	0.48	41.52	0.29	30.49
66	July (after)	3	smartweed	<5	161.38	3301.5	0.345	<.001	65.16	1.29	0.64	ND	0.24	31.15
67	July (after)	3	vervain	38.71	97.97	2928.8	0.018	<.001	68.81	0.75	0.53	ND	0.38	20.48
68	June (before)	1	soil	9800.85	179.14	11.2	5.26	17.67	10018.99	0.18	1.12	ND	0.09	33.99
69	June (before)	1	soil	7691.11	188.92	7.1	4.60	13.50	8810.89	0.12	0.91	ND	0.09	37.18
70	June (before)	1	soil	2465.39	31.25	8.9	2.04	4.97	4536.81	0.05	2.67	ND	0.02	25.32
71	June (before)	2	soil	6367.41	217.41	63.9	4.26	11.06	10704.66	0.12	1.12	12.41	0.21	42.43
72	June (before)	3	soil	13355.79	195.94	46.2	6.68	25.88	14484.37	0.19	1.52	ND	0.05	27.82
73	July (after)	1	soil	3069.11	53.05	7.1	2.16	7.51	5844.23	0.06	2.74	ND	0.05	25.75
74	July (after)	1	soil	9026.15	166.67	18.3	4.68	15.99	10097.43	0.15	1.55	ND	0.10	36.12
75	July (after)	2	soil	2880.54	95.23	30.2	2.04	4.68	4818.75	0.06	1.12	ND	0.10	24.99
76	July (after)	3	soil	9788.93	146.31	29.0	5.29	20.07	12778.76	0.17	1.32	ND	0.06	21.83

Appendix 2. January 22, 2013 data summary

COE 2012 Warner Park Vegetation and Soil Residue Study

James P. Bennett

January 22, 2013

Factors

1. 2 Dates of sampling: June 22 (before R&B) and July 23 (after), 2012
2. 3 Sites: launch mound (1), island south of mound (2), spectator area east of mound (3)
3. 16 Plant species: bulk leaf samples, 5 species of which were at all sites and dates
4. 2 Plant types: herbaceous and woody
5. 1 Soil sample at each site and date

Results

1. 67 plant samples analyzed
2. 9 soil samples analyzed
3. 11 tissue and soil concentrations:

    Al: 8 BDL values
    Ba: 0 BDL values
    Chloride: 0 BDL values
    Co: 12 BDL values
    Cr: 62 BDL values
    Fe: 0 BDL values
    K: 0 BDL values
    Mg: 0 BDL values
    S: 0 BDL values
    Sr: 0 BDL values
    Perchlorate: 66 BDL values

Total number of data points = 688

Discussion

Questions for COE to discuss:

