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April 15, 2011

Mr. John Strang
New York State Department of Environmental Conservation
1130 North Westcott Road
Schenectady, New York 12306-2014

Re: December 2010 Groundwater Sampling Results
Additional Evaluation of Lagoon Area Groundwater
Operable Unit 1
BASF Corporation, Rensselaer Site, Rensselaer, New York

Dear Mr. Strang:

As discussed at the January 26, 2011 meeting with the New York State Department of Environmental Conservation (NYSDEC) Natural Resource Damage (NRD) group, Roux Associates, Inc. (Roux Associates) has recently conducted groundwater sampling in the former Lagoon Area of the BASF Corporation (BASF) Rensselaer site. The objective of the sampling was to evaluate current levels of arsenic in lagoon groundwater after installation of replacement groundwater monitoring wells. These results provide additional perspective on groundwater conditions and have been used to provide to the NYSDEC this letter supplementing the July 19, 2010 Focused Feasibility Study (FFS), Lagoon Area Groundwater.

## Background

As discussed in the FFS, BASF has conducted a series of remedial actions designed to limit the mobility and impact of arsenic in the former Lagoon Area. These include removal of the sludge and liquids from the lagoons, removal of soil containing the highest concentrations of arsenic, conducting *in situ* treatment of groundwater, and most recently, installation of a cap across the entire former Lagoon Area.

### Lagoon Closure

The Lagoon Remediation Program was performed between October 2003 and June 2005. All waste material was removed and transported off-site for disposal, and the lagoon rip-rap was treated to remove residuals and placed back in the bottoms of the lagoons. As part of the closure 16,000 cubic yards of sludge and 6,347,500 gallons of water were treated and disposed of offsite. Samples from the clay below the lagoons were recovered and analyzed. It was shown that the post remediation samples were clean and the closure complete.

Soil Removal

Soil from the Lagoon Area containing the highest concentrations of arsenic was removed in two phases. The first phase, conducted in November 2002, consisted of the removal of approximately 3,800 cubic yards (5,500 tons) of soil. An additional 1,600 tons of soil were removed from beneath the north lagoon berm in April and May 2005. As shown on Plate 1 and Figure 1, the levels of arsenic remaining in soil above the water table in former Lagoon Area range from less than the NYSDEC Recommended Soil Cleanup Objective (RSCO) of 13 milligrams per kilogram (mg/kg) to 773 mg/kg. Arsenic concentrations in unsaturated zone soil across the majority of the former Lagoon Area were less than 100 mg/kg following the removal.

*In Situ* Treatment

In June 2004, BASF provided to the NYSDEC a work plan to conduct *in situ* treatment of arsenic in groundwater in the former Lagoon Area, rather than continue the extraction and treatment of groundwater from the area. Due to the silty nature of the saturated zone, the low saturated thickness beneath a significant portion of the Lagoon Area (less than 2 feet), and high dissolved solids groundwater, extraction and treatment of groundwater--even with collection trenches--proved to be not practicable. In May 2005, Enviro Associates, International (EAI) conducted an initial injection of Metals Remediation Compound (MRC$^{TM}$) into the former Lagoon Area. The theory behind the injection was that the MRC$^{TM}$, which consisted of a food-grade organic carbon source and a sulfate source, would create highly reducing conditions and provide adequate sulfate such that the arsenic in groundwater would precipitate as insoluble arsenic sulfides.

Several rounds of groundwater sampling were conducted following the initial injection of MRC$^{TM}$, and the results were positive. With the exception of conditions in PZ-10, which was located immediately adjacent to the former wastewater treatment system building, substantial decreases in arsenic concentrations were observed throughout the former Lagoon Area. As presented in the August 2007 Remedial Action Report and Remedial Action Work Plan, arsenic levels were reduced by as much as 81–98 percent in the majority of locations throughout the former Lagoon Area.

Despite the promising reductions in lagoon arsenic concentrations (see Figures 2A, 2B, and 2C), the NYSDEC Class GA ground water standard for arsenic of 25 micrograms per liter (µg/L) was not achieved after the first injection. Additionally, some rebound in arsenic concentrations was observed during groundwater sampling conducted between January and June 2006. Based on the initial observations of arsenic concentration reduction, a second round of injection was conducted in August 2006.

Groundwater sampling conducted following the second round of MRC$^{TM}$ injection provided results similar to those obtained following the first round of injection. Arsenic concentrations in groundwater declined, but did not meet the 25 µg/L standard for arsenic. Additionally, following a period of approximately ten months from August 2006 through May 2007 during which arsenic levels remained relatively stable, some limited rebound in arsenic concentrations was observed (graphs in Figures 2A, 2B, and 2C).

