ADDENDUM 1 (2012) TO

WORK PLAN FOR PILOT TEST TO ADD NITRATE TO THE HYPOLIMNION OF ONONDAGA LAKE

Prepared for:

Honeywell

301 Plainfield Road, Suite 330
Syracuse, NY 13212

Prepared by:

PARSONS

301 Plainfield Road, Suite 350
Syracuse, New York 13212

and

UPSTATE FRESHWATER INSTITUTE

P.O. Box 506
Syracuse, New York 13214

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LIST OF ACRONYMS

CH_3Hg	methylmercury
DUSR	Data Usability and Summary Report
Fe^{2+}	ferrous iron
H_2S	hydrogen sulfide
Hg	mercury
ISUS	*in situ* ultraviolet spectrophotometer
NO_x	nitrate+nitrite
NYSDEC	New York State Department of Environmental Conservation
QAPP	quality assurance project plan
SMU	Sediment Management Unit
S^{2-}	sulfide
SOP	standard operating procedure
SU	Syracuse University
$T\text{-}NH_3$	total ammonia
UFI	Upstate Freshwater Institute
USEPA	United States Environmental Protection Agency

EXECUTIVE SUMMARY

This first addendum to the Work Plan for Pilot Test to Add Nitrate to the Hypolimnion of Onondaga Lake (Parsons and Upstate Freshwater Institute (UFI), 2011) summarizes plans for the continuation of nitrate addition during 2012, the second year of the three-year nitrate addition pilot test being conducted in Onondaga Lake on behalf of Honeywell International (hereafter called Honeywell). Nitrate addition efforts during 2012 will also include deep basin (Sediment Management Unit 8 or SMU 8) surface water monitoring, the scope for which is included in this work plan addendum. Nitrate addition objectives remain unchanged for 2012. The objectives for surface water monitoring as discussed in the Onondaga Lake Maintenance and Monitoring Scope (Parsons, Anchor QEA and Exponent, in preparation) are to assess remedy effectiveness based on relevant preliminary remediation goals presented in the lake bottom Record of Decision (NYSDEC and USEPA, 2005) and to provide information supporting long-term lake recovery. Surface water monitoring is also needed in SMU 8 to assess the effectiveness of nitrate addition. Surface water monitoring in SMU 8 during 2012 is a follow up to baseline surface water monitoring conducted in SMU 8 on behalf of Honeywell from 2008 through 2011.

The 2012 work scope for nitrate addition is the same as the 2011 work scope (Parsons and UFI, 2011). Additions of nitrate are anticipated to start in late June 2012, proceed at a pace of three applications totaling approximately 6.9 metric tons of nitrate-nitrogen each week, and be completed by early-to-mid October.

Deep basin surface water monitoring that was part of the baseline monitoring efforts from 2008 through 2011 will be completed during 2012 as part of the nitrate addition effort. Laboratory analyses of surface water samples from South Deep will include measurements of low-level total mercury, low-level methylmercury and other water column parameters important to assess the effectiveness of nitrate addition. The scope of surface water monitoring for mercury in the profundal zone during 2012 does not include extensive sampling at North Deep or water sampling for mercury analyses at 10 other locations conducted during 2011. Rationale for the 2012 surface water monitoring work scope is presented in this work plan addendum. Sediment trap monitoring will also be continued during 2012.

Field and laboratory work efforts for nitrate addition monitoring will be based on standardized procedures and quality assurance worksheets contained in the Quality Assurance Project Plan (QAPP) for 2012 lake efforts (Parsons, UFI and Anchor QEA, draft) consistent with procedures implemented in prior years. The only QAPP worksheet unique to 2012 nitrate addition monitoring is Worksheet 20 presented as Table 4 that summarizes the numbers of water samples to be analyzed in a laboratory.

SECTION 1

INTRODUCTION

The remedy for Onondaga Lake is being completed in accordance with a Consent Decree (United States District Court, Northern District of New York, 2007; 89-CV-815) between Honeywell and the New York State Department of Environmental Conservation (NYSDEC). The nitrate addition pilot test is being conducted in the hypolimnion of Onondaga Lake as a three-year pilot test from 2011 through 2013.

