Kings Bay Adaptive Management (KBAM) Phytoremediation Demonstration Project – Final Report

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Executive Summary

The Kings Bay Adaptive Management (KBAM) Phytoremediation Demonstration Project was initiated in early 2012 to document the feasibility of using floating aquatic plants for water quality improvements in Kings Bay, Citrus County, Florida. The KBAM Project demonstration facility was constructed with necessary permits in Kings Bay on the south side of Parker Island. Water hyacinths were inoculated into a floating PVC pipe corral on a number of occasions during the four-year study. Seasonal water quality monitoring was conducted to assess baseline conditions. Water quality monitoring was conducted to assess the effects of the floating plants on water clarity and nutrient levels.

Key results of the KBAM Project are summarized as follows:

- Water quality in this area of Kings Bay is dominated by spring flow but undergoes excessive daily swings in concentrations of dissolved oxygen, pH, and turbidity as a result of a proliferation of planktonic and benthic algae. Water clarity in this area of the bay is limited to a few meters as opposed to typically more than 20 m clarity in spring boils such as Hunter and Three Sisters Springs.
- Specific conductance is much higher in Kings Bay than indicated by historic records before the 1970s. The source of this saltier water appears to be the result of salt water intrusion into the Floridan aquifer in the vicinity of Kings Bay and Crystal River.
- Kings Bay in the vicinity of Parker Island is impaired for the following Florida Class III water quality standards: dissolved oxygen, pH, nitrate-nitrogen, specific conductance, and transparency. These exceedances are in violation of state laws (Outstanding Florida Waters and antidegradation) that are intended to protect Kings Bay from any degradation due to permitted human activities;
- Manatee herbivory prevented the initial establishment of a viable reproducing colony of water hyacinths in the treatment area. This obstacle was overcome by placing the water hyacinths in floating manatee exclusion cages.
- A small improvement in water clarity in the vicinity of the floating aquatic plants was documented. No other water quality benefits were evident based on the limited sampling.
- Significant wildlife resources were supported by the caged water hyacinths. Observed species included water-dependent birds, adult and juvenile fish, aquatic insects that provide food for fish, and blue crabs. Much lower faunal populations were observed in uncaged water hyacinths and in areas of floating filamentous algae outside the KBAM enclosure.

The KBAM Phytoremediation Project was successful at developing the technology to manage populations of beneficial plants along developed shorelines in Kings Bay. The KBAM manatee exclusion cages represent an effective prototype that can be replicated by the Southwest Florida Water Management District and other state and local agencies to accomplish shoreline restoration.

Section 1.0 Introduction

The Crystal River/Kings Bay springs complex includes more than 70 spring vents which account for 99 percent of the fresh water entering the 600-acre Kings Bay (FSI 2016). Crystal River, which emerges from the northwest end of Kings Bay, is a spring run that travels westward approximately six miles before entering the Gulf of Mexico.

Kings Bay has experienced numerous anthropogenic manipulations over the past 50 years that have resulted in significant ecological impairments, including reduction of spring inflows, increased nutrient concentrations, loss of native submerged aquatic vegetation, increased algal blooms, and loss of water clarity. While various proposals exist for restoration of the Kings Bay environment, to-date none of the existing efforts have been successful at making progress towards comprehensive water quality and biological improvement (FSI 2016).

The Howard T. Odum Florida Springs Institute (FSI) has adopted restoration of the spring-dominated Kings Bay ecosystem as a priority project in concert with local stakeholders, local volunteers, and other scientists. FSI initiated the Kings Bay Adaptive Management (KBAM) Phytoremediation Demonstration Project (Project) was in March 2012 as one step toward this restoration goal. The KBAM project enlisted floating aquatic plants for natural phytoremediation of water quality and reduction in populations of planktonic and benthic algae. This KBAM Project Final Report summarizes the activities and progress made during the nearly four-year KBAM Phytoremediation Demonstration Project.

Project Location

Figure 1 identifies the location of the KBAM Project. The phytoremediation demonstration area was located in Kings Bay along the east side of Parker Island. The KBAM treatment area or "corral" was about 80 feet wide by 120 feet long, allowing adequate clearance for boat traffic into that arm of the bay, and is delineated by a floating channel marker, orange buoys, and floating PVC booms. The PVC booms are intended to hold in aquatic floating plants and to exclude boating access, and are anchored at the corners and open below water to allow manatee access. An informational sign was located adjacent to the KBAM corral (Figure 2 andFigure 3).

Figure 1. KBAM Phytoremediation Demonstration Project location adjacent to Parker Island

Figure 2. KBAM Phytoremediation Demonstration Project Treatment Area PVC corral booms following installation in March 2012

Figure 3. KBAM Project information sign and Waynesburg University volunteers in the completed KBAM corral

Section 2.0 Methods

The KBAM Project was initiated in March 2012 with construction of the treatment area. Project field activities included treatment area construction, local harvesting and inoculation of the corral with floating aquatic plants (primarily water hyacinths), and water quality monitoring (multi-parameter water quality data sonde deployments, field parameter water quality profiles, vertical light attenuation and secchi disk measurements, and analysis of nitrate-nitrogen).

Permitting

A variety of permissions and permits were required to initiate the KBAM Project. In January and February 2012 Dr. Robert Knight, Principal Investigator for FSI, met with representatives of the U.S. Fish and Wildlife Service Crystal River National Wildlife Refuge, the Florida Fish and Wildlife Conservation Commission, the Southwest Florida Water Management District, the University of Florida Center for Aquatic Plants, Citrus County, and the City of Crystal River to discuss the goals and objectives of the proposed KBAM Project. After considerable discussion, these groups gave their conceptual approval for FSI to move forward with a limited demonstration project for three years. They also identified a list of permits that would be necessary to proceed with this work. These approvals/permits included the following:

- Standard manatee conditions permit for in-water work from the U.S. Fish and Wildlife Service;
- A letter of conceptual approval from the Florida Fish and Wildlife Conservation Commission;
- A *de minimus* dredge and fill permit from the Florida Department of Environmental protection (FDEP);
- A Section 404 permit from the U.S. Army Corps of Engineers (USACOE);
- A permit to harvest and move regulated plants from the Florida Department of Agriculture and Community Services (FDACS) that was extended for the four-year project duration; and
- A waterway markers permit from the Florida Fish and Wildlife Conservation Commission (FWC).

All approvals/permits were received by March 4, 2012 and are attached in Appendix A.

Funding support for the KBAM Project was requested from the agencies listed above. None of the federal, state, and local agencies provided financial support. However, all cooperated and assisted by facilitating permitting. Also, the USFWS generously provided space for project construction, use of their facilities and grounds, and access to the Parker Island KBAM corral from their boat docks. The City of Crystal River generously provided use of a small stormwater pond located on Cutler Spur Drive as a nursery area for cultivating water hyacinths (Figure 4).

Financial support for treatment area corral construction materials and substantial volunteer labor was generously provided by students and faculty from Waynesburg University in Waynesburg, Pennsylvania. During the third year of the KBAM Project, additional funding was provided by Save the Manatee Club and Stetson University for expenses related to construction

of manatee-exclusion cages. FSI and KBSA staff and other volunteers, including students and faculty from Waynesburg University, donated more than 1,500 hours of their time to the implementation and reporting needed for the successful completion of this project.

Figure 4. The City of Crystal River's Cutler Spur Stormwater Pond was used as a protected nursery for water hyacinth propagation (photograph from December 2012)

Field Events

Table 1 summarizes the dates for each of the KBAM Project field activities, including corral and cage construction, harvesting and inoculation of floating aquatic plants (primarily water hyacinths) into the corral, construction and installation of manatee exclusion cages, multi-parameter water quality data sonde deployments, field parameter water quality profiles, vertical light attenuation and secchi disk measurements, and nitrate-nitrogen water quality grab samples.

Table 1. KBAM Phytoremediation Demonstration Project field events

Date	Construc-tion	Plant Manage-ment	Sonde Deploy ment	Field Parameters	Light Attenuation	Secchi	NOx-N Samples
3/5/2012	X	X		X	X	X	
3/6-3/8/2012	X	X					
3/9/2012	X	X	D				
3/23/2012		X	R/D	X	X	X	
4/30/2012	X	X	R	X	X	X	
5/30/2012				X	X	X	
6/11/2012		X					
9/4/2012		X	D				
10/4/2012			R				
12/7/2012		X	D	X	X	X	
12/21/2012		X	R	X	X	X	
4/24/2013	X	X		X			
6/19/2013	X	X	D	X			
6/28/2013				X	X		
7/8/2013		X	R	X	X	X	
10/21/2013			D	X	X	X	X
10/28/2013				X	X	X	X
11/13/2013			R				
5/28/2014	X	X					
7/2/2014			D	X	X	X	
7/17/2014			R	X	X	X	
11/19/2014	X	X					
5/1/2015		X	D	X	X	X	X
5/15/2015			R	X	X	X	X
7/8/2015		X		X	X	X	

*D – sonde deployment; R– sonde retrieval

Construction

In March 2012, under the direction of Dr. Chad Sethman, 16 Waynesburg University students and two chaperones spent their spring break working under the supervision of Dr. Knight to build and inoculate the KBAM Project corral with water hyacinths.

Manatee feeding within the demonstration area proved to be a problem, regardless of the plant density introduced. In order to keep manatees from eating the water hyacinths, floating manatee exclusion cages were developed (Figure 5). Two prototypes of these manatee exclusion devices were built and placed in the hyacinth corral to demonstrate that water hyacinth could successfully grow in Kings Bay in spite of elevated salinities and seasonally high manatee

populations. The dimensions of the initial prototype cages were 4 ft x 8 ft x 2.5 ft deep, and four were installed between April 2013 and June 2013. In May 2014, ten additional manatee exclusion cages were built and installed within the KBAM Project demonstration area. This second generation of manatee exclusion cages were built using lighter materials and were four times larger (8 ft x 16 ft x 2.5 ft deep) than the original prototype, at the same cost per cage (Figure 6 and Figure 7). In November 2014, sixteen additional large manatee exclusion cages were built and installed.

Floating Aquatic Plant Harvest and Inoculation

Water hyacinths were collected from local sources to inoculate the KBAM Project on several occasions throughout the project duration (Figure 8 through Figure 10). In December 2012, a protected nursery for growing water hyacinths and other floating aquatic plants was established in one of the City's stormwater basins adjacent to the project site (near the north end of Cutler Spur, Figure 4). This nursery area provided the KBAM Project with an ample supply of floating plants for inoculation of the KBAM corral until winter 2014. In July 2013 an aquatic weed harvester was used to completely fill the KBAM treatment area corral to test if plants could be added at a density high enough to survive manatee foraging (Figure 10). Regardless of the planting density, manatees effectively decimated any water hyacinths placed into the floating PVC corral; consequently the floating manatee exclusion water hyacinth cages were developed. As noted above, manatee exclusion cages were added in multiple stages. Each new manatee exclusion cage was inoculated from either existing cages with healthy plant material, from the Cutler Spur nursery, or other sources in the vicinity of the project site, eventually resulting in approximately 70% plant coverage in the KBAM Project demonstration area.

Figure 5. Floating manatee exclusion water hyacinth cages

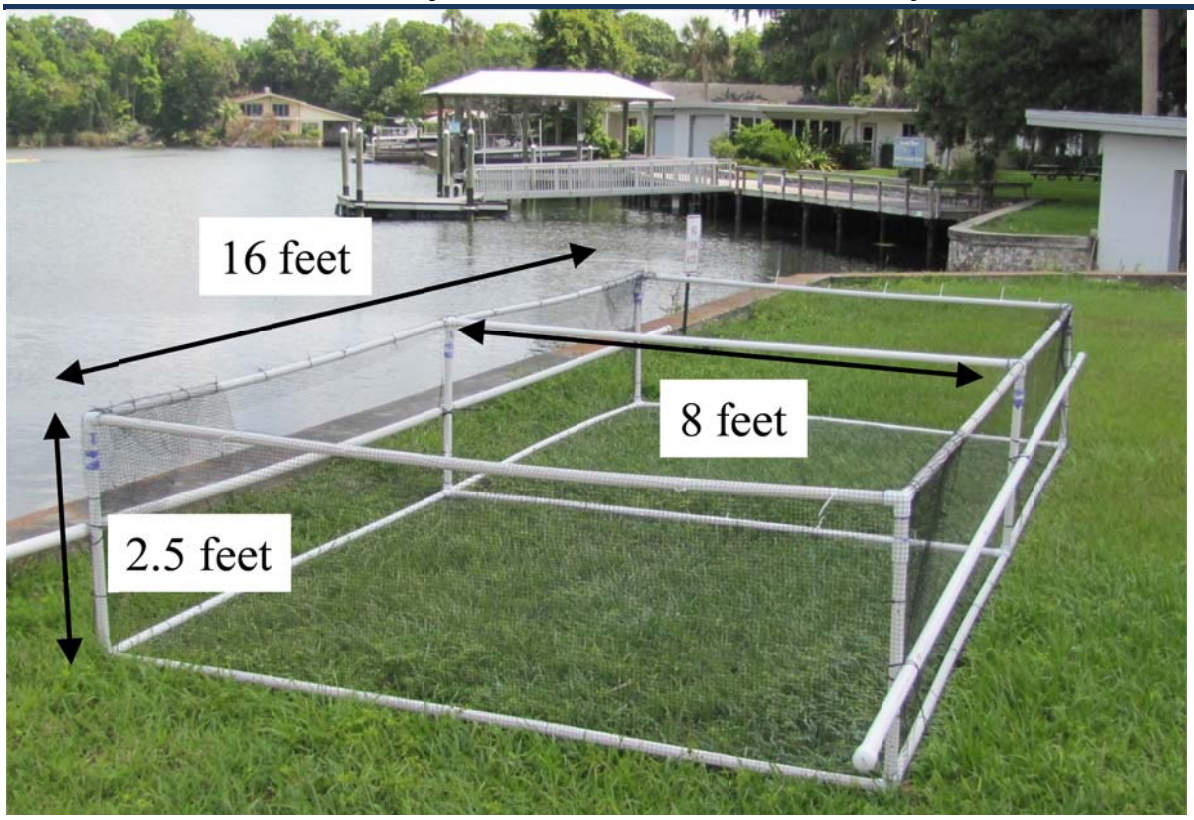

Figure 6. Floating manatee exclusion water hyacinth cage dimensions

Figure 7. Transport of the floating manatee exclusion water hyacinth cage to the KBAM corral

Figure 8. Local water hyacinth source in natural wetland.

Figure 9. Water hyacinth harvest and installation.

Figure 10. Use of aquatic weed harvester for water hyacinth inoculation during July 2013.

Monitoring Stations

Figure 11 identifies the locations of six water quality sampling stations monitored between February 2012 and November 2015. Field parameter water quality profiles, Nutrient grab samples, vertical light attenuation, and secchi disk measurements were collected from each of these stations.

Figure 11. KBAM Project water quality monitoring stations.

Water Quality

A multi-parameter water quality data sonde (YSI 6920v2) was deployed in and around the treatment area on multiple occasions (Table 1) to record temperature, specific conductance, pH, dissolved oxygen, and turbidity on an hourly basis. The water quality sonde was calibrated before each deployment and post calibrated following each retrieval and download. The water quality sonde was suspended in the water column approximately 2 feet below the water surface. The water quality sonde was placed in a protective PVC housing with holes to allow water flow-through conditions during deployment.

Vertical field parameter water quality profiles were measured at each of the six stations with the YSI 6920v2 (or equivalent). Water temperature, specific conductance, pH, dissolved oxygen, and turbidity were measured vertically through the water column. Calibration and maintenance of

water quality meters was conducted according to factory instructions and calibrated at least twice during each sampling event, at the start and finish.

Surface water grab samples were collected at each of the six monitoring stations at the beginning and end of sonde deployments in 2014 and 2015 (Table 1). Each sample was analyzed for nitrate+nitrite-nitrogen (NOx-N) by Advanced Environmental Labs (AEL) in Gainesville, Florida. Samples were collected into pre-preserved laboratory bottles and placed on ice until delivered to the laboratory.

Light Measurements

A Licor LI-1000 data logger with an underwater photosynthetically active radiation (PAR) sensor (LI-192) and an air PAR sensor (LI-200SA) was used to measure vertical light attenuation in the water column at the six stations (Figure 11). These sensors measure light in the 400-700 nm wavelength range which is the visible portion of the spectrum that supports plant photosynthesis. Data from these sensors were used to develop light attenuation coefficients for estimation of the light available to underwater vegetation.

Secchi Disk Visibility

Water clarity was assessed at the six stations (Figure 11) using vertical secchi disk visibility. The vertical secchi depth is the depth below the water surface where the disk disappears from sight. Horizontal secchi disk readings were also collected on occasion to allow visibility estimates for periods when vertical readings were limited by the shallow water depth.

2.9 Biology

Macroinvertebrates

Semi-quantitative biological sampling was conducted in November 2015 as part of the KBAM Project close out. Aquatic invertebrates were sampled from a known area of water hyacinth roots by draining them through a screened bucket. For each sample a 0.25 m^2 PVC pipe frame was randomly placed over the hyacinths, the plants within the quadrat square lifted and quickly placed over the 1 mm mesh screen, and all retained material placed in a sealable plastic bag and placed on ice for transport. In the laboratory, all macroscopic invertebrates were picked, sorted, and counted.

Quantitative faunal samples were collected in and adjacent to the KBAM demonstration site on November 21, 2015 using a "Hyacinth Dredge" (Figure 12). This sampling device has a sampling area of 0.67 m^2 and consists of a wooden frame with large and small mesh that is forced under the floating water hyacinth plants.

Figure 12. Hyacinth dredge used to collect fauna living in and among the floating water hyacinths.

Fish

Fish populations using the KBAM water hyacinth cages for shelter were qualitatively assessed by SCUBA divers. Two divers carefully entered the corral area under the floating cages with powerful underwater lights and visually identified and counted the visible fish.

Juvenile fish were also captured living within the manatee exclusion cages. These fish presumably entered the cages when smaller than the one quarter-inch mesh and then could not escape when they grew larger.

Section 3.0 Results

This section summarizes field data collected as part of the KBAM Phytoremediation Demonstration Project from 2012 to 2015.

3.1 Estimates of Water Hyacinth Cover

Periodic visual estimates of water hyacinth cover in the corral were made throughout the KBAM project duration. Plant cover varied from near zero to more than 90%.

3.2 Water Quality

3.2.1 Water Quality Data Sondes

Table 2 summarizes field parameter results from the data sonde deployed adjacent to the KBAM Project corral (Station KB-3 on Figure 11) between 2012 and 2015, with detailed time series data in Appendix B.

Table 2. Water quality data sonde summary in the KBAM Project area.

Stats	Temp (C)	DO (%)	DO (mg/L)	pH (SU)	SpCond (uS/cm)	Turbidty (NTU)
Average	24.4	76.4	6.31	8.36	2,172	1.53
Median	24.3	71.6	5.99	8.34	1,792	1.11
Minimum	20.4	10.0	0.83	7.49	638	0.00
Maximum	29.6	186	15.0	9.59	5,767	211
Std Dev	1.27	28.8	2.28	0.36	1,034	3.44
N	7,670	7,670	7,670	7,670	7,670	6,552

Study Period: March 2012 – May 2015

Dissolved oxygen concentrations were observed to vary in a diurnal pattern, showing a rise in DO concentration during the day due to primary productivity and decreasing concentrations at night as a result of community respiration (Figure 7). DO averaged 6.31 mg/L over the study period, ranging from a minimum of 0.83 mg/L to a maximum of 15.0 mg/L. While the average DO of about 6 mg/L is adequate for a healthy aquatic environment and exceeds the Florida Class III (freshwaters designated as suitable for the propagation of a health fish and wildlife population and water contact recreation) DO criterion of 5 mg/L, the observed range of DO concentrations in Kings Bay at the KBAM Project site is indicative of an impaired water body. DO concentrations significantly over 100% saturation indicate nutrient-enriched algal bloom conditions. Daytime maximum DO concentrations were often above 100% saturation (approximately 75% of the days monitored). Nighttime DO concentrations regularly were below 5 mg/L (>71% of the nights monitored), indicating excessive community respiration in the water column and in the benthos (bottom-dwelling organisms). These two observations indicate eutrophic (high nutrient/polluted) conditions and the presence of a substantial population of planktonic (free floating micro algae) and benthic macro algae.

A similar diurnal pattern was observed in pH ranging from 7.49 to 9.59 standard units (SU) with an average of 8.36 SU (Figure 13). The Florida Class III standard for pH is a range from 6.5 to 8.5 SU. The water quality data from the KBAM Project site exceeded the pH 8.5 Class III criterion on 83% of the days monitored.

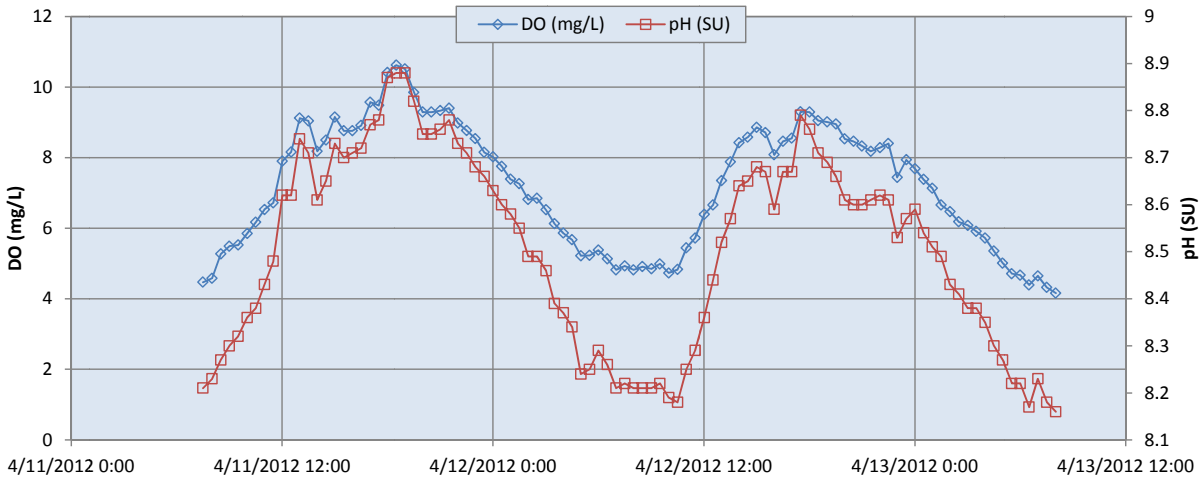

Figure 13. Typical diurnal pattern for dissolved oxygen and pH in the KBAM Project area.

Specific conductance measured at the KBAM Project site ranged from 638 to 5,767 uS/cm, with an average of 2,172 uS/cm over the study period. The Florida Class III water quality standard for specific conductance is "shall never be increased more than 50% above background or 1,275 uS/cm, whichever is greater". Based on historic specific conductance for Kings Bay in the vicinity of Parker Island (Rosenau 1977 as cited in SWFWMD 2005), the background specific conductance is assumed to be about 555 uS/cm and therefore the applicable standard is about 820 uS/cm. Using the 2003 mean specific conductance reported by the SWFWMD (2004) of 1,200 uS/cm results in a more relaxed criterion of 1,800 uS/cm. The average values of specific conductance measured in this study and in other recent studies in Kings Bay have documented a clear trend of increasing exceedances of the Class III standard for specific conductance.

Water temperature was observed to be in a relatively narrow range (20.4 to 29.6 ^{o}C) with an average of about 24.4 ^{o}C, and displayed a muted diurnal pattern in response to fluctuating air temperature. This consistency in water temperature over the sampling period provides evidence that the majority of the water at this station in Kings Bay is derived from local springs and not from mixing with estuarine or marine waters.

Turbidity was generally low over the study period (average 1.5 NTU, median 1.1 NTU) with some intermittent spikes resulting in daily maximum readings of approximately 63, 91, and 211 NTU. Any turbidity measurement above about 30 NTU is an exceedance of the Class III criterion. Violations of this water quality standard were recorded on only three of the days monitored. A slight inverse relationship was observed between turbidity and conductivity, presumably in relation to daily tidal changes at the study site (slightly higher turbidity during periods with low conductivity and stage). Turbidity in natural springs is much lower than the

values observed in the area of the KBAM project. Since Kings Bay is also classified as an Outstanding Florida Water, the observed increases in turbidity can also be considered as a violation of Florida law.

Table 3 provides a summary of field parameter results from data sondes simultaneously deployed underneath the water hyacinth cages within the KBAM Project area and at neighboring docks in July 2014 and May 2015, with detailed time series data presented in Attachment B. The purpose of the paired sonde deployments was to compare continuous field parameter readings from inside and outside the water hyacinth area. The sonde deployment locations outside of the water hyacinth corral area were both on nearby docks (July 2014 – east of KB-2 on neighbors dock; May 2015 – east of KB-5 on USFWS dock).

On average, field parameters were similar between sondes deployed inside the corral and outside of the water hyacinth corral on neighboring docks. Water temperature varied by less than 0.7 °C between the two locations, while DO was slightly lower under the water hyacinths (approximately 0.7 mg/L lower on average). pH and specific conductance differences were less than 0.35 SU and 56 uS/cm between the two locations, respectively. Turbidity was slightly lower under the floating water hyacinths with an average difference of 0.1 NTU.

Water Quality Field Parameter Profiles

Results by station for field parameter vertical profile data collected between March 2012 and July 2015 are presented in Table 4. Detailed profile data by station are included in Appendix C.

The water depth at each station generally increases from north to south, with KB-1 being the most shallow (average 1.0 meters) and KB-5/6 being the deepest (average 2.1 meters).

Water temperature showed little change with depth, providing additional evidence that the water at this location in Kings Bay is predominantly derived from spring inflows.

Specific conductance generally increased with depth; however the magnitude was dependent on tidal conditions during sampling. For example, during the April 30, 2012 monitoring event, specific conductance ranged from 3,761 uS/cm at the water surface (1 ft) to 6,175 uS/cm near the bottom (7 ft). This density stratification was typically observed at the deeper stations (KB-5 and KB-6) during high tide conditions, with fresher water floating over a wedge of denser saltwater.

Dissolved oxygen concentrations were variable with depth in the water column. A majority of the DO profiles had higher DO concentrations and percent saturation values with depth. This is not the usual profile observed in quiescent waters and may be indicative of significant photosynthesis by benthic algae. All stations had similar yearly average DO concentrations, ranging from 5.31 to 8.32 mg/L.

As with DO, pH measurements generally increased with depth. All stations had similar yearly average pH concentrations, ranging from 7.77 to 8.45 SU.

Turbidity generally increased with depth with the highest measurements usually occurring at the bottom of the water column for each station. The range of yearly average concentrations was from 0 to 9.5 NTU.

Table 3. Comparison of water quality sonde data from underneath the water hyacinth cages and at a nearby dock.

	Temp (C)		DO (%)		DO (mg/L)		pH (SU)		SpCond (uS/cm)		Turbidty (NTU)	
Stats	**Dock**	**Exp**	**Dock**	**Exp**	**Dock**	**Exp**	**Dock**	**Exp**	**Dock**	**Exp**	**Dock**	**Exp**
7/2/2014 - 7/13/2014												
Average	25.8	25.1	84.2	75.7	6.81	6.18	8.38	8.12	1,207	1,263	1.42	1.33
Median	25.7	24.8	83.1	67.4	6.73	5.58	8.37	8.04	1,167	1,212	1.00	1.00
Min	23.6	23.6	21.4	23.9	1.81	2.01	7.71	7.55	964	787	0.10	0.00
Max	28.5	28.2	147	174	11.6	14.2	8.98	8.97	1,714	1,990	9.20	7.00
Std Dev	1.16	1.07	27.2	35.4	2.10	2.79	0.292	0.367	160	243	1.34	1.10
N	523	524	523	524	523	524	523	524	523	524	523	524
5/1/2015 - 5/15/2015												
Average	24.6	24.7	96.2	86.1	7.93	7.08	8.42	8.76	1,534	1,505	0.86	0.75
Median	24.5	24.6	93.7	84.0	7.70	6.91	8.43	8.77	1,554	1,489	0.50	0.40
Min	22.4	22.1	32.8	24.6	2.77	2.06	7.69	7.99	724	919	0.00	0.00
Max	27.4	27.5	192	184	15.5	15.0	9.17	9.59	2,451	2,528	124	22.0
Std Dev	1.14	1.15	32.9	34.7	2.61	2.77	0.345	0.366	325	337	4.88	1.79
N	663	671	663	671	663	671	663	671	663	671	663	671

Exp – underneath the water hyacinth experimental area; Dock - outside of the water hyacinth demonstration area

Table 4. Water quality field Parameter profile summary

Parameter	Year	KB-1		KB-2		KB-3		KB-4		KB-5		KB-6		Average	
		Surf	Bot	Surf	Bot	Surf	Bot	Surf	Bot	Surf	Bot	Surf	Bot	Surf	Bot
Temp (C)	2012	23.28	24.26	23.42	24.37	23.11	23.04	23.97	23.84	24.07	24.25	23.92	23.79	23.59	23.77
	2013	24.11	23.96	23.79	23.77	24.01	23.70	23.94	23.71	24.09	23.66	24.07	24.07	24.02	23.81
	2014	25.71	24.66	25.60	24.50	25.31	24.35	25.76	24.35	25.14	24.12	25.76	23.83	25.55	24.30
	2015	24.68	23.90	24.47	24.10	24.41	24.51	23.80	23.70	23.85	23.86	24.44	24.37	24.32	24.09
	Avg	24.44	24.19	24.32	24.18	24.21	23.90	24.37	23.90	24.29	23.97	24.55	24.01	24.36	24.03
DO (%)	2012	68.63	72.15	70.90	80.50	67.80	70.02	65.53	67.23	64.20	71.10	73.23	84.33	68.00	72.94
	2013	80.37	76.80	90.97	82.30	80.37	82.27	73.20	91.87	74.87	83.43	74.70	99.57	79.08	86.04
	2014	72.00	79.25	71.75	79.10	72.80	73.75	74.45	78.80	67.75	72.45	76.50	68.40	72.54	75.29
	2015	94.33	95.00	82.20	72.20	75.90	77.25	67.90	86.05	68.90	80.00	72.10	87.10	77.67	84.18
	Avg	78.83	80.80	78.95	78.53	74.22	75.82	70.27	80.99	68.93	76.75	74.13	84.85	74.22	79.62
DO (mg/L)	2012	5.80	6.00	5.97	6.66	5.76	5.96	5.46	5.63	5.31	5.88	6.09	7.02	5.70	6.10
	2013	6.71	6.45	7.57	6.92	6.73	6.94	6.15	7.73	6.26	7.05	6.26	8.32	6.61	7.24
	2014	5.85	6.58	5.84	6.58	5.95	6.13	6.03	6.59	5.55	6.06	6.22	5.77	5.90	6.28
	2015	7.79	8.00	6.84	6.05	6.25	6.42	5.66	7.28	5.76	6.71	5.97	7.22	6.44	7.04
	Avg	6.54	6.75	6.55	6.55	6.17	6.36	5.82	6.81	5.72	6.42	6.13	7.08	6.16	6.66
pH (SU)	2012	7.79	7.77	7.92	7.84	7.95	7.94	7.78	7.82	7.87	7.79	7.84	7.87	7.87	7.85
	2013	8.04	8.12	8.28	8.19	8.18	8.19	8.08	8.29	8.20	8.26	8.26	8.45	8.18	8.25
	2014	8.16	8.22	8.18	8.19	8.18	8.19	8.23	8.15	8.16	8.16	8.21	8.12	8.19	8.17
	2015	8.27	8.17	8.21	7.89	8.05	8.01	8.03	8.27	8.08	8.22	7.88	8.07	8.08	8.12
	Avg	8.06	8.07	8.15	8.03	8.09	8.08	8.03	8.13	8.08	8.11	8.05	8.13	8.08	8.09
SpCond (uS/cm)	2012	2,750	3,374	2,908	3,644	2,620	3,179	3,200	4,085	3,296	4,489	2,866	4,367	2,925	3,833
	2013	1,817	2,119	1,853	2,139	1,819	2,179	1,810	2,168	1,840	2,121	1,794	3,478	1,822	2,367
	2014	1,474	1,601	1,452	1,614	1,586	1,788	1,615	1,892	1,561	1,705	1,558	1,385	1,541	1,664
	2015	1,310	1,195	1,175	1,175	1,511	1,808	1,095	1,257	1,128	1,380	1,426	1,918	1,302	1,517
	Avg	1,838	2,072	1,847	2,143	1,884	2,238	1,930	2,350	1,956	2,424	1,911	2,787	1,894	2,336
Turbidity (NTU)	2012	2.87	2.85	2.30	6.25	1.77	5.68	1.58	3.70	2.05	8.00	2.20	9.47	2.13	5.99
	2013	0.45	1.60	0.35	2.60	0.40	5.25	0.00	3.65	0.05	4.05	0.45	1.60	0.28	3.13
	2014	0.35	1.55	0.35	1.15	0.35	0.60	0.34	1.25	0.05	0.75	0.15	0.45	0.27	0.96
	2015	0.20	0.40	0.15	0.40	0.48	2.05	0.05	0.65	0.15	0.45	0.17	0.50	0.20	0.74
	Avg	0.97	1.60	0.79	2.60	0.75	3.40	0.49	2.31	0.58	3.31	0.74	3.00	0.72	2.70
Depth (m)	2012	0.71		0.93		1.39		1.74		1.91		1.87		1.42	
	2013	0.96		1.12		1.55		1.71		2.26		2.12		1.62	
	2014	1.21		1.25		1.80		1.86		2.19		2.13		1.74	
	2015	1.01		1.25		1.45		1.82		2.08		1.94		1.59	
	Avg	0.97		1.14		1.55		1.78		2.11		2.01		1.59	

Surf = Surface; Bot = Bottom

Nitrate+Nitrite-N Grab Samples

Water quality grab samples were collected from the six stations (Figure 11) and analyzed for nitrate+nitrite (NOx-N) during four events between 2013 and 2015. The results are presented in Table 5. NOx-N concentrations averaged 0.05 mg/L for all stations combined, ranging from 0.004 mg/L (KB-2) to 0.14 mg/L (KB-6).