The groundwater monitoring results following the two injections were presented to the NYSDEC in the August 2007 Remedial Action Report and Remedial Action Work Plan Based on a review of the results BASF concluded that, although significant reductions in arsenic concentrations had been achieved, it was not likely that the 25 µg/L standard for arsenic could be achieved using this technology. Additionally, BASF predicted that additional rebound in arsenic concentrations was likely to occur when the MRC$^{TM}$ was depleted because it was not practicable to inject sufficient sulfate to prevent the oxidation-reduction (redox) conditions in the aquifer from returning to pre-injection levels.

At a November 2, 2007 meeting between the NYSDEC and BASF, the NYSDEC requested that BASF conduct one additional round of focused injection with the specific objective of assessing whether additional reductions in dissolved arsenic concentrations in groundwater using the MRC$^{TM}$ were achievable and sustainable. A Work Plan presenting the scope of work for the third MRC$^{TM}$ injection was provided to the NYSDEC in February 2008, and the injections were conducted in June 2008. As with the first two rounds, groundwater monitoring was conducted following the third injection. However, because of cap construction work planned in the former Lagoon Area, sampling was terminated in August 2008. During the August 2008 sampling, the results in comparison to pre-treatment levels in 2005 were mixed. Some wells showed declines ranging from 12 – 91 percent, while an increase was observed in one location (Figures 2A, 2B, and 2C).

The cumulative results of the three rounds of MRC$^{TM}$ injection were summarized in the July 19, 2010 FFS. The results of the groundwater sampling, along with additional information obtained from the technical literature were the basis for the conclusion in the FFS that additional *in situ* treatment of arsenic in groundwater would not result in further sustained reductions in arsenic concentrations.

During a September 28, 2010 project status meeting with the NYSDEC, BASF was requested to provide additional support for this conclusion. At that time, installation of the replacement groundwater monitoring wells was pending completion of the cap construction, and it was decided to await the results from these wells before responding to the NYSDEC request.

### Cap Construction

In June 2008, Roux Associates provided to the NYSDEC a work plan to install a vegetated phytotechnology cap across the former Lagoon Area. Based on water budget calculations prepared by Roux Associates and provided to the NYSDEC, the cap was designed to provide functional equivalence to a low permeability cap[1], and included grading to promote runoff, and the use of a planting layer that would both store precipitation in the soil matrix and use plant evapotranspiration to prevent infiltration into the subsurface.

The cap was installed in 2009 and 2010. At this time, all plantings have been completed and the water management function will increase as the plantings mature.

## December 2010 Groundwater Sampling Results

On December 7, 2010, groundwater samples were obtained from ten Lagoon Area monitoring wells, including the eight replacement wells. The samples were analyzed for Target Analyte List (TAL) Metals. Both unfiltered and filtered samples (using a 0.45 micron filter) were collected.

The results of the groundwater sampling are presented in Table 1 and Figure 3. As shown on Table 1, arsenic, manganese, and sodium were all found above their respective Ambient Water-Quality Standards and Guidance Value (AWQSGV). With the exception of the arsenic concentrations in LG-MW-4R, all three metals were found at levels greater than the AWQSGV in all unfiltered and unfiltered samples from all wells.

Of particular import in the comparison of the arsenic concentrations in the replacement wells with the arsenic concentrations found prior to the MRC™ injections were initiated. As presented in Figures 2A, 2B, and 2C, arsenic concentrations in replacement wells MW-4R and PZ–6R remain at levels well below those found prior to initiating treatment in 2005. However, levels in MW-2R, MW-6R, and PZ-14R are higher than those observed in April 2005.

As presented on Figure 3, positive redox conditions were observed in MW-2R and MW-4R. All of the other wells in the former Lagoon Area were found to have relatively strongly reducing conditions (ORP of -168 to -97 mV).

## Discussion

After evaluating the results of the post-treatment groundwater monitoring results and conducting additional review of the technical literature regarding the behavior of arsenic in groundwater, it has been concluded that:

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[1] A low permeability cap was specified in the September 2003 Record of Decision.

1. While the MRC$^{TM}$ injections were effective in achieving sustained reductions in arsenic concentrations in groundwater in some portions of the former Lagoon Area, the results were not sustained in all locations.

2. Although arsenic is found in relatively low concentrations in unsaturated zone soil throughout the majority of the former Lagoon Area, indicating that no source areas remain above the water table, geochemical conditions are such that the Class GA groundwater standard of 25 µg/L is not achieved.

3. Although the high concentrations sources of arsenic were excavated, and three rounds of *in situ* treatment were performed, the geochemical conditions of the saturated zone beneath the Lagoon area are such that the Class GA groundwater standard of 25 µg/L are not achievable using known remedial technologies.