This first addendum to Honeywell's 2011 work plan for the nitrate addition pilot test (Parsons and UFI, 2011) presents changes to the work scope for Honeywell's 2012 nitrate addition pilot test effort and incorporates 2012 remedial goal surface water monitoring in the deep water portion of Onondaga Lake given dredging and capping in the lake are scheduled to begin in July 2012. Contents of this work plan addendum are consistent with objectives, program elements, and data uses outlined in the 2011 work plan for the nitrate addition pilot test and with objectives and elements for surface water remedial goal monitoring presented in the Monitoring and Monitoring Scope (Parsons, Anchor QEA and Exponent, in preparation),

This work plan addendum for 2012 has been developed in part based on results from the successful 2011 nitrate addition pilot test work. Methylmercury concentrations measured in deep waters during 2011 were lower than during any recent prior year as a result of adding nitrate (Parsons and UFI, 2012). Objectives, data uses, and rationale for modifying the 2011 work scope are presented in this first section of the work plan addendum. Work scope modifications for 2012 are changes in the monitoring effort presented in Section 2. Sampling and analysis work proposed in this work plan addendum for 2012 will employ the Quality Assurance Project Plan (QAPP) developed for the lake remediation effort (Parsons, Anchor QEA and UFI, in preparation) consistent with procedures employed during the 2008-2011 baseline monitoring effort in Onondaga Lake completed on behalf of Honeywell.

1.1 OBJECTIVES

Onondaga Lake becomes thermally stratified each year typically beginning in late May and continuing through mid-to-late October. Oxygen and nitrate concentrations in the hypolimnion decline gradually over time as the lake remains stratified. When concentrations of oxygen become depleted and nitrate-nitrogen concentrations decline to below 0.5 to 1.0 mg/L, sediments can release methylmercury to the water column and inorganic mercury in the water column can become methylated.

The objective of adding nitrate is to demonstrate the ability to maintain nitrate concentrations in the hypolimnion of Onondaga Lake (i.e., waters deeper than 30 ft. that stratify each summer) at levels sufficient to inhibit release of methylmercury from lake sediment to overlying waters while the lake is stratified (typically from late May until mid-to-late October).

The objectives of surface water monitoring in Onondaga Lake are to:

- Assess lake remedy effectiveness based on relevant preliminary remediation goals presented in the lake bottom Record of Decision
- Provide information supporting long-term lake recovery
- Assess the effectiveness of nitrate addition

Mercury is the only Onondaga Lake chemical parameter of interest for which surface water concentrations have consistently exceeded applicable standards and guidance values based on baseline monitoring of lake conditions completed on behalf of Honeywell from 2008 through 2011. As a result, mercury will be the primary focus of remedial goal surface water monitoring in Onondaga Lake, and the only water quality parameter with a remedial goal that will be monitored in the deep water zone (SMU 8) as part of this pilot test. Additional surface water monitoring related directly to construction activities will be conducted in Onondaga Lake during 2012 as described in the Water Quality Management and Monitoring Plan (Anchor QEA and Parsons, 2012, draft).

1.2 SUMMARY OF 2011 NITRATE ADDITION AND MONITORING RESULTS

On behalf of Honeywell International, nitrate was added to the lower, stratified waters of Onondaga Lake as 40 single-day applications between June 30 and October 10, 2011. For each application of nitrate, a target dose of 4,800 gallons of liquid calcium nitrate solution was applied over a four to seven hour period directly to deep hypolimnion waters at one of three pre-determined locations. Forty single-day applications of nitrate were completed in 2011. Typically, nitrate was applied at each of the three locations one day a week. One application location was in the northern half of Onondaga Lake, and the other two application locations were in the southern half of the lake.

Sufficient quantities of nitrate were added to and distributed naturally throughout the lower waters of Onondaga Lake in 2011 to inhibit methylmercury release from sediment. The target minimum nitrate-nitrogen concentration throughout the lower hypolimnion in 2011 while the lake was stratified was 1.0 milligrams per liter based on data available prior to 2011. The target quantity of nitrate applied during each single-day application was 2.3 metric tons which equated to 4,800 gallons of the liquid calcium nitrate. Given the liquid calcium nitrate has a density approximately 1.5 times as dense as water, dilution of the nitrate solution with lake epilimnion water at a ratio of epilimnion water to nitrate for each application ranging from 140 to 1 to over 500 to 1 was conducted to keep the nitrate near but above the bottom of the lake. Figure 1 is a photo of the self-propelled barge used to apply nitrate during 2011.