Table 5. Nitrate+nitrite-N concentrations in KBAM Project grab samples.

Date	KB-1	KB-2	KB-3	KB-4	KB-5	KB-6	Average
10/21/2013	0.015	0.004	0.067	0.084	0.069	0.065	0.051
10/28/2013	0.029	0.020	0.029	0.027	0.023	0.037	0.028
2013 Avg	0.022	0.012	0.048	0.056	0.046	0.051	0.039
5/1/2015	0.029	0.045	0.090	0.065	0.070	0.140	0.073
5/15/2015	0.035	0.042	0.074	0.072	0.068	0.049	0.057
2015 Avg	0.032	0.044	0.082	0.069	0.069	0.095	0.065
Average	0.027	0.028	0.065	0.062	0.058	0.073	0.052

Light Measurements

Table 6 presents the diffuse attenuation coefficient and percent transmittance estimates at each station between March 2012 and December 2015, with detailed data in Appendix D.

The range of diffuse attenuation coefficients ranged from 0.30 to 1.29 m^{-1}, with an average of 0.69 m^{-1} for all stations combined. Station KB-3 was the most variable; however this station also had more monitoring events. The KB-3 station also had the lowest percent transmittance (average 49% @ 1m) of all stations (range from 49 to 56% @ 1m). The average percent transmittance for all stations over the study period was 53% @ 1m, and generally displayed an increase over the study period. Typical spring run systems in Florida have light transmittance values between 65 and 90% @ 1m (WSI 2010). The light transmittance measurements from this portion of Kings Bay are often lower than is typical for spring-fed water bodies.

Figure 14 provides a summary of percent transmittance estimates measured in May 2015 directly adjacent to the water hyacinth corral (Exp – south [S], southeast [SE}, northeast [NE], north [N]), and from the six KB water quality stations (Figure 11). The purpose was to compare water clarity from inside and outside the KBAM Project area. Percent transmittance averaged 62% @ 1m adjacent to the treatment area and 69% a@ 1 m at the other KB stations.

Table 6. PAR attenuation estimates for the KBAM Project stations.

Stn	Year	k (Diffuse Attenuation m^{-1})	Transmittance, 1m (%)	Absorption, 1m (%)
KB1	2012	0.71	52.48	47.52
	2013	0.70	50.65	49.35
	2014	0.63	63.41	46.59
	2015	0.52	60.53	39.47
	Avg	0.65	56.85	46.15
KB2	2012	0.73	50.45	49.55
	2013	0.72	48.91	51.09
	2014	0.79	46.24	53.76
	2015	0.30	73.99	26.01
	Avg	0.65	53.85	46.15
KB3	2012	1.29	33.87	66.13
	2013	0.74	47.83	52.17
	2014	0.49	62.12	37.88
	2015	0.32	73.81	26.19
	Avg	0.87	48.92	51.08
KB4	2012	0.80	45.14	54.86
	2013	0.56	57.02	42.98
	2014	0.65	53.33	46.67
	2015	0.47	62.97	37.03
	Avg	0.63	53.94	46.06
KB5	2012	0.83	43.86	56.14
	2013	0.56	57.25	42.75
	2014	0.76	47.75	52.25
	2015	0.38	69.40	30.60
l	Avg	0.67	52.02	47.98
KB6	2012	0.66	52.13	47.87
	2013	0.85	43.16	56.84
	2014	0.52	60.12	39.88
	2015	0.46	64.16	35.84
l	Avg	0.63	54.64	45.36
Average		0.69	52.75	47.25

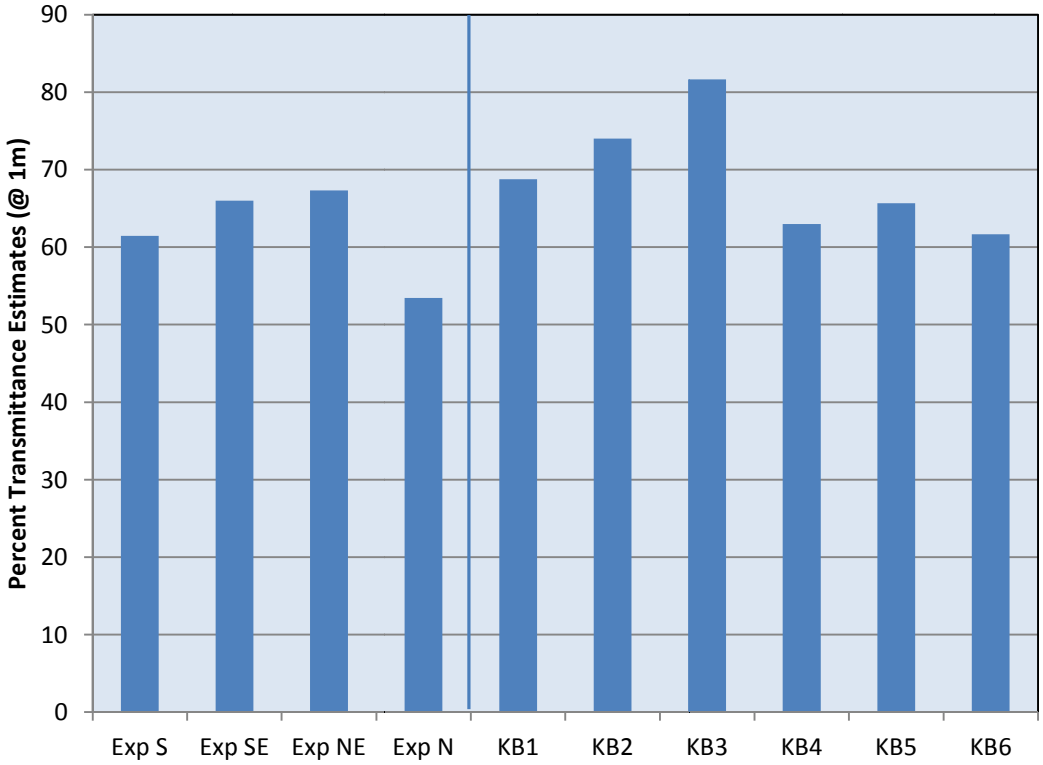

Figure 14. PAR percent transmittance estimates (@ 1m) – May 2015

Secchi Disk Visibility

Water clarity was assessed at the six water quality stations between March 2012 and July 2015 based on secchi disk visibility. Table 7 presents the water clarity estimates for each station. All stations had vertical secchi disk visibility exceeding the water depth during numerous times of sampling. In 2014 and 2015, horizontal secchi disk reading were measured to assess water clarity without depth restrictions. The range of actual measured vertical secchi distances (less than the water depth) ranged from 1.3 to 2.1 meters for station KB-3/5 and KB-5/6, respectively. Horizontal secchi distances ranged from 2.0 to 4.3 meters.

Florida's water quality criterion for transparency (the depth of the "compensation point" for aquatic photosynthesis - approximately equal to two times the secchi depth) is no more than a 10% decline. Typical secchi distances (horizontal) in springs are between 20 and 100 m (60 to 300 ft). Assuming a baseline or natural secchi depth at the lowest end of this range (20 m) and an estimated compensation point of 40 m, a 10% decline would be a secchi depth reduction of about 2 m to a minimum of 18 m. None of the measured secchi depths in Kings Bay were above 5 m, indicating that the Class III transparency standard is exceeded almost continuously.

Table 7. Secchi disk visibility (m).

Date	KB-1	KB-2	KB-3	KB-4	KB-5	KB-6
Vertical						
3/5/12	>0.30	>0.56	>1.20	>1.22	1.32	>1.46
3/23/12	>0.76	>0.83	>1.37	>1.62	>1.80	1.77
4/30/12	>1.07	>1.40	>1.83	1.98	1.91	1.98
5/30/12			>1.77	1.83	>1.68	
12/7/12			1.31			
12/21/12			>1.25			
7/8/13	>0.91	>0.99	>1.54	>1.68	2.05	2.10
10/21/13	>0.91	>1.01	>1.43	>1.62	>2.20	>1.80
10/28/13	>1.07	>1.37				
7/2/2014	>1.14	>1.22	>1.80	>1.80	>2.18	>2.11
7/17/2014	>1.28	>1.28	>1.80	1.71	1.92	>2.16
Horizontal						
7/17/2014						2.07
5/1/2015	4.27		4.27			4.27
5/15/2015						3.67
7/8/15						2.01

3.3 Biology

3.3.1 Macroinvertebrates and Fish

Faunal sampling in November 2015 in the caged and uncaged water hyacinths determined that caged plants that were not subject to manatee herbivory had much higher populations of grass shrimp, crayfish, killifish, mosquitofish, odonates (dragonfly and damselfly larvae), and water spiders. Faunal populations in the uncaged water hyacinths were considerably lower than in the caged plant communities, due to the grazing activities of manatees. Floating mats of filamentous algae outside the KBAM enclosure had elevated populations of snails and amphipods.

Adult and juvenile fish were also observed inside and underneath the caged water hyacinths. Fish species that were noted included redfish, snook, largemouth bass, and various sunfish.

Table 8. KBAM Faunal Assemblage Density (org./m²) Collected from Caged and Uncaged Water Hyacinths and from Floating Filamentous Algae Mats on November 21, 2015 by Stetson University

Faunal Species	Caged Hyacinths	Uncaged Hyacinths	Floating Filamentous Algae
Palaemonetes paludosus (Grass Shrimp)	194.25	24.00	2.50
Procambarus paeninsulanus (Crayfish)	50.25	24.75	0.50
Amphipod (Hyalella azteca)	0.00	0.00	4.50
Callinectes sapidus (Blue crab)	1.50	1.13	0.00
Heterandria formosa (Least killifish)	28.50	16.50	1.50
Lucania goodei (Bluefin killifish)	3.75	4.50	0.00
Gambusia affinis (Mosquitofish)	22.50	6.00	0.00
Lepomis punctatus (Bluegill)	0.00	0.38	0.00
Odonata (Dragonfly)	24.75	18.00	0.00
Odonata (Damselfly)	2.25	0.38	0.50
Gastropod	0.00	2.63	14.00
Water spider	3.00	1.13	0.00
Diving bug	0.75	0.00	0.00

note: faunal densities are in number per square meter of surface area

3.3.2 Manatees

Manatees were observed using the corral area for shelter and foraging by field technicians on several occasions. No quantitative counts were made but based on anecdotal information, there were from one to three manatees feeding on the floating hyacinths at any given time.

Section 4.0 KBAM Project Close Out, Conclusions, and Recommendations

4.1 Introduction

When originally conceived in 2012, the KBAM Project schedule included about three years for permitting, construction, inoculation and grow-in with water hyacinths, water quality monitoring, and reporting. The actual project duration was nearly four years due to the learning curve associated with the initial poor survivability of the water hyacinths due to manatee grazing. With the decision to engineer manatee exclusion cages in 2013, the KBAM project entered into the final two years of environmental monitoring. This report presents a complete summary of this four-year investigation of the phytoremediation potential of managed water hyacinths in Kings Bay.

4.2 Project Close Out

KBAM monitoring was completed and the project was closed out in November 2015. Close out included removing all floating aquatic plants from the manatee exclusion cages and placing them in the existing PVC corral. With the onset of the winter manatee season in Kings Bay it was expected that all plants would be naturally harvested by manatees before the conclusion of the 2015-2016 winter season. By January 2016, all of the water hyacinths had been consumed by manatees; and all cages, the floating PVC corral, and all other physical structures were removed by February 5, 2016. A number of the manatee exclusion cages constructed for the KBAM project will be reused for ongoing phytoremediation research by Stetson University and the Florida Springs Institute.

4.3 Conclusions

Water hyacinths and other floating aquatic plants have a long history of use for phytoremediation of impaired water quality. For this reason the KBAM Project was not considered to be an experiment but rather a demonstration of a known technology in a new setting. Before the KBAM project was initiated it was already well known that:

- Water hyacinths are one of the fastest growing floating aquatic plant species in Florida;
- When well established, water hyacinths shade the underlying water column, thereby reducing the ability of other aquatic plants and algae to obtain the light they need for photosynthesis and propagation;
- Water hyacinths are tolerant of a wide range of water quality conditions, including nutrients, salinity, and temperature;
- Water hyacinths are palatable to manatees and to a variety of introduced insects, mites, and fungi;
- Water hyacinths are susceptible to freezing temperatures; and

- Water hyacinths are easily controlled by aquatic herbicides.

All of these well known facts about the ecology of water hyacinths were confirmed during the KBAM Phytoremediation Project in Kings Bay.

What was not known prior to the KBAM Project was the best approach to engineer a water hyacinth phytoremediation system to increase water clarity in Kings Bay. The KBAM Project contributed a considerable amount of new knowledge to aid with full scale phytoremediation project implementation. Key new findings were:

- The size of the water hyacinth corral and the plant cover built for this project was not sufficient to measurably improve the water quality in the arm of Kings Bay south of Parker Island. Some reductions in turbidity were recorded but water circulation rate and equipment and sampling limitations precluded definitive results about water clarity improvements. However, qualitatively it was clear that usable sunlight was greatly reduced underneath the water hyacinth plants, in turn resulting in reductions in production of phytoplanktonic and benthic algae.
- Water hyacinths and presumably other aquatic plants such as native species like water lettuce, pennywort, frog's bit, and duckweed can be successfully grown in Kings Bay, in spite of elevated salinity entering the bay from natural springs experiencing salt water intrusion;
- A self-maintaining, attractive, floating aquatic plant system can be economically established along developed Kings Bay shorelines for the express purpose of providing natural phytoremediation benefits.

Additional information concerning water quality impairments in Kings Bay demonstrated as a result of the KBAM Project includes:

- Kings Bay dissolved oxygen concentrations fluctuate wildly as a result of eutrophic conditions and the proliferation of excessive populations of phytoplanktonic and benthic algae. These swings in dissolved oxygen result in seasonal and daily violations of Florida's Class III water quality criterion for dissolved oxygen.
- Kings Bay pH levels are also highly variable for the same reasons as dissolved oxygen and also violate state standards for hydrogen ion concentrations in Class III waters.
- Saline waters discharging from Kings Bay springs exceed allowable limits for changes to the specific conductance Florida's water quality criterion for Class III waters.
- Reductions in water clarity in Kings Bay as a result of algal proliferation also violate the state standards for water transparency.

4.4 Recommendations

The Kings Bay Adaptive Management Phytoremediation Demonstration Project conducted by the Florida Springs Institute has achieved its intended purposes of proving feasibility, developing improved design standards, and demonstrating that natural shoreline restoration projects have a role in restoring environmental conditions in Kings Bay. The logical next step in implementation of this technology is to install larger phytoremediation systems with careful accounting of costs and continuing monitoring of effectiveness. The Southwest Florida Water

Management District is currently taking the lead with this next phase of technology implementation.

While water hyacinths were selected for the KBAM Project because of their well-known desirable properties for phytoremediation, this plant species is unpopular with some local residents who have previously witnessed its explosive growth in poorly managed contexts. While this concern is not valid in controlled environments, it can be addressed by utilizing less invasive, native, floating aquatic plant species as previously suggested. It is recommended that side-by-side demonstrations of this technology be monitored to determine the costs and benefits of using alternative plant species for phytoremediation in Kings Bay.

The ratio between areal plant cover versus area of uncovered water with specific water quality benefits has not been empirically established by the KBAM Project. This is a key design parameter for full-scale implementation of phytoremediation technologies. The next phase of this technology development needs to focus resources on determining the most appropriate ratio for each plant species or assemblage that is used for this purpose. It is also a priority to determine if partial shading by floating aquatic plant systems can be used to facilitate the recovery of native submerged aquatic plant species such as eelgrass in Kings Bay.

Preliminary work from the KBAM Project indicates that floating aquatic plant phytoremediation systems provide considerable ecological value by supporting productive macroinvertebrate communities that serve as forage for small fish and in turn support larger fish and sport fishing. Phase 2 efforts to implement this technology should spend adequate resources on documenting the ancillary ecosystem services of these managed plant communities.

Finally, it is important for any persons with interest in the future of Kings Bay to remember that no phytoremediation system will have the ability to restore the bay to its crystal clarity and abundant populations of waving grasses and darting fish. As documented in the Florida Springs Institute's Kings Bay/Crystal River Springs Restoration Plan (FSI 2016), those attributes will not be recovered until the following, easy to understand steps are taken by public officials:

- Groundwater pumping throughout the Springs Coast Region must be significantly reduced to restore a large fraction of historic flows to the springs feeding Kings Bay and the Crystal River. This flow restoration is critical to undo the loss of water clarity that results from increased hydraulic residence times in Kings Bay and the resulting proliferation of phytoplanktonic algae.
- Decreased groundwater pumping is also critical to undo the effects of saltwater intrusion into the former freshwater portions of the coastal Floridan Aquifer and springs.
- Nutrient levels in Kings Bay need to be significantly reduced by eliminating all unnecessary applications of nitrogen-containing fertilizers throughout the springshed that includes most of Citrus County and large portions of surrounding counties.
- Native plant communities have the potential to recover in Kings Bay once freshwater flows are increased and nutrient levels are lowered. But just as importantly, management of populations of nuisance aquatic plants in Kings Bay should not be based

on out-of-date plant eradication methods that harm the vitality of the whole aquatic ecosystem.

The future of Kings Bay and Crystal River can be bright if the public and their leaders learn from the hard lessons of the past and embark on a path of holistic ecosystem management.

Section 5.0 References

Florida Springs Institute (FSI). 2016. Kings Bay/Crystal River Springs Restoration plan. (www.floridaspringsinstitute.org).

Rosenau, J.C., G.L. Faukner, C.W. Hendry, and R.W. Hull. 1977. Springs of Florida. Florida Department of Natural Resources, Bureau of Geology Bulletin No. 31. Tallahassee, Florida.

Southwest Florida Water Management District (SWFWMD). 2005. Crystal River/Kings Bay Technical Summary 1966 – 2004. Surface Water Improvement and Management (SWIM) Program, Resource Management Department.

Wetland Solutions, Inc. (WSI). 2010. An Ecosystem-Level Study of Florida's Springs. Prepared for Florida Fish and Wildlife Conservation Commission, St. Johns River Water Management District, Southwest Florida Water Management District, Florida Department of Environmental Protection, and Three Rivers Trust. 213 pp.

Appendix A

Permits

January 30, 2012

Florida Fish and Wildlife Conservation Commission

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MyFWC.com

To Whom It May Concern:

The Fish and Wildlife Conservation Commission (FWC), Invasive Plant Management Section supports the Florida Springs Institute's (FSI) request for a permit to use *Eichhornia crassipes* (water hyacinth) in a small scale phytoremediation demonstration project within Crystal River/Kings Bay. The FWC supports this one time effort for data collection provided that water hyacinth are placed and maintained within anchored PVC frame(s) as described in the attached permit application. If at the end of the demonstration project it is determined by FWC that any remaining water hyacinth need to be controlled/removed, FWC will take the necessary steps to accomplish the control/removal of the plants. The FWC does not support the unrestrained introduction of water hyacinth into Kings Bay.

There are some critical time considerations for the implementation of this project. Anything you can do to expedite the issuance of a permit to the FSI would be greatly appreciated. If you have any questions or need for information that I can assist with, please contact me.

Sincerely,

William E. Caton

William E. Caton, Section Leader
Florida Fish and Wildlife Conservation Commission
Invasive Plant Management Section
3900 Commonwealth Boulevard, MS 705
Tallahassee, FL 32399-3000
850-617-9430
bill.caton@myfwc.com

STANDARD MANATEE CONDITIONS FOR IN-WATER WORK

2011

The permittee shall comply with the following conditions intended to protect manatees from direct project effects:

a. All personnel associated with the project shall be instructed about the presence of manatees and manatee speed zones, and the need to avoid collisions with and injury to manatees. The permittee shall advise all construction personnel that there are civil and criminal penalties for harming, harassing, or killing manatees which are protected under the Marine Mammal Protection Act, the Endangered Species Act, and the Florida Manatee Sanctuary Act.

b. All vessels associated with the construction project shall operate at "Idle Speed/No Wake" at all times while in the immediate area and while in water where the draft of the vessel provides less than a four-foot clearance from the bottom. All vessels will follow routes of deep water whenever possible.

c. Siltation or turbidity barriers shall be made of material in which manatees cannot become entangled, shall be properly secured, and shall be regularly monitored to avoid manatee entanglement or entrapment. Barriers must not impede manatee movement.

d. All on-site project personnel are responsible for observing water-related activities for the presence of manatee(s). All in-water operations, including vessels, must be shutdown if a manatee(s) comes within 50 feet of the operation. Activities will not resume until the manatee(s) has moved beyond the 50-foot radius of the project operation, or until 30 minutes elapses if the manatee(s) has not reappeared within 50 feet of the operation. Animals must not be herded away or harassed into leaving.

e. Any collision with or injury to a manatee shall be reported immediately to the Florida Fish and Wildlife Conservation Commission (FWC) Hotline at 1-888-404-3922. Collision and/or injury should also be reported to the U.S. Fish and Wildlife Service in Jacksonville (1-904-731-3336) for north Florida or Vero Beach (1-772-562-3909) for south Florida, and to FWC at ImperiledSpecies@myFWC.com

f. Temporary signs concerning manatees shall be posted prior to and during all in-water project activities. All signs are to be removed by the permittee upon completion of the project. Temporary signs that have already been approved for this use by the FWC must be used. One sign which reads *Caution: Boaters* must be posted. A second sign measuring at least 8 ½" by 11" explaining the requirements for "Idle Speed/No Wake" and the shut down of in-water operations must be posted in a location prominently visible to all personnel engaged in water-related activities. These signs can be viewed at MyFWC.com/manatee. Questions concerning these signs can be sent to the email address listed above.

CAUTION: MANATEE HABITAT

All project vessels

IDLE SPEED / NO WAKE

When a manatee is within 50 feet of work
all in-water activities must

SHUT DOWN

Report any collision with or injury to a manatee:

Wildlife Alert:

1-888-404-FWCC(3922)

cell *FWC or #FWC

DIVISION OF PLANT INDUSTRY
(352) 372-3505

POST OFFICE BOX 147100
GAINESVILLE, FLORIDA 32614-7100

1911 S.W. 34TH STREET
GAINESVILLE, FLORIDA 32608

FLORIDA DEPARTMENT OF AGRICULTURE AND CONSUMER SERVICES

COMMISSIONER ADAM H. PUTNAM

February 7, 2012

Dr. Robert L. Knight, Ph.D.
5302 NW 156th Avenue
Gainesville, Florida 32653

Dear Dr. Knight:

Enclosed please find DACS PI-208 Application/Permit Number: 2012-003 to move listed organisms regulated by the State of Florida.

The application/permit and information supplied has been reviewed by the Division of Plant Industry specialists and has been:

Approved X / Valid until 02/07/2014 or Disapproved _____

If approved, the following restrictions/conditions may apply:_____

_____

_____

If disapproved, please find the following justification:_____

_____

_____

Please contact Dr. Wayne Dixon, Acting Director at DPI, Post Office Box 147100, Gainesville, Florida, 32614-7100, (352) 372-3505, Ext. 108, if you have any questions about the permit.

WND/dh

cc: Mr. Tyson Emery
Dr. Greg Hodges

Enclosure(s)

ADAM H. PUTNAM
COMMISSIONER

Florida Department of Agriculture and Consumer Services
Division of Plant Industry

APPLICATION AND PERMIT TO MOVE ORGANISMS REGULATED BY THE STATE OF FLORIDA

Section 581.083, 581.211, F.S.

1911 S.W. 34th Street/PO Box 147100, Gainesville, Florida 32614-7100
Phone: (352)372-3505 Fax: (352)334-0737

Page 1 of 2

THIS SECTION TO BE COMPLETED BY STATE OFFICIAL

Permit Number	☑ Approved ☐ Disapproved	Conditions
2012-003	Signature Wayne N Dixon	
Valid Until	Title Assistant Director	
2/7/2014	Date 2/7/2012	

THIS SECTION TO BE COMPLETED BY APPLICANT

1. Renewal of Permit? ☐ Yes ☒ No
If yes, indicate permit number

2. Name: Robert L. Knight, PhD.
Title: Director, Howard T. Odum Florida Springs Institute
Physical Address: 5302 NW 156th Ave., Gainesville, FL, 32653

3. Mailing Address: 5302 NW 156th Ave, Gainesville, FL, 32653

4. Telephone No.: 386-462-1003 5. Fax No.: 386-462-3196 6. Email Address: bknight@floridaspringsinstitute.org

7. I/We agree to comply with the stipulations of this agreement, and understand that a permit may be subject to other conditions specified.
Signature of Applicant Robert L. Knight Date 1/27/2012

8. Type of Organisms to be Moved ☐ Arthropods ☐ Plant Pathogens ☐ Nematodes ☒ Noxious Weeds
☐ Genetically Altered Organisms ☐ Biological Control Agents ☐ Other (Specify):

Scientific Names of Organisms to be Moved	Classification (Order, Family, Other)	Life Stages	Number of Specimens	Shipped From	In U.S. Yes/No	Host Material Included	Approved (√)
9. Eichhornia crassipes		Mature	500 lbs	Local source	☒ ☐	NA	
10.					☐ ☐		
11.					☐ ☐		
12.					☐ ☐		

➢ ☐ **In addition to the above listed organisms, additional organisms to be moved are listed starting at Line # 35**

13. Number of Shipments	14. Port of Arrival	15. Approximate Date of Arrival or Interstate Movement
NA	NA	March 2012

16. Destination/Location of Movement	17. Method of Shipment ☐ Air ☐ Air Freight ☒ Auto ☐ Baggage
Kings Bay, Citrus County	18. ☐ Other (Specify)

19. Supplier No. 01 - Name & Address	20. Supplier No. 02 - Name & Address	21. Supplier No. 03 - Name & Address
NA	NA	NA

22. General Purpose of Request (Be specific)
Scientific Research

23. Intended Use (Be specific)
Phytoremediation of water quality

24. Methods to be Used to Prevent Organisms Escape (Be specific)
40 gallon lined and covered plastic trash containers

25. Method of Final Disposition of Organisms and Host Material (Accompanying materials and containers? (Be specific))
Natural manatee grazing and decay

Standards and Safe Guards of Permit: 1). All organisms must be shipped in sturdy, escape-proof containers. 2). Upon receipt, all packaging material and shipping containers shall be sterilized or destroyed immediately after removing organisms. 3). Organisms shall be kept only within the laboratory at the permittee's address. 4). No living organisms kept under this permit shall be removed from confined area except by prior approval from this office. 5). Without prior notice and during reasonable hours, authorized State Regulatory Officials shall be allowed to inspect the conditions under which the organisms are kept. 6). All organisms kept under this permit shall be destroyed at the completion of the intended use, and not later than the expiration date. 7). All necessary precautions must be taken to prevent escape. In the event of an escape, notify this office.

Under authority of Chapter 581.083, Florida Statues (FS), and Rule Chapter 5B-57, Florida Administrative Code (FAC), permission is hereby granted to the applicant named above to move the organisms described, except as deleted, subject to the conditions stated on, or attached to, this application. This permit not valid unless signed by an official authorized representative of the department. Failure to comply with stipulations of this agreement may result in penalties as stipulated in Rule 5B-57.0010, FAC, and Section 581.211, FS.

Florida Department of Agriculture and Consumer Services
Division of Plant Industry

APPLICATION AND PERMIT TO MOVE ORGANISMS REGULATED BY THE STATE OF FLORIDA

Page 2 of 2 Permit Number 2012-003

26. Plant Pathogens or Nematodes – Indicate Why Indigenous Pathogens or Nematodes, If Present and/or Available, Would Not Serve the Purposes of the Investigation
NA

27. Plant Pathogens or Nematodes – What Are the Benefits of the Introduction?
NA

28. Plant Pathogens or Nematodes – What Are the Risks of the Introduction?
NA

29. Plant Pathogens or Nematodes – Please Provide Pertinent Literature References or Reprints
NA

30. List all personnel who will be involved with the project at this location. The individual listed on page 1, in item number 2 is responsible for the individual(s) listed below to be in compliance with this permit

Project Assistant No. 01 Ron Clarke	Project Assistant No. 02 Scott Knight	Project Assistant No. 03 Emma Knight	Project Assistant No. 04 Chad Sethman
Project Assistant No. 05 Jason Evans	Project Assistant No. 06 Steve Kingery	Project Assistant No. 07	Project Assistant No. 08

31. Indicate Location of Work, and Briefly Describe the Test Facility and Methodology to be Used
Kings Bay adjacent to Parker Island; floating PVC booms

32. Indicate Sanitation Procedures to be Used to Contain Pathogen in the Test Area, and Security Measures to Prohibit Unauthorized Access to Pathogen to Test Site
NA

33. Time Required for Completion of Project
3 years

34. Will the organism be retained? ☐ Yes ☐ No If Yes, Where and Why?
NA

➢ **Additional Organisms To Be Moved Continued From Line # 12**

	Scientific Names of Organisms to be Moved	Classification *(Order, Family, Other)*	Life Stages	Number of Specimens	Shipped From	In U.S. Yes	In U.S. No	Host Material Included	Approved (√)
35.						☐	☐		
36.						☐	☐		
37.						☐	☐		
38.						☐	☐		
39.						☐	☐		
40.						☐	☐		
41.						☐	☐		
42.						☐	☐		
43.						☐	☐		
44.						☐	☐		
45.						☐	☐		
46.						☐	☐		
47.						☐	☐		
48.						☐	☐		
49.						☐	☐		
50.						☐	☐		
51.						☐	☐		
52.						☐	☐		
53.						☐	☐		
54.						☐	☐		

Standards and Safe Guards of Permit: 1). All organisms must be shipped in sturdy, escape-proof containers. 2). Upon receipt, all packaging material and shipping containers shall be sterilized or destroyed immediately after removing organisms. 3). Organisms shall be kept only within the laboratory at the permittee's address. 4). No living organisms kept under this permit shall be removed from confined area except by prior approval from this office. 5). Without prior notice and during reasonable hours, authorized State Regulatory Officials shall be allowed to inspect the conditions under which the organisms are kept. 6). All organisms kept under this permit shall be destroyed at the completion of the intended use, and not later than the expiration date. 7). All necessary precautions must be taken to prevent escape. In the event of an escape, notify this office.

Under authority of Chapter 581.083, Florida Statues (FS), and Rule Chapter 5B-57, Florida Administrative Code (FAC), permission is hereby granted to the applicant named above to move the organisms described, except as deleted, subject to the conditions stated on, or attached to, this application. This permit not valid unless signed by an official authorized representative of the department. Failure to comply with stipulations of this agreement may result in penalties as stipulated in Rule 5B-57.0010, FAC, and Section 581.211, FS.

Florida Uniform Waterway Marker

FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION Division of Law Enforcement, Boating and Waterways Section 620 South Meridian Street, Mail Station 1M Tallahassee, Florida 32399-1600 (850) 488-5600

Permit Owner Name: Robert Knight
Permit Owner Address: Florida Springs Institute
5302 NW 156th Ave
GAINESVILLE, FLORIDA 32653
UNITED STATES

Permit Number: FUWM-12-011
Effective Date: 3/1/2012
Expiration Date: Perpetual

IS AUTHORIZED TO:

1. The Florida Fish and Wildlife Conservation Commission (FWC) received your request on February 17, 2012. The request included an application and supporting documentation to install a 'Research Area' buoy within Kings Bay in Citrus County for the purpose of conducting research with hydrilla. Based on the complete information submitted with your February 17, 2012, request, pursuant to Rule 68D-23.106, Florida Administrative Code, (Marker Placement Conditions) your request for a permit has been approved subject to the following conditions:

AUTHORIZED LOCATION(S): Hydrilla Research Area Kings Bay
Counties: CITRUS
Waterway: KINGS BAY

Permittee Signature:_____ Date:_____

Not valid unless signed. By signature, confirms that all information provided to issue the permit is accurate and complete, and indicates acceptance and understanding of the provisions and conditions listed below. **Any false statements or misrepresentations when applying for this permit may result in felony charges and will result in revocation of this permit.**

Authorized By: RYAN MOREAU Authorized for: Nick Wiley, Executive Director

Authorizing Signature: Ryan Moreau Date: 03/01/2012

Waterway Management Unit

PERMIT CONDITIONS AND PROVISIONS:

1 Permit is approved contingent upon the consent of and, if necessary, the issuance of appropriate permits by the United States Army Corps of Engineers and the United States Coast Guard.