These observations are the basis for the FFS conclusion that Alternative 3, continued injections of MRC$^{TM}$ will not achieve the SCGs or further reduce toxicity, mobility or volume through treatment. Additional discussion to support this conclusion is presented in the following sections.

### Relationship between Arsenic in Soil and Groundwater

Arsenic is present in groundwater because either natural or anthropogenic arsenic present in the formation dissolves into the groundwater. The concentrations of dissolved arsenic in groundwater are limited or controlled by either precipitation reactions or sorption onto minerals in the formation. In precipitation reactions, the dissolved-phase arsenic will, under the correct geochemical conditions, form insoluble precipitates with iron, barium, sulfides and other materials. In sorption, the dissolved arsenic will, under certain geochemical conditions, adsorb onto aquifer matrix surfaces; usually due to the presence of iron and manganese oxy-hydroxide coatings on aquifer matrix particle surfaces, as will be discussed below.

The extent to which these reactions occur is determined by the composition of the formation and the geochemistry of the groundwater. In particular, redox conditions in the aquifer strongly affect the extent to which arsenic will sorb/precipitate to the solid phase or be present in the dissolved phase. As extensively documented in the literature, the partitioning of arsenic between the solid and dissolved phases is controlled to a large degree by the arsenic adsorption and co-precipitation with iron oxides and iron oxyhydroxides. Further, under oxidizing conditions, the dominant species of arsenic present is most likely to be arsenate [As(V)], which can also sorb onto other materials, including clays.

Under reducing conditions, however, the iron oxides and iron oxyhydroxides undergo reductive dissolution (they dissolve into the groundwater), and the coprecipitated and sorbed arsenic is released to the dissolved phase. Additionally, under reducing conditions, arsenite [As(III)] is the primary form of arsenic found, and it does not sorb as effectively to matrices other than iron oxides and iron oxyhydroxides.

Therefore, the dissolved-phase concentrations of arsenic will typically be greater under reducing conditions than under oxidizing conditions.

Distribution Coefficient

The relationship between the arsenic concentration in soil and the arsenic concentration in groundwater is usually expressed as the "partitioning" or "distribution" coefficient, $K_d$. This coefficient is typically expressed in units of milligrams per kilogram (mg/kg) in soil per milligrams per liter (mg/l) in groundwater (mg/kg / mg/l). Simplifying units, the $K_d$ is typically expressed as liters per kilogram (l/kg) or the equivalent milliliters per gram (ml/g). The higher the $K_d$, the greater the partitioning to the sorbed phase compared to the dissolved phase.

The most recent groundwater data and the soil sampling results obtained during the Remedial Investigation for the former Lagoon were used to calculate the range of arsenic distribution coefficients across the former Lagoon Area.

For example, in MW-4R, the most recent concentration of arsenic in groundwater was 7.2 µg/L, and the arsenic concentration in soil in adjacent boring LG-SB-114 at the 8'- 10' depth was 8 mg/kg. Using the relationship of:

$$K_d = \frac{Cs}{Cgw} \quad \text{or} \quad K_d = \frac{8\ mg/kg}{.0072\ mg/l}$$

> where $C_s$ is the soil arsenic concentration (mg/kg), and $C_{gw}$ is the groundwater arsenic concentration (mg/l), a distribution coefficient of approximately 1,100 l/kg is obtained.

However, the distribution coefficient in PZ-6R, located along the western side of the former Lagoon Area, is very different. The most recent concentration of arsenic in groundwater was 700 µg/L. At adjacent soil boring location LG-SB-108, arsenic was found at a concentration of 143 mg/kg in the 8' – 10' interval. Using the relationship:

$$K_d = \frac{143\ mg/kg}{.700\ mg/l}$$

> a $K_d$ of approximately 200 l/kg is obtained. In other words, the arsenic partitions to groundwater in PZ-6R at a ratio five times greater than at PZ-4R.

The explanation for this observation is most likely the differing geochemistry in the immediate vicinity of each well. As shown in the attached groundwater sampling logs, although neither MW-4R nor PZ-6R contained any measurable amount of dissolved oxygen, the oxidation-reduction potential (ORP) in MW-4R was positive, while the ORP in PZ-6R was strongly negative (-168 mV). A similar observation is obtained when comparing the estimated distribution in MW-2R, in which a positive ORP was obtained, with that in MW-5R, in which reducing conditions were observed. The calculated distribution coefficient in MW-2R is approximately 500 l/kg while in MW-5R it is approximately 15 l/kg.