Monitoring of lake surface water during 2011 nitrate addition efforts was based on 34 locations where water quality was monitored three times weekly, two locations where water samples were collected weekly for laboratory analyses, and 10 locations where water samples were collected monthly for mercury analyses. Four indicator parameters (i.e., nitrate, sulfide, water temperature and specific conductivity) were measured in lake water three times weekly with *in situ* instrumentation at 34 locations throughout SMU 8 and at 0.25-meter water depth intervals: Mercury, nitrate, nitrite, ammonia, ferrous iron, and sulfide were measured in water column samples collected weekly at South Deep and at North Deep while nitrate was being applied. In addition, mercury analyses were conducted of water samples collected monthly at ten other locations.

Recurring seasonal depletion of nitrate and increases in methylmercury concentrations in lower depths of SMU 8 were prevented during 2011 as a result of nitrate additions (Figure 2). Methylmercury water concentrations in the lake hypolimnion were the lowest on record (Parsons and UFI, 2012).

1.3 WORK SCOPE MODIFICATIONS FOR 2012

Pilot test operations on the barge in 2012 are anticipated to be generally the same as in 2011 (Parsons and UFI, 2011) with two changes. First, larger dilution water pumps may be used on the barge in 2012 which would alter the size of flexible piping entering and exiting the dilution water pumps. Second, additional safety features are being added on the barge such as a more elevated position on the barge for the barge captain to enhance visibility while moving the barge.

Operations on shore during 2011 to store liquid calcium nitrate in a double-walled tank and add nitrate to the barge were conducted primarily at the Syracuse Inner Harbor. To ease access in 2012, plans are being made to provide nitrate storage and shore access to the barge adjacent to the lake shoreline owned by Honeywell.

Deep basin water quality conditions were very similar during the baseline monitoring period from 2008 through 2011 as summarized in Figure 2. This 2012 work plan addendum includes three modifications to the 2011 monitoring scope. These three modifications for monitoring during 2012 and rationale for the modifications are as follows:

- **Surface water sampling and analysis for mercury at South Deep only**

  During 2011, surface water sampling for mercury analyses was conducted at the North Deep location at the same frequency as conducted at the South Deep location. This additional work at North Deep during 2011 was based on additional sampling for the first year of the nitrate addition pilot test compared to prior years. Baseline monitoring results from past years show mercury concentrations in the southern portion of SMU 8 are similar to but generally higher than mercury concentrations in the northern portion due to more inputs of mercury to the southern portion. Conditions at the South Deep location are therefore conservatively representative of conditions throughout the deep-water portion of the lake. Surface water methylmercury results from 2011 show a strong correlation between South Deep and North Deep (Figure 3A). Higher surface water mercury concentrations at North Deep compared to South Deep during 2011 were limited to a single sampling event on September 26, 2011.

- **Zooplankton sampling and analysis for mercury at South Deep only**

  The correlation of zooplankton methylmercury results for 2011 between South Deep and North Deep is strong (Figure 3B). Average methylmercury concentrations in zooplankton collected at South Deep and North Deep during 2011 were 0.006 and 0.005 milligram per kilogram, respectively. The average total mercury in zooplankton collected at both South Deep and North Deep during 2011 was 0.15 milligram per kilogram (part per million). Zooplankton sampling during 2011 was conducted at the same frequency at both locations. Zooplankton samples will be collected from South Deep during 2012 at the same frequency as collected during 2011 with the most intense sampling being weekly from early September until fall turnover. The 2012 zooplankton sampling scope is described in the Tissue Monitoring Work Plan for 2012 and the same as the zooplankton sampling scope completed in 2008 and 2010 which is more than the zooplankton sampling scope completed in 2009. If Daphnia zooplankton are observed while zooplankton samples are being collected and sufficient biomass can be collected, then separate Daphnia samples will be submitted for mercury analysis as was done during recent years when Daphnia were observed.

- **Monthly surface water sampling and analyses for mercury from ten ISUS locations not included**

  In 2011, the purpose of monitoring mercury in surface water at ten ISUS locations monthly was to compare mercury concentrations with nitrate concentrations measured more frequently. Table 4C in the 2011 Baseline Monitoring Report (Parsons, Exponent and Anchor QEA, 2011, draft) presents a comparison of results from the ten ISUS locations with results from South Deep and North Deep measured from samples collected on the same six dates. The mean methylmercury concentration measured near the lake bottom at South Deep was 0.11 nanograms per liter compared to an average of 0.09 nanograms per liter measured near the lake bottom at the 10 ISUS locations. Concentrations of methylmercury at the lake bottom were very low throughout the 2011 nitrate addition efforts compared to concentrations measured in prior years (Figure 2). Surface water monitoring at South Deep during 2012 will include measurements near the lake bottom (Table 1).