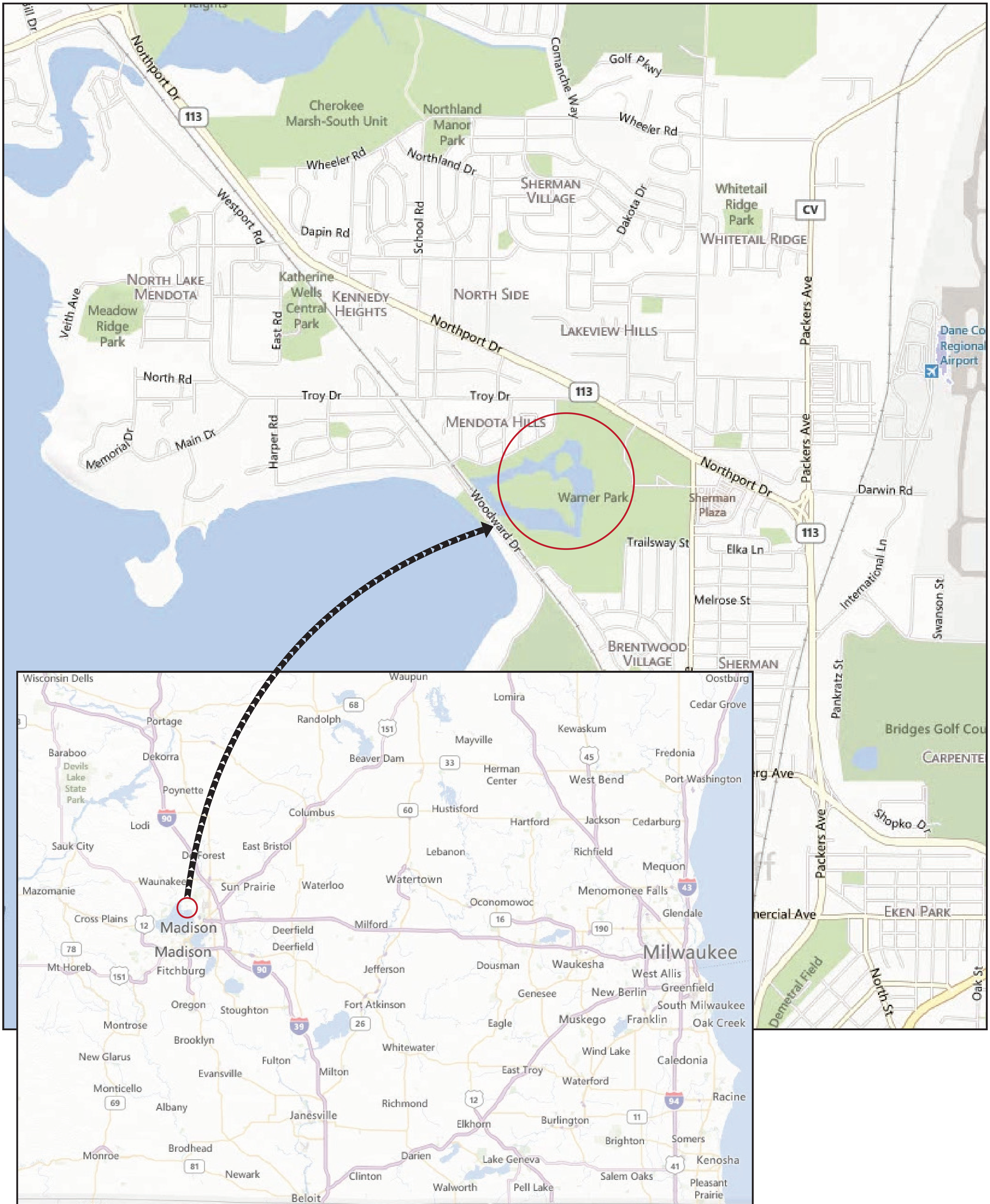
1. Are there differences in concentrations before and after the fireworks?
2. Are there differences in concentrations among the 3 sites?
3. Are there differences among species in concentrations?
4. Are there correlations among the elements that mean anything?
5. How high are the concentrations?