**Summary**

It is apparent that localized variations in redox conditions is the controlling factor in the variations in concentrations of arsenic measured in groundwater. The redox conditions are mediated by high iron concentrations in the aquifer matrix beneath the former Lagoon Area and which helps explain why *in situ* remedial efforts have yielded mixed results. As shown on Plate 1 and Figure 1, the arsenic concentrations in soil across the entire former Lagoon Area are generally consistent, supporting a conclusion that the differences in arsenic concentrations in groundwater are not primarily a function of arsenic concentrations in soil. However, in the four wells in which reducing conditions were observed, arsenic concentrations ranged from 270 µg/L to 13,000 µg/L, but were 7.2 µg/L and 94 µg/L in the two wells in which oxidizing conditions were observed.

As has been presented to the NYSDEC in previous documents, including the FFS, there is little, if any, groundwater flow through the former Lagoon Area due to the presence of the cap, the bulkhead, and the low transmissivity of the formation. Operation of the groundwater extraction and treatment system along the western border of the Main Plant prevents any meaningful flow from east to west into the former Lagoon Area, the bulkhead along the Hudson River prevents flow from the former Lagoon Area into the river, and the cap limits the infiltration of rainwater into the lagoon area. As documented in the June 29, 2010 letter providing the results of the PZ-10 investigation, groundwater is present as a thin, stagnant perched water zone in a low transmissivity formation beneath the former Lagoon Area. This statement is supported by the depth to groundwater measurements (11.5 – 15.3 feet) from the December 2010 sampling event.

Therefore, the reducing conditions observed in groundwater beneath the former Lagoon Area are further promoted due to the negligible supply of groundwater or recharge. The limited dissolved oxygen (DO) in the groundwater beneath the former Lagoon Area will be rapidly depleted, and reducing conditions will be created. This is illustrated by the absence of any measurable DO in any well except MW-2R and MW-4R (Figure 3).

The reducing conditions created by the stagnant groundwater would be predicted, based on the known sensitivity of arsenic to redox conditions, to result in elevated arsenic concentrations in groundwater. Therefore, the groundwater geochemistry creates conditions under which arsenic partitioning to groundwater is favored over sorption to the soil matrix. Under these conditions, even achieving the NYSDEC RSCO for arsenic in soil would not ensure that the NYSDEC groundwater standard for arsenic of 25 µg/L would be achieved. Using, for example the distribution coefficient calculated at PZ-6R (200 l/kg), the equilibrium groundwater concentration associated with the RSCO for soil (13 mg/kg) would be 65 µg/L.

**Conclusions**

The above discussion, calculations and observations support several conclusions regarding dissolved arsenic in Lagoon Area groundwater:

1. Dissolved arsenic is in local equilibrium with adsorbed and precipitated arsenic below the water table.
2. The primary factor influencing the concentrations of arsenic in groundwater is the redox condition in groundwater—which tend to be reducing—not the arsenic concentrations in soil.
3. The redox conditions are mediated largely by high iron concentrations beneath the lagoon area.
4. The reducing conditions are exacerbated by the absence of significant groundwater flow through the former Lagoon Area.
5. Although lower concentrations of dissolved phase arsenic were sustained in MW-4R and PZ-6R in response to *in situ* remediation, they were not sustained in other locations of the former Lagoon Area.
6. While further temporary reductions in dissolved phase arsenic concentrations may be achieved through additional MRC injections, rebound will occur as equilibrium conditions are re-established.

The results of the December groundwater monitoring and the analysis provided above support a conclusion that the recommendation in the FFS to continue groundwater monitoring and conduct operation and maintenance of the cap is the appropriate remedial alternative for groundwater in the former Lagoon Area. The previous remediation efforts conducted by BASF, including the lagoon remediation, soil removal, installation of the groundwater extraction and treatment system and construction of the cap, provide a protective solution for the lagoon groundwater. There is no potential for direct contact with the ground water, and both the hydraulic and the sediment chemistry data support the conclusion that there is no impact to the sediment adjacent to the former Lagoon Area.

Additional active remediation of arsenic in Lagoon Area groundwater will not provide further sustainable reductions in arsenic concentrations. The December 2010 groundwater monitoring results document that additional MRC$^{TM}$ injections will not provide additional sustainable reductions in arsenic concentrations. Further, additional soil removal to achieve the NYSDEC RSCO for soil is not guaranteed to result in achieving the 25 µg/L arsenic standard. The reducing conditions responsible for the elevated arsenic are directly related to the fact that there is virtually no groundwater flow, and therefore virtually no arsenic transport, through the former Lagoon Area. As a result, the arsenic in groundwater is essentially immobile, and presents negligible to no risk to human health or the environment.