Nitrate concentrations will be measured three times weekly with the ISUS at 0.25-meter water depth intervals and at each of 34 locations. If nitrate measurements during 2012 show significant concentrations below the nitrate objective of 1 mg/L as nitrogen in the hypolimnion at locations away from South Deep, then water samples and analyses for low-level total mercury and low-level methylmercury will be conducted in the vicinity of that location until nitrate-nitrogen concentrations climb back to their intended levels of 1.0 mg/L or higher. Based on 2011 pilot test monitoring results, significant concentrations of nitrate-nitrogen below 1.0 mg/L that could result in a release of methylmercury from sediments are defined as concentrations below 0.7 mg/L on two consecutive monitoring days.

SECTION 2

2012 DEEP BASIN (SMU 8) SURFACE WATER MONITORING AND SEDIMENT TRAP DEPLOYMENTS

Surface water samples for laboratory analyses will be collected at South Deep at the depths and frequencies specified in Table 1 consistent with the frequency of baseline surface water mercury monitoring (Parsons and Exponent, 2011). Analytes will be those pertinent to nitrate addition based on the sequence of electron acceptor reduction from oxygen to nitrate to ferrous iron to sulfide to methane (Table 2).

Spatially detailed monitoring of multiple parameters with the ISUS rapid profiling instrument (Table 3) will be conducted weekly at 34 locations. Field samples and quality control samples for laboratory analyses of water samples are listed in Table 4. In addition, a total of 10 profiles of total dissolved gases will be conducted during 2012 at a pace of one profile every other week from June through October.

Consistent with baseline monitoring efforts conducted during the years 2008 through 2011, *in situ* robotic measurements of dissolved oxygen, temperature, specific conductance, pH, fluorometric chlorophyll, redox potential, and turbidity will be at least made daily from May through November 2012 at 1-meter water depth intervals from a buoy located at South Deep (Table 5). Although these data will not be presented formally as part of the Honeywell monitoring program, the robotic data will again be available online at www.ourlake.org within a few hours of data measurements being collected.

Sediment trap samples will be collected again during 2012 at South Deep consistent with UFI's sediment trap design and deployment protocols. A set of three traps will be deployed weekly from June to October 2012 at the South Deep sampling site below the thermocline (at the 10-meter water depth). Sediment traps will generally be deployed for seven-day intervals. After retrieval, supernatant will be drained off via a stoppered opening located in the side of the traps well above the deposited sediments. The samples will then be homogenized, poured into polyethylene bottles, and put on ice. Solids from one trap collected on each date will be analyzed for total suspended solids. Solids from one trap collected on each date when zooplankton are collected will be analyzed for low-level total mercury.

Health and safety, quality assurance, data validation, data management and reporting for the 2012 nitrate addition efforts will be consistent with 2011 nitrate addition efforts. Interim results will be reviewed with NYSDEC as nitrate addition is being conducted. A report will be prepared that will summarize 2012 nitrate addition results. Surface water data usability will be presented in a Data Usability Summary Report that will be presented as an appendix to the 2012 report.

SECTION 3

REFERENCES

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FIGURES

FIGURE 1

PHOTO OF BARGE USED TO CONDUCT 2011 NITRATE ADDITION

FIGURE 2

VOLUME-WEIGHTED HYPOLIMNETIC AVERAGE WATER QUALITY CONDITIONS (10 TO 19-METER WATER DEPTHS)

DO – dissolved oxygen
Fe^{2+} - ferrous iron
MeHg – methylmercury
NO_3^- - nitrate-nitrogen
H_2S_T – sulfide
mgL^{-1} – milligram per liter (mg/L)