2 It is unlawful to place markers on private submerged lands or other property or structure not owned by the person or governmental entity placing them without first receiving the written consent of the owner of the submerged lands, other property, or structure as to the placement of the markers. A copy of such written consent, if required, must be provided to the FWC's Boating and Waterways Section. (Pursuant to Section 327.40, Florida Statutes (F.S.), the placement of any uniform waterway marker on

state-owned submerged lands does not subject such lands to the lease requirements of Chapter 253, F.S.)

3 Permit provides for the placement of one (1) uniform waterway "Research Area" information marker at the coordinate position identified on both the map and in the application.

4 Permit authorizes the placement of markers and does not authorize any invasion of private rights, grant any exclusive privileges, or obviate the necessity of complying with any other federal, state or local laws or regulations.

5 All markers associated with this permit must be installed within a reasonable period of time. Upon completion of the installation of markers, the Permittee will notify this office in writing within 30 days. If the latitude and longitude of any marker installed is different from that listed in the application, a request for a permit amendment must be submitted. Such a request must include the final "as-built" latitude and longitude in degrees and decimal minutes (referenced to the WGS-84 datum) for the markers installed.

6 Permittee must comply with the marker specifications and placement requirements detailed in Rules 68D-23.106, 68D-23.108 and 68D-23.109, F.A.C. The permit number and, if applicable, reference to the regulatory instrument creating the restricted area must be displayed on each marker. These numbers and/or letters must be displayed in black block characters measuring at least one inch in height. Retroreflective materials must be used for all white background and international orange displays on markers. An example of an authorized "Research Area" marker is enclosed as Attachment A.

7 Permittee must immediately report discrepancies of markers covered by this permit and make corrections to discrepancies within 30 days. Reports of discrepant markers and/or notice of corrective action completed will be made by calling FWC's Boating and Waterways Section at (850) 488-5600.

8 Permittee must comply with Rule 68D-23.110, F.A.C., which requires the inspection of all markers triennially, notification of completed inspection made to FWC within five (5) days, and maintenance of the inspection documentation. Failure to inspect and maintain documentation of the results of the marker inspection is grounds for rescinding the permit. Please be advised that FWC may request a copy of the inspection documentation at any time.

9 Permittee, by accepting this permit and placement of the uniform waterway markers, does hereby, to the extent authorized by law, agree and promise to hold harmless the State of Florida, its employees, agents or successors, from fault with respect to any claim or claims arising from alleged negligence in the placement, maintenance, operation and removal of any and all marker(s) placed pursuant to the permit. Permittee further agrees to indemnify the State of Florida for any and all legal fees and costs incurred in defense of any suit brought against the state as a result of alleged negligence by the Permittee in the placement, maintenance, operation, or removal of the uniform waterway marker(s).

10 Permittee shall comply with Rule 68D-23.106(4), F.A.C., in the event of discontinuance or removal of any marker covered by this permit.

11 Failure to comply with the requirements or conditions of this permit shall be cause for immediate revocation of the permit.

12 The FWC retains the right to modify or rescind this permit should information become available indicating the permitted activity is likely to create a serious threat to public safety or that the recipient does not need the permit (in its current form). If you have any questions regarding this permit or its applicability, please contact our office at (850) 488-5600.

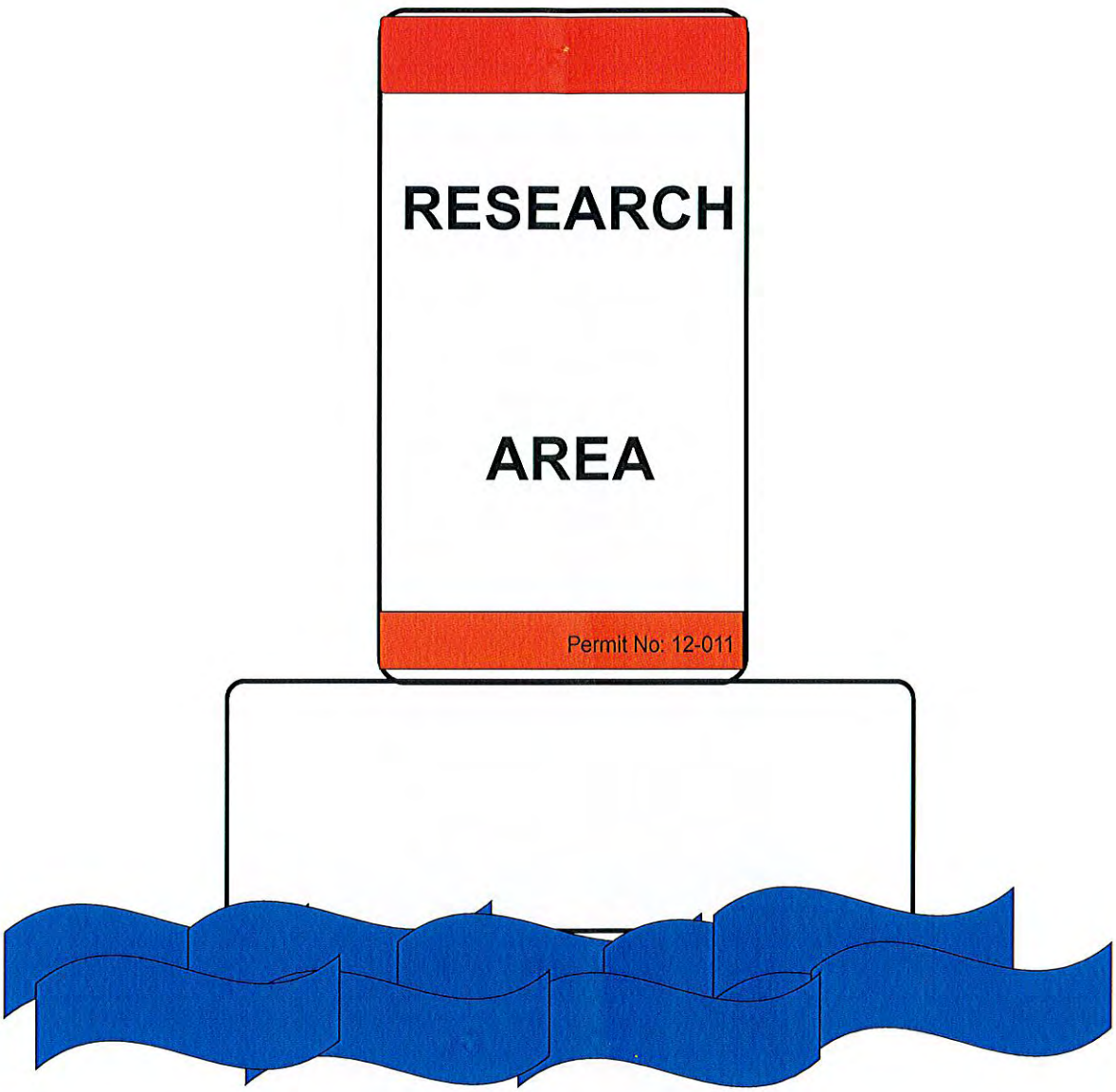
A person whose substantial interests are affected by FWC's action may petition for an administrative proceeding (hearing) under sections 120.569 and 120.57 of the Florida Statutes. A person seeking a hearing on FWC's action shall file a petition for hearing with the agency within 21 days of receipt of written notice of the decision. The petition must contain the information and otherwise comply with section 120.569, Florida Statutes, and the uniform rules of the Florida Division of Administration, chapter 28-106, Florida Administrative Code. Upon such notification, the Permittee shall cease all work

authorized by this permit until the petition is resolved. The enclosed Explanation of Rights statement provides additional information as to the rights of parties whose substantial interests are or may be affected by this action.

Markers Information

Local ID	Latitude	Longitude	Site	Location	Mount Code	Waterway
1	28.884433	82.59361	BAY/SOUND	Water	BUOY	KINGS BAY

	ID	Direction	Symbol	Shape	Message
Sign	A	Buoy	SQUARE	BUOY	Other


RESEARCH
AREA
Permit No: 12-011

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
2831 NW 41ST STREET, SUITE K
GAINESVILLE, FL 32606

REPLY TO
ATTENTION OF

March 5, 2012

Jacksonville Permits Section
Gainesville Field Office
SAJ-2012-00536(LP-JED)

Robert L. Knight
The Florida Springs Institute
5302 Northwest 156th Avenue
Gainesville, Fl 32653

Dear Mr. Knight:

This is in reference to your request for a Department of the Army (DA) permit to perform work in or affecting waters of the United States. If you determine that the permit provided is acceptable in its entirety and you have chosen to proceed with the authorized activity, then upon recommendation of the Chief of Engineers, pursuant to Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403), you are authorized under a Letter of Permission to construct two 160 foot by 80 foot enclosures using floating PVC pipe booms secured to the bay bottom with coated steel cable. The proposal is to fill the enclosures with water hyacinths. The purpose of the work is to determine, if over a three year period, the floating aquatic plants will provide enough shade to displace the existing phytoplankton and filamentous algae which could lead to improved water quality, improved water clarity, and the re-establishment of desirable submerged aquatic plants. The project is located on the eastern shore of Parker Island in King's Bay, the headwaters of Crystal River. The project is located in Section 28, Township 18 South, Range 17 East, Crystal River, Citrus County, Florida.

Geographic Position: Latitude 28.8845472
Longitude -82.5935805

The project must be completed in accordance with the two enclosed construction drawings, and the general and special conditions which are incorporated in, and made a part of, the permit.

Special Conditions:

1. **Self Certification:** Within 60 days of completion of the work authorized, the attached "Self-Certification Statement of Compliance" must be completed and submitted to the U.S. Army Corps of Engineers. Mail the completed form to the Regulatory Division, Enforcement Section U.S. Army Corps of Engineers, P.O. Box 4970, Jacksonville, FL 32232-0019.

2. **Regulatory Agency Changes:** Should any other regulatory agency require changes to the work authorized or obligated by this permit, the Permittee is advised that a

modification to this permit instrument is required prior to initiation of those changes. It is the Permittee's responsibility to request a modification of this permit from the Gainesville Regulatory Office.

3. **Historic Properties:** No structure or work shall adversely affect or disturb properties listed in the National Register of Historic Places or those eligible for inclusion in the National Register. Prior to the start of work, the Permittee or other party on the Permittee's behalf, shall conduct a search in the National Register Information System (NRIS). Information can be found at; http://www.cr.nps.gov/nr/research/nris.htm. Information on properties eligible for inclusion in the National Register can be identified by contacting the Florida Master File Office by email at fmsfile@dos.state.fl.us or by telephone at 850-245-6440. If unexpected cultural resources are encountered at any time within the project area that was not the subject of a previous cultural resource assessment survey, work should cease in the immediate vicinity of such discoveries. The permittee, or other party, should notify the SHPO immediately, as well as the appropriate Army Corps of Engineers office. After such notifications, project activities should not resume without verbal and/or written authorization from the SHPO. If unmarked human remains are encountered, all work shall stop immediately, and the proper authorities notified in accordance with Section 872.05, Florida Statutes, unless on Federal lands. After such notifications, project activities on non-Federal lands shall not resume without verbal and/or written authorization from the Florida State Archaeologist for finds under his or her jurisdiction.

4. **Assurance of Navigation and Maintenance:** The Permittee understands and agrees that, if future operations by the United States require the removal, relocation, or other alteration, of the structures or work herein authorized, or if, in the opinion of the Secretary of the Army or his authorized representative, said structure or work shall cause unreasonable obstruction to the free navigation of the navigable waters, the Permittee will be required, upon due notice from the U.S. Army Corps of Engineers, to remove, relocate, or alter the structural work or obstructions caused thereby, without expense to the United States. No claim shall be made against the United States on account of any such removal or alteration.

5. **Manatee Conditions:** The Permittee shall comply with the "Standard Manatee Conditions for In-Water Work – 2011" enclosed herein.

6. **Sea Turtle and Smalltooth Sawfish Conditions:** The Permittee shall comply with National Marine Fisheries Service's "Sea Turtle and Smalltooth Sawfish Construction Conditions" dated March 23, 2006 enclosed herein.

7. **Maintenance and Removal:** For the duration of the study, the Permittee shall maintain the enclosures in a manner that will prevent the enclosed water hyacinths from escaping outside of the enclosure into King's Bay. If compliance with this special condition requires the alteration of the design depicted on the enclosed construction drawings, the Permittee shall utilize the appropriate Department of the Army application process to obtain a modification to this Letter of Permission. Furthermore, within 30 days of the completion of the three year study period, the Permittee shall remove the enclosures and the enclosed water hyacinths from King's Bay. For purposes of this special condition, the timeframe of the three year study period shall begin on the date of this letter.

If the work authorized is not completed on or before **March 5, 2017**, authorization, if not previously revoked or specifically extended, shall cease and be null and void.

This letter contains an initial proffered permit for your proposed project. If you object to this decision, you may request an administrative appeal under Corps' regulations at 33 CFR Part 331. Enclosed you will find a Notification of Appeal Process fact sheet and Request for Appeal (RFA) form. If you request to appeal this determination/decision, you must submit a completed RFA form to the South Atlantic Division Office at the following address:

Mr. Jason Steele
South Atlantic Division
U.S. Army Corps of Engineers
CESAD-CM-CO-R, Room 9M15
60 Forsyth St., SW.
Atlanta, Georgia 30303-8801.

Mr. Steele can be reached by telephone number at 404-562-5137, or by facsimile at 404-562-5138.

In order for an RFA to be accepted by the Corps, the Corps must determine that it is complete, that it meets the criteria for appeal under 33 CFR Part 331.5, and that it has been received by the Division office within 60 days of the date of the RFA. Should you decide to submit an RFA form, it must be received at the above address by May 3, 2012. It is not necessary to submit an RFA form to the Division office, if you do not object to the determination/decision in this letter.

Should you have any questions regarding this letter, please contact the project manager James "Bo" Davidson in writing at the letterhead address, by telephone at 352-264-7672, or by email at: jmaes.e.davidson2@usace.army.mil.

The Corps Jacksonville District Regulatory Division is committed to improving service to our customers. We strive to perform our duty in a friendly and timely manner while working to preserve our environment. We invite you to take a few minutes to visit http://per2.nwp.usace.army.mil/survey.html and complete our automated Customer Service Survey. Your input is appreciated – favorable or otherwise. Please be aware this web address is case sensitive and should be entered as it appears above.

BY AUTHORITY OF THE SECRETARY OF THE ARMY:

Alfred A. Pantano, Jr.
Colonel, U.S. Army
District Commander

Enclosures:
Self-Certification Statement of Compliance (1 page)
Permit Transfer Request (1 page)
General Conditions (1 page)
Standard Manatee Conditions for In-Water Work (2 pages)
Sea Turtle and Smalltooth Sawfish Construction Conditions (1 page)
Request for Appeal Form (2 pages)
Project Plans (2 pages)

Copy Furnished:

CESAJ-RD-PE

GENERAL CONDITIONS
33 CFR PART 320-330
PUBLISHED FR DATED 13 NOVEMBER 1986

1. The time limit for completing the work authorized ends on **March 5, 2017**. If you find that you need more time to complete the authorized activity, submit your request for a time extension to this office for consideration at least one month before the above date is reached.

2. You must maintain the activity authorized by this permit in good condition and in conformance with the terms and conditions of this permit. You are not relieved of this requirement if you abandon the permitted activity, although you may make a good faith transfer to a third party in compliance with General Condition 4 below. Should you wish to cease to maintain the authorized activity or should you desire to abandon it without a good faith transfer, you must obtain a modification of this permit from this office, which may require restoration of the area.

3. If you discover any previously unknown historic or archeological remains while accomplishing the activity authorized by this permit, you must immediately notify this office of what you have found. We will initiate the Federal and state coordination required to determine if the remains warrant a recovery effort of if the site is eligible for listing in the National Register of Historic Places.

4. If you sell the property associated with this permit you must obtain the signature of the new owner in the space provided and forward a copy of the permit to this office to validate the transfer of this authorization.

5. If a conditioned water quality certification has been issued for your project, you must comply with the conditions specified in the certification as special conditions to this permit. For your convenience, a copy of the certification is attached if it contains such conditions.

6. You must allow a representative from this office to inspect the authorized activity at any time deemed necessary to ensure that it is being or has been accomplished in accordance with the terms and conditions of your permit.

STANDARD MANATEE CONDITIONS FOR IN-WATER WORK
2011

The permittee shall comply with the following conditions intended to protect manatees from direct project effects:

a. All personnel associated with the project shall be instructed about the presence of manatees and manatee speed zones, and the need to avoid collisions with and injury to manatees. The permittee shall advise all construction personnel that there are civil and criminal penalties for harming, harassing, or killing manatees which are protected under the Marine Mammal Protection Act, the Endangered Species Act, and the Florida Manatee Sanctuary Act.

b. All vessels associated with the construction project shall operate at "Idle Speed/No Wake" at all times while in the immediate area and while in water where the draft of the vessel provides less than a four-foot clearance from the bottom. All vessels will follow routes of deep water whenever possible.

c. Siltation or turbidity barriers shall be made of material in which manatees cannot become entangled, shall be properly secured, and shall be regularly monitored to avoid manatee entanglement or entrapment. Barriers must not impede manatee movement.

d. All on-site project personnel are responsible for observing water-related activities for the presence of manatee(s). All in-water operations, including vessels, must be shutdown if a manatee(s) comes within 50 feet of the operation. Activities will not resume until the manatee(s) has moved beyond the 50-foot radius of the project operation, or until 30 minutes elapses if the manatee(s) has not reappeared within 50 feet of the operation. Animals must not be herded away or harassed into leaving.

e. Any collision with or injury to a manatee shall be reported immediately to the Florida Fish and Wildlife Conservation Commission (FWC) Hotline at 1-888-404-3922. Collision and/or injury should also be reported to the U.S. Fish and Wildlife Service in Jacksonville (1-904-731-3336) for north Florida or Vero Beach (1-772-562-3909) for south Florida, and to FWC at ImperiledSpecies@myFWC.com

f. Temporary signs concerning manatees shall be posted prior to and during all in-water project activities. All signs are to be removed by the permittee upon completion of the project. Temporary signs that have already been approved for this use by the FWC must be used. One sign which reads *Caution: Boaters* must be posted. A second sign measuring at least 8 ½" by 11" explaining the requirements for "Idle Speed/No Wake" and the shut down of in-water operations must be posted in a location prominently visible to all personnel engaged in water-related activities. These signs can be viewed at MyFWC.com/manatee. Questions concerning these signs can be sent to the email address listed above.

CAUTION: MANATEE HABITAT

All project vessels

IDLE SPEED / NO WAKE

When a manatee is within 50 feet of work
all in-water activities must

SHUT DOWN

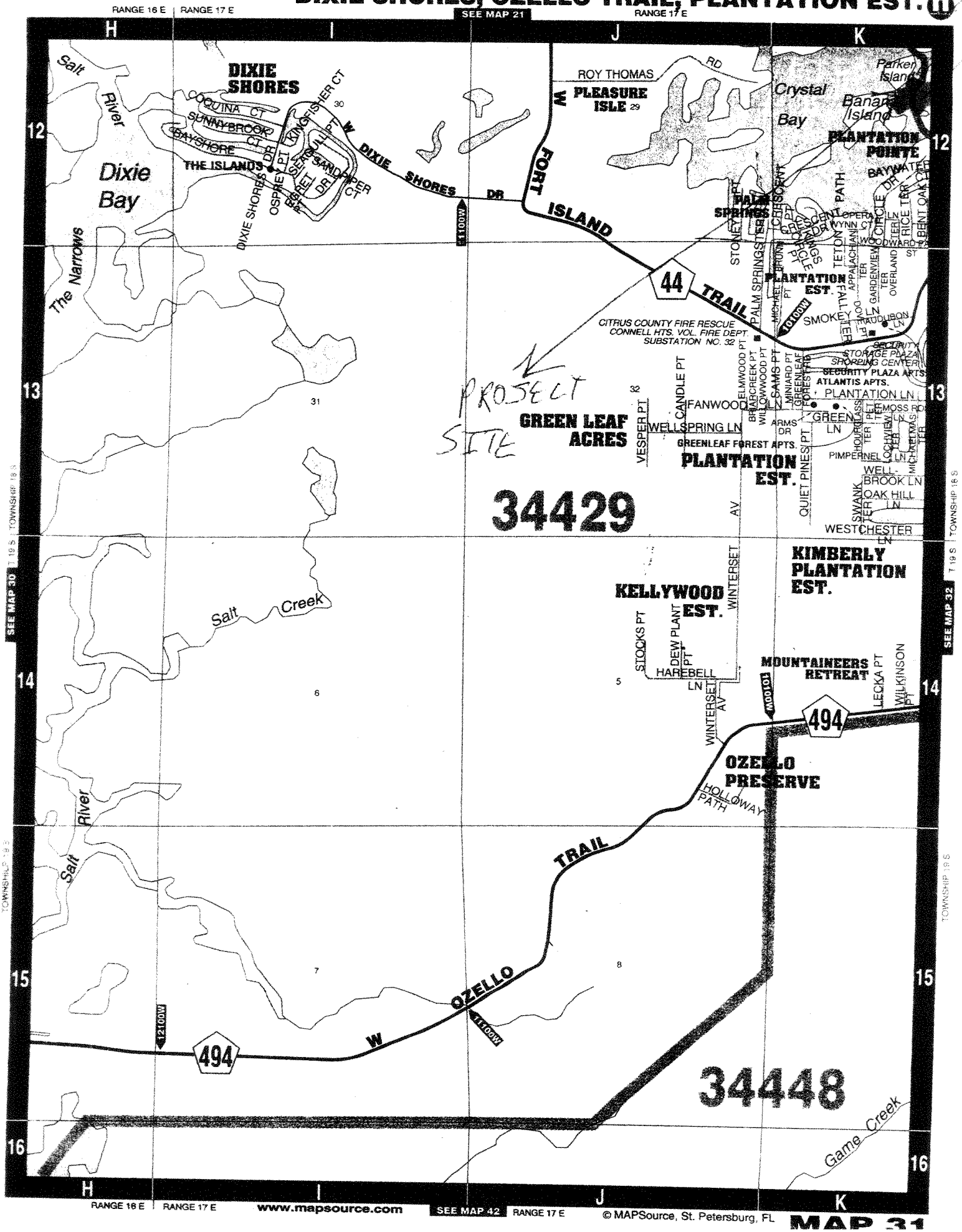
Report any collision with or injury to a manatee:

Wildlife Alert:

1-888-404-FWCC(3922)

cell *FWC or #FWC

DIXIE SHORES, OZELLO TRAIL, PLANTATION EST.



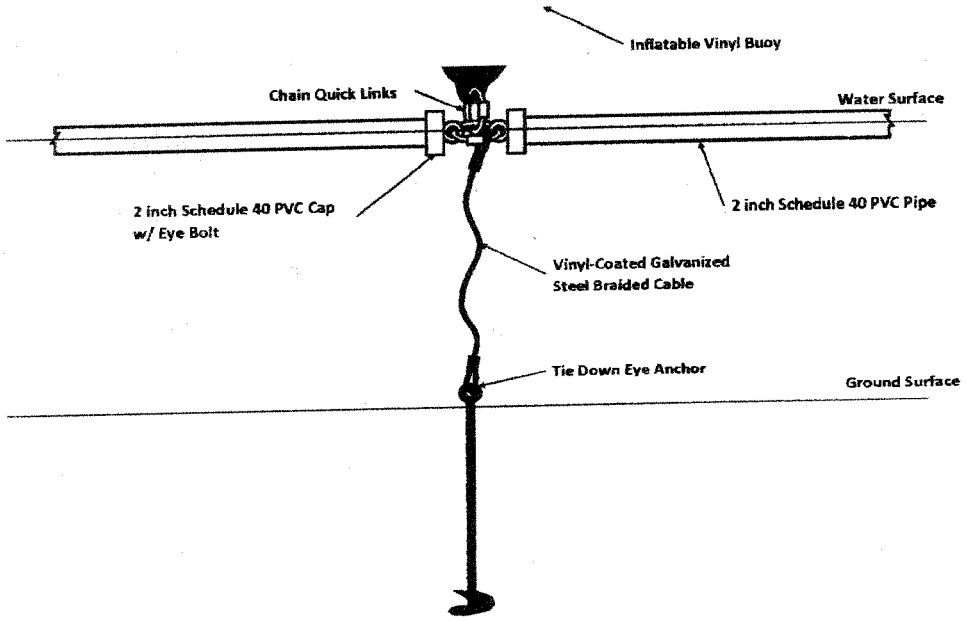


EXHIBIT 2
Plan view of the Boom Design for the Kings Bay Adaptive Management Phytoremediation Study

PARKER Island

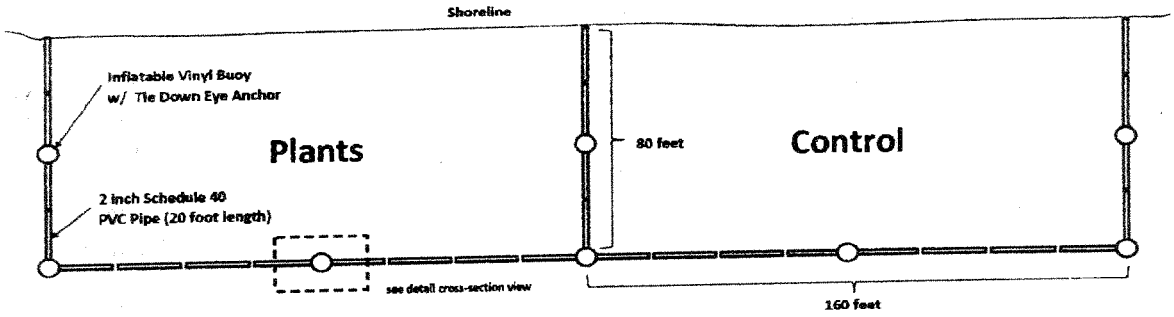


EXHIBIT 3
Plan view of the Plot Design for the Kings Bay Adaptive Management Phytoremediation Study

Teresa Calleson/R4/FWS/DOI

02/02/2012 04:18 PM

To "Davidson, James E SAJ" <James.E.Davidson2@usace.army.mil>

cc "Bob Knight" <bknight@floridaspringsinstitute.org>, Michael Lusk'" <Michael_Lusk@fws.gov, Shannon White, Heath Rauschenberger,

bcc

Subject Kings Bay Adaptive Management Phytoremediation Project - MANLAA concurrence

2011_StandardConditionsForIn-waterWork.pdf

Bo,

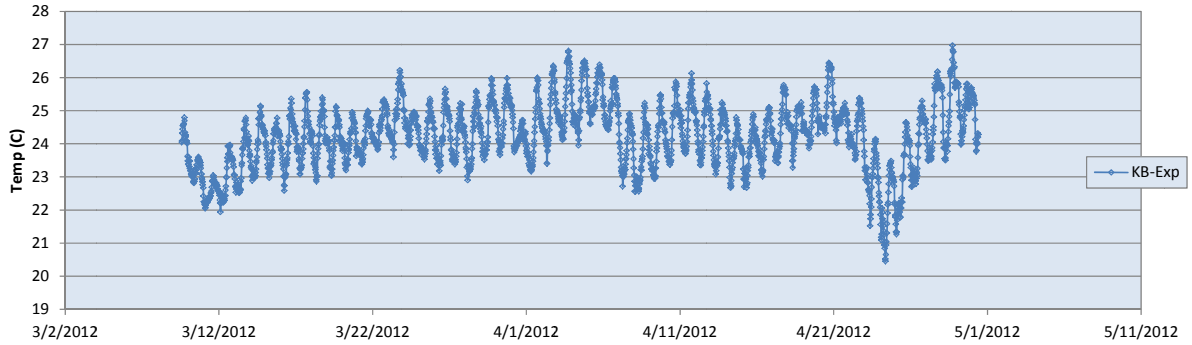
While the Service does not support the widespread reintroduction of water hyacinths into the Kings Bay system, the Service has no objections to this trial phytoremediation project using water hyacinths to potentially enhance water clarity and the overall aquatic plant community. The project is small in scope and consists of one treatment area and one control area on the east side of Parker Island. Each of the plots will be 80 feet wide by 200 feet long, and will provide no barriers to navigational traffic. The study area will be delineated using floating PVC booms, which will also function in confining the vegetation. The boom assembly will consist of multiple 20-foot lengths of PVC pipe anchored to the bottom using four-inch screw anchors. As designed, the assembly will not restrict manatee access. The project area will be further marked with fluorescent orange floats and signed as a study area. Monitoring will occur on a monthly basis for a three-year period. The water hyacinths will be removed at the conclusion of the study. During our review, USFWS-Jacksonville staff coordinated with Michael Lusk (USFWS-Crystal River) and also Ron Mezich and Kent Smith with FWC.

Based on the project scope, it is my opinion that the project may best be characterized as "may affect, not likely to adversely affect" the West Indian manatee, with incorporation of the Standard Manatee Construction Conditions for In-Water Work (2011; specifically, provisions a, b, d, and e, as appropriate). As such, the Service provides its concurrence with the MANLAA determination. If modifications are made to the project that may affect manatees or its habitat; if the applicant fails to comply with the permit conditions; if additional information involving potential effects to the manatee or other listed species not previously considered becomes available; or if take of manatees occurs during construction, consultation will be reinitiated. Please let me know if you have any questions or require anything further from the Service. Thanks!