WARNER PARK

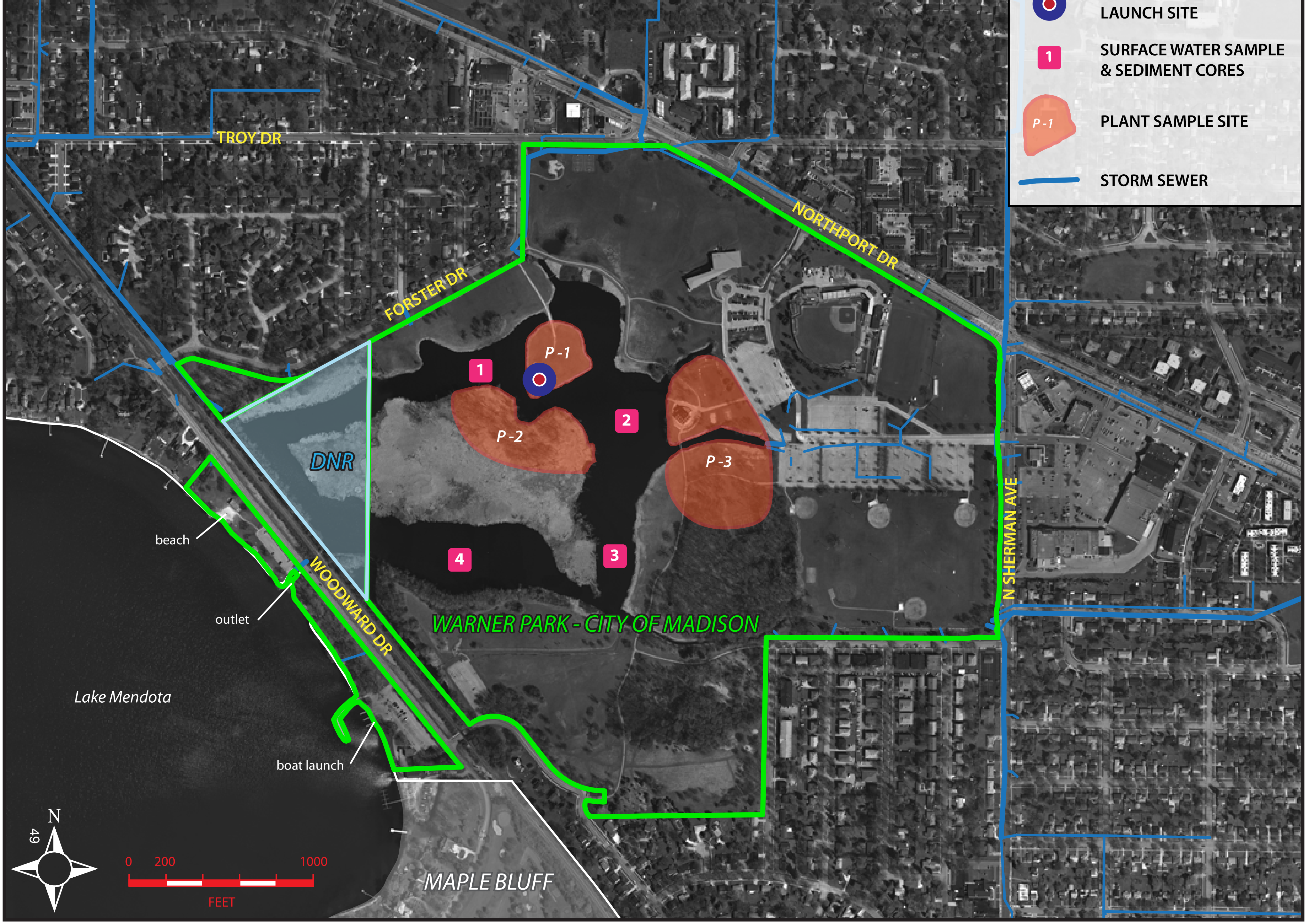
FIREWORKS ENVIRONMENTAL IMPACT BASELINE STUDY 2012

PROJECT LOCATION MAPS

Warner Park, Madison, WI



Warner Park Fireworks Sampling Sites



RESOLUTIONS

City of Madison

City of Madison
Madison, WI 53703
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Master

File Number: 24511

File ID:	24511	**File Type:**	Operating Budget Amendment	**Status:**	Passed
Version:	1	**Reference:**		**Controlling Body:**	Finance Department
Lead Referral:				**File Created Date :**	11/11/2011
File Name:	OPERATING BUDGET AMENDMENT # 3			**Final Action:**	11/15/2011

Title: OPERATING BUDGET AMENDMENT # 3 - Room Tax Fund / Rhythm and Booms, p. 18

Notes:

		CC Agenda Date:	11/15/2011
		Agenda Number:	
Sponsors:	Anita Weier and Sue Ellingson	**Effective Date:**	
Attachments:		**Enactment Number:**	
Author:		**Hearing Date:**	
Entered by:		**Published Date:**	

History of Legislative File

Ver-sion:	Acting Body:	Date:	Action:	Sent To:	Due Date:	Return Date:	Result:
1	COMMON COUNCIL	11/15/2011	Adopt the following Amendment(s) to the Substitute				Pass

Action Text: A motion was made by Ald. Cnare, seconded by Ald. Bidar-Sielaff, to Adopt the following Amendment(s) to the Substitute. The motion passed by voice vote/other.