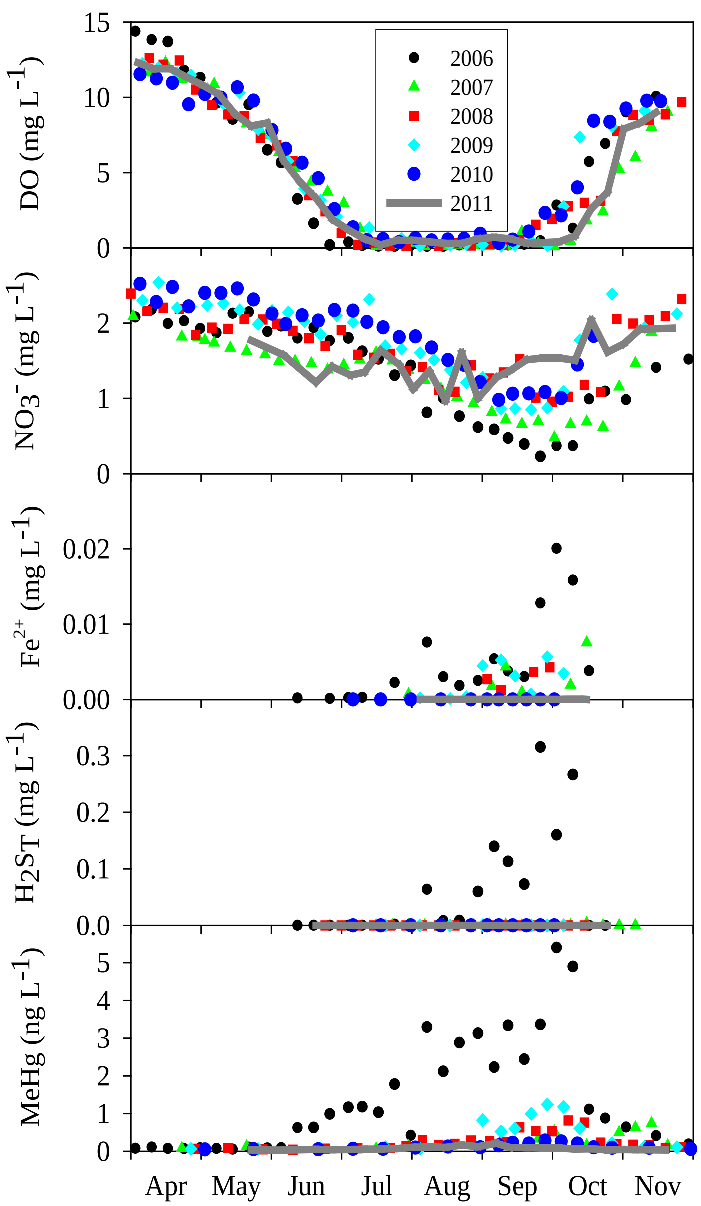
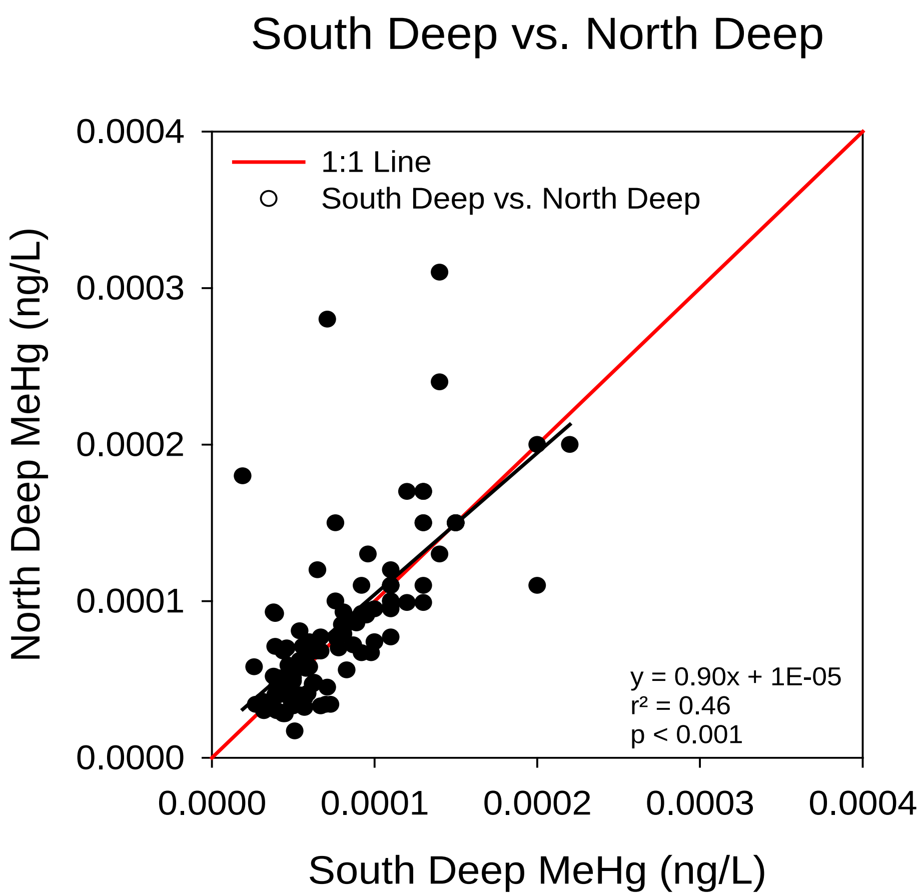