Terri Calleson
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
7915 Baymeadows Way, Suite 200
Jacksonville, Florida 32256-7517
904-731-3286 (office)
850-922-4330 (main)
850-922-4338 (fax)
Email: Teresa_Calleson@fws.gov
http:/www.fws.gov/northflorida

Appendix B

Water Quality Data Sonde Summary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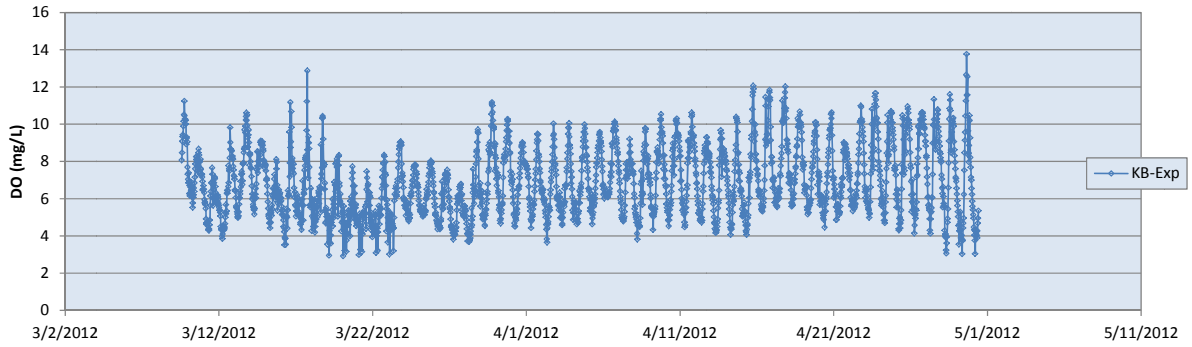
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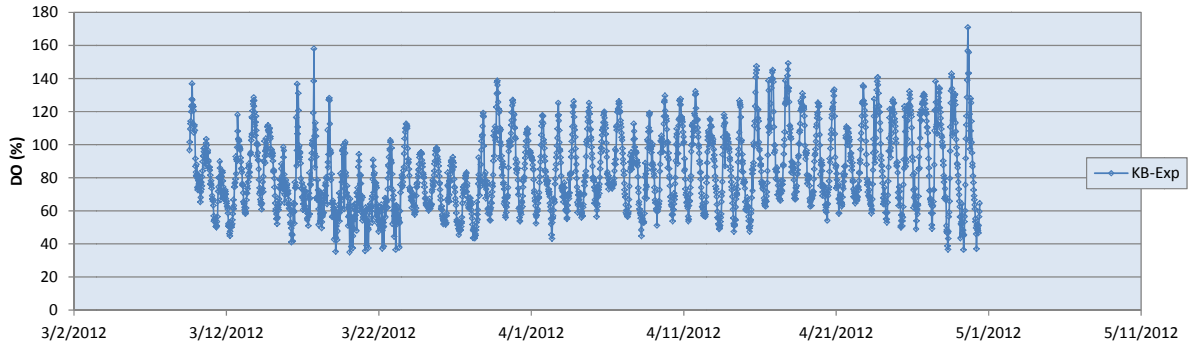
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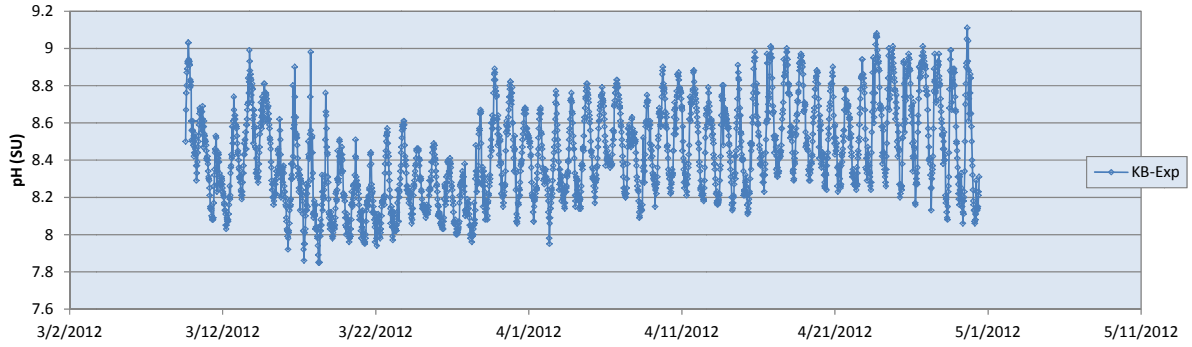
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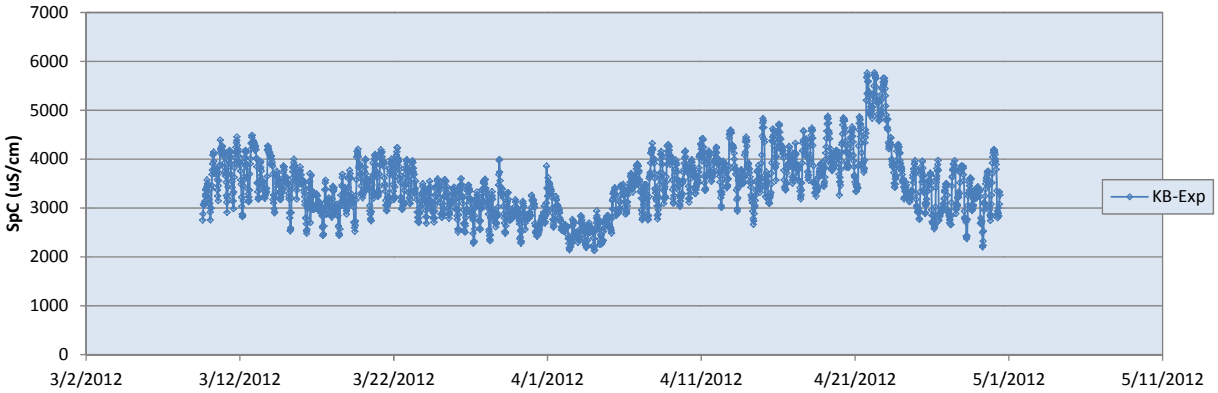
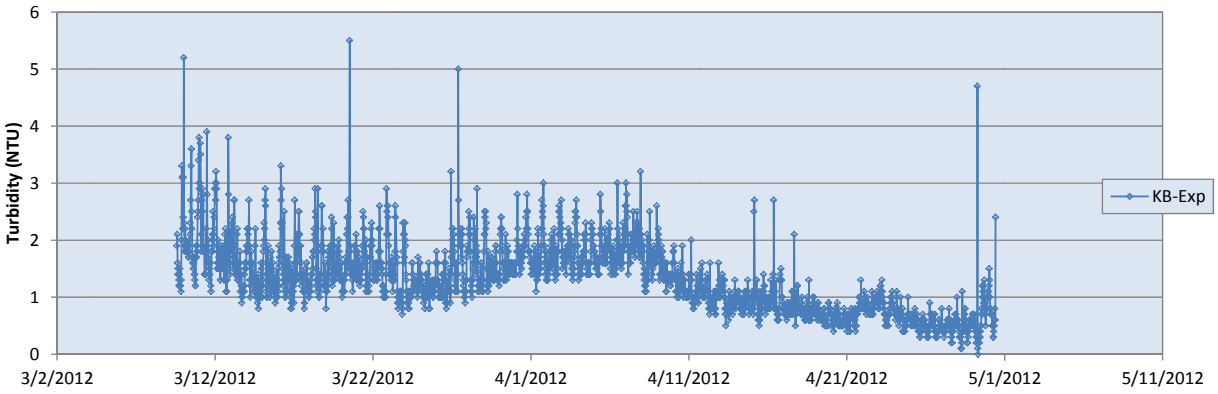
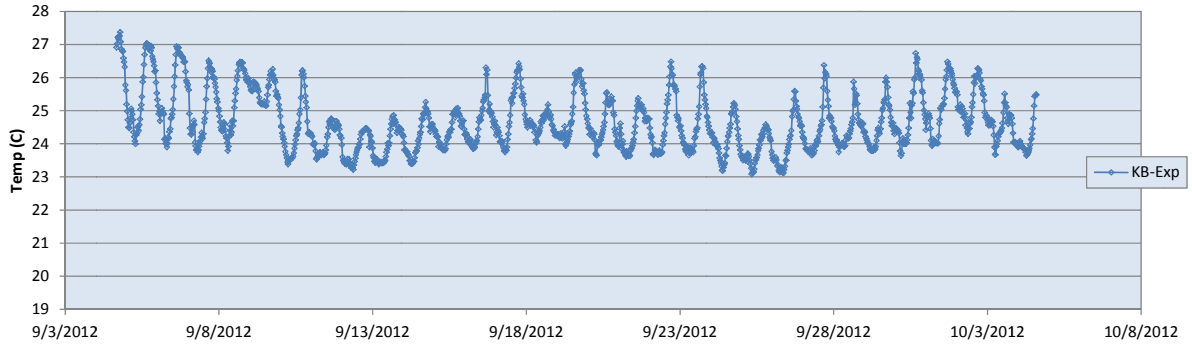
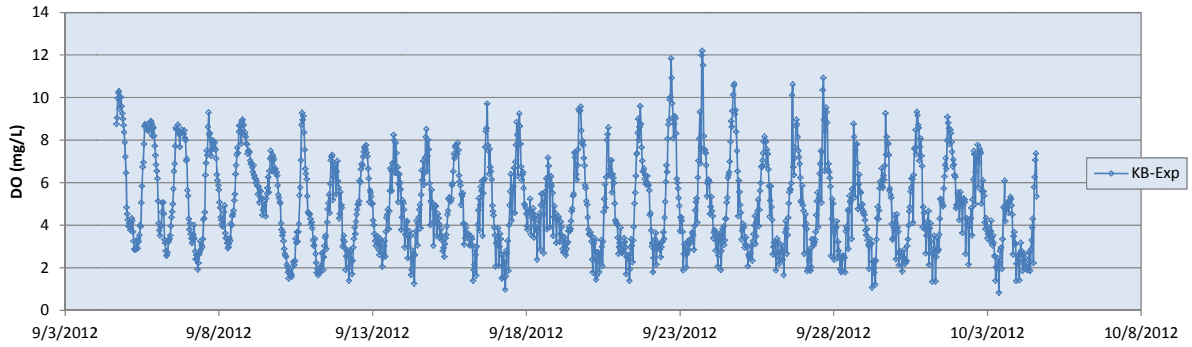
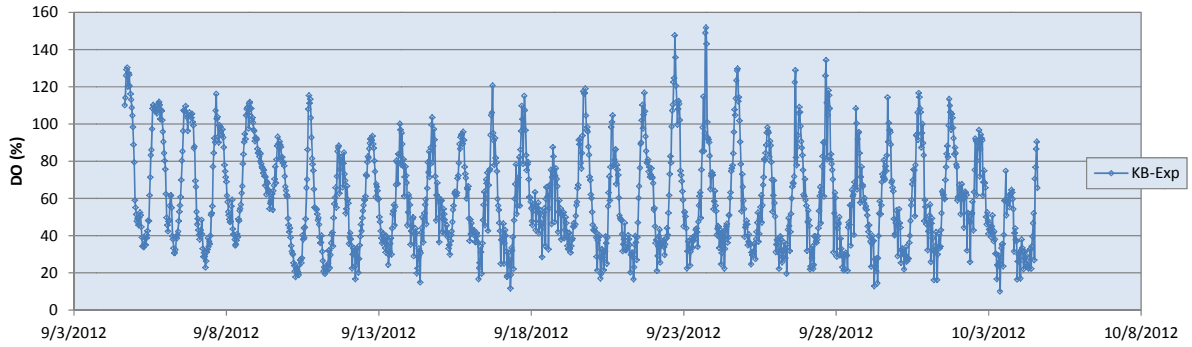
8.2
8
7.8
7.6
3/2/2012
3/12/2012
3/22/2012
4/1/2012
4/11/2012
4/21/2012
5/1/2012
5/11/2012
KB-Exp

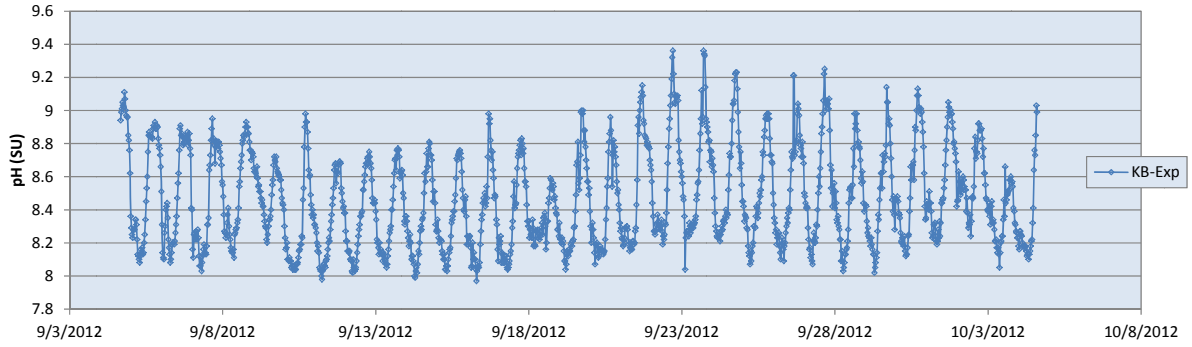

SpC (uS/cm)
7000
6000
5000
4000
3000
2000
1000
0
3/2/2012
3/12/2012
3/22/2012
4/1/2012
4/11/2012
4/21/2012
5/1/2012
5/11/2012
KB-Exp

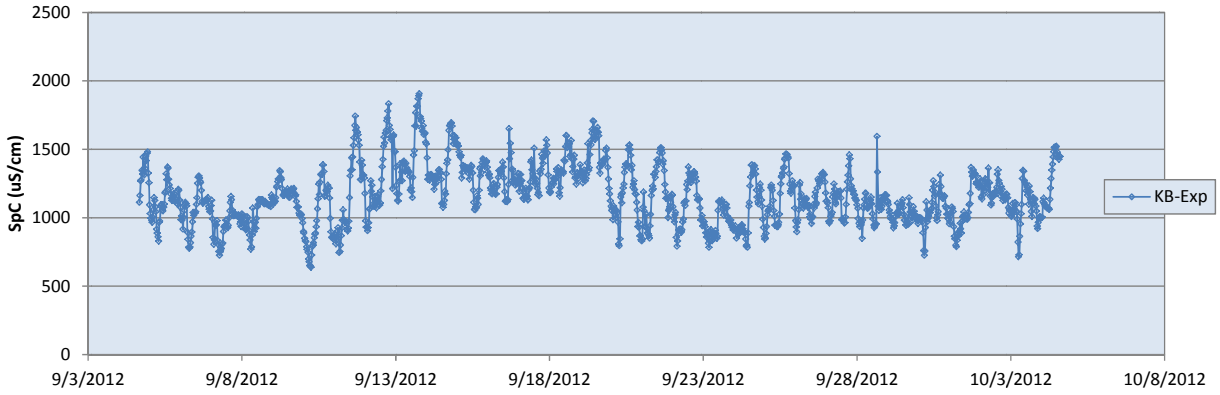

Turbidity (NTU)
6
5
4
3
2
1
0
3/2/2012
3/12/2012
3/22/2012
4/1/2012
4/11/2012
4/21/2012
5/1/2012
5/11/2012
KB-Exp

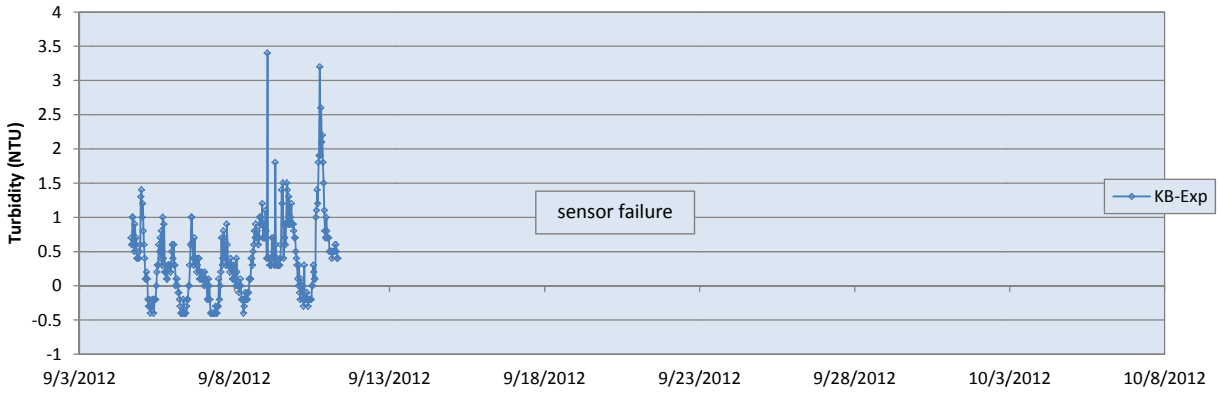

Temp (C)
28
27
26
25
24
23
22
21
20
19
9/3/2012
9/8/2012
9/13/2012
9/18/2012
9/23/2012
9/28/2012
10/3/2012
10/8/2012
KB-Exp

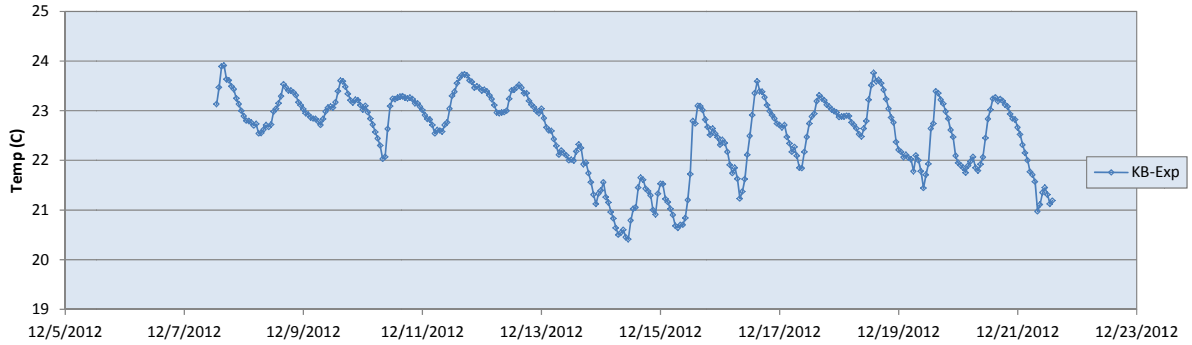

DO (mg/L)
14
12
10
8
6
4
2
0
9/3/2012
9/8/2012
9/13/2012
9/18/2012
9/23/2012
9/28/2012
10/3/2012
10/8/2012
KB-Exp

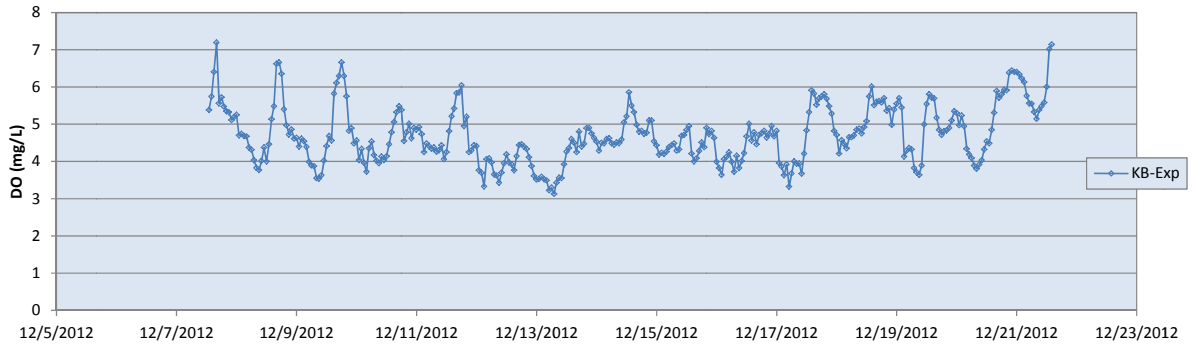

DO (%)
160
140
120
100
80
60
40
20
0
9/3/2012
9/8/2012
9/13/2012
9/18/2012
9/23/2012
9/28/2012
10/3/2012
10/8/2012
KB-Exp

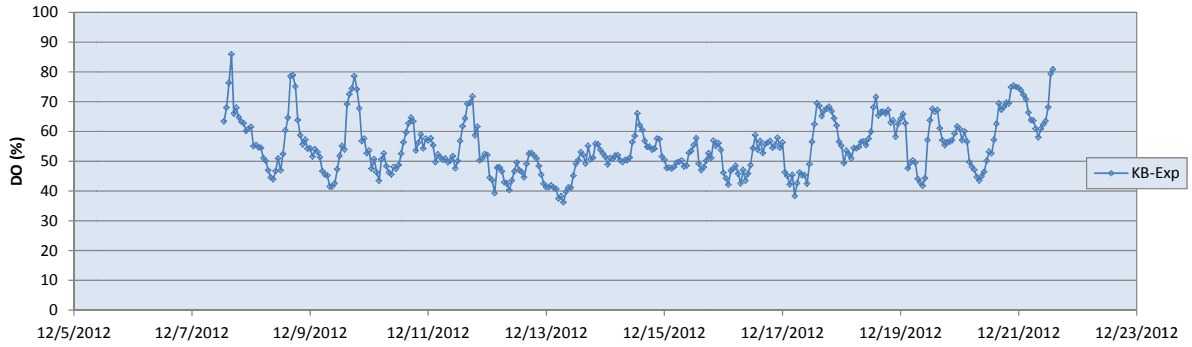

pH (SU)
9.6
9.4
9.2
9
8.8
8.6
8.4
8.2
8
7.8
9/3/2012
9/8/2012
9/13/2012
9/18/2012
9/23/2012
9/28/2012
10/3/2012
10/8/2012
KB-Exp

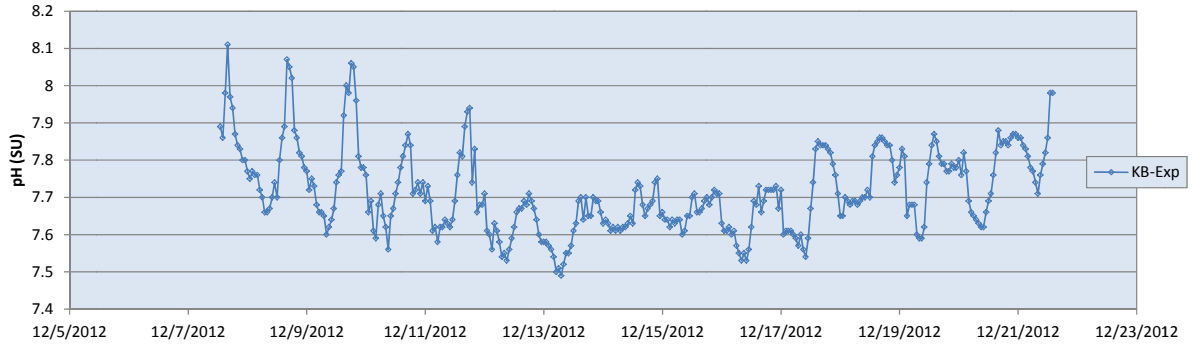

2500
2000
1500
1000
500
0
SpC (uS/cm)
9/3/2012
9/8/2012
9/13/2012
9/18/2012
9/23/2012
9/28/2012
10/3/2012
10/8/2012
KB-Exp

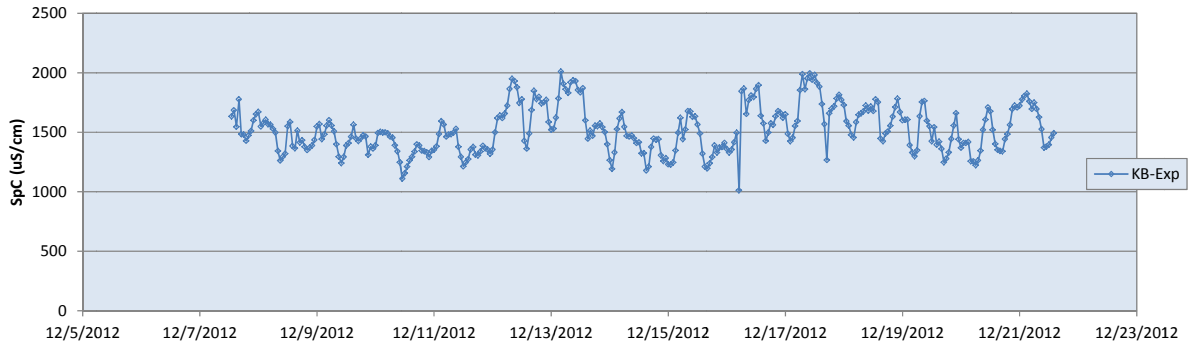

4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
Turbidity (NTU)
sensor failure
9/3/2012
9/8/2012
9/13/2012
9/18/2012
9/23/2012
9/28/2012
10/3/2012
10/8/2012
KB-Exp

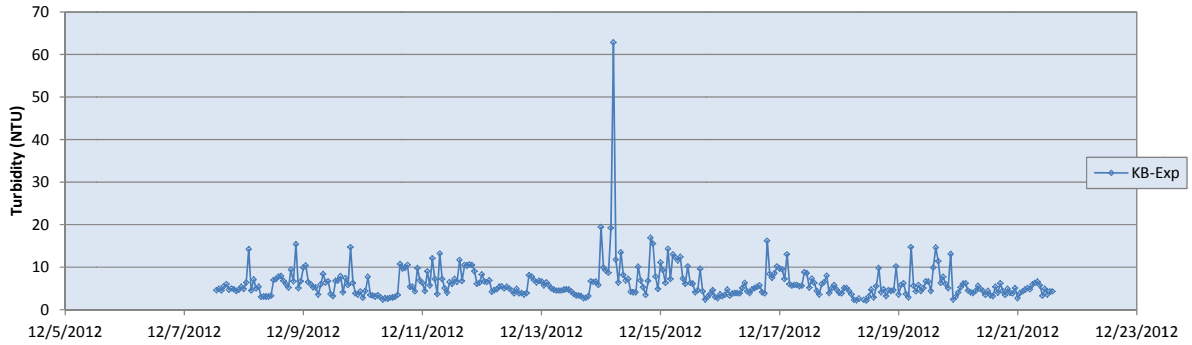

Temp (C)
25
24
23
22
21
20
19
12/5/2012
12/7/2012
12/9/2012
12/11/2012
12/13/2012
12/15/2012
12/17/2012
12/19/2012
12/21/2012
12/23/2012
KB-Exp

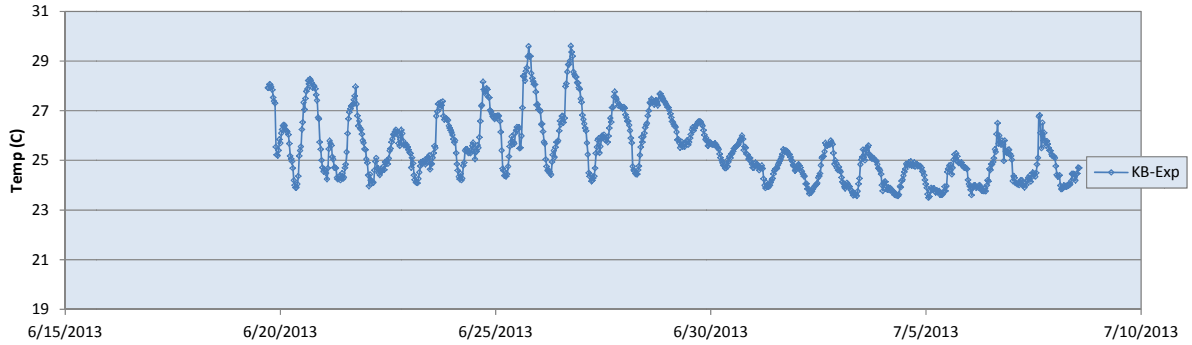

DO (mg/L)
8
7
6
5
4
3
2
1
0
12/5/2012
12/7/2012
12/9/2012
12/11/2012
12/13/2012
12/15/2012
12/17/2012
12/19/2012
12/21/2012
12/23/2012
KB-Exp

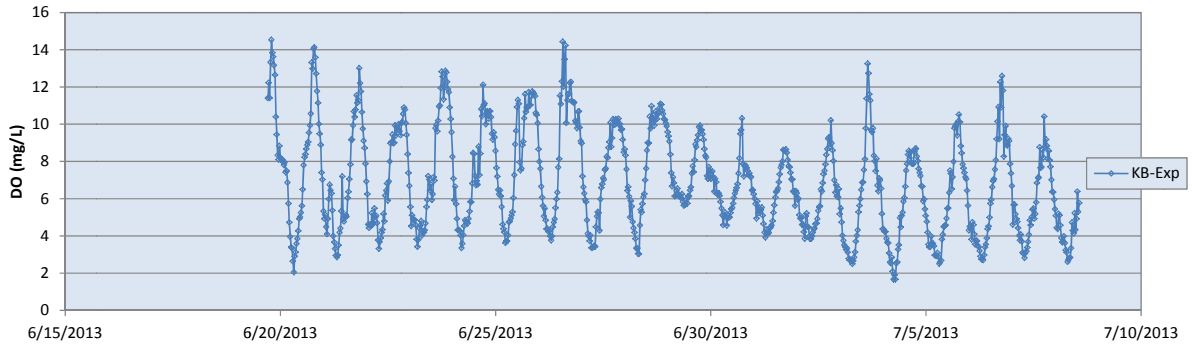

DO (%)
100
90
80
70
60
50
40
30
20
10
0
12/5/2012
12/7/2012
12/9/2012
12/11/2012
12/13/2012
12/15/2012
12/17/2012
12/19/2012
12/21/2012
12/23/2012
KB-Exp

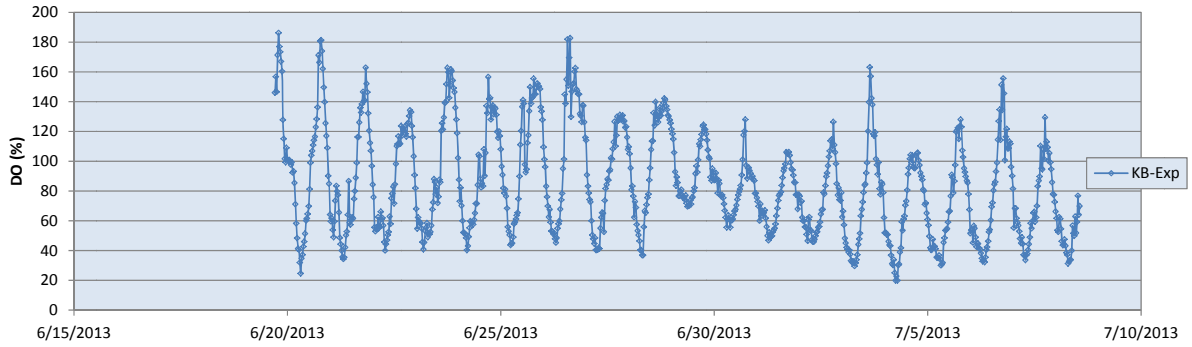

pH (SU)
8.2
8.1
8
7.9
7.8
7.7
7.6
7.5
7.4
12/5/2012
12/7/2012
12/9/2012
12/11/2012
12/13/2012
12/15/2012
12/17/2012
12/19/2012
12/21/2012
12/23/2012
KB-Exp

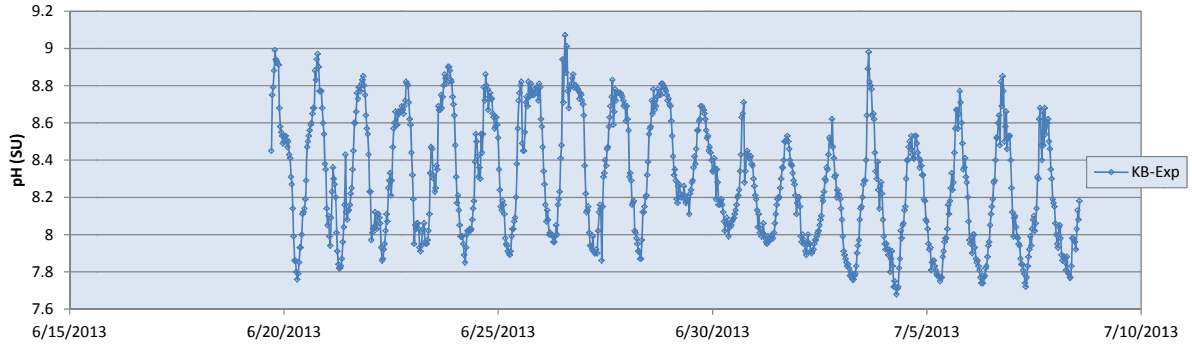

SpC (uS/cm)
2500
2000
1500
1000
500
0
12/5/2012
12/7/2012
12/9/2012
12/11/2012
12/13/2012
12/15/2012
12/17/2012
12/19/2012
12/21/2012
12/23/2012
KB-Exp

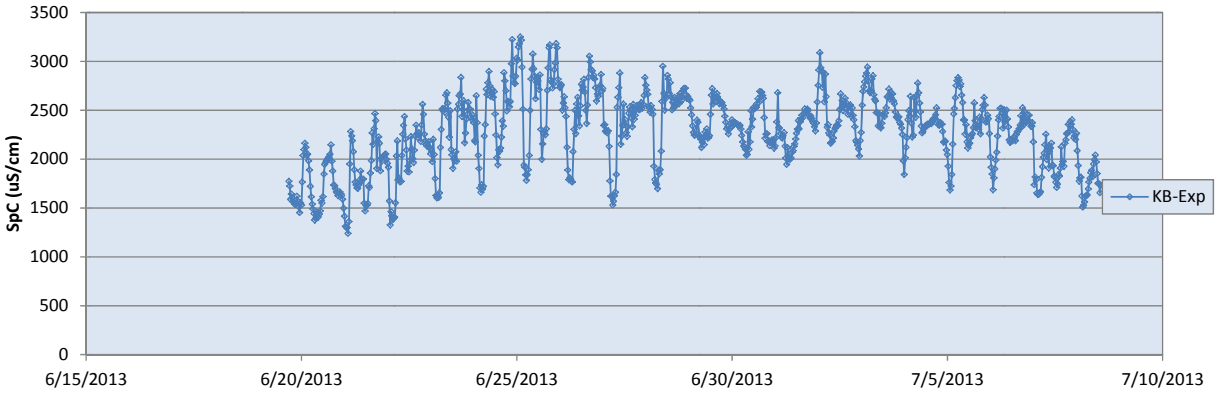

Turbidity (NTU)
70
60
50
40
30
20
10
0
12/5/2012
12/7/2012
12/9/2012
12/11/2012
12/13/2012
12/15/2012
12/17/2012
12/19/2012
12/21/2012
12/23/2012
KB-Exp