We greatly appreciate the NYSDEC continuing to work cooperatively with BASF toward the goal of completion of the remediation of OU-1 at the BASF Rensselaer Site.

If you have any questions, or require additional information, please do not hesitate to call.

Sincerely,

ROUX ASSOCIATES, INC.

Nathan Epler

Nathan Epler, Ph.D.
Principal Hydrogeologist

cc: J. Douglas Reid-Green, BASF Corporation
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Charlie McGuckin, Roux Associates

# Table 1. Summary of Metals in Groundwater, BASF Rensselaer

| Parameter (Concentrations in µg/L) | NYSDEC AWQSGVs (µg/L) | **Sample Designation:** | LG-MW-2R | LG-MW-2R | LG-MW-4R | LG-MW-4R | LG-MW-5R | LG-MW-5R | LG-MW-6R |
|---|---|---|---|---|---|---|---|---|---|
| | | **Sample Date:** | 12/7/2010 | 12/7/2010 | 12/7/2010 | 12/7/2010 | 12/7/2010 | 12/7/2010 | 12/7/2010 |
| | | | | Filtered | | Filtered | | Filtered | |
| Aluminum | -- | | 125 U | 125 U | 26.9 J | 125 U | 47.6 J | 125 U | 55.4 J |
| Antimony | 3 | | 2.3 J | 1.9 J | 4 U | 4 U | 4 U | 4 U | 4 U |
| Arsenic | 25 | | **93.2** | **93.6** | 6.4 | 7.2 | **760** | **680** | **13400** |
| Barium | 1000 | | 187 | 187 | 94.2 | 96.4 | 227 | 225 | 210 |
| Beryllium | 3 | | 2.5 U | 2.5 U N | 2.5 U | 2.5 U N | 2.5 U | 2.5 U N | 2.5 U |
| Cadmium | 5 | | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U |
| Calcium | -- | | 283000 | 273000 | 137000 | 135000 | 212000 | 198000 | 193000 |
| Chromium | 50 | | 2.9 J | 2.5 J | 2.8 J | 2.2 J | 1.5 J | 1.5 J | 2.3 J |
| Cobalt | -- | | 2.5 U | 2.5 U | 0.81 J | 0.85 J | 3.2 | 3.2 | 3 |
| Copper | 200 | | 1 J | 1.1 J | 1.4 J | 1.2 J | 0.56 J | 0.57 J | 5 U |
| Iron | -- | | 187 | 130 | 223 | 191 | 15700 | 15500 | 39500 |
| Lead | 25 | | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U |
| Magnesium | -- | | 41500 | 42500 | 19100 | 19600 | 31200 | 30300 | 31400 |
| Manganese | 1 | | **43.3** | **40.4** | **333** | **330** | **1600** | **1560** | **3290** |
| Mercury | 0.7 | | 0.2 U | 0.2 U | 0.2 U | 0.2 U | 0.2 U | 0.2 U | 0.2 U |
| Nickel | 100 | | 1.9 J | 2 J | 1.5 J | 1.7 J | 1.8 J | 1.8 J | 1.7 J |
| Potassium | -- | | 6420 | 6300 | 2780 | 2760 | 3140 | 2640 | 5670 |
| Selenium | 10 | | 1.5 J | 1.1 J | 5 U | 5 U | 5 U | 5 U | 5 U |
| Silver | 50 | | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U |
| Sodium | 20000 | | **293000** | **309000** | **23600** | **24400** | **115000** | **113000** | **48700** |
| Thallium | 0.5 | | 3.5 U | 3.5 U | 3.5 U | 3.5 U | 3.5 U | 3.5 U | 3.5 U |
| Vanadium | -- | | 1.2 J | 1.2 J | 1.2 J | 1 J | 0.52 J | 0.63 J | 0.73 J |
| Zinc | 2000 | | 25 U | 25 U | 25 U | 25 U | 2.9 J | 25 U | 25 U |

NYSDEC - New York State Department of Environmental Conservation
AWQSGVs - Ambient Water-Quality Standards and Guidance Values
µg/L -Micrograms per liter
J - Estimated Value
U - Compound was analyzed for but not detected
DUP - Duplicate
- - No NYSDEC AWQSGV available
Bold data indicates that parameter was detected above the NYSDEC AWQSGVs
NA - Compound was not analyzed by laboratory
N- Spiked sample recovery is not within control limits