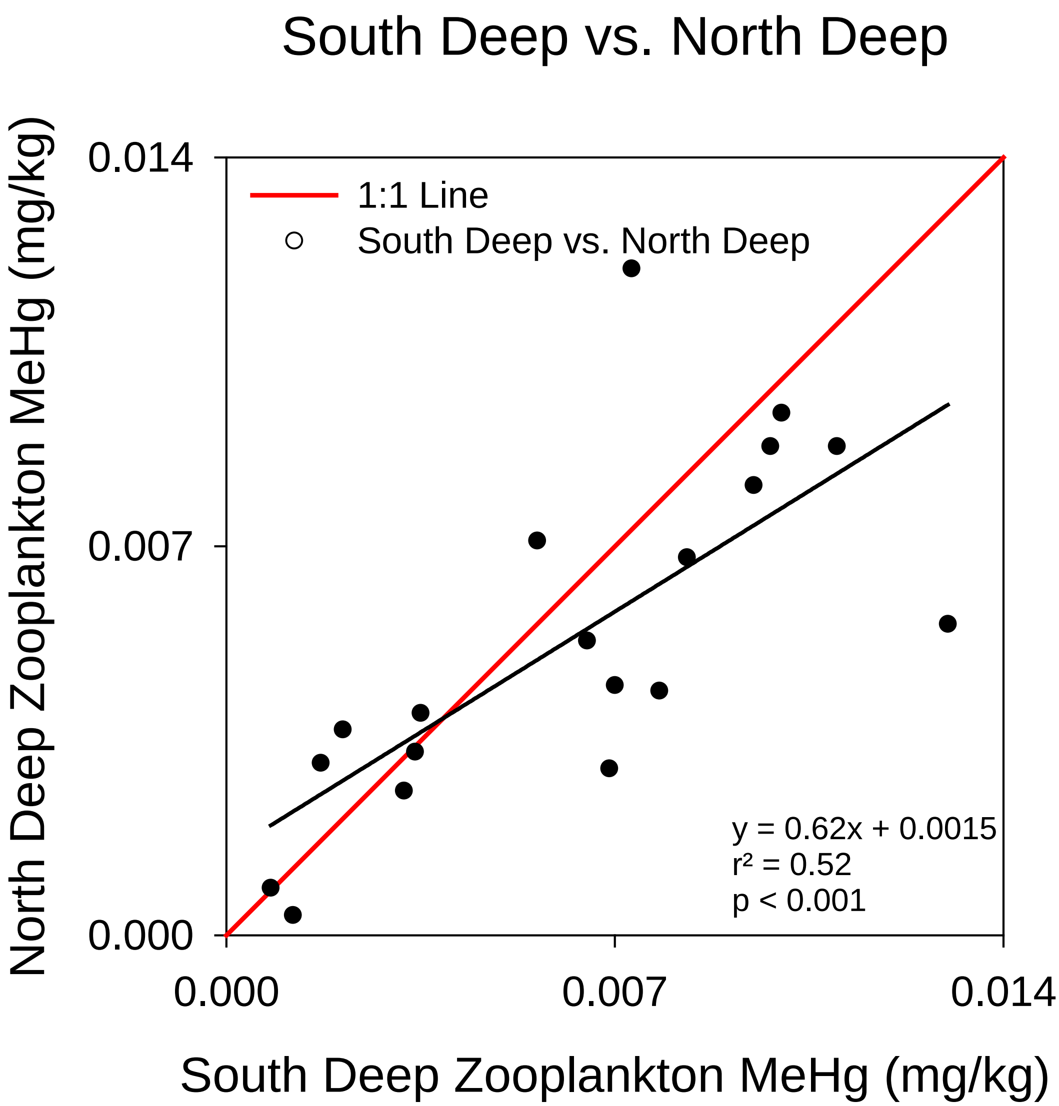
FIGURE 3

COMPARISON OF 2011 MERCURY RESULTS FROM SOUTH DEEP AND NORTH DEEP FOR SURFACE WATER AND ZOOPLANKTON

A. Surface Water



B. Zooplankton



TABLES

TABLE 1
WATER COLUMN SAMPLING SCHEDULE FOR 2012

Month	Water Column		
	Frequency	Sampling Date	South Deep Depths (m)
June	bi-weekly	6/4, 6/11, 6/25	2, 12, 18
July	weekly	7/2, 7/9, 7/16, 7/23 and 7/30	2, 10, 12, 16, 18
August	weekly	8/6, 8/13, 8/20, 8/27	2, 10, 12, 16, 18
September	weekly	9/4, 9/10, 9/17, 9/24	2, 10, 12, 14, 16, 18
October	weekly	10/1, 10/8, 10/15, 10/22, and 10/29	2, 10, 12, 14, 16, 18
November	bi-weekly	11/5, 11/19	2, 12, 18

Notes: 1. This sampling schedule is based on the lake being stratified from late May until the end of October and nitrate being added from late June until mid-October to maintain nitrate concentrations in the lake's hypolimnion above 1 milligram per liter. Weather and variations in lake inflows may result in changing the above dates. Any potential adjustments will be discussed with NYSDEC before being implemented.

2. Sediment traps will also be deployed and collected again in 2012 consistent with 2011 efforts.

TABLE 2
SPECIFICATIONS FOR 2012 LAKE MONITORING LABORATORY ANALYTES

Parameter	Method	South Deep Depths (m) and Dates	Total Number of Field Samples for 2012[x]
WATER			
Nitrate plus nitrite (NO_X)	EPA 353.2	See Table 1	119
Nitrite (NO_2^-)	EPA 353.2	See Table 1	119
Total ammonia ($T\text{-}NH_3$)	EPA 350.1	See Table 1	119
Dissolved organic and total inorganic carbon	SM18-20 5310C	See Table 1	119
Chloride	SM 18-20 4500 Cl^- C	See Table 1	119
Calcium	SM 18-20 3111B	See Table 1	119
+*Total mercury	EPA 1631E	See Table 1	119