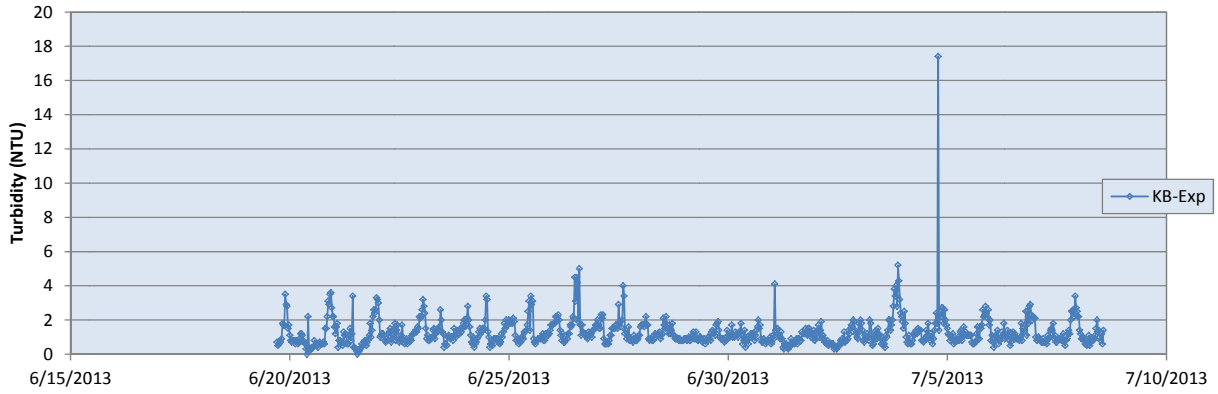

Temp (C)
31
29
27
25
23
21
19
6/15/2013
6/20/2013
6/25/2013
6/30/2013
7/5/2013
7/10/2013
KB-Exp

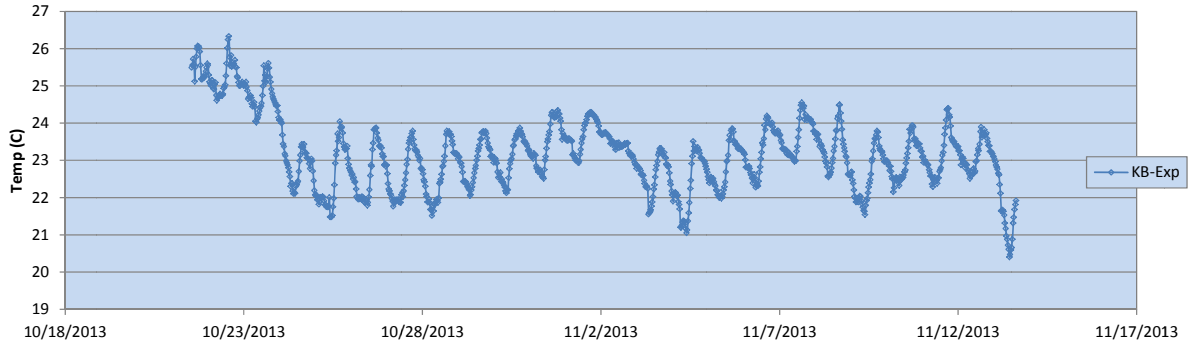

DO (mg/L)
16
14
12
10
8
6
4
2
0
6/15/2013
6/20/2013
6/25/2013
6/30/2013
7/5/2013
7/10/2013
KB-Exp

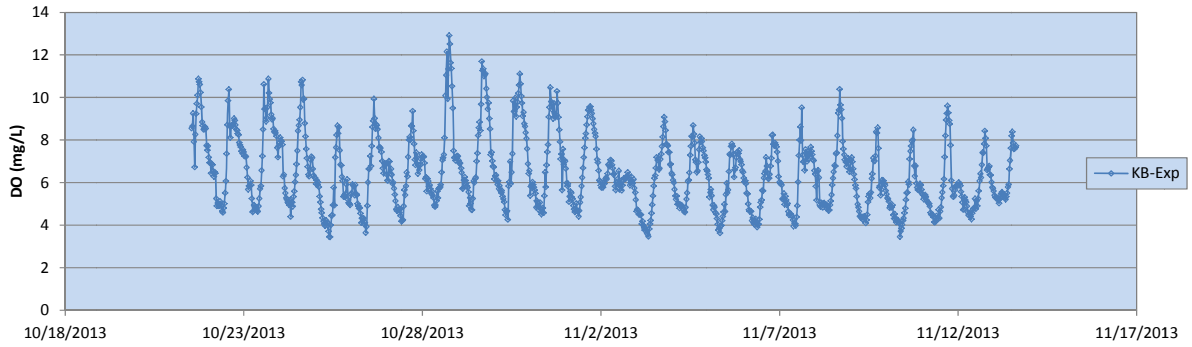

DO (%)
200
180
160
140
120
100
80
60
40
20
0
6/15/2013
6/20/2013
6/25/2013
6/30/2013
7/5/2013
7/10/2013
KB-Exp

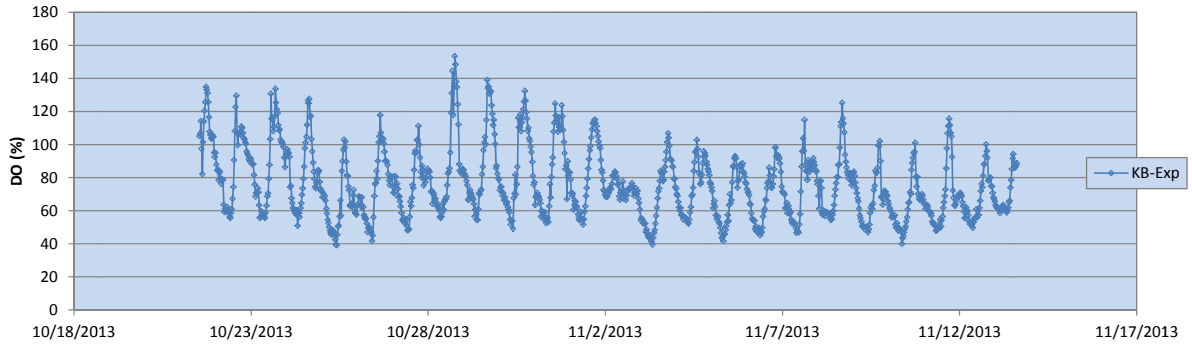

pH (SU)
9.2
9
8.8
8.6
8.4
8.2
8
7.8
7.6
6/15/2013
6/20/2013
6/25/2013
6/30/2013
7/5/2013
7/10/2013
KB-Exp

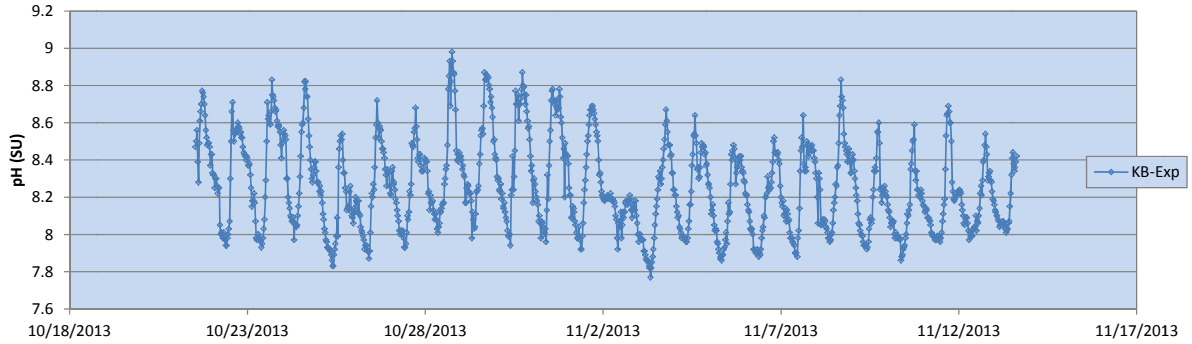

SpC (uS/cm)
3500
3000
2500
2000
1500
1000
500
0
6/15/2013
6/20/2013
6/25/2013
6/30/2013
7/5/2013
7/10/2013
KB-Exp

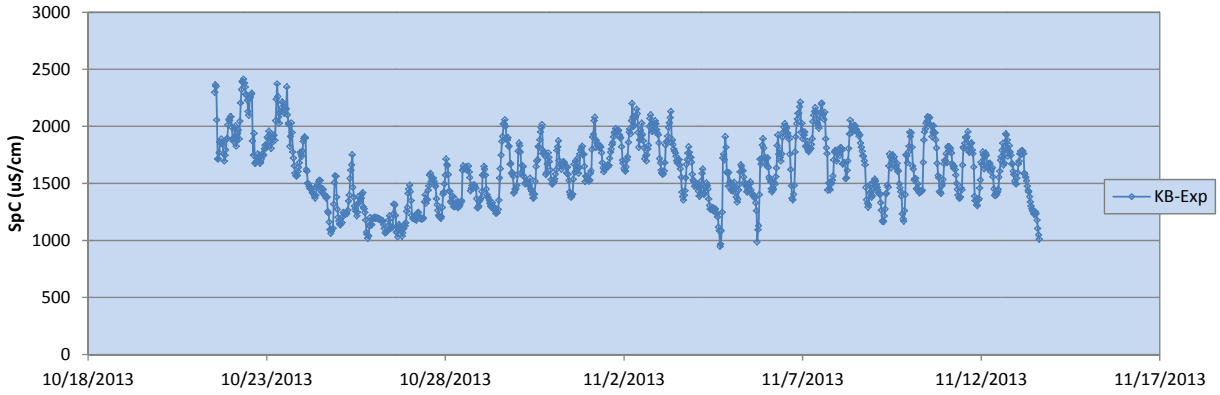

Turbidity (NTU)
20
18
16
14
12
10
8
6
4
2
0
6/15/2013
6/20/2013
6/25/2013
6/30/2013
7/5/2013
7/10/2013
KB-Exp

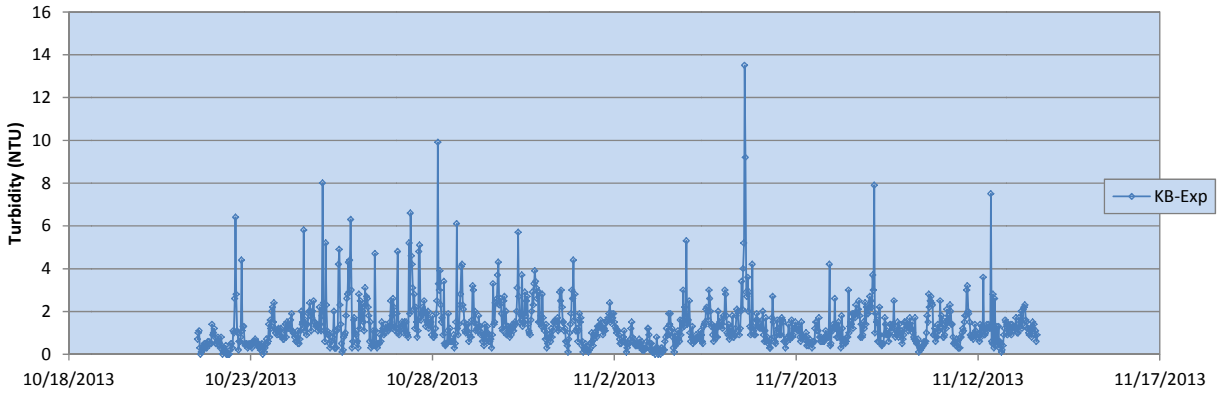

Temp (C)
27
26
25
24
23
22
21
20
19
10/18/2013
10/23/2013
10/28/2013
11/2/2013
11/7/2013
11/12/2013
11/17/2013
KB-Exp

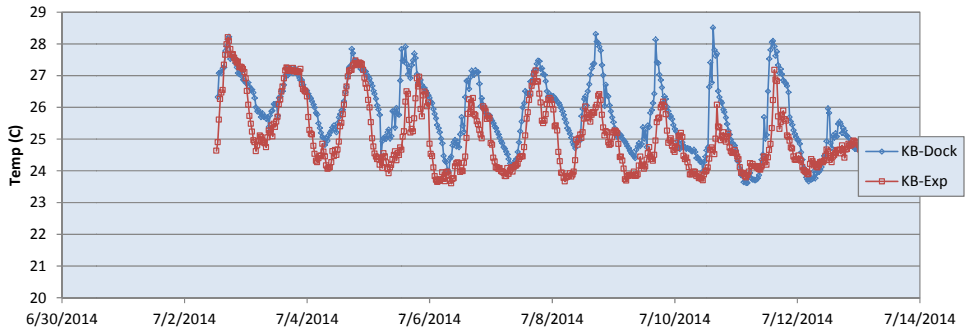

DO (mg/L)
14
12
10
8
6
4
2
0
10/18/2013
10/23/2013
10/28/2013
11/2/2013
11/7/2013
11/12/2013
11/17/2013
KB-Exp


DO (%)
180
160
140
120
100
80
60
40
20
0
10/18/2013
10/23/2013
10/28/2013
11/2/2013
11/7/2013
11/12/2013
11/17/2013
KB-Exp

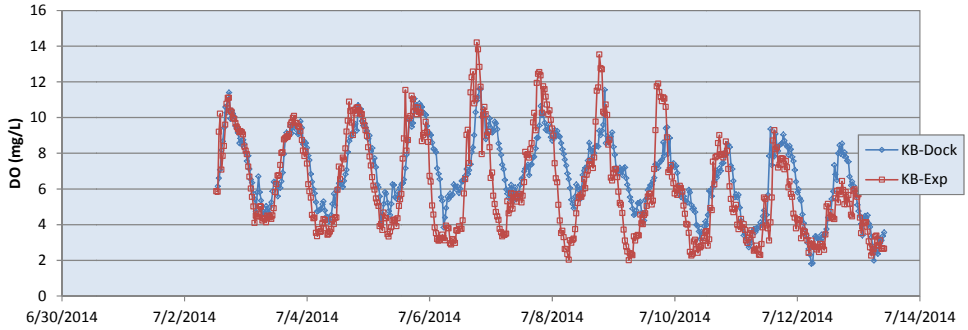

pH (SU)
9.2
9
8.8
8.6
8.4
8.2
8
7.8
7.6
10/18/2013
10/23/2013
10/28/2013
11/2/2013
11/7/2013
11/12/2013
11/17/2013
KB-Exp


SpC (uS/cm)
3000
2500
2000
1500
1000
500
0
10/18/2013
10/23/2013
10/28/2013
11/2/2013
11/7/2013
11/12/2013
11/17/2013
KB-Exp

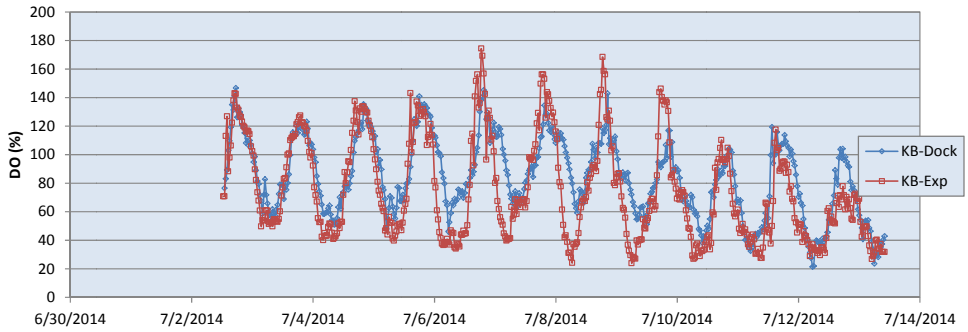

Turbidity (NTU)
16
14
12
10
8
6
4
2
0
10/18/2013
10/23/2013
10/28/2013
11/2/2013
11/7/2013
11/12/2013
11/17/2013
KB-Exp



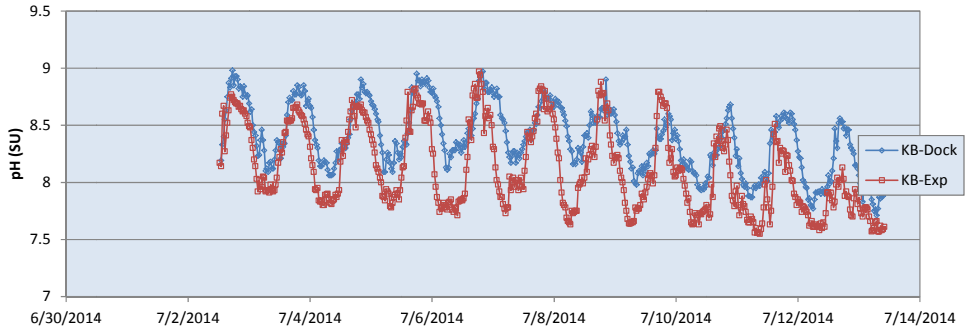
Stats	KB-Dock	KB-Exp
Average	25.76	25.07
Median	25.72	24.75
Min	23.61	23.60
Max	28.51	28.21
Std Dev	1.16	1.07
N	523	524



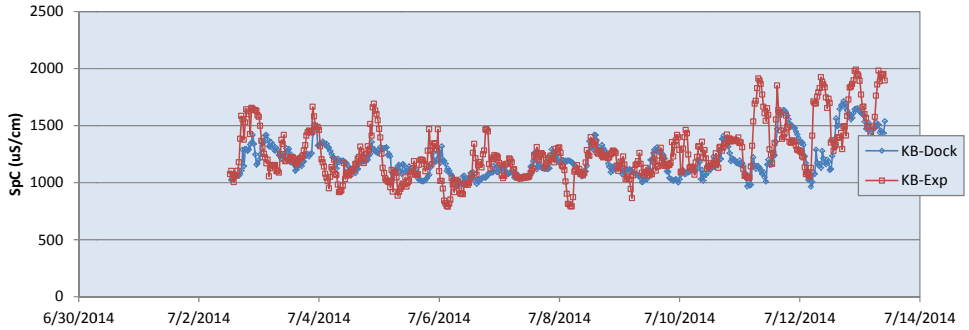
Stats	KB-Dock	KB-Exp
Average	6.81	6.18
Median	6.73	5.58
Min	1.81	2.01
Max	11.6	14.2
Std Dev	2.10	2.79
N	523	524



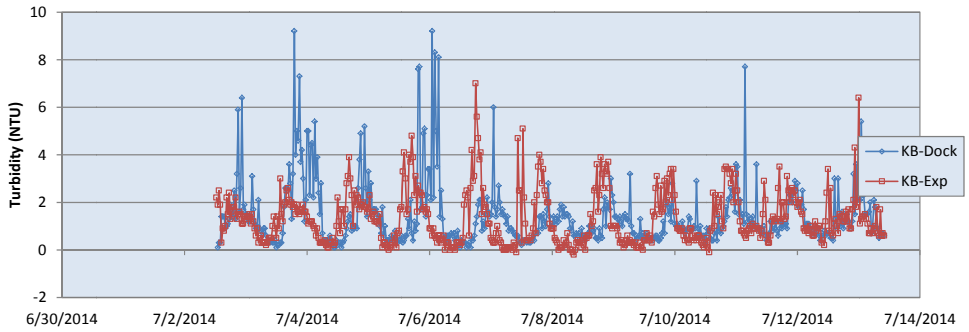
Stats	KB-Dock	KB-Exp
Average	84.25	75.75
Median	83.10	67.40
Min	21.40	23.90
Max	146.7	174.3
Std Dev	27.17	35.40
N	523	524



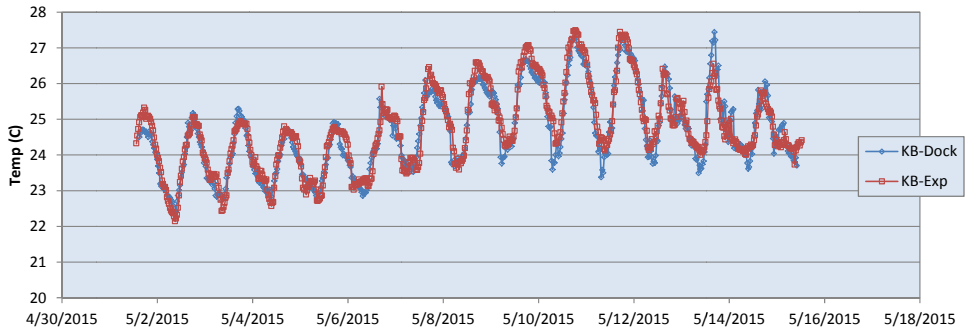
Stats	KB-Dock	KB-Exp
Average	8.38	8.12
Median	8.37	8.04
Min	7.71	7.55
Max	8.98	8.97
Std Dev	0.29	0.37
N	523	524



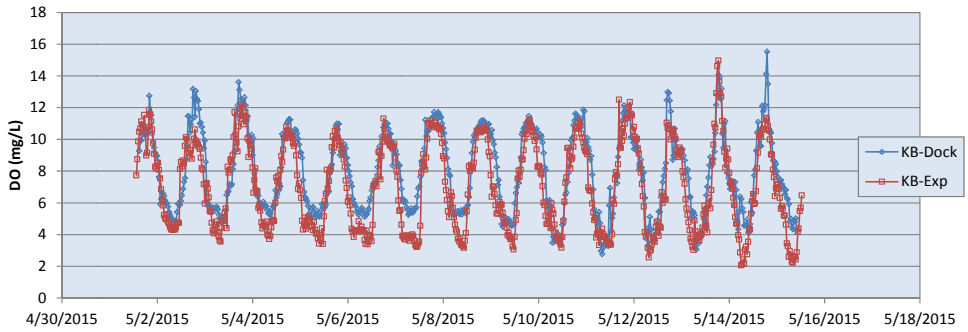
Stats	KB-Dock	KB-Exp
Average	1,207	1,263
Median	1,167	1,212
Min	964	787
Max	1,714	1,990
Std Dev	160	243
N	523	524



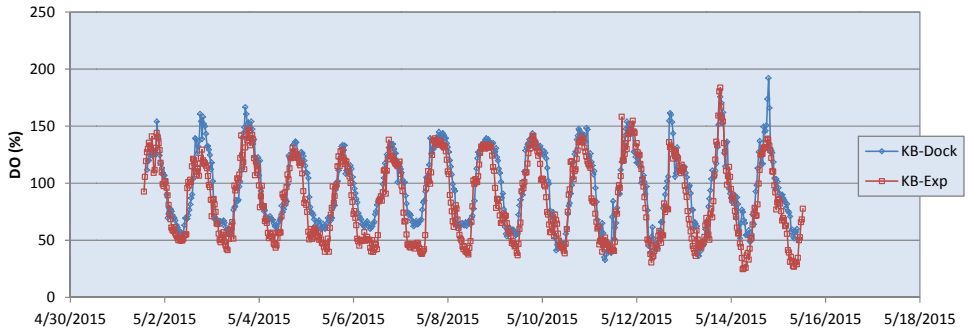
Stats	KB-Dock	KB-Exp
Average	1.42	1.33
Median	1.00	1.00
Min	0.10	-0.20
Max	9.2	7.0
Std Dev	1.34	1.10
N	523	524



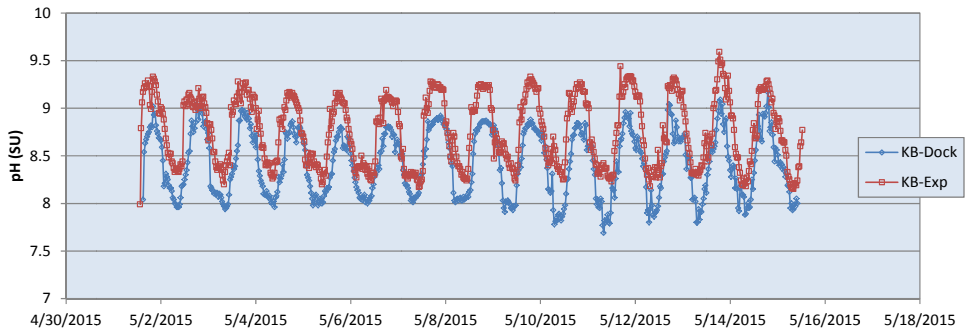
Stats	KB-Dock	KB-Exp
Average	24.65	24.73
Median	24.50	24.60
Min	22.38	22.14
Max	27.44	27.49
Std Dev	1.14	1.15
N	663	671



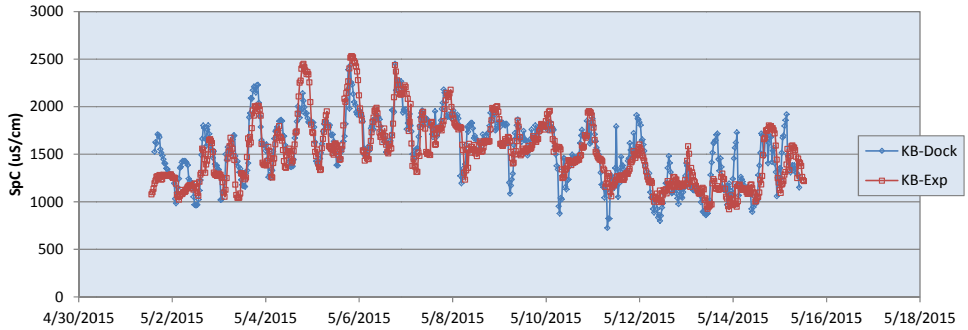
Stats	KB-Dock	KB-Exp
Average	7.93	7.08
Median	7.70	6.91
Min	2.77	2.06
Max	15.5	15.0
Std Dev	2.61	2.77
N	663	671



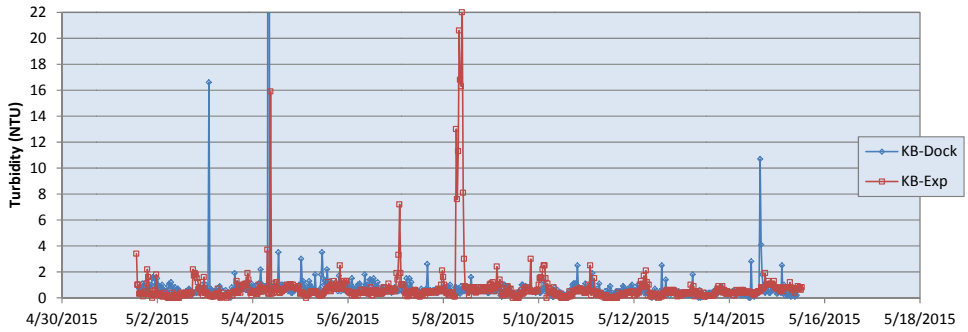
Stats	KB-Dock	KB-Exp
Average	96.20	86.13
Median	93.70	84.00
Min	32.80	24.60
Max	192.0	183.6
Std Dev	32.94	34.75
N	663	671



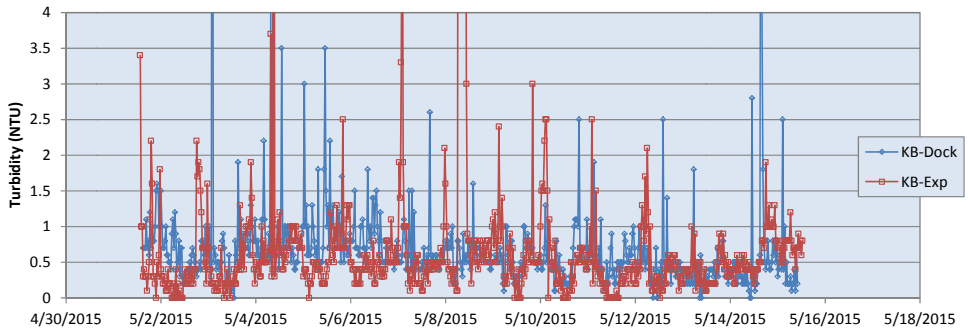
Stats	KB-Dock	KB-Exp
Average	8.42	8.76
Median	8.43	8.77
Min	7.69	7.99
Max	9.17	9.59
Std Dev	0.35	0.37
N	663	671



Stats	KB-Dock	KB-Exp
Average	1,534	1,505
Median	1,554	1,489
Min	724	919
Max	2,451	2,528
Std Dev	325	337
N	663	671



Stats	KB-Dock	KB-Exp
Average	0.86	0.75
Median	0.50	0.40
Min	0.00	0.00
Max	124.4	22.0
Std Dev	4.88	1.79
N	663	671



Stats	KB-Dock	KB-Exp
Average	0.86	0.75
Median	0.50	0.40
Min	0.00	0.00
Max	124.4	22.0
Std Dev	4.88	1.79
N	663	671

Appendix C

Field Parameter Profile Data

	DO (%)		DO (mg/L)		pH (SU)		SpCond (umhos/cm)		Temp (C)		Turbidity (NTU)	
Station	Surf	Bot	Surf	Bot	Surf	Bot	Surf	Bot	Surf	Bot	Surf	Bot
KB-1												
20120305	68.9		6.07		8.25		1,866		21.3		3.2	
20120323	61.7	64.2	5.12	5.36	8.07	8.11	3,397	3,541	24.0	24.1	0.6	0.9
20120430	75.3	80.1	6.20	6.63	7.05	7.42	2,987	3,207	24.5	24.5	4.8	4.8
20130708	88.3	96.0	7.23	7.93	8.17	8.42	1,827	2,162	25.1	24.7		
20131021	70.7	55.1	5.82	4.53	7.87	7.83	2,281	2,571	24.9	25.0	0.4	2.6
20131028	82.1	79.3	7.09	6.89	8.08	8.11	1,343	1,625	22.3	22.3	0.5	0.6
20140702	71.3	67.8	5.76	5.65	8.06	8.11	1,082	963	26.0	24.4	0.6	0.4
20140717	72.7	90.7	5.93	7.50	8.26	8.32	1,865	2,239	25.4	25.0	0.1	2.7
20150501	120.5	110.0	10.10	9.31	8.90	8.69	1,200	1,196	23.7	23.5	0.5	0.6
20150515	89.7	80.0	7.38	6.68	7.78	7.64	1,291	1,194	25.0	24.3	0.2	0.2
20150708	72.8		5.90		8.12		1,440		25.3		-0.1	
KB-2												
20120305	64.8		5.67		8.14		1,824		21.6		0.7	
20120323	71.9	69.1	5.94	5.73	8.11	8.10	3,512	3,547	24.2	24.2	1.2	2.7
20120430	76.0	91.9	6.29	7.59	7.51	7.58	3,389	3,740	24.5	24.5	5.0	9.8
20130708	108.2	78.5	8.84	6.53	8.26	8.16	1,950	2,130	25.3	24.1		
20131021	82.7	84.7	6.79	6.96	8.17	8.22	2,221	2,431	25.1	24.9	0.6	2.2
20131028	82.0	83.7	7.09	7.27	8.42	8.20	1,387	1,855	22.3	22.3	0.1	3.0
20140702	69.7	73.4	5.69	6.15	8.09	8.14	1,043	973	25.7	24.1	0.5	1.1
20140717	73.8	84.8	5.98	7.01	8.27	8.24	1,861	2,255	25.5	24.9	0.2	1.2
20150501	90.3		7.66		8.43		1,155		23.5		0.3	
20150515	74.1	72.2	6.01	6.05	7.98	7.89	1,195	1,175	25.4	24.1	0.0	0.4
KB-3												
20120305	62.1	67.4	5.32	5.93	8.04	8.08	1,681	1,646	21.9	21.5	0.6	2.5
20120323	65.9	68.3	5.47	5.66	8.05	8.07	3,301	3,455	24.1	24.2	0.2	0.8
20120430	82.3	101.7	6.72	8.37	7.34	7.39	3,221	4,236	25.1	24.8	4.6	5.4
20120530	55.6	44.8	4.55	3.64	7.93	7.78	4,236	5,839	24.9	25.0	0.5	2.6
20121207	50.7	41.5	4.41	3.57	7.88	7.81	1,804	2,205	22.0	22.2		
20121221	90.2	96.4	8.06	8.61	8.43	8.50	1,477	1,692	20.8	20.6	3.0	17.1
20130708	79.4	69.8	6.51	5.85	8.14	8.13	1,913	2,060	24.8	23.8		
20131021	73.4	85.1	6.06	7.00	8.14	8.26	2,018	2,550	24.7	25.0	0.3	7.2
20131028	88.3	91.9	7.62	7.96	8.27	8.18	1,525	1,926	22.5	22.3	0.5	3.3
20140702	71.4	77.1	5.82	6.43	8.10	8.16	1,124	1,324	25.6	24.2	0.5	0.5
20140717	74.2	70.4	6.07	5.83	8.26	8.21	2,047	2,251	25.0	24.5	0.2	0.7
20150501	80.2		6.66		8.31		1,066		23.5		0.0	
20150515	59.3	72.0	4.93	6.05	7.82	7.99	1,110	1,175	24.5	24.1	0.0	0.4
20150708	88.2	82.5	7.17	6.78	8.03	8.03	2,356	2,440	25.3	25.0	1.5	3.7