# Table 1. Summary of Metals in Groundwater, BASF Rensselaer

| | NYSDEC | **Sample Designation:** | LG-MW-6R | LG-MW-25 | LG-MW-25 | LG-MW-26 | LG-MW-26 | LG-PZ-6R | LG-PZ-6R | LG-PZ-10R |
|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | AWQSGVs | **Sample Date:** | 12/7/2010 | 12/7/2010 | 12/7/2010 | 12/7/2010 | 12/7/2010 | 12/7/2010 | 12/7/2010 | 12/7/2010 |
| (Concentrations in µg/L) | (µg/L) | | Filtered | | Filtered | | Filtered | | Filtered | |
| Aluminum | -- | | 125 U | 23700 | 125 U | 2660 | 39.2 J | 214 | 125 U | 125 U |
| Antimony | 3 | | 4 U | 1.3 J | 1.1 J | 4 U | 4 U | 4 U | 4 U | 1.6 J |
| Arsenic | 25 | | **13100** | **120** | **43.8** | **112** | **103** | **688** | **700** | **7320** |
| Barium | 1000 | | 213 | 495 | 203 | 109 | 102 | 105 | 106 | 9.8 |
| Beryllium | 3 | | 2.5 U N | 1.1 J | 2.5 U N | 2.5 U | 2.5 U N | 2.5 U | 2.5 U N | 2.5 U |
| Cadmium | 5 | | 2.5 U | 0.63 J | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U |
| Calcium | -- | | 188000 | 184000 | 162000 | 74800 | 75800 | 134000 | 130000 | 148000 |
| Chromium | 50 | | 2.5 J | 41.9 | 1.6 J | 6.8 | 2.3 J | 2.2 J | 2.3 J | 2.3 J |
| Cobalt | -- | | 3 | 20.5 | 1.5 J | 1.9 J | 2.5 U | 2.5 U | 2.5 U | 0.85 J |
| Copper | 200 | | 5 U | 144 | 5 U | 6.4 | 0.56 J | 0.67 J | 5 U | 1 J |
| Iron | -- | | 41000 | 49800 | 5740 | 4270 | 966 | 13800 | 13800 | 512 |
| Lead | 25 | | 2.5 U | **410** | 2.5 U | 17.4 | 0.5 J | 0.65 J | 2.5 U | 2.5 U |
| Magnesium | -- | | 32100 | 35600 | 24800 | 8200 | 7980 | 24800 | 24900 | 28400 |
| Manganese | 1 | | **3330** | **3230** | **2580** | **1030** | **960** | **1390** | **1410** | **302** |
| Mercury | 0.7 | | 0.2 U | **2.7** | 0.2 U | 0.075 J | 0.2 U | 0.2 U | 0.2 U | 0.2 U |
| Nickel | 100 | | 1.7 J | 41 | 1.3 J | 3.8 | 0.84 J | 0.84 J | 0.52 J | 2.8 |
| Potassium | -- | | 5680 | 11500 | 9390 | 16400 | 16500 | 3300 | 3250 | 6380 |
| Selenium | 10 | | 5 U | 4.3 J | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| Silver | 50 | | 2.5 U | 1.3 J | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U |
| Sodium | 20000 | | **50400** | **131000** | **136000** | **39400** | **43600** | **49500** | **50600** | **73900** |
| Thallium | 0.5 | | 3.5 U | 3.5 U | **1.7 J** | 3.5 U | 3.5 U | 3.5 U | 3.5 U | 3.5 U |
| Vanadium | -- | | 0.75 J | 35.2 | 0.8 J | 5 | 0.98 J | 1 J | 0.95 J | 1.9 J |
| Zinc | 2000 | | 25 U | 303 | 25 U | 16.3 J | 25 U | 3.9 J | 25 U | 38 |