+*Total mercury, dissolved	EPA 1631E	2-meter water depth once in June, bi-weekly thereafter plus the 14 meter water depth biweekly 9/10 to 11/5.	17
+*Methylmercury	EPA 1630	See Table 1	119
Sulfide (°H_2S method 2)	SM 18-20 4500 S^{2-} G	Weekly at three anoxic water depths during nitrate applications	54
Ferrous iron (Fe^{2+})	Heaney and Davison (1977)	Weekly at three anoxic water depths during nitrate applications	54
Methane	Addess (1990)	Weekly at three anoxic water depths from mid-July to mid-October	42
Soluble reactive phosphorus	SM 18-20 4500-PE	Ten different dates from late June through October from five different water depths (2 to 18 meters).	50
SEDIMENT TRAP SOLIDS (10-meter water depth)			
Total suspended solids	SM 2540D	Weekly	23
Total mercury	EPA 1631E	Every two weeks from May 31 to November 19 except weekly in September and October prior to lake turnover	17

Notes for Table 2:

The timing of nitrate application is assumed to be the week of June 25 through the week of October 15 (17 weeks) based on typical summertime lake conditions and 2011 nitrate addition results.

[x] Field samples based on dates and water depths presented in Table 1. See QAPP Worksheet #20 (Table 4) for total number of samples to laboratory including field blanks and field duplicates at one depth for total mercury and methylmercury, field duplicates for dissolved total mercury and for zooplankton total mercury and methylmercury. Field blanks are sample bottles that are filled in the laboratory, transported to the field, and then poured into a second sample bottle that is taken back to the laboratory for analysis.

[+] Total mercury and methyl mercury analysis will be performed by a qualified laboratory contracted by Honeywell. All other laboratory analyses will be performed by UFI.