	DO (%)		DO (mg/L)		pH (SU)		SpCond (umhos/cm)		Temp (C)		Turbidity (NTU)	
Station	Surf	Bot	Surf	Bot	Surf	Bot	Surf	Bot	Surf	Bot	Surf	Bot
KB-4												
20120305	59.9	66.3	5.20	5.84	8.01	8.11	1,608	1,604	22.0	21.6	1.6	3.0
20120323	67.8	74.7	5.61	6.17	8.01	8.10	3,170	3,654	24.2	24.4	0.0	1.6
20120430	73.5	88.6	6.05	7.31	7.29	7.49	3,395	4,372	24.6	24.7	4.5	8.0
20120530	60.9	39.3	4.96	3.20	7.81	7.59	4,626	6,710	25.0	24.7	0.2	2.2
20130708	73.3	65.4	6.10	5.50	8.08	8.12	1,782	1,941	24.3	23.9		
20131021	67.5	108.3	5.57	8.89	8.05	8.44	2,035	2,607	24.8	25.0	0.0	2.9
20131028	78.8	101.9	6.77	8.81	8.10	8.31	1,612	1,956	22.7	22.3	0.0	4.4
20140702	72.0	73.7	5.80	6.20	8.14	8.09	1,153	1,387	26.2	24.2	0.5	0.4
20140717	76.9	83.9	6.25	6.97	8.32	8.21	2,076	2,397	25.3	24.6	0.2	2.1
20150501	72.1	81.8	5.99	6.95	8.12	8.27	1,055	1,229	23.4	23.3	0.1	0.7
20150515	63.7	90.3	5.32	7.60	7.93	8.27	1,135	1,284	24.2	24.1	0.0	0.6
KB-5												
20120305	59.6	58.3	5.08	5.00	8.06	7.97	2,030	2,537	22.0	22.5	2.8	5.1
20120323	66.9	69.8	5.55	5.80	8.03	7.99	3,167	3,460	24.2	24.2	0.9	3.8
20120430	74.6	96.5	6.14	7.88	7.64	7.70	3,460	4,732	24.8	25.0	4.5	22.0
20120530	55.7	59.8	4.45	4.82	7.73	7.49	4,525	7,225	25.3	25.3	0.0	1.1
20130708	73.2	62.1	6.00	5.23	8.10	8.08	1,798	1,798	24.8	23.8		
20131021	71.3	83.9	5.90	6.90	8.12	8.21	2,126	2,499	24.8	24.8	0.1	4.3
20131028	80.1	104.3	6.88	9.01	8.39	8.50	1,597	2,066	22.7	22.4	0.0	3.8
20140702	58.7	63.4	4.82	5.31	7.99	8.06	1,052	1,093	24.9	23.9	0.0	0.0
20140717	76.8	81.5	6.28	6.80	8.32	8.25	2,070	2,316	25.3	24.3	0.1	1.5
20150501	72.5	72.0	6.06	6.11	8.17	8.19	1,058	1,123	23.4	23.3	0.2	0.7
20150515	65.3	88.0	5.46	7.30	7.99	8.24	1,197	1,637	24.3	24.4	0.1	0.2
KB-6												
20120305	63.3	76.5	5.43	6.57	8.00	8.11	1,900	3,656	22.5	22.5	0.8	22.0
20120323	72.2	70.8	5.98	5.88	7.97	7.94	2,937	3,269	24.1	24.3	1.1	1.3
20120430	84.2	105.7	6.86	8.61	7.55	7.57	3,761	6,175	25.2	24.6	4.7	5.1
20130708	68.1	103.0	5.58	8.43	8.11	8.41	1,885	2,940	25.1	25.1		
20131021	64.9	77.0	5.41	6.39	8.10	8.18	1,744	5,085	24.2	24.5	0.3	2.5
20131028	91.1	118.7	7.79	10.15	8.58	8.76	1,752	2,408	22.9	22.6	0.6	0.7
20140702	77.5	74.6	6.24	6.31	8.17	8.24	1,138	971	26.2	23.8	0.3	0.8
20140717	75.5	62.2	6.19	5.23	8.25	8.00	1,977	1,799	25.4	23.9	0.0	0.1
20150501	77.5	75.7	6.51	6.42	8.16	8.23	1,001	1,181	23.3	23.4	0.4	0.5
20150515	75.4	120.9	6.22	9.86	8.13	8.59	1,350	2,284	24.8	25.3	0.1	0.5
20150708	63.4	64.7	5.17	5.37	7.34	7.39	1,926	2,289	25.2	24.4	0.0	0.5

Appendix D

PAR Attenuation Estimates

KBAM Phytoremediation Demonstration Project

Site	Stn	Date	Time	Rep	Depth (m) z	corr Air (Io)	raw Air (Io)	Water (Iz)	ln(Iz)	ln(Io/Iz)	k (m-1)	k (diffuse attenuation coefficient = slope, m-1) k (m-1)	Percent Transmittance (1m)	Birgean Percentile Absorption (1m)	Flag
KB	KB1	3/5/2012	10:27	1	Air	1,454.0	1,436.0	1,454.0				0.365	69.42	30.58	
					0.03	1,437.8	1,420.0	1,072.0	6.98						
					0.30	1,460.1	1,442.0	975.7	6.88	0.403	1.322				
					0.61	1,468.2	1,450.0	877.8	6.78	0.514	0.844				
KB	KB1	3/5/2012	10:27	2	Air	1,431.0	1,431.0	1,431.0				0.612	54.21	45.79	
					0.03	1,443.0	1,443.0	1,159.0	7.06						
					0.30	1,445.0	1,445.0	1,012.0	6.92	0.356	1.169				
					0.61	1,446.0	1,446.0	840.3	6.73	0.543	0.890				
KB	KB2	3/5/2012	10:34	1	Air	1,151.0	1,521.0	1,151.0				0.611	54.28	45.72	
					0.03	1,154.0	1,525.0	1,163.0	7.06						
					0.30	1,156.3	1,528.0	918.1	6.82	0.231	0.757				
					0.61	1,155.5	1,527.0	761.6	6.64	0.417	0.684				
KB	KB2	3/5/2012	10:34	2	Air	1,428.0	1,523.0	1,428.0				0.347	70.69	29.31	
					0.03	1,425.2	1,520.0	971.2	6.88						
					0.30	1,428.0	1,523.0	834.9	6.73	0.537	1.761				
					0.61	1,431.8	1,527.0	753.1	6.62	0.642	1.054				
KB	KB3	3/5/2012	10:48	1	Air	1,216.0	1,606.0	1,216.0				0.728	48.29	51.71	
					0.03	1,228.1	1,622.0	1,107.0	7.01						
					0.30	1,220.5	1,612.0	1,039.0	6.95	0.161	0.528				
					0.61	1,199.3	1,584.0	1,027.0	6.93	0.155	0.254				
					0.91	1,199.3	1,584.0	777.9	6.66	0.433	0.473				
					1.22	1,181.9	1,561.0	526.8	6.27	0.808	0.663				
KB	KB3	3/5/2012	10:48	2	Air	1,469.0	1,569.0	1,469.0				0.305	73.72	26.28	X
					0.03	1,460.6	1,560.0	1,024.0	6.93						
					0.30	1,460.6	1,560.0	920.2	6.82	0.462	1.516				
					0.61	1,457.8	1,557.0	336.8	5.82	1.465	2.403				
					0.91	1,451.2	1,550.0	722.4	6.58	0.698	0.763				
					1.22	1,457.8	1,557.0	521.7	6.26	1.028	0.843				
KB	KB1	3/23/2012	10:18	1	Air	935.8	1,085.0	935.8				1.335	26.33	73.67	
					0.03	937.5	1,087.0	954.6	6.86						
					0.15	934.9	1,084.0	793.6	6.68	0.164	1.075				
					0.30	934.9	1,084.0	550.5	6.31	0.530	1.738				
					0.61	932.4	1,081.0	416.2	6.03	0.807	1.323				
KB	KB1	3/23/2012	10:18	2	Air	1,239.0	1,073.0	1,239.0				1.133	32.20	67.80	
					0.03	1,241.3	1,075.0	897.8	6.80						
					0.15	1,245.9	1,079.0	717.8	6.58	0.551	3.618				
					0.30	1,247.1	1,080.0	660.6	6.49	0.635	2.085				
					0.61	1,248.2	1,081.0	436.0	6.08	1.052	1.725				
KB	KB2	3/23/2012	10:33	1	Air	959.5	1,163.0	959.5				1.088	33.70	66.30	
					0.03	951.2	1,153.0	939.2	6.85						
					0.15	957.0	1,160.0	780.3	6.66	0.204	1.340				
					0.30	955.4	1,158.0	673.4	6.51	0.350	1.148				
					0.61	952.1	1,154.0	474.0	6.16	0.697	1.144				
KB	KB2	3/23/2012	10:33	2	Air	1,362.0	1,134.0	1,362.0				1.227	29.31	70.69	
					0.03	1,365.6	1,137.0	974.9	6.88						
					0.15	1,370.4	1,141.0	792.8	6.68	0.547	3.591				
					0.30	1,378.8	1,148.0	690.2	6.54	0.692	2.270				
					0.61	1,383.6	1,152.0	460.6	6.13	1.100	1.804				
KB	KB3	3/23/2012	10:47	1	Air	1,177.0	1,200.0	1,177.0				1.048	35.07	64.93	
					0.03	1,063.2	1,084.0	1,081.0	6.99						
					0.15	1,056.4	1,077.0	865.0	6.76	0.200	1.311				
					0.30	1,173.1	1,196.0	786.4	6.67	0.400	1.312				
					0.61	1,191.7	1,215.0	525.7	6.26	0.818	1.343				
					0.91	1,217.2	1,241.0	419.3	6.04	1.066	1.166				
					1.22	1,217.2	1,241.0	326.3	5.79	1.317	1.080				

KBAM Phytoremediation Demonstration Project

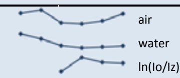
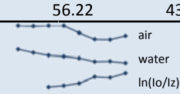
Site	Stn	Date	Time	Rep	Depth (m) z	corr Air (Io)	raw Air (Io)	Water (Iz)	ln(Iz)	ln(Io/Iz)	k (m-1)	k (diffuse attenuation coefficient = slope, m-1) k (m-1)	Percent Transmittance (1m)	Birgean Percentile Absorption (1m)	Flag
KB	KB3	3/23/2012	10:47	2	Air	1,371.0	1,152.0	1,371.0				0.966	38.07	61.93	
					0.03	1,372.2	1,153.0	1,129.0	7.03						
					0.15	1,385.3	1,164.0	873.3	6.77	0.461	3.027				
					0.30	1,419.8	1,193.0	787.7	6.67	0.589	1.933				
					0.61	1,446.0	1,215.0	640.2	6.46	0.815	1.337				
					0.91	1,460.3	1,227.0	461.9	6.14	1.151	1.259				
					1.22	1,472.2	1,237.0	329.3	5.80	1.498	1.228				
KB	KB4	3/23/2012	11:04	1	Air	473.4	601.1	473.4				0.790	45.37	54.63	
					0.03	550.3	698.7	541.6	6.29						
					0.15	939.6	1,193.0	788.7	6.67	0.175	1.148				
					0.30	893.9	1,135.0	632.3	6.45	0.346	1.136				
					0.61	507.3	644.1	275.8	5.62	0.609	1.000				
					0.91	1,107.3	1,406.0	517.4	6.25	0.761	0.832				
					1.22	1,158.5	1,471.0	401.7	6.00	1.059	0.869				
KB	KB4	3/23/2012	11:04	2	Air	1,445.0	1,424.0	1,445.0				0.878	41.55	58.45	
					0.03	1,418.6	1,398.0	1,093.0	7.00						
					0.15	1,484.6	1,463.0	986.7	6.89	0.409	2.681				
					0.30	1,489.6	1,468.0	874.9	6.77	0.532	1.746				
					0.61	1,495.7	1,474.0	661.8	6.49	0.815	1.338				
					0.91	1,496.8	1,475.0	504.7	6.22	1.087	1.189				
					1.22	1,490.7	1,469.0	392.1	5.97	1.335	1.095				
KB	KB5	3/23/2012	11:24	1	Air	1,477.0	1,624.0	1,477.0				0.842	43.07	56.93	
					0.03	1,477.0	1,624.0	1,303.0	7.17						
					0.15	1,474.3	1,621.0	1,068.0	6.97	0.322	2.115				
					0.30	1,487.0	1,635.0	954.7	6.86	0.443	1.454				
					0.61	1,487.9	1,636.0	718.7	6.58	0.728	1.194				
					0.91	1,475.2	1,622.0	520.2	6.25	1.042	1.140				
					1.22	1,457.9	1,603.0	417.4	6.03	1.251	1.026				
					1.52	1,453.4	1,598.0	342.0	5.83	1.447	0.949				
KB	KB5	3/23/2012	11:24	2	Air	1,672.0	1,576.0	1,672.0				0.871	41.86	58.14	
					0.03	1,666.7	1,571.0	1,244.0	7.13						
					0.15	1,663.5	1,568.0	1,071.0	6.98	0.440	2.889				
					0.30	1,672.0	1,576.0	943.4	6.85	0.572	1.878				
					0.61	1,680.5	1,584.0	733.6	6.60	0.829	1.360				
					0.91	1,694.3	1,597.0	540.3	6.29	1.143	1.250				
					1.22	1,710.2	1,612.0	408.4	6.01	1.432	1.175				
					1.52	1,695.3	1,598.0	346.3	5.85	1.588	1.042				
KB	KB6	3/23/2012	11:44	1	Air	1,404.0	1,587.0	1,404.0				0.833	43.49	56.51	
					0.03	1,387.2	1,568.0	1,329.0	7.19						
					0.15	1,383.7	1,564.0	1,105.0	7.01	0.225	1.476				
					0.30	1,381.9	1,562.0	903.1	6.81	0.425	1.396				
					0.61	1,387.2	1,568.0	733.7	6.60	0.637	1.045				
					0.91	1,388.1	1,569.0	580.5	6.36	0.872	0.953				
					1.22	1,376.6	1,556.0	422.0	6.05	1.182	0.970				
					1.52	1,377.5	1,557.0	346.6	5.85	1.380	0.905				
KB	KB6	3/23/2012	11:44	2	Air	1,321.0	1,576.0	1,321.0				0.784	45.66	54.34	
					0.03	1,317.6	1,572.0	1,324.0	7.19						
					0.15	1,318.5	1,573.0	1,042.0	6.95	0.235	1.544				
					0.30	1,321.0	1,576.0	918.7	6.82	0.363	1.192				
					0.61	1,318.5	1,573.0	727.2	6.59	0.595	0.976				
					0.91	1,305.9	1,558.0	542.6	6.30	0.878	0.961				
					1.22	1,305.1	1,557.0	456.9	6.12	1.050	0.861				
					1.52	1,305.1	1,557.0	348.1	5.85	1.322	0.867				
KB	KB1	4/30/2012	10:23	1	Air	1,486.0	1,684.0	1,486.0				0.414	66.09	33.91	
					0.03	1,478.1	1,675.0	1,054.0	6.96						
					0.15	1,464.8	1,660.0	951.3	6.86	0.432	2.832				
					0.30	1,476.3	1,673.0	848.0	6.74	0.554	1.819				
					0.61	1,473.6	1,670.0	803.1	6.69	0.607	0.996				
					0.91	1,473.6	1,670.0	676.8	6.52	0.778	0.851				

Site	Stn	Date	Time	Rep	Depth (m) z	corr Air (Io)	raw Air (Io)	Water (Iz)	ln(Iz)	ln(Io/Iz)	k (m-1)	k (diffuse attenuation coefficient = slope, m-1) k (m-1)	Percent Transmittance (1m)	Birgean Percentile Absorption (1m)	Flag
KB	KB1	4/30/2012	10:23	2	Air	1,494.0	1,642.0	1,494.0				0.406	66.64	33.36	
					0.03	1,499.5	1,648.0	1,160.0	7.06						
					0.15	1,517.7	1,668.0	919.5	6.82	0.501	3.288				
					0.30	1,517.7	1,668.0	919.5	6.82	0.501	1.644				
					0.61	1,510.4	1,660.0	829.6	6.72	0.599	0.983				
					0.91	1,519.5	1,670.0	678.6	6.52	0.806	0.882				
KB	KB2	4/30/2012	10:43	1	Air	1,282.0	1,619.0	1,282.0				0.538	58.36	41.64	
					0.03	1,281.2	1,618.0	1,149.0	7.05						
					0.15	1,285.2	1,623.0	974.0	6.88	0.277	1.819				
					0.30	1,286.8	1,625.0	940.5	6.85	0.313	1.028				
					0.61	1,282.0	1,619.0	744.7	6.61	0.543	0.891				
					0.91	1,278.8	1,615.0	660.1	6.49	0.661	0.723				
KB	KB2	4/30/2012	10:43	2	Air	1,577.0	1,621.0	1,577.0				0.574	56.35	43.65	
					0.03	1,579.9	1,624.0	1,285.0	7.16						
					0.15	1,579.9	1,624.0	1,030.0	6.94	0.428	2.807				
					0.30	1,579.9	1,624.0	934.3	6.84	0.525	1.724				
					0.61	1,578.9	1,623.0	754.9	6.63	0.738	1.211				
					0.91	1,569.2	1,613.0	666.4	6.50	0.856	0.937				
KB	KB3	4/30/2012	11:59	1	Air	1,889.0	1,660.0	1,889.0				0.677	50.83	49.17	
					0.03	2,234.9	1,964.0	1,417.0	7.26						
					0.15	2,238.4	1,967.0	1,193.0	7.08	0.629	4.129				
					0.30	2,223.6	1,954.0	1,150.0	7.05	0.659	2.163				
					0.61	2,198.5	1,932.0	977.6	6.89	0.810	1.329				
					0.91	2,217.9	1,949.0	749.6	6.62	1.085	1.186				
					1.22	2,207.6	1,940.0	612.3	6.42	1.282	1.052				
					1.52	2,240.6	1,969.0	485.5	6.19	1.529	1.003				
KB	KB3	4/30/2012	11:59	2	Air	1,898.0	1,952.0	1,898.0				0.666	51.36	48.64	
					0.03	1,908.7	1,963.0	1,546.0	7.34						
					0.15	1,927.2	1,982.0	1,273.0	7.15	0.415	2.721				
					0.30	1,934.9	1,990.0	1,074.0	6.98	0.589	1.931				
					0.61	1,915.5	1,970.0	1,029.0	6.94	0.621	1.019				
					0.91	1,889.2	1,943.0	796.4	6.68	0.864	0.945				
					1.22	1,912.6	1,967.0	625.9	6.44	1.117	0.916				
					1.52	1,915.5	1,970.0	488.0	6.19	1.367	0.897				
KB	KB4	4/30/2012	11:04	1	Air	1,413.0	1,738.0	1,413.0				0.770	46.30	53.70	
					0.03	1,412.2	1,737.0	1,269.0	7.15						
					0.15	1,413.8	1,739.0	1,236.0	7.12	0.134	0.882				
					0.30	1,413.8	1,739.0	1,015.0	6.92	0.331	1.087				
					0.61	1,410.6	1,735.0	841.6	6.74	0.516	0.847				
					0.91	1,412.2	1,737.0	749.6	6.62	0.633	0.693				
					1.22	1,419.5	1,746.0	574.1	6.35	0.905	0.743				
					1.52	1,404.1	1,727.0	384.7	5.95	1.295	0.850				
KB	KB4	4/30/2012	11:04	2	Air	1,611.0	1,721.0	1,611.0				0.692	50.04	49.96	
					0.03	1,609.1	1,719.0	1,224.0	7.11						
					0.15	1,619.4	1,730.0	1,090.0	6.99	0.396	2.598				
					0.30	1,627.8	1,739.0	951.0	6.86	0.538	1.763				
					0.61	1,623.2	1,734.0	867.3	6.77	0.627	1.028				
					0.91	1,622.2	1,733.0	709.4	6.56	0.827	0.905				
					1.22	1,621.3	1,732.0	550.5	6.31	1.080	0.886				
					1.52	1,616.6	1,727.0	399.8	5.99	1.397	0.917				
KB	KB5	4/30/2012		1	Air	1,740.0	1,771.0	1,740.0				0.723	48.51	51.49	
					0.03	1,747.9	1,779.0	1,619.0	7.39						
					0.15	1,746.9	1,778.0	1,188.0	7.08	0.386	2.530				
					0.30	1,765.5	1,797.0	1,093.0	7.00	0.480	1.573				
					0.61	1,756.7	1,788.0	871.9	6.77	0.701	1.149				
					0.91	1,763.6	1,795.0	706.0	6.56	0.915	1.001				
					1.22	1,777.3	1,809.0	573.8	6.35	1.131	0.927				
					1.52	1,934.5	1,969.0	485.5	6.19	1.382	0.907				

Site	Stn	Date	Time	Rep	Depth (m) z	corr Air (Io)	raw Air (Io)	Water (Iz)	ln(Iz)	ln(Io/Iz)	k (m-1)	k (diffuse attenuation coefficient = slope, m-1) k (m-1)	Percent Transmittance (1m)	Birgean Percentile Absorption (1m)	Flag
KB	KB5	4/30/2012		2	Air	1,759.0	1,804.0	1,759.0				0.742	47.62	52.38	
					0.03	1,755.1	1,800.0	1,490.0	7.31						
					0.15	1,755.1	1,800.0	1,244.0	7.13	0.344	2.258				
					0.30	1,754.1	1,799.0	1,087.0	6.99	0.479	1.570				
					0.61	1,758.0	1,803.0	944.4	6.85	0.621	1.019				
					0.91	1,760.0	1,805.0	746.2	6.61	0.858	0.938				
					1.22	1,761.9	1,807.0	566.4	6.34	1.135	0.931				
					1.52	1,920.9	1,970.0	488.0	6.19	1.370	0.899				
KB	KB6	4/30/2012		1	Air	1,856.0	2,076.0	1,856.0				0.464	62.90	37.10	
					0.03	1,850.6	2,070.0	1,588.0	7.37						
					0.15	1,855.1	2,075.0	1,206.0	7.10	0.431	2.826				
					0.30	1,851.5	2,071.0	1,209.0	7.10	0.426	1.398				
					0.61	1,839.9	2,058.0	962.2	6.87	0.648	1.063				
					0.91	1,840.8	2,059.0	896.7	6.80	0.719	0.787				
					1.22	1,855.1	2,075.0	823.9	6.71	0.812	0.666				
					1.52	1,862.3	2,083.0	622.1	6.43	1.096	0.719				
KB	KB6	4/30/2012		2	Air	1,981.0	2,061.0	1,981.0				0.572	56.46	43.54	
					0.03	1,982.0	2,062.0	1,657.0	7.41						
					0.15	1,969.5	2,049.0	1,321.0	7.19	0.399	2.621				
					0.30	1,943.5	2,022.0	1,202.0	7.09	0.481	1.576				
					0.61	1,957.0	2,036.0	1,127.0	7.03	0.552	0.905				
					0.91	1,983.9	2,064.0	943.3	6.85	0.743	0.813				
					1.22	1,998.3	2,079.0	759.7	6.63	0.967	0.793				
					1.52	2,001.2	2,082.0	606.6	6.41	1.194	0.783				
KB	KB3	5/30/2012	11:25	1	Air	647.4	741.1	647.4				0.987	37.25	62.75	
					0.03	656.1	751.1	545.1	6.30						
					0.15	659.5	754.9	462.6	6.14	0.355	2.326				
					0.30	662.3	758.1	402.4	6.00	0.498	1.635				
					0.61	666.4	762.9	306.8	5.73	0.776	1.273				
					0.91	667.7	764.3	231.3	5.44	1.060	1.159				
					1.22	665.5	761.8	161.1	5.08	1.418	1.163				
					1.52	671.1	768.2	122.7	4.81	1.699	1.115				
KB	KB3	5/30/2012	11:25	2	Air	811.9	780.9	811.9				0.939	39.09	60.91	
					0.03	811.0	780.0	581.9	6.37						
					0.15	806.5	775.7	471.6	6.16	0.537	3.521				
					0.30	801.6	771.0	410.3	6.02	0.670	2.197				
					0.61	800.2	769.6	293.6	5.68	1.003	1.645				
					0.91	800.2	769.6	293.6	5.68	1.003	1.096				
					1.22	802.4	771.8	170.8	5.14	1.547	1.269				
					1.52	799.3	768.8	123.8	4.82	1.865	1.224				
KB	KB4	5/30/2012	11:47	1	Air	1,532.0	1,854.0	1,532.0				0.838	43.24	56.76	
					0.03	1,538.6	1,862.0	1,335.0	7.20						
					0.15	1,546.9	1,872.0	1,162.0	7.06	0.286	1.877				
					0.30	1,556.0	1,883.0	1,072.0	6.98	0.373	1.222				
					0.61	1,562.6	1,891.0	757.5	6.63	0.724	1.188				
					0.91	1,552.7	1,879.0	557.9	6.32	1.024	1.119				
					1.22	1,572.5	1,903.0	480.0	6.17	1.187	0.973				
					1.52	1,569.2	1,899.0	386.4	5.96	1.401	0.920				
KB	KB4	5/30/2012	11:47	2	Air	1,676.0	1,745.0	1,676.0				0.813	44.33	55.67	
					0.03	1,725.9	1,797.0	1,316.0	7.18						
					0.15	1,920.9	2,000.0	1,251.0	7.13	0.429	2.814				
					0.30	1,847.9	1,924.0	1,097.0	7.00	0.521	1.711				
					0.61	1,874.8	1,952.0	780.0	6.66	0.877	1.439				
					0.91	1,892.1	1,970.0	734.9	6.60	0.946	1.034				
					1.22	1,865.2	1,942.0	514.8	6.24	1.287	1.056				
					1.52	1,821.0	1,896.0	380.5	5.94	1.566	1.027				

KBAM Phytoremediation Demonstration Project

Site	Stn	Date	Time	Rep	Depth (m) z	corr Air (Io)	raw Air (Io)	Water (Iz)	ln(Iz)	ln(Io/Iz)	k (m-1)	k (diffuse attenuation coefficient = slope, m-1) k (m-1)	Percent Transmittance (1m)	Birgean Percentile Absorption (1m)	Flag
KB	KB5	5/30/2012	12:08	1	Air	1,652.0	1,816.0	1,652.0				0.904	40.51	59.49	
					0.03	1,655.6	1,820.0	1,333.0	7.20						
					0.15	1,652.0	1,816.0	1,119.0	7.02	0.390	2.556				
					0.30	1,649.3	1,813.0	1,039.0	6.95	0.462	1.516				
					0.61	1,648.4	1,812.0	864.0	6.76	0.646	1.060				
					0.91	1,652.0	1,816.0	668.6	6.51	0.905	0.989				
					1.22	1,658.4	1,823.0	440.0	6.09	1.327	1.088				
					1.52	1,658.4	1,823.0	336.8	5.82	1.594	1.046				
KB	KB5	5/30/2012	12:08	2	Air	1,816.0	1,821.0	1,816.0				0.878	41.56	58.44	
					0.03	1,816.0	1,821.0	1,317.0	7.18						
					0.15	1,815.0	1,820.0	1,080.0	6.98	0.519	3.406				
					0.30	1,815.0	1,820.0	1,074.0	6.98	0.525	1.721				
					0.61	1,813.0	1,818.0	925.8	6.83	0.672	1.103				
					0.91	1,815.0	1,820.0	703.8	6.56	0.947	1.036				
					1.22	1,811.0	1,816.0	456.2	6.12	1.379	1.131				
					1.52	1,814.0	1,819.0	342.8	5.84	1.666	1.093				
KB	KB3	12/7/2012	12:00	1	Air	212.4	212.4	212.4				1.199	30.15	69.85	
					0.15	212.4	212.4	127.3	4.85						
					0.30	212.4	212.4	83.0	4.42	0.939	3.081				
					0.46	212.4	212.4	59.3	4.08	1.276	2.790				
					0.61	212.4	212.4	49.4	3.90	1.458	2.392				
					0.76	212.4	212.4	36.6	3.60	1.758	2.307				
					0.91	212.4	212.4	42.4	3.75	1.612	1.763				
KB	KB3	12/7/2012	12:00	2	Air	428.4	428.4	428.4				0.917	39.98	60.02	
					0.15	428.4	428.4	316.5	5.76						
					0.30	428.4	428.4	245.1	5.50	0.558	1.832				
					0.46	428.4	428.4	191.6	5.26	0.805	1.760				
					0.61	428.4	428.4	188.8	5.24	0.819	1.344				
					0.76	428.4	428.4	172.3	5.15	0.911	1.195				
					0.91	428.4	428.4	121.0	4.80	1.264	1.383				
					1.07	428.4	428.4	121.0	4.80	1.264	1.185				
					1.22	428.4	428.4	104.8	4.65	1.408	1.155				
KB	KB3	12/7/2012	12:00	3	Air	441.9	441.9	441.9				1.481	22.74	77.26	
					0.15	441.9	441.9	246.7	5.51						
					0.30	441.9	441.9	281.9	5.64	0.450	1.475				
					0.46	441.9	441.9	213.4	5.36	0.728	1.592				
					0.61	441.9	441.9	191.0	5.25	0.839	1.376				
					0.76	441.9	441.9	137.5	4.92	1.168	1.532				
					0.91	441.9	441.9	86.3	4.46	1.633	1.786				
					1.07	441.9	441.9	89.1	4.49	1.601	1.501				
					1.22	441.9	441.9	80.0	4.38	1.709	1.402				
KB	KB3	12/7/2012	12:00	4	Air	173.2	173.2	173.2				1.136	32.11	67.89	
					0.15	173.2	173.2	185.2	5.22						
					0.30	173.2	173.2	257.6	5.55	-0.397	-1.302				
					0.46	173.2	173.2	128.7	4.86	0.297	0.650				
					0.61	173.2	173.2	108.3	4.68	0.470	0.770				
					0.76	173.2	173.2	82.9	4.42	0.737	0.967				
					0.91	173.2	173.2	68.3	4.22	0.931	1.018				
					1.07	173.2	173.2	61.5	4.12	1.035	0.970				
					1.22	173.2	173.2	97.7	4.58	0.573	0.470				
KB	KB3	12/21/2012	14:52	1	Air	184.8	184.8	184.8				4.008	1.82	98.18	
					0.15	184.8	184.8	151.2	5.02						
					0.30	184.8	184.8	133.7	4.90	0.323	1.061				
					0.46	184.8	184.8	112.1	4.72	0.500	1.094				
					0.61	184.8	184.8	39.4	3.67	1.545	2.535				
KB	KB3	12/21/2012	14:52	2	Air	194.7	194.7	194.7				2.002	13.50	86.50	
					0.15	194.7	194.7	119.9	4.79						
					0.30	194.7	194.7	131.9	4.88	0.389	1.276				
					0.46	194.7	194.7	71.8	4.27	0.997	2.181				
					0.61	194.7	194.7	71.7	4.27	0.999	1.639				