Notes:

Text of Legislative File 24511

Fiscal Note

Trf To Genl Fd.: Rhythm & Booms - City Agency Base Costs:	$(7,225)
Trf To Genl Fd.: Warner Park Contamination Testing:	$7,225
Warner Park Contamination Testing:	$17,775
Rhythm & Booms Cash Contribution:	$(17,775)
Total:	$0
Levy Impact:	$0
TOAH Impact:	$0

Title

OPERATING BUDGET AMENDMENT # 3 - Room Tax Fund / Rhythm and Booms, p. 18

Body

Shift $25,000 in Room Tax funding from Rhythm and Booms to testing of contamination of sediment, soil, vegetation and water at Warner Park in, under and near the lagoon. This expenditure would occur only if the City's Committee on the Environment obtains matching funds. If matching funds are not obtained, this funding will become available for Rhythm and Booms. The Agreement with Madison Fireworks Fund expired on July 31, 2011.

City of Madison

City of Madison
Madison, WI 53703
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Master

File Number: 24511

File ID:	24511	**File Type:**	Operating Budget Amendment	**Status:**	Passed
Version:	2	**Reference:**		**Controlling Body:**	Finance Department
Lead Referral:				**File Created Date :**	11/11/2011
File Name:	OPERATING BUDGET AMENDMENT # 3			**Final Action:**	11/15/2011

Title: OPERATING BUDGET AMENDMENT # 3 - Room Tax Fund / Rhythm and Booms, p. 18

Notes:

		CC Agenda Date:	11/15/2011
		Agenda Number:	
Sponsors:	Anita Weier and Sue Ellingson	**Effective Date:**	
Attachments:	Version 1.pdf	**Enactment Number:**	
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Trf To Genl Fd.: Rhythm & Booms - City Agency Base Costs:	$~~(7,225)~~
Trf To Genl Fd.: Warner Park Contamination Testing:	$~~7,225~~
Warner Park Contamination Testing:	$~~17,775~~
Rhythm & Booms Cash Contribution:	~~$(17,775)~~
<u>Consulting Services</u>	$<u>50,000</u>
<u>Contribution/Donation</u>	<u>(25,000)</u>
Total:	<u>$25,000</u>
Levy Impact:	$<u>25,000</u>
TOAH Impact:	$<u>0.28</u>

Title

OPERATING BUDGET AMENDMENT # 3 - Room Tax Fund / Rhythm and Booms, p. 18

Body

~~Shift $25,000 in Room Tax funding from Rhythm and Booms to testing of contamination of sediment, soil, vegetation and water at Warner Park in, under and near the lagoon. This expenditure would occur only if the City's Committee on the Environment obtains matching funds. If matching funds are not obtained, this funding will become available for Rhythm and Booms. The Agreement with Madison Fireworks Fund expired on July 31, 2011.~~ Provide $25,000 for testing of contamination of sediment, soil, vegetation and water at Warner Park in, under and near the lagoon. This expenditure would occur only if hte City's Committee on the Environment obtains matching funds.

Legislation Text

File #: 25022, **Version:** 1

Fiscal Note

One of the amendments to the 2012 Executive Operating Budget provided for $50,000 of consulting services in Public Health to study contamination at Warner Park. Of this amount, $25,000 was to be provided by the Public Health levy (City only), with a matching amount of contributions or donations. This resolution amends the 2012 Adopted Operating Budget by eliminating the matching requirement, and moving the $25,000 of levy support from Public Health to the Engineering Division. This amendment would therefore be levy-neutral. No additional appropriation is required.

GN01-54950-535000	$3,000	(Engineering - Consulting)
GN01-54951-535000	$22,000	(Engineering - Lab Services)
UA77-54950-774000	($50,000)	(Public Health - Consulting)
UA77-78890-774000	$25,000	(Public Health - Other Revenues)

Title

Amending the 2012 Public Health and Engineering Operating Budget to appropriate $25,000 for a study to establish a baseline level of contamination for sediment, soil, vegetation and water at Warner Park and the Lagoons.