TABLE 3

LIST OF ISUS (WATER) PARAMETERS

Parameter	Sensor[x]	Performance Accuracy/Resolution	Attribute/Value
Nitrate ($^{+}NO_3^-$)	Satlantic ISUS V2	0.5 μM (dl[1])	status, preferred electron acceptor
Sulfide ($^{+}HS^-$)	Satlantic ISUS V2		redox constituent, SO_4^-reduction
Temperature (T)	SBE 3F	± 0.002 °C/0.0003 °C	Stratification
Specific conductance (SC)	SBE4	± 3 μS/cm/0.1 μS/cm	tracer/stratification
Beam attenuation coefficient at 660 nm (**c**$_{660}$)	Wetlabs C-Star	± 0.1% transmission	particle indicator
Optical backscattering (OBS)	D&A OBS-3	± 0.25 NTU/0.1 NTU	particle indicator
Chlorophyll fluorescence (Chl_f)	Wetlabs WETstar	± NA/0.1 μg/L Chl	vertical pattern of phyto
Photosynthetically active irradiance PAR[6]	Li-Cor LI-193	± 5% reading	light penetration

[x] factory calibrated annually, maintained according to manufacturers instructions

[+] as described in Johnson and Coletti (2002)

[1] detection limit

TABLE 4

QAPP WORKSHEET 20 – FIELD QUALITY CONTROL SAMPLE SUMMARY TABLE FOR 2012 SMU 8 SURFACE WATER MONITORING

Matrix	Analytical Group	Concen-tration Level	Analytical and Preparation SOP Reference[1]	No. of Field Samples for Laboratory Analyses[2]	No. of Field Duplicates	Inorganic No. of MS[3]	No. of Field Blanks[4]	No. of Equip. Blanks	No. of PT Samples	Total No. of Samples to Lab
Water	Nitrate + Nitrite as N (NO_x)	Low		119	24		24			167
Water	Nitrate as N (NO_2)	Low		119	24		24			167
Water	Ammonia as N ($T\text{-}NH_3$)	Low		119	24		24			167
Water	Dissolved organic and total inorganic carbon	Low		119	24		24			167
Water	Chloride	Low		119	24		24			167
Water	Calcium			119	24		24			167
Water	Ferrous iron	Low		54	18		18			90
Water	Sulfide as S (Method 2)	Low		54	18		18			90
Water	Methane	Low		42	14		14			70
Water	Soluble reactive phosphorus	Low		50	10		10			70
Water	Total mercury	Low		119	24		24	12		179
Water	Filtered mercury	Low		17	2		2	2		23
Water	Methyl mercury	Low		119	24		24	12		179
Sediment trap solids	Total suspended solids	Moderate		23						23
Sediment trap solids	Total mercury	Low		17	5					22

Notes for Table 4:

[1] See Worksheet 23 in the Quality Assurance Project Plan (Parsons, UFI and Anchor QEA, 2012, in preparation).
[2] See Tables 1 and 2. Samples collected at different depths at the same location are counted separately.
[3] Matrix spike and matrix spike duplicate samples prepared by the laboratory at a frequency of at least one pair per 20 samples.
[4] Field blanks will consist of analyte-free water (i.e., water containing the analyte at concentrations below the minimum detection limit) placed in a clean sample bottle in the laboratory, transported to the field, and then poured into a second clean sample bottle for transport back to the laboratory.

TABLE 5

SPECIFICATIONS OF PROBES FOR ROBOTIC MONITORING AT SOUTH DEEP

Parameter	**Probe (YSI*)**	**Performance Accuracy/Resolution**	**Attribute/Value**
dissolved oxygen (DO)	6562	± 2% reading/0.1% saturation	electron acceptor
temperature (T)	6560	± 0.15 °C/0.01 °C	thermal stratification, mixing
specific conductance (SC)	6560	± 0.5% reading/1 μS	tracer, signature of injected chemical
pH	6565	± 0.2 units/0.01 units	chemical equilibria, sulfide species
fluorometric chl (Chl_f)	6025	± NA/0.1 μg/L Chl	metric of phytoplankton biomass
redox potential	6565	± 20 mV/ 0.1 mV	indicator of redox status
turbidity (Tn)	6136	± 2 NTU/0.1 NTU	vertical pattern of particles

* Model number of Yellow Springs Instruments (YSI) instrumentation