Site	Stn	Date	Time	Rep	Depth (m) z	corr Air (Io)	raw Air (Io)	Water (Iz)	ln(Iz)	ln(Io/Iz)	k (m-1)	k (diffuse attenuation coefficient = slope, m-1) k (m-1)	Percent Transmittance (1m)	Birgean Percentile Absorption (1m)	Flag
KB	KB3	12/21/2012	14:52	3	Air	201.2	201.2	201.2				0.182	83.36	16.64	X
					0.15	201.2	201.2	165.0	5.11						
					0.30	201.2	201.2	104.2	4.65	0.658	2.160				
					0.46	201.2	201.2	100.5	4.61	0.694	1.519				
					0.61	201.2	201.2	98.5	4.59	0.714	1.171				
KB	KB1	7/8/2013	11:24	1	Air	251.6	290.3	251.6	5.53			0.368	69.22	30.78	
					0.03	232.6	268.4	169.4	5.13						
					0.15	262.0	302.3	124.9	4.83	0.741	4.861				
					0.30	243.7	281.2	116.9	4.76	0.735	2.410				
					0.61	235.3	271.5	83.8	4.43	1.033	1.694				
					0.91	176.9	204.1	67.8	4.22	0.959	1.049				
KB	KB1	7/8/2013	11:24	1	Air	203.2	207.8	203.2	5.31			0.157	85.45	14.55	X
					0.03	216.1	221.0	145.4	4.98						
					0.15	164.8	168.5	69.4	4.24	0.864	5.670				
					0.30	160.7	164.3	44.5	3.80	1.283	4.210				
					0.61	172.2	176.1	55.3	4.01	1.137	1.865				
					0.91	200.6	205.1	66.2	4.19	1.109	1.213				
KB	KB2	7/8/2013	11:52	1	Air	1,845.0	2,073.0	1,845.0				0.607	54.49	45.51	
					0.03	1,887.7	2,121.0	1,389.0	7.24						
					0.15	1,885.9	2,119.0	1,226.0	7.11	0.431	2.826				
					0.30	1,699.9	1,910.0	1,028.0	6.94	0.503	1.650				
					0.61	1,554.9	1,747.0	850.2	6.75	0.604	0.990				
					0.91	1,637.6	1,840.0	657.4	6.49	0.913	0.998				
KB	KB2	7/8/2013	11:52	2	Air	1,820.0	1,831.0	1,820.0	7.51			0.787	45.54	54.46	
					0.03	1,962.1	1,974.0	1,440.0	7.27						
					0.15	1,884.6	1,896.0	1,201.0	7.09	0.451	2.956				
					0.30	1,915.4	1,927.0	1,201.0	7.09	0.467	1.531				
					0.61	1,894.5	1,906.0	925.7	6.83	0.716	1.175				
					0.91	1,904.5	1,916.0	681.0	6.52	1.028	1.125				
KB	KB3	7/8/2013	12:08	1	Air	1,759.0	2,017.0	1,759.0				0.603	54.73	45.27	
					0.03	1,753.8	2,011.0	1,340.0	7.20						
					0.15	1,727.6	1,981.0	1,189.0	7.08	0.374	2.452				
					0.30	1,738.9	1,994.0	1,131.0	7.03	0.430	1.411				
					0.61	1,782.5	2,044.0	942.1	6.85	0.638	1.046				
					0.91	1,790.4	2,053.0	772.6	6.65	0.840	0.919				
					1.22	1,753.8	2,011.0	650.3	6.48	0.992	0.814				
KB	KB3	7/8/2013	12:08	2	Air	1,847.0	2,088.0	1,847.0	7.52			0.580	56.01	43.99	
					0.03	1,862.9	2,106.0	1,459.0	7.29						
					0.15	1,796.6	2,031.0	1,215.0	7.10	0.391	2.567				
					0.30	1,768.3	1,999.0	1,121.0	7.02	0.456	1.495				
					0.61	1,771.8	2,003.0	953.2	6.86	0.620	1.017				
					0.91	1,758.5	1,988.0	779.9	6.66	0.813	0.889				
					1.22	1,784.2	2,017.0	654.3	6.48	1.003	0.823				
KB	KB4	7/8/2013	12:29	1	Air	1,889.0	2,225.0	1,889.0	7.54			0.567	56.70	43.30	
					0.03	1,880.5	2,215.0	1,453.0	7.28						
					0.15	1,861.0	2,192.0	1,345.0	7.20	0.325	2.131				
					0.30	1,827.0	2,152.0	1,194.0	7.09	0.425	1.396				
					0.61	1,810.9	2,133.0	1,021.0	6.93	0.573	0.940				
					0.91	1,813.4	2,136.0	841.9	6.74	0.767	0.839				
					1.22	1,810.9	2,133.0	720.2	6.58	0.922	0.756				
					1.52	1,776.9	2,093.0	584.2	6.37	1.112	0.730				
KB	KB4	7/8/2013	12:29	2	Air	1,899.0	2,152.0	1,899.0	7.55			0.576	56.22	43.78	
					0.03	1,896.4	2,149.0	1,570.0	7.36						
					0.15	1,899.0	2,152.0	1,316.0	7.18	0.367	2.406				
					0.30	1,899.0	2,152.0	1,211.0	7.10	0.450	1.476				
					0.61	1,862.8	2,111.0	1,035.0	6.94	0.588	0.964				
					0.91	1,830.2	2,074.0	710.3	6.57	0.946	1.035				
					1.22	1,828.4	2,072.0	740.0	6.61	0.905	0.742				
					1.52	1,847.8	2,094.0	577.0	6.36	1.164	0.764				

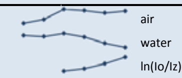
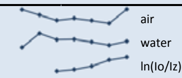
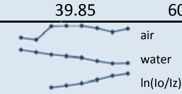
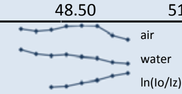
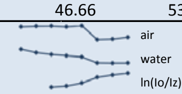
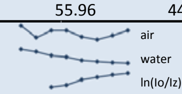
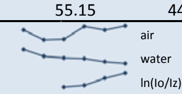
Site	Stn	Date	Time	Rep	Depth (m) z	corr Air (Io)	raw Air (Io)	Water (Iz)	ln(Iz)	ln(Io/Iz)	k (m-1)	k (diffuse attenuation coefficient = slope, m-1) k (m-1)	Percent Transmittance (1m)	Birgean Percentile Absorption (1m)	Flag
KB	KB5	7/8/2013	12:48	1	Air	1,860.0	2,173.0	1,860.0	7.53			0.584	55.79	44.21	
					0.03	1,866.8	2,181.0	1,453.0	7.28						
					0.15	1,875.4	2,191.0	1,216.0	7.10	0.433	2.843				
					0.30	1,872.0	2,187.0	1,127.0	7.03	0.507	1.665				
					0.61	1,854.0	2,166.0	1,091.0	6.99	0.530	0.870				
					0.91	1,844.6	2,155.0	876.6	6.78	0.744	0.814				
					1.22	1,828.3	2,136.0	689.4	6.54	0.975	0.800				
					1.52	592.2	691.9	169.1	5.13	1.253	0.822				
KB	KB5	7/8/2013	12:48	2	Air	1,938.0	2,162.0	1,938.0	7.57			0.651	52.14	47.86	
					0.03	1,973.9	2,202.0	1,453.0	7.28						
					0.15	1,115.1	1,244.0	772.3	6.65	0.367	2.410				
					0.30	1,808.9	2,018.0	1,022.0	6.93	0.571	1.873				
					0.61	1,942.5	2,167.0	904.5	6.81	0.764	1.254				
					0.91	1,883.3	2,101.0	927.7	6.83	0.708	0.774				
					1.22	722.0	805.4	246.5	5.51	1.075	0.881				
					1.52	504.6	562.9	127.9	4.85	1.372	0.901				
KB	KB6	7/8/2013	13:09	1	Air	1,828.0	2,139.0	1,828.0	7.51			0.918	39.93	60.07	
					0.03	1,859.6	2,176.0	1,506.0	7.32						
					0.15	1,848.5	2,163.0	1,277.0	7.15	0.370	2.427				
					0.30	1,877.6	2,197.0	1,242.0	7.12	0.413	1.356				
					0.61	1,686.1	1,973.0	874.6	6.77	0.656	1.077				
					0.91	699.4	818.4	266.2	5.58	0.966	1.056				
					1.22	507.1	593.4	145.4	4.98	1.249	1.025				
					1.52	365.9	428.2	73.1	4.29	1.610	1.056				
KB	KB6	7/8/2013	13:09	2	Air	575.0	655.4	575.0	6.35			0.990	37.17	62.83	
					0.03	331.6	378.0	236.0	5.46						
					0.15	292.3	333.2	178.0	5.18	0.496	3.255				
					0.30	294.4	335.6	138.2	4.93	0.756	2.481				
					0.61	320.2	365.0	122.3	4.81	0.963	1.579				
					0.91	349.7	398.6	17.2	2.84	3.012	3.294				
					1.22	365.8	417.0	79.5	4.38	1.526	1.252				
					1.52	373.6	425.8	72.5	4.28	1.640	1.076				
KB	KB1	10/21/2013	11:20	1	Air	787.5	909.1	787.5	6.67			0.864	42.16	57.84	
					0.03	868.0	1,002.0	785.6	6.67						
					0.15	751.2	867.2	505.1	6.22	0.397	2.604				
					0.30	666.2	769.1	395.0	5.98	0.523	1.715				
					0.61	685.6	791.5	311.2	5.74	0.790	1.296				
					0.76	1,231.8	1,422.0	490.2	6.19	0.921	1.209				
KB	KB1	10/21/2013	11:20	2	Air	1,781.0	1,694.0	1,781.0	7.48			0.893	40.95	59.05	
					0.03	1,803.1	1,715.0	1,327.0	7.19						
					0.15	1,819.9	1,731.0	1,090.0	6.99	0.513	3.364				
					0.30	1,821.0	1,732.0	923.1	6.83	0.679	2.229				
					0.61	1,828.3	1,739.0	773.8	6.65	0.860	1.410				
					0.76	1,569.7	1,493.0	521.1	6.26	1.103	1.447				
KB	KB2	10/21/2013	11:40	1	Air	1,518.0	1,766.0	1,518.0	7.33			0.739	47.76	52.24	
					0.03	1,502.5	1,748.0	1,198.0	7.09						
					0.15	1,509.4	1,756.0	965.4	6.87	0.447	2.933				
					0.30	1,512.0	1,759.0	886.9	6.79	0.533	1.750				
					0.61	1,495.7	1,740.0	753.6	6.62	0.685	1.124				
					0.91	1,457.0	1,695.0	522.6	6.26	1.025	1.121				
KB	KB2	10/21/2013	11:40	2	Air	622.7	726.6	622.7	6.43			0.701	49.59	50.41	
					0.03	670.3	782.2	558.6	6.33						
					0.15	901.6	1,052.0	551.6	6.31	0.491	3.224				
					0.30	1,284.7	1,499.0	739.8	6.61	0.552	1.811				
					0.61	1,487.8	1,736.0	687.6	6.53	0.772	1.266				
					0.91	1,453.5	1,696.0	526.4	6.27	1.016	1.111				

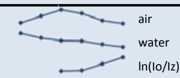
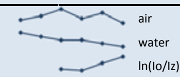
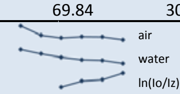
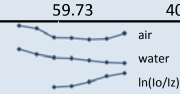
KBAM Phytoremediation Demonstration Project

Site	Stn	Date	Time	Rep	Depth (m) z	corr Air (Io)	raw Air (Io)	Water (Iz)	ln(Iz)	ln(Io/Iz)	k (m-1)	k (diffuse attenuation coefficient = slope, m-1) k (m-1)	Percent Transmittance (1m)	Birgean Percentile Absorption (1m)	Flag
KB	KB3	10/21/2013	11:52	1	Air	1,454.0	1,558.0	1,454.0	7.28			0.818	44.13	55.87	
					0.03	1,556.7	1,668.0	1,109.0	7.01						
					0.15	1,571.6	1,684.0	989.1	6.90	0.463	3.038				
					0.30	1,590.3	1,704.0	946.8	6.85	0.519	1.701				
					0.61	1,588.4	1,702.0	745.4	6.61	0.757	1.241				
					0.91	1,364.4	1,462.0	494.5	6.20	1.015	1.110				
					1.22	1,097.5	1,176.0	291.6	5.68	1.325	1.087				
KB	KB3	10/21/2013	11:52	2	Air	1,277.0	1,393.0	1,277.0	7.15			0.819	44.08	55.92	
					0.03	1,580.4	1,724.0	1,215.0	7.10						
					0.15	1,562.1	1,704.0	1,002.0	6.91	0.444	2.914				
					0.30	1,477.8	1,612.0	882.5	6.78	0.516	1.691				
					0.61	1,448.4	1,580.0	668.0	6.50	0.774	1.270				
					0.91	1,246.7	1,360.0	446.4	6.10	1.027	1.123				
					1.22	1,070.7	1,168.0	290.6	5.67	1.304	1.070				
KB	KB4	10/21/2013	12:06	1	Air	1,577.0	1,698.0	1,577.0	7.36			0.575	56.27	43.73	
					0.03	1,612.3	1,736.0	1,113.0	7.01						
					0.15	1,609.5	1,733.0	924.7	6.83	0.554	3.637				
					0.30	1,588.1	1,710.0	826.2	6.72	0.653	2.144				
					0.61	1,567.7	1,688.0	732.4	6.60	0.761	1.248				
					0.91	1,546.4	1,665.0	594.1	6.39	0.957	1.046				
					1.22	1,551.9	1,671.0	472.9	6.16	1.188	0.975				
KB	KB4	10/21/2013	12:06	2	Air	1,553.0	1,605.0	1,553.0	7.35			0.564	56.87	43.13	
					0.03	1,551.1	1,603.0	1,079.0	6.98						
					0.15	1,533.6	1,585.0	928.0	6.83	0.502	3.296				
					0.30	1,523.0	1,574.0	837.4	6.73	0.598	1.962				
					0.61	1,535.6	1,587.0	694.8	6.54	0.793	1.301				
					0.91	1,552.0	1,604.0	609.8	6.41	0.934	1.022				
					1.22	1,573.3	1,626.0	518.0	6.25	1.111	0.911				
KB	KB5	10/21/2013	12:21	1	Air	826.7	936.5	826.7	6.72			0.614	54.13	45.87	
					0.03	1,483.0	1,680.0	1,223.0	7.11						
					0.15	1,515.7	1,717.0	997.1	6.90	0.419	2.748				
					0.30	1,521.9	1,724.0	923.1	6.83	0.500	1.640				
					0.61	1,522.8	1,725.0	757.0	6.63	0.699	1.147				
					0.91	1,558.9	1,766.0	647.7	6.47	0.878	0.961				
					1.22	1,562.5	1,770.0	536.6	6.29	1.069	0.877				
					1.52	1,108.7	1,256.0	315.6	5.75	1.257	0.824				
KB	KB5	10/21/2013	12:21	2	Air	465.0	502.6	465.0	6.14			0.583	55.80	44.20	
					0.03	497.0	537.2	327.9	5.79						
					0.15	536.9	580.3	316.2	5.76	0.529	3.474				
					0.30	587.9	635.4	322.6	5.78	0.600	1.969				
					0.61	708.3	765.6	330.2	5.80	0.763	1.252				
					0.91	893.8	966.1	345.1	5.84	0.952	1.041				
					1.22	867.2	937.3	272.0	5.61	1.159	0.951				
					1.52	1,024.2	1,107.0	276.6	5.62	1.309	0.859				
KB	KB6	10/21/2013	13:09	1	Air	373.0	390.2	373.0	5.92			0.631	53.23	46.77	
					0.03	372.8	390.0	258.4	5.55						
					0.15	372.6	389.8	206.2	5.33	0.592	3.883				
					0.30	378.5	396.0	190.1	5.25	0.689	2.260				
					0.61	384.4	402.1	161.5	5.08	0.867	1.422				
					0.91	394.4	412.6	132.5	4.89	1.091	1.193				
					1.22	406.5	425.2	113.5	4.73	1.276	1.046				
					1.52	421.8	441.2	99.5	4.60	1.444	0.948				
KB	KB6	10/21/2013	13:09	2	Air	490.8	527.7	490.8	6.20			0.659	51.75	48.25	
					0.03	491.2	528.1	395.6	5.98						
					0.15	484.9	521.4	287.2	5.66	0.524	3.437				
					0.30	471.3	506.7	254.9	5.54	0.615	2.016				
					0.61	460.8	495.4	199.0	5.29	0.840	1.377				
					0.91	448.4	482.1	157.0	5.06	1.049	1.148				
					1.22	432.1	464.6	125.9	4.84	1.233	1.011				
					1.52	413.6	444.7	100.3	4.61	1.417	0.930				

Site	Stn	Date	Time	Rep	Depth (m) z	corr Air (Io)	raw Air (Io)	Water (Iz)	ln(Iz)	ln(Io/Iz)	k (m-1)	k (diffuse attenuation coefficient = slope, m-1) k (m-1)	Percent Transmittance (1m)	Birgean Percentile Absorption (1m)	Flag
KB	KB1	10/28/2013	12:00	1	Air	1,493.0	1,433.0	1,493.0	7.31			0.720	48.69	51.31	
					0.03	1,488.8	1,429.0	980.7	6.89						
					0.15	1,484.7	1,425.0	915.2	6.82	0.484	3.175				
					0.30	1,518.0	1,457.0	819.2	6.71	0.617	2.024				
					0.61	1,523.2	1,462.0	647.1	6.47	0.856	1.404				
					0.91	1,502.4	1,442.0	517.2	6.25	1.066	1.166				
					1.07	1,468.0	1,409.0	472.0	6.16	1.135	1.064				
KB	KB1	10/28/2013	12:00	2	Air	1,416.0	1,398.0	1,416.0	7.26			0.649	52.25	47.75	
					0.15	1,413.0	1,395.0	924.9	6.83	0.424	2.781				
					0.30	1,477.8	1,459.0	761.4	6.64	0.663	2.176				
					0.61	1,454.5	1,436.0	636.4	6.46	0.827	1.356				
					0.91	1,466.6	1,448.0	571.2	6.35	0.943	1.031				
					1.07	1,429.2	1,411.0	478.3	6.17	1.095	1.026				
KB	KB2	10/28/2013	12:32	1	Air	1,360.0	1,524.0	1,360.0	7.22			0.756	46.97	53.03	
					0.03	1,351.1	1,514.0	1,043.0	6.95						
					0.15	1,344.8	1,507.0	859.8	6.76	0.447	2.935				
					0.30	1,343.0	1,505.0	810.5	6.70	0.505	1.657				
					0.61	1,346.6	1,509.0	645.8	6.47	0.735	1.205				
					0.91	1,346.6	1,509.0	525.1	6.26	0.942	1.030				
					1.22	1,352.9	1,516.0	385.4	5.95	1.256	1.030				
KB	KB2	10/28/2013	12:32	2	Air	1,488.0	1,503.0	1,488.0	7.31			0.711	49.10	50.90	
					0.03	1,493.0	1,508.0	1,042.0	6.95						
					0.15	1,495.9	1,511.0	838.6	6.73	0.579	3.798				
					0.30	1,493.9	1,509.0	790.5	6.67	0.637	2.088				
					0.61	1,492.0	1,507.0	656.9	6.49	0.820	1.346				
					0.91	1,493.9	1,509.0	534.3	6.28	1.028	1.124				
					1.22	1,500.9	1,516.0	390.0	5.97	1.348	1.105				
KB	KB3	10/28/2013	12:40	1	Air	1,462.0	1,507.0	1,462.0	7.29			0.816	44.23	55.77	
					0.03	1,467.8	1,513.0	1,112.0	7.01						
					0.15	1,466.9	1,512.0	835.3	6.73	0.563	3.695				
					0.30	1,463.9	1,509.0	745.9	6.61	0.674	2.212				
					0.61	1,464.9	1,510.0	604.4	6.40	0.885	1.452				
					0.91	1,465.9	1,511.0	478.3	6.17	1.120	1.225				
					1.22	1,464.9	1,510.0	374.7	5.93	1.363	1.118				
					1.52	1,468.8	1,514.0	264.8	5.58	1.713	1.124				
KB	KB3	10/28/2013	12:40	2	Air	1,392.0	1,493.0	1,392.0	7.24			0.825	43.83	56.17	
					0.03	1,400.4	1,502.0	948.5	6.85						
					0.15	1,399.5	1,501.0	855.8	6.75	0.492	3.227				
					0.30	1,397.6	1,499.0	764.6	6.64	0.603	1.979				
					0.61	1,404.1	1,506.0	636.2	6.46	0.792	1.299				
					0.91	1,402.3	1,504.0	494.3	6.20	1.043	1.140				
					1.22	1,410.6	1,513.0	390.0	5.97	1.286	1.055				
					1.52	1,412.5	1,515.0	268.8	5.59	1.659	1.089				
KB	KB4	10/28/2013	12:55	1	Air	1,419.0	1,548.0	1,419.0	7.26			0.559	57.16	42.84	
					0.03	1,420.8	1,550.0	1,290.0	7.16						
					0.15	1,416.3	1,545.0	919.3	6.82	0.432	2.836				
					0.30	1,408.9	1,537.0	772.6	6.65	0.601	1.971				
					0.61	1,409.8	1,538.0	692.8	6.54	0.710	1.165				
					0.91	1,414.4	1,543.0	589.4	6.38	0.875	0.957				
					1.22	1,416.3	1,545.0	505.2	6.22	1.031	0.845				
					1.52	1,419.0	1,548.0	404.4	6.00	1.255	0.824				
KB	KB4	10/28/2013	12:55	2	Air	1,064.0	1,549.0	1,064.0	6.97			0.530	58.88	41.12	
					0.03	1,067.4	1,554.0	881.9	6.78						
					0.15	1,061.3	1,545.0	829.5	6.72	0.246	1.617				
					0.30	1,064.7	1,550.0	721.1	6.58	0.390	1.278				
					0.61	1,068.8	1,556.0	638.8	6.46	0.515	0.844				
					0.91	1,065.4	1,551.0	547.0	6.30	0.667	0.729				
					1.22	1,066.7	1,553.0	440.3	6.09	0.885	0.726				
					1.52	1,064.0	1,549.0	401.6	6.00	0.974	0.639				

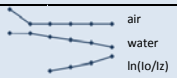
Site	Stn	Date	Time	Rep	Depth (m) z	corr Air (Io)	raw Air (Io)	Water (Iz)	ln(Iz)	ln(Io/Iz)	k (m-1)	k (diffuse attenuation coefficient = slope, m-1) k (m-1)	Percent Transmittance (1m)	Birgean Percentile Absorption (1m)	Flag
KB	KB5	10/28/2013	13:13	1	Air	1,451.0	1,545.0	1,451.0	7.28			0.452	63.64	36.36	
					0.03	1,424.7	1,517.0	1,086.0	6.99						
					0.15	1,433.2	1,526.0	904.2	6.81	0.461	3.022				
					0.30	1,458.5	1,553.0	823.2	6.71	0.572	1.877				
					0.61	1,493.3	1,590.0	723.7	6.58	0.724	1.188				
					0.91	1,491.4	1,588.0	646.6	6.47	0.836	0.914				
					1.22	1,482.9	1,579.0	576.4	6.36	0.945	0.775				
					1.52	1,482.9	1,579.0	486.0	6.19	1.116	0.732				
KB	KB5	10/28/2013	13:13	2	Air	1,473.0	1,566.0	1,473.0	7.30			0.477	62.03	37.97	
					0.03	1,470.2	1,563.0	1,167.0	7.06						
					0.15	1,468.3	1,561.0	895.4	6.80	0.495	3.245				
					0.30	1,464.5	1,557.0	882.1	6.78	0.507	1.663				
					0.61	1,469.2	1,562.0	751.8	6.62	0.670	1.099				
					0.91	1,473.9	1,567.0	652.6	6.48	0.815	0.891				
					1.22	1,482.4	1,576.0	556.0	6.32	0.981	0.804				
					1.52	1,482.4	1,576.0	483.3	6.18	1.121	0.735				
KB	KB6	10/28/2013	13:29	1	Air	1,399.0	1,394.0	1,399.0	7.24			1.039	35.38	64.62	
					0.03	1,451.2	1,446.0	1,046.0	6.95						
					0.15	1,368.9	1,364.0	932.0	6.84	0.384	2.522				
					0.30	1,377.9	1,373.0	918.0	6.82	0.406	1.332				
					0.61	1,428.1	1,423.0	621.4	6.43	0.832	1.365				
					0.91	1,447.2	1,442.0	445.3	6.10	1.179	1.289				
					1.22	1,438.1	1,433.0	334.6	5.81	1.458	1.196				
					1.52	1,466.2	1,461.0	259.1	5.56	1.733	1.137				
KB	KB6	10/28/2013	13:29	2	Air	1,448.0	1,507.0	1,448.0	7.28			0.879	41.51	58.49	
					0.03	1,461.5	1,521.0	1,021.0	6.93						
					0.15	1,428.8	1,487.0	867.6	6.77	0.499	3.273				
					0.30	1,430.7	1,489.0	824.3	6.71	0.551	1.809				
					0.61	1,428.8	1,487.0	737.4	6.60	0.661	1.085				
					0.91	1,438.4	1,497.0	561.2	6.33	0.941	1.029				
					1.22	1,462.4	1,522.0	388.2	5.96	1.326	1.088				
					1.52	1,407.6	1,465.0	257.8	5.55	1.697	1.114				
KB	KB1	7/17/2014	10:40	1	Air	1,836.0	1,600.0	1,836.0	7.52			0.757	46.89	53.11	
					0.03	1,877.3	1,636.0	1,367.0	7.22						
					0.15	1,776.3	1,548.0	1,098.0	7.00	0.481	3.157				
					0.30	1,716.7	1,496.0	957.4	6.86	0.584	1.916				
					0.61	1,691.4	1,474.0	761.1	6.63	0.799	1.310				
					0.91	1,693.7	1,476.0	581.8	6.37	1.069	1.169				
					1.22	1,754.5	1,529.0	490.1	6.19	1.275	1.046				
KB	KB1	7/17/2014	10:40	2	Air	1,712.0	1,422.0	1,712.0	7.45			0.087	91.67	8.33	X
					0.03	1,402.0	1,386.0	1,402.0	7.25						
					0.15	1,095.0	1,587.0	1,095.0	7.00	0.000	0.000				
					0.30	1,919.1	1,594.0	102.8	4.63	2.927	9.602				
					0.61	1,929.9	1,603.0	836.1	6.73	0.836	1.372				
					0.91	1,962.4	1,630.0	675.6	6.52	1.066	1.166				
					1.22	1,944.4	1,615.0	505.2	6.22	1.348	1.105				
KB	KB2	7/17/2014	10:56	1	Air	1,998.0	1,756.0	1,998.0	7.60			1.005	36.59	63.41	
					0.03	1,994.6	1,753.0	1,633.0	7.40						
					0.15	2,045.8	1,798.0	1,339.0	7.20	0.424	2.781				
					0.30	1,892.2	1,663.0	1,074.0	6.98	0.566	1.858				
					0.61	1,929.7	1,696.0	694.0	6.54	1.023	1.678				
					0.91	1,820.5	1,600.0	511.4	6.24	1.270	1.389				
					1.22	1,844.4	1,621.0	428.4	6.06	1.460	1.197				
KB	KB2	7/17/2014	10:56	2	Air	1,117.0	982.3	1,117.0	7.02			0.980	37.54	62.46	
					0.03	1,096.9	964.6	880.5	6.78						
					0.15	1,016.3	893.7	636.5	6.46	0.468	3.070				
					0.30	961.8	845.8	562.1	6.33	0.537	1.762				
					0.61	1,224.7	1,077.0	472.2	6.16	0.953	1.563				
					0.91	2,091.2	1,839.0	604.7	6.40	1.241	1.357				
					1.22	1,920.6	1,689.0	447.7	6.10	1.456	1.194				

Site	Stn	Date	Time	Rep	Depth (m) z	corr Air (Io)	raw Air (Io)	Water (Iz)	ln(Iz)	ln(Io/Iz)	k (m-1)	k (diffuse attenuation coefficient = slope, m-1) k (m-1)	Percent Transmittance (1m)	Birgean Percentile Absorption (1m)	Flag
KB	KB3	7/17/2014	11:09	1	Air	1,283.0	1,324.0	1,283.0	7.16			0.646	52.39	47.61	
					0.03	1,447.7	1,494.0	1,225.0	7.11						
					0.15	1,882.8	1,943.0	1,390.0	7.24	0.303	1.991				
					0.30	1,825.7	1,884.0	1,197.0	7.09	0.422	1.385				
					0.61	1,722.0	1,777.0	880.4	6.78	0.671	1.100				
					1.22	1,802.4	1,860.0	665.0	6.50	0.997	0.818				
KB	KB3	7/17/2014	11:09	2	Air	202.7	1,825.0	202.7	5.31			0.665	51.41	48.59	
					0.03	163.4	1,471.0	1,225.0	7.11						
					0.15	124.3	1,119.0	767.2	6.64	-1.820	-11.943				
					0.30	139.1	1,252.0	791.6	6.67	-1.739	-5.706				
					0.61	122.8	1,106.0	596.3	6.39	-1.580	-2.592				
					0.91	102.5	923.3	368.2	5.91	-1.278	-1.398				
					1.22	206.0	1,855.0	645.6	6.47	-1.142	-0.937				
KB	KB4	7/17/2014	11:26	1	Air	2,100.0	361.0	2,100.0	7.65			0.920	39.85	60.15	
					0.03	470.0	80.8	1,758.0	7.47						
					0.15	10,680.3	1,836.0	1,445.0	7.28	2.000	13.125				
					0.30	11,064.3	1,902.0	1,266.0	7.14	2.168	7.112				
					0.61	11,070.1	1,903.0	1,038.0	6.95	2.367	3.883				
					0.91	9,092.2	1,563.0	626.9	6.44	2.674	2.925				
					1.22	6,212.7	1,068.0	299.3	5.70	3.033	2.488				
					1.52	8,719.9	1,499.0	340.9	5.83	3.242	2.127				
KB	KB5	7/17/2014	11:44	1	Air	1,952.0	1,746.0	1,952.0	7.58			0.724	48.50	51.50	
					0.03	1,757.5	1,572.0	1,407.0	7.25						
					0.15	1,869.3	1,672.0	1,209.0	7.10	0.436	2.859				
					0.30	2,181.2	1,951.0	1,335.0	7.20	0.491	1.611				
					0.61	2,244.9	2,008.0	1,080.0	6.98	0.732	1.200				
					0.91	2,202.4	1,970.0	892.1	6.79	0.904	0.988				
					1.22	1,414.2	1,265.0	424.6	6.05	1.203	0.987				
					1.52	1,056.6	945.1	260.4	5.56	1.401	0.919				
KB	KB5	7/17/2014	11:44	2	Air	2,096.0	1,924.0	2,096.0	7.65			0.762	46.66	53.34	
					0.03	2,165.7	1,988.0	1,640.0	7.40						
					0.15	2,184.2	2,005.0	1,400.0	7.24	0.445	2.919				
					0.30	2,097.1	1,925.0	1,241.0	7.12	0.525	1.721				
					0.61	2,215.8	2,034.0	1,063.0	6.97	0.735	1.205				
					0.91	829.8	761.7	268.8	5.59	1.127	1.233				
					1.22	884.4	811.8	244.5	5.50	1.286	1.055				
					1.52	1,074.4	986.2	260.0	5.56	1.419	0.931				
KB	KB6	7/17/2014	12:02	1	Air	1,980.0	1,837.0	1,980.0	7.59			0.580	55.96	44.04	
					0.03	1,961.7	1,820.0	1,730.0	7.46						
					0.15	1,972.5	1,830.0	1,357.0	7.21	0.374	2.454				
					0.30	1,972.5	1,830.0	1,211.0	7.10	0.488	1.601				
					0.61	1,962.8	1,821.0	888.6	6.79	0.792	1.300				
					0.91	1,958.4	1,817.0	772.5	6.65	0.930	1.017				
					1.22	1,964.9	1,823.0	679.2	6.52	1.062	0.871				
					1.52	1,972.5	1,830.0	616.1	6.42	1.164	0.764				
KB	KB6	7/17/2014	12:02	2	Air	2,045.0	1,867.0	2,045.0	7.62			0.537	58.46	41.54	
					0.03	2,031.9	1,855.0	1,633.0	7.40						
					0.15	2,024.2	1,848.0	1,357.0	7.21	0.400	2.624				
					0.30	2,028.6	1,852.0	1,321.0	7.19	0.429	1.407				
					0.61	2,015.4	1,840.0	1,023.0	6.93	0.678	1.112				
					0.91	2,011.0	1,836.0	925.8	6.83	0.776	0.848				
					1.22	2,006.7	1,832.0	741.4	6.61	0.996	0.817				
					1.52	2,007.8	1,833.0	667.2	6.50	1.102	0.723				
KB	KB1	7/2/2014	10:07	1	Air	1,546.0	1,375.0	1,546.0	7.34			0.595	55.15	44.85	
					0.03	1,528.0	1,359.0	1,117.0	7.02						
					0.15	1,529.1	1,360.0	1,004.0	6.91	0.421	2.761				
					0.30	1,552.7	1,381.0	964.0	6.87	0.477	1.564				
					0.61	1,546.0	1,375.0	771.0	6.65	0.696	1.141				
					0.91	1,553.9	1,382.0	659.1	6.49	0.858	0.938				