Body

WHEREAS, the 2012 Operating Budget appropriated $25,000 in the budget of Public Health Madison Dane County to manage the testing for contamination in and around Warner Park and the Lagoons, and,

WHEREAS, the budget item was subject to a match of $25,000 from sources obtained by the City's Committee on the Environment, and

WHEREAS, now the City's Committee on the Environment is unable to secure a full $25,000 from outside sources but may be able to secure sufficient funds necessary to produce a meaningful baseline assessment of the level of contamination in and around Warner Park and the Lagoons.

NOW, THEREFORE BE IT RESOLVED, that the 2012 Operating Budgets of Public Health and Engineering are amended to appropriate $25,000 for a study to establish a baseline level of contamination for sediment, soil, vegetation and water at Warner Park and the Lagoons.

BE IT FURTHER RESOLVED, that the previously budgeted $25,000 be transferred from the Public Health Madison Dane County budget to the Engineering budget and that Engineering oversee and manage the baseline study with review by Public Health.

BE IT FURTHER RESOLVED that there are no restrictions or requirements for obtaining matching funds or "in kind service" other than the requirement that the Committee on the Environment obtain funds in addition to the City's $25,000 such that a meaningful baseline study can be obtained.

File #:	25239 Version: 1	Name:	Resolution Authorizing The Mayor And City Clerk To Apply For And Accept A Wisconsin Department of Natural Resources (WDNR) Lake Planning Grant To Test in and Around Warner Park Lagoons for Possible Contaminants Related to Fireworks Displays.
Type:	Resolution	Status:	Passed
File created:	1/30/2012	In control:	BOARD OF PUBLIC WORKS
On agenda:	2/28/2012	Final action:	2/28/2012
Enactment date:	2/29/2012	Enactment #:	RES-12-00148
Title:	Resolution Authorizing The Mayor And City Clerk To Apply For And Accept A Wisconsin Department of Natural Resources (WDNR) Lake Planning Grant To Test in and Around Warner Park Lagoons for Possible Contaminants Related to Fireworks Displays. (Various ADs)		
Sponsors:	BOARD OF PUBLIC WORKS		

Fiscal Note
This resolution authorizes applying for a DNR Lake Planning Grant in the amount of $3,000. In-kind expenses are included in the 2012 Operating Budget of the Engineering Division, as appropriated by File 25022.

Title
Resolution Authorizing The Mayor And City Clerk To Apply For And Accept A Wisconsin Department of Natural Resources (WDNR) Lake Planning Grant To Test in and Around Warner Park Lagoons for Possible Contaminants Related to Fireworks Displays. (Various ADs)
Body
PREAMBLE

Current literature indicates that fireworks release certain contaminants that may be harmful to both public health and the environment. A previous study of the Warner Park Lagoons was limited to three water samples taken a month after the fireworks display. Members of the public and the Committee on the Environment have raised concern about the long-term accumulation of contaminants in the sediments of the lagoon and the soils in the area, which may in turn be taken up by the vegetation. This study is to establish a baseline for the current level of contaminants in the area of the Warner Park Lagoons. City Engineering staff will collect the necessary field data with assistance from Public Health Madison Dane County.

The Wisconsin Department of Natural Resources Lake Planning Grant Program offers financial assistance for lake planning projects that will improve and protect water quality. City Engineering will apply for this grant in 2012. Should the City of Madison receive a grant for this project, the funds would be used to help with lab costs associated with analyzing field samples.

NOW, THEREFORE BE IT RESOLVED, that the Mayor and City Clerk apply for and accept a Wisconsin Department of Natural Resources (WDNR) Lake Planning Grant to test in and around Warner Park Lagoons for possible contaminants related to fireworks displays;
and

BE IT FURTHER RESOLVED, that the City Engineer is authorized to receive and spend the anticipated grant amount of $3,000.