NYSDEC - New York State Department of Environmental Conservation

AWQSGVs - Ambient Water-Quality Standards and Guidance Values

µg/L -Micrograms per liter

J - Estimated Value

U - Compound was analyzed for but not detected

DUP - Duplicate

- - No NYSDEC AWQSGV available

Bold data indicates that parameter was detected above the NYSDEC AWQS

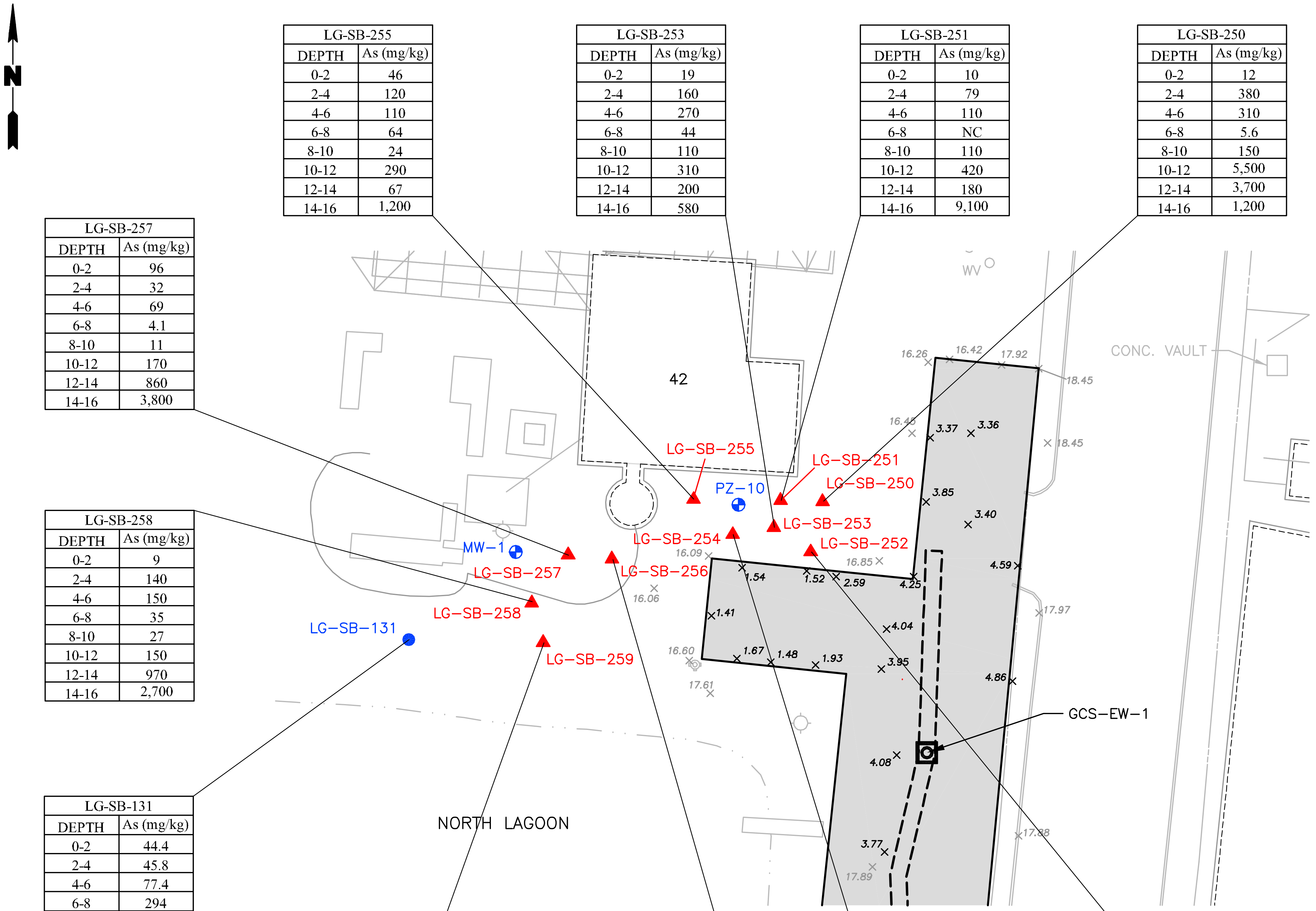
NA - Compound was not analyzed by laboratory

N- Spiked sample recovery is not within control limits

# Table 1. Summary of Metals in Groundwater, BASF Rensselaer

| Parameter (Concentrations in µg/L) | NYSDEC AWQSGVs (µg/L) | **Sample Designation:**<br>**Sample Date:** | LG-PZ-10R<br>12/7/2010<br>Filtered | LG-PZ-14R<br>12/7/2010 | LG-PZ-14R<br>12/7/2010<br>Filtered | LG-PZ-15R<br>12/7/2010 | LG-PZ-15R<br>12/7/2010<br>Filtered | LG-PZ-24R<br>12/7/2010 | LG-PZ-24R<br>12/7/2010<br>Filtered |
|---|---|---|---|---|---|---|---|---|---|
| Aluminum | -- | | 125 U | 53.4 J | 125 U | 803 | 60.9 J | 268 | 125 U |
| Antimony | 3 | | 1.2 J | 4 U | 4 U | 4 U | 4 U | 4 U | 4 U |
| Arsenic | 25 | | **7480** | **298** | **270** | **648** | **602** | **552** | **286** |
| Barium | 1000 | | 10.6 | 151 | 155 | 149 | 142 | 102 | 97.2 |
| Beryllium | 3 | | 2.5 U N | 2.5 U | 2.5 U N | 2.5 U | 2.5 U N | 2.5 U | 2.5 U N |
| Cadmium | 5 | | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 1.2 J | 1.3 J |
| Calcium | -- | | 145000 | 98400 | 97700 | 165000 | 163000 | 228000 | 227000 |
| Chromium | 50 | | 2.7 J | 1.5 J | 1.6 J | 4.5 J | 2.6 J | 3.7 J | 2.4 J |
| Cobalt | -- | | 0.83 J | 2.5 U | 2.5 U | 2.9 | 2.4 J | 1.8 J | 1.8 J |
| Copper | 200 | | 0.91 J | 5 U | 5 U | 2.7 J | 0.86 J | 4.4 J | 3.3 J |
| Iron | -- | | 604 | 14300 | 14200 | 3160 | 1850 | 2000 | 776 |
| Lead | 25 | | 2.5 U | 2.5 U | 2.5 U | 1.6 J | 2.5 U | 0.81 J | 2.5 U |
| Magnesium | -- | | 29200 | 13900 | 14200 | 29300 | 29900 | 53800 | 55600 |
| Manganese | 1 | | **326** | **2900** | **2860** | **1640** | **1670** | **886** | **906** |
| Mercury | 0.7 | | 0.2 U | 0.2 U | 0.2 U | 0.2 U | 0.2 U | 0.2 U | 0.2 U |
| Nickel | 100 | | 2.9 | 0.8 J | 1.2 J | 4.8 | 3.9 | 36.5 | 37.7 |
| Potassium | -- | | 6360 | 5000 | 4890 | 5340 | 5070 | 8650 | 8580 |
| Selenium | 10 | | 1.5 J | 5 U | 1 J | 5 U | 5 U | 2.8 J | 3.2 J |
| Silver | 50 | | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U | 2.5 U |
| Sodium | 20000 | | **77400** | **201000** | **210000** | **126000** | **135000** | **289000** | **304000** |
| Thallium | 0.5 | | 3.5 U | 3.5 U | 3.5 U | 3.5 U | 3.5 U | 3.5 U | 3.5 U |
| Vanadium | -- | | 2.2 J | 0.78 J | 0.77 J | 2.6 | 1.1 J | 1.8 J | 1.3 J |
| Zinc | 2000 | | 36.9 | 27.7 | 25 U | 7.3 J | 25 U | 289 | 282 |

NYSDEC - New York State Department of Environmental Conservation
AWQSGVs - Ambient Water-Quality Standards and Guidance Values
µg/L -Micrograms per liter
J - Estimated Value
U - Compound was analyzed for but not detected
DUP - Duplicate
- - No NYSDEC AWQSGV available
Bold data indicates that parameter was detected above the NYSDEC AWQS
NA - Compound was not analyzed by laboratory
N- Spiked sample recovery is not within control limits



| LG-SB-255 | |
|---|---|
| DEPTH | As (mg/kg) |
| 0-2 | 46 |
| 2-4 | 120 |
| 4-6 | 110 |
| 6-8 | 64 |
| 8-10 | 24 |
| 10-12 | 290 |
| 12-14 | 67 |
| 14-16 | 1,200 |

| LG-SB-253 | |
|---|---|
| DEPTH | As (mg/kg) |
| 0-2 | 19 |
| 2-4 | 160 |
| 4-6 | 270 |
| 6-8 | 44 |
| 8-10 | 110 |
| 10-12 | 310 |
| 12-14 | 200 |
| 14-16 | 580 |

| LG-SB-251 | |
|---|---|
| DEPTH | As (mg/kg) |
| 0-2 | 10 |
| 2-4 | 79 |
| 4-6 | 110 |
| 6-8 | NC |
| 8-10 | 110 |
| 10-12 | 420 |
| 12-14 | 180 |
| 14-16 | 9,100 |

| LG-SB-250 | |
|---|---|
| DEPTH | As (mg/kg) |
| 0-2 | 12 |
| 2-4 | 380 |
| 4-6 | 310 |
| 6-8 | 5.6 |
| 8-10 | 150 |
| 10-12 | 5,500 |
| 12-14 | 3,700 |
| 14-16 | 1,200 |

| LG-SB-257 | |
|---|---|
| DEPTH | As (mg/kg) |
| 0-2 | 96 |
| 2-4 | 32 |
| 4-6 | 69 |
| 6-8 | 4.1 |
| 8-10 | 11 |
| 10-12 | 170 |
| 12-14 | 860 |
| 14-16 | 3,800 |

| LG-SB-258 | |
|---|---|
| DEPTH | As (mg/kg) |
| 0-2 | 9 |
| 2-4 | 140 |
| 4-6 | 150 |
| 6-8 | 35 |
| 8-10 | 27 |
| 10-12 | 150 |
| 12-14 | 970 |
| 14-16 | 2,700 |

| LG-SB-131 | |
|---|---|
| DEPTH | As (mg/kg) |