Site	Stn	Date	Time	Rep	Depth (m) z	corr Air (Io)	raw Air (Io)	Water (Iz)	ln(Iz)	ln(Io/Iz)	k (m-1)	k (diffuse attenuation coefficient = slope, m-1) k (m-1)	Percent Transmittance (1m)	Birgean Percentile Absorption (1m)	Flag
KB	KB1	7/2/2014	10:07	2	Air	1,554.0	1,343.0	1,554.0	7.35			0.541	58.20	41.80	
					0.03	1,578.3	1,364.0	1,271.0	7.15						
					0.15	1,599.1	1,382.0	1,008.0	6.92	0.461	3.028				
					0.30	1,637.3	1,415.0	928.9	6.83	0.567	1.860				
					0.61	1,641.9	1,419.0	719.4	6.58	0.825	1.354				
					0.91	1,613.0	1,394.0	687.6	6.53	0.853	0.932				
KB	KB2	7/2/2014	10:25	1	Air	1,636.0	1,530.0	1,636.0	7.40			0.622	53.71	46.29	
					0.03	1,655.2	1,548.0	1,320.0	7.19						
					0.15	1,673.4	1,565.0	1,138.0	7.04	0.386	2.530				
					0.30	1,662.7	1,555.0	1,111.0	7.01	0.403	1.323				
					0.61	1,642.4	1,536.0	885.2	6.79	0.618	1.014				
					0.91	1,633.9	1,528.0	706.6	6.56	0.838	0.917				
KB	KB2	7/2/2014	10:25	2	Air	1,599.0	1,561.0	1,599.0	7.38			0.560	57.10	42.90	
					0.03	1,624.6	1,586.0	1,345.0	7.20						
					0.15	1,669.7	1,630.0	1,126.0	7.03	0.394	2.585				
					0.30	1,608.2	1,570.0	1,132.0	7.03	0.351	1.152				
					0.61	1,645.1	1,606.0	922.6	6.83	0.578	0.949				
					0.91	1,578.5	1,541.0	722.0	6.58	0.782	0.855				
KB	KB3	7/2/2014	10:45	1	Air	1,871.0	1,570.0	1,871.0	7.53			0.290	74.81	25.19	
					0.03	1,871.0	1,570.0	1,393.0	7.24						
					0.15	1,856.7	1,558.0	1,218.0	7.10	0.422	2.766				
					0.30	1,842.4	1,546.0	1,215.0	7.10	0.416	1.366				
					0.61	1,855.5	1,557.0	1,084.0	6.99	0.538	0.882				
					1.22	1,859.1	1,560.0	912.4	6.82	0.712	0.584				
KB	KB3	7/2/2014	10:45	2	Air	1,627.0	1,793.0	1,627.0	7.39			0.359	69.84	30.16	
					0.03	1,472.7	1,623.0	1,386.0	7.23						
					0.15	1,431.0	1,577.0	1,189.0	7.08	0.185	1.216				
					0.30	1,451.0	1,599.0	1,057.0	6.96	0.317	1.039				
					0.61	1,446.4	1,594.0	1,021.0	6.93	0.348	0.571				
					0.91	1,399.2	1,542.0	853.8	6.75	0.494	0.540				
KB	KB4	7/2/2014	11:05	1	Air	1,970.0	1,775.0	1,970.0	7.59			0.515	59.73	40.27	
					0.03	1,931.2	1,740.0	1,512.0	7.32						
					0.15	1,813.5	1,634.0	1,227.0	7.11	0.391	2.564				
					0.30	1,806.9	1,628.0	1,179.0	7.07	0.427	1.401				
					0.61	1,784.7	1,608.0	993.0	6.90	0.586	0.962				
					0.91	1,793.5	1,616.0	813.0	6.70	0.791	0.865				
					1.22	1,867.9	1,683.0	751.8	6.62	0.910	0.746				
KB	KB4	7/2/2014	11:05	2	Air	1,643.0	1,842.0	1,643.0	7.40			0.504	60.42	39.58	
					0.03	1,564.5	1,754.0	1,581.0	7.37						
					0.15	1,485.1	1,665.0	1,248.0	7.13	0.174	1.141				
					0.30	1,395.0	1,564.0	1,094.0	7.00	0.243	0.797				
					0.61	1,333.5	1,495.0	895.7	6.80	0.398	0.653				
					0.91	1,563.6	1,753.0	907.5	6.81	0.544	0.595				
					1.22	1,521.7	1,706.0	745.7	6.61	0.713	0.585				
KB	KB5	7/2/2014	11:27	1	Air	1,956.0	1,900.0	1,956.0	7.58			1.080	33.95	66.05	
					0.03	1,938.5	1,883.0	1,481.0	7.30						
					0.15	1,939.5	1,884.0	1,374.0	7.23	0.345	2.262				
					0.30	1,953.9	1,898.0	1,288.0	7.16	0.417	1.367				
					0.61	1,949.8	1,894.0	1,175.0	7.07	0.506	0.831				
					0.91	1,953.9	1,898.0	180.0	5.19	2.385	2.608				
					1.22	1,908.6	1,854.0	816.0	6.70	0.850	0.697				
KB	KB5	7/2/2014	11:27	2	Air	1,924.0	1,880.0	1,924.0	7.56			0.480	61.88	38.12	
					0.03	1,893.3	1,850.0	1,602.0	7.38						
					0.15	1,851.3	1,809.0	1,309.0	7.18	0.347	2.275				
					0.30	1,853.4	1,811.0	1,180.0	7.07	0.451	1.481				
					0.61	1,874.9	1,832.0	1,053.0	6.96	0.577	0.946				
					0.91	1,924.0	1,880.0	858.0	6.75	0.808	0.883				
					1.22	1,892.3	1,849.0	823.0	6.71	0.833	0.683				

Site	Stn	Date	Time	Rep	Depth (m) z	corr Air (Io)	raw Air (Io)	Water (Iz)	ln(Iz)	ln(Io/Iz)	k (m-1)	k (diffuse attenuation coefficient = slope, m-1) k (m-1)	Percent Transmittance (1m)	Birgean Percentile Absorption (1m)	Flag
KB	KB6	7/2/2014	11:45	1	Air	2,178.0	1,986.0	2,178.0	7.69			0.272	76.17	23.83	
					0.03	2,278.9	2,078.0	1,653.0	7.41						
					0.15	2,309.6	2,106.0	1,492.0	7.31	0.437	2.867				
					0.30	2,365.5	2,157.0	1,256.0	7.14	0.633	2.077				
					0.61	9,020.2	8,225.0	351.7	5.86	3.244	5.322				
					0.91	1,237.1	1,128.0	772.8	6.65	0.470	0.515				
					1.22	2,357.9	2,150.0	764.2	6.64	1.127	0.924				
					1.52	635.4	579.4	189.1	5.24	1.212	0.795				
					1.83	1,259.0	1,148.0	257.0	5.55	1.589	0.869				
KB	KB6	7/2/2014	11:45	2	Air	1,956.0	1,900.0	1,956.0	7.58			0.696	49.88	50.12	
					0.03	2,061.0	2,002.0	2,170.0	7.68						
					0.15	1,404.2	1,364.0	1,096.0	7.00	0.248	1.626				
					0.30	1,404.2	1,364.0	947.9	6.85	0.393	1.289				
					0.61	1,057.3	1,027.0	654.9	6.48	0.479	0.786				
					0.91	1,098.4	1,067.0	571.4	6.35	0.654	0.715				
					1.22	739.3	718.1	292.4	5.68	0.928	0.761				
					1.52	1,575.1	1,530.0	538.6	6.29	1.073	0.704				
					1.83	979.9	951.8	216.2	5.38	1.511	0.826				
KB	KB1	5/1/2015	11:28	1	Air	1,414.2	1,412.2	1,414.2	7.25			0.340	71.20	28.80	
					0.03	1,481.9	1,479.8	1,479.8	7.30						
					0.15	1,481.9	1,479.8	1,288.8	7.16	0.140	0.916				
					0.30	1,481.9	1,479.8	1,239.7	7.12	0.178	0.585				
					0.46	1,481.9	1,479.8	1,211.1	7.10	0.202	0.441				
					0.61	1,481.9	1,479.8	1,093.0	7.00	0.304	0.499				
KB	KB1	5/1/2015	11:28	2	Air	1,087.3	1,087.3	1,087.3	6.99			0.326	72.20	27.80	
					0.03	1,495.4	1,495.4	1,495.4	7.31						
					0.15	1,495.4	1,495.4	1,289.2	7.16	0.148	0.974				
					0.30	1,495.4	1,495.4	1,017.5	6.93	0.385	1.263				
					0.46	1,495.4	1,495.4	1,133.4	7.03	0.277	0.606				
					0.61	1,495.4	1,495.4	1,054.0	6.96	0.350	0.574				
KB	KB2	5/1/2015	11:35	1	Air	1,250.1	1,250.1	1,250.1	7.13			0.274	76.03	23.97	
					0.03	1,494.1	1,494.1	1,495.1	7.31						
					0.15	1,494.1	1,494.1	1,295.7	7.17	0.142	0.935				
					0.30	1,494.1	1,494.1	1,233.6	7.12	0.192	0.629				
					0.46	1,494.1	1,494.1	1,185.0	7.08	0.232	0.507				
					0.61	1,494.1	1,494.1	1,142.5	7.04	0.268	0.440				
KB	KB2	5/1/2015	11:35	2	Air	1,481.9	1,481.9	1,481.9	7.30			0.338	71.31	28.69	
					0.03	1,506.3	1,506.3	1,506.3	7.32						
					0.15	1,506.3	1,506.3	1,309.2	7.18	0.140	0.920				
					0.30	1,506.3	1,506.3	1,274.9	7.15	0.167	0.547				
					0.46	1,506.3	1,506.3	1,204.1	7.09	0.224	0.490				
					0.61	1,506.3	1,506.3	1,123.8	7.02	0.293	0.481				
KB	KB3	5/1/2015	11:43	1	Air	1,473.4	1,473.4	1,473.4	7.30			0.130	87.78	12.22	
					0.03	1,478.5	1,478.5	1,478.5	7.30						
					0.15	1,478.5	1,478.5	1,158.5	7.05	0.244	1.600				
					0.30	1,478.5	1,478.5	1,192.7	7.08	0.215	0.705				
					0.61	1,478.5	1,478.5	1,249.7	7.13	0.168	0.276				
					1.22	1,478.5	1,478.5	1,020.5	6.93	0.371	0.304				
KB	KB3	5/1/2015	11:43	2	Air	1,467.5	1,467.5	1,467.5	7.29			0.334	71.61	28.39	
					0.03	1,480.6	1,480.6	1,480.6	7.30						
					0.15	1,480.6	1,480.6	1,341.3	7.20	0.099	0.648				
					0.30	1,480.6	1,480.6	1,251.9	7.13	0.168	0.550				
					0.61	1,480.6	1,480.6	1,120.4	7.02	0.279	0.457				
					0.91	1,480.6	1,480.6	1,039.2	6.95	0.354	0.387				
KB	KB4	5/1/2015	11:50	1	Air	1,512.5	1,512.5	1,512.5	7.32			0.304	73.80	26.20	
					0.03	1,573.1	1,573.1	1,573.1	7.36						
					0.15	1,573.1	1,573.1	1,317.4	7.18	0.177	1.164				
					0.30	1,573.1	1,573.1	1,346.1	7.20	0.156	0.511				
					0.46	1,573.1	1,573.1	1,214.1	7.10	0.259	0.567				
					0.61	1,573.1	1,573.1	1,168.5	7.06	0.297	0.488				

Site	Stn	Date	Time	Rep	Depth (m) z	corr Air (Io)	raw Air (Io)	Water (Iz)	ln(Iz)	ln(Io/Iz)	k (m-1)	k (diffuse attenuation coefficient = slope, m-1) k (m-1)	Percent Transmittance (1m)	Birgean Percentile Absorption (1m)	Flag
KB	KB4	5/1/2015	11:50	2	Air	1,537.4	1,537.4	1,537.4	7.34			0.504	60.41	39.59	
					0.03	1,531.0	1,531.0	1,531.0	7.33						
					0.15	1,531.0	1,531.0	1,424.7	7.26	0.072	0.472				
					0.30	1,531.0	1,531.0	1,337.4	7.20	0.135	0.444				
					0.46	1,531.0	1,531.0	1,255.4	7.14	0.198	0.434				
					0.61	1,531.0	1,531.0	1,126.4	7.03	0.307	0.503				
KB	KB5	5/1/2015	11:56	1	Air	1,482.9	1,482.9	1,482.9	7.30			0.235	79.06	20.94	
					0.03	1,544.5	1,544.5	1,544.5	7.34						
					0.15	1,544.5	1,544.5	1,378.6	7.23	0.114	0.746				
					0.30	1,544.5	1,544.5	1,317.4	7.18	0.159	0.522				
					0.46	1,544.5	1,544.5	1,254.5	7.13	0.208	0.455				
					0.61	1,544.5	1,544.5	1,243.6	7.13	0.217	0.355				
KB	KB5	5/1/2015	11:56	2	Air	344.1	344.1	344.1	5.84			0.938	39.13	60.87	X
					0.03	348.7	348.7	348.7	5.85						
					0.15	348.7	348.7	310.7	5.74	0.115	0.757				
					0.30	348.7	348.7	244.1	5.50	0.357	1.170				
					0.46	348.7	348.7	219.9	5.39	0.461	1.008				
					0.61	348.7	348.7	199.7	5.30	0.557	0.914				
KB	KB6	5/1/2015	11:45	1	Air	1,618.4	1,618.4	1,618.4	7.39			0.397	67.22	32.78	
					0.03	1,654.7	1,654.7	1,654.7	7.41						
					0.15	1,654.7	1,654.7	1,441.2	7.27	0.138	0.906				
					0.30	1,654.7	1,654.7	1,378.2	7.23	0.183	0.600				
					0.46	1,654.7	1,654.7	1,334.1	7.20	0.215	0.471				
					0.61	1,654.7	1,654.7	1,190.7	7.08	0.329	0.540				
KB	KB6	5/1/2015	11:45	2	Air	1,674.9	1,674.9	1,674.9	7.42			0.551	57.66	42.34	
					0.03	1,683.4	1,683.4	1,683.4	7.43						
					0.15	1,683.4	1,683.4	1,503.2	7.32	0.113	0.743				
					0.30	1,683.4	1,683.4	1,426.8	7.26	0.165	0.543				
					0.46	1,683.4	1,683.4	1,284.9	7.16	0.270	0.591				
					0.61	1,683.4	1,683.4	1,176.8	7.07	0.358	0.587				
C	CS	5/1/2015	10:50	1	Air	1,354.0	1,354.0	1,354.0	7.21			0.537	58.44	41.56	
					0.03	1,350.4	1,350.4	1,350.4	7.21						
					0.15	1,350.4	1,350.4	1,208.5	7.10	0.111	0.728				
					0.30	1,350.4	1,350.4	1,122.1	7.02	0.185	0.608				
					0.46	1,350.4	1,350.4	996.2	6.90	0.304	0.665				
					0.61	1,350.4	1,350.4	957.1	6.86	0.344	0.565				
C	CS	5/1/2015	10:50	2	Air	1,285.0	1,285.0	1,285.0	7.16			0.355	70.11	29.89	
					0.03	1,237.1	1,237.1	1,237.1	7.12						
					0.15	1,237.1	1,237.1	1,158.5	7.05	0.066	0.431				
					0.30	1,237.1	1,237.1	1,125.1	7.03	0.095	0.311				
					0.46	1,237.1	1,237.1	1,073.0	6.98	0.142	0.311				
					0.61	1,237.1	1,237.1	982.7	6.89	0.230	0.378				
C	CSE	5/1/2015	10:57	1	Air	1,303.7	1,303.7	1,303.7	7.17			0.324	72.30	27.70	
					0.03	1,371.7	1,371.7	1,371.7	7.22						
					0.15	1,371.7	1,371.7	1,159.0	7.06	0.168	1.106				
					0.30	1,371.7	1,371.7	1,100.0	7.00	0.221	0.724				
					0.46	1,371.7	1,371.7	1,070.4	6.98	0.248	0.542				
					0.61	1,371.7	1,371.7	991.9	6.90	0.324	0.532				
C	CSE	5/1/2015	10:57	2	Air	1,338.2	1,338.2	1,338.2	7.20			0.396	67.28	32.72	
					0.03	1,324.8	1,324.8	1,324.8	7.19						
					0.15	1,324.8	1,324.8	1,207.1	7.10	0.093	0.611				
					0.30	1,324.8	1,324.8	1,135.5	7.03	0.154	0.506				
					0.46	1,324.8	1,324.8	1,078.8	6.98	0.205	0.449				
					0.61	1,324.8	1,324.8	1,004.0	6.91	0.277	0.455				
C	CNE	5/1/2015	11:07	1	Air	1,270.1	1,270.1	1,270.1	7.15			0.295	74.48	25.52	
					0.03	1,565.3	1,565.3	1,565.3	7.36						
					0.15	1,565.3	1,565.3	1,197.6	7.09	0.268	1.757				
					0.30	1,565.3	1,565.3	1,151.6	7.05	0.307	1.007				
					0.46	1,565.3	1,565.3	1,142.0	7.04	0.315	0.690				
					0.61	1,565.3	1,565.3	1,034.0	6.94	0.415	0.680				



Site	Stn	Date	Time	Rep	Depth (m) z	corr Air (Io)	raw Air (Io)	Water (Iz)	ln(Iz)	ln(Io/Iz)	k (m-1)	k (diffuse attenuation coefficient = slope, m-1) k (m-1)	Percent Transmittance (1m)	Birgean Percentile Absorption (1m)	Flag
C	CNE	5/1/2015	11:07	2	Air	1,348.1	1,348.1	1,348.1	7.21			0.310	73.35	26.65	
					0.03	1,310.5	1,310.5	1,310.5	7.18						
					0.15	1,310.5	1,310.5	1,215.4	7.10	0.075	0.494				
					0.30	1,310.5	1,310.5	1,198.5	7.09	0.089	0.293				
					0.46	1,310.5	1,310.5	1,092.6	7.00	0.182	0.398				
					0.61	1,310.5	1,310.5	1,070.9	6.98	0.202	0.331				
C	CN	5/1/2015	11:13	1	Air	1,341.5	1,341.5	1,341.5	7.20			0.816	44.23	55.77	
					0.03	1,386.5	1,386.5	1,386.5	7.23						
					0.15	1,386.5	1,386.5	1,196.3	7.09	0.148	0.968				
					0.30	1,386.5	1,386.5	1,090.0	6.99	0.241	0.789				
					0.46	1,386.5	1,386.5	1,014.9	6.92	0.312	0.682				
					0.61	1,386.5	1,386.5	809.5	6.70	0.538	0.883				
C	CN	5/1/2015	11:13	2	Air	1,361.2	1,361.2	1,361.2	7.22			0.561	57.05	42.95	
					0.03	1,340.5	1,340.5	1,340.5	7.20						
					0.15	1,340.5	1,340.5	1,185.5	7.08	0.123	0.806				
					0.30	1,340.5	1,340.5	1,095.6	7.00	0.202	0.662				
					0.46	1,340.5	1,340.5	1,010.1	6.92	0.283	0.619				
					0.61	1,340.5	1,340.5	915.9	6.82	0.381	0.625				
KB	KB1	5/15/2015	11:18	1	Air	1,297.1	1,297.1	1,297.1	7.17			0.397	67.25	32.75	
					0.03	1,420.7	1,420.7	1,420.7	7.26						
					0.15	1,420.7	1,420.7	1,186.3	7.08	0.180	1.183				
					0.30	1,420.7	1,420.7	1,118.6	7.02	0.239	0.784				
					0.46	1,420.7	1,420.7	1,055.2	6.96	0.297	0.651				
					0.61	1,420.7	1,420.7	988.8	6.90	0.362	0.595				
KB	KB1	5/15/2015	11:18	2	Air	971.9	971.9	971.9	6.88			0.441	64.37	35.63	
					0.03	583.8	583.8	583.8	6.37						
					0.15	583.8	583.8	407.5	6.01	0.360	2.359				
					0.30	583.8	583.8	375.8	5.93	0.441	1.445				
					0.46	583.8	583.8	356.3	5.88	0.494	1.080				
KB	KB2	5/15/2015	11:35	1	Air	1,250.1	1,250.1	1,250.1	7.13			0.274	76.03	23.97	
					0.03	1,494.1	1,494.1	1,495.1	7.31						
					0.15	1,494.1	1,494.1	1,295.7	7.17	0.142	0.935				
					0.30	1,494.1	1,494.1	1,233.6	7.12	0.192	0.629				
					0.46	1,494.1	1,494.1	1,185.0	7.08	0.232	0.507				
					0.61	1,494.1	1,494.1	1,142.5	7.04	0.268	0.440				
KB	KB2	5/15/2015	11:35	2	Air	1,601.0	1,601.0	1,601.0	7.38			0.320	72.60	27.40	
					0.03	1,680.3	1,680.3	1,680.3	7.43						
					0.15	1,680.3	1,680.3	1,366.5	7.22	0.207	1.356				
					0.30	1,680.3	1,680.3	1,334.8	7.20	0.230	0.755				
					0.46	1,680.3	1,680.3	1,307.5	7.18	0.251	0.549				
					0.61	1,680.3	1,680.3	1,169.4	7.06	0.362	0.595				
KB	KB3	5/15/2015	11:43	1	Air	1,462.8	1,462.8	1,462.8	7.29			0.167	84.63	15.37	
					0.03	1,786.3	1,786.3	1,786.3	7.49						
					0.15	1,786.3	1,786.3	1,354.7	7.21	0.277	1.815				
					0.30	1,786.3	1,786.3	1,229.3	7.11	0.374	1.226				
					0.61	1,786.3	1,786.3	1,142.9	7.04	0.447	0.733				
					1.22	1,786.3	1,786.3	1,106.9	7.01	0.479	0.393				
KB	KB3	5/15/2015	11:43	2	Air	1,550.6	1,550.6	1,550.6	7.35			0.192	82.55	17.45	
					0.03	1,622.6	1,622.6	1,622.6	7.39						
					0.15	1,622.6	1,622.6	1,385.6	7.23	0.158	1.036				
					0.30	1,622.6	1,622.6	1,360.4	7.22	0.176	0.578				
					0.61	1,622.6	1,622.6	1,272.3	7.15	0.243	0.399				
					0.91	1,622.6	1,622.6	1,202.4	7.09	0.300	0.328				
KB	KB4	5/15/2015	11:50	1	Air	438.2	438.2	438.2	6.08			0.605	54.58	45.42	
					0.03	396.9	396.9	396.9	5.98						
					0.15	396.9	396.9	318.9	5.76	0.219	1.436				
					0.30	396.9	396.9	293.5	5.68	0.302	0.990				
					0.46	396.9	396.9	274.7	5.62	0.368	0.805				
					0.61	396.9	396.9	239.7	5.48	0.504	0.827				

Site	Stn	Date	Time	Rep	Depth (m) z	corr Air (Io)	raw Air (Io)	Water (Iz)	ln(Iz)	ln(Io/Iz)	k (m-1)	k (diffuse attenuation coefficient = slope, m-1) k (m-1)	Percent Transmittance (1m)	Birgean Percentile Absorption (1m)	Flag
KB	KB4	5/15/2015	11:50	2	Air	396.3	396.3	396.3	5.98			0.461	63.08	36.92	
					0.03	365.6	365.6	365.6	5.90						
					0.15	365.6	365.6	312.8	5.75	0.156	1.023				
					0.30	365.6	365.6	293.5	5.68	0.220	0.721				
					0.46	365.6	365.6	271.9	5.61	0.296	0.648				
					0.61	365.6	365.6	253.9	5.54	0.365	0.598				
KB	KB5	5/15/2015	12:01	1	Air	409.6	409.6	409.6	6.02			0.515	59.74	40.26	
					0.03	463.2	463.2	463.2	6.14						
					0.15	463.2	463.2	354.0	5.87	0.269	1.764				
					0.30	463.2	463.2	325.9	5.79	0.352	1.153				
					0.46	463.2	463.2	303.3	5.71	0.423	0.926				
					0.61	463.2	463.2	279.1	5.63	0.507	0.831				
KB	KB5	5/15/2015	12:01	2	Air	504.3	504.3	504.3	6.22			0.542	58.17	41.83	
					0.03	468.2	468.2	468.2	6.15						
					0.15	468.2	468.2	357.5	5.88	0.270	1.770				
					0.30	468.2	468.2	306.4	5.72	0.424	1.391				
					0.46	468.2	468.2	286.0	5.66	0.493	1.078				
					0.61	468.2	468.2	277.8	5.63	0.522	0.856				
KB	KB6	5/15/2015	12:13	1	Air	1,144.1	1,144.1	1,144.1	7.04			0.660	51.69	48.31	
					0.03	1,194.1	1,194.1	1,194.1	7.09						
					0.15	1,194.1	1,194.1	1,045.2	6.95	0.133	0.874				
					0.30	1,194.1	1,194.1	981.0	6.89	0.197	0.645				
					0.46	1,194.1	1,194.1	892.9	6.79	0.291	0.636				
					0.61	1,194.1	1,194.1	771.3	6.65	0.437	0.717				
KB	KB6	5/15/2015	12:13	2	Air	970.2	970.2	970.2	6.88			0.355	70.10	29.90	
					0.03	1,259.9	1,259.9	1,259.9	7.14						
					0.15	1,259.9	1,259.9	1,019.7	6.93	0.212	1.388				
					0.30	1,259.9	1,259.9	989.2	6.90	0.242	0.794				
					0.46	1,259.9	1,259.9	932.9	6.84	0.300	0.657				
					0.61	1,259.9	1,259.9	868.1	6.77	0.372	0.611				
C	CS	5/15/2015	10:15	1	Air	1,432.3	1,432.3	1,432.3	7.27			0.426	65.29	34.71	
					0.03	1,495.4	1,495.4	1,495.4	7.31						
					0.15	1,495.4	1,495.4	1,111.2	7.01	0.297	1.949				
					0.30	1,495.4	1,495.4	1,137.7	7.04	0.273	0.897				
					0.46	1,495.4	1,495.4	975.8	6.88	0.427	0.934				
C	CS	5/15/2015	10:15	2	Air	446.2	446.2	446.2	6.10			0.653	52.03	47.97	
					0.03	1,565.3	1,565.3	1,565.3	7.36						
					0.15	1,565.3	1,565.3	1,334.8	7.20	0.159	1.045				
					0.30	1,565.3	1,565.3	1,181.6	7.07	0.281	0.923				
					0.46	1,565.3	1,565.3	1,105.6	7.01	0.348	0.760				
					0.61	1,565.3	1,565.3	979.3	6.89	0.469	0.769				
C	CSE	5/15/2015	10:57	1	Air	1,427.0	1,427.0	1,427.0	7.26			0.546	57.92	42.08	
					0.03	1,620.4	1,620.4	1,620.4	7.39						
					0.15	1,620.4	1,620.4	1,289.6	7.16	0.228	1.498				
					0.30	1,620.4	1,620.4	1,185.9	7.08	0.312	1.024				
					0.46	1,620.4	1,620.4	1,079.1	6.98	0.407	0.889				
					0.61	1,620.4	1,620.4	1,008.4	6.92	0.474	0.778				
C	CSE	5/15/2015	10:57	2	Air	1,414.8	1,414.8	1,414.8	7.25			0.409	66.42	33.58	
					0.03	1,516.7	1,516.7	1,516.7	7.32						
					0.15	1,516.7	1,516.7	1,235.0	7.12	0.205	1.348				
					0.30	1,516.7	1,516.7	1,173.3	7.07	0.257	0.842				
					0.46	1,516.7	1,516.7	1,090.8	6.99	0.330	0.721				
					0.61	1,516.7	1,516.7	1,027.9	6.94	0.389	0.638				
C	CNE	5/15/2015	11:07	1	Air	1,395.0	1,395.0	1,395.0	7.24			0.506	60.28	39.72	
					0.03	1,519.7	1,519.7	1,519.7	7.33						
					0.15	1,519.7	1,519.7	1,295.7	7.17	0.159	1.046				
					0.30	1,519.7	1,519.7	1,196.3	7.09	0.239	0.785				
					0.46	1,519.7	1,519.7	1,137.7	7.04	0.290	0.633				
					0.61	1,519.7	1,519.7	1,018.8	6.93	0.400	0.656				

KBAM Phytoremediation Demonstration Project

Site	Stn	Date	Time	Rep	Depth (m) z	corr Air (Io)	raw Air (Io)	Water (Iz)	ln(Iz)	ln(Io/Iz)	k (m-1)	k (diffuse attenuation coefficient = slope, m-1) k (m-1)	Percent Transmittance (1m)	Birgean Percentile Absorption (1m)	Flag
C	CNE	5/15/2015	11:07	2	Air	1,460.9	1,460.9	1,460.9	7.29			0.491	61.19	38.81	
					0.03	1,521.5	1,521.5	1,521.5	7.33						
					0.15	1,521.5	1,521.5	1,250.6	7.13	0.196	1.287				
					0.30	1,521.5	1,521.5	1,162.9	7.06	0.269	0.882				
					0.46	1,521.5	1,521.5	1,068.7	6.97	0.353	0.773				
					0.61	1,521.5	1,521.5	1,002.3	6.91	0.417	0.685				
C	CN	5/15/2015	11:13	1	Air	1,421.7	1,421.7	1,421.7	7.26			0.540	58.30	41.70	
					0.03	1,518.0	1,518.0	1,518.0	7.33						
					0.15	1,518.0	1,518.0	1,262.7	7.14	0.184	1.208				
					0.30	1,518.0	1,518.0	1,191.1	7.08	0.243	0.796				
					0.46	1,518.0	1,518.0	1,101.2	7.00	0.321	0.702				
					0.61	1,518.0	1,518.0	985.4	6.89	0.432	0.709				
C	CN	5/15/2015	11:13	2	Air	1,460.5	1,460.5	1,460.5	7.29			0.613	54.16	45.84	
					0.03	1,640.8	1,640.8	1,640.8	7.40						
					0.15	1,640.8	1,640.8	1,293.6	7.17	0.238	1.560				
					0.30	1,640.8	1,640.8	1,204.5	7.09	0.309	1.014				
					0.46	1,640.8	1,640.8	1,090.4	6.99	0.409	0.894				
					0.61	1,640.8	1,640.8	979.3	6.89	0.516	0.847				
KB	KB1	7/8/2015	12:44	1	Air	1,586.5	1,586.5	1,586.5	7.37			0.887	41.19	58.81	
					0.03	1,611.1	1,611.1	1,611.7	7.39						
					0.15	1,611.1	1,611.1	1,445.0	7.28	0.109	0.714				
					0.30	1,611.1	1,611.1	1,393.5	7.24	0.145	0.476				
					0.61	1,611.1	1,611.1	1,034.0	6.94	0.443	0.727				
					0.76	1,611.1	1,611.1	853.4	6.75	0.635	0.834				
KB	KB1	7/8/2015	12:44	2	Air	1,659.8	1,659.8	1,659.8	7.41			0.756	46.94	53.06	
					0.03	1,689.0	1,689.0	1,689.0	7.43						
					0.15	1,689.0	1,689.0	1,422.1	7.26	0.172	1.129				
					0.30	1,689.0	1,689.0	1,288.3	7.16	0.271	0.888				
					0.61	1,689.0	1,689.0	1,036.1	6.94	0.489	0.802				
					0.76	1,689.0	1,689.0	891.2	6.79	0.639	0.839				
KB	KB3	7/8/2015	12:03	1	Air	1,575.0	1,575.0	1,575.0	7.36			0.664	51.50	48.50	
					0.03	1,514.5	1,514.5	1,514.5	7.32						
					0.15	1,514.5	1,514.5	1,368.2	7.22	0.102	0.667				
					0.30	1,514.5	1,514.5	1,249.7	7.13	0.192	0.631				
					0.61	1,514.5	1,514.5	1,012.3	6.92	0.403	0.661				
KB	KB3	7/8/2015	12:03	2	Air	1,388.5	1,388.5	1,388.5	7.24			0.435	64.75	35.25	
					0.03	1,758.9	1,758.9	1,758.9	7.47						
					0.15	1,758.9	1,758.9	1,415.5	7.26	0.217	1.425				
					0.30	1,758.9	1,758.9	1,291.8	7.16	0.309	1.013				
					0.61	1,758.9	1,758.9	1,154.6	7.05	0.421	0.691				
KB	KB6	7/8/2015	11:49	1	Air	1,142.6	1,142.6	1,142.6	7.04			0.688	50.28	49.72	
					0.03	1,266.6	1,266.6	1,266.6	7.14						
					0.15	1,266.6	1,266.6	1,460.3	7.29	-0.142	-0.934				
					0.30	1,266.6	1,266.6	1,187.2	7.08	0.065	0.212				
					0.61	1,266.6	1,266.6	1,044.8	6.95	0.193	0.316				
KB	KB6	7/8/2015	11:49	2	Air	490.4	490.4	490.4	6.20			0.128	87.99	12.01	
					0.03	413.5	413.5	413.5	6.02						
					0.15	413.5	413.5	336.8	5.82	0.205	1.346				
					0.30	413.5	413.5	375.5	5.93	0.096	0.316				
					0.61	413.5	413.5	343.2	5.84	0.186	0.306				
					0.91	413.5	413.5	317.1	5.76	0.265	0.290				
C	CNE	7/8/2015	12:32	1	Air	1,598.0	1,598.0	1,598.0	7.38			1.323	26.64	73.36	
					0.03	767.0	767.0	767.0	6.64						
					0.15	767.0	767.0	481.6	6.18	0.465	3.054				
					0.30	767.0	767.0	368.8	5.91	0.732	2.402				
					0.46	767.0	767.0	321.8	5.77	0.869	1.900				

Site	Stn	Date	Time	Rep	Depth (m) z	corr Air (Io)	raw Air (Io)	Water (Iz)	ln(Iz)	ln(Io/Iz)	k (m-1)	k (diffuse attenuation coefficient = slope, m-1) k (m-1)	Percent Transmittance (1m)	Birgean Percentile Absorption (1m)	Flag
C	CNE	7/8/2015	12:32	2	Air	1,581.2	1,581.2	1,581.2	7.37			0.952	38.59	61.41	
					0.03	1,590.0	1,590.0	1,590.0	7.37						
					0.15	1,590.0	1,590.0	1,286.6	7.16	0.212	1.389				
					0.30	1,590.0	1,590.0	1,052.2	6.96	0.413	1.354				
					0.46	1,590.0	1,590.0	840.8	6.73	0.637	1.394				
					0.61	1,590.0	1,590.0	854.7	6.75	0.621	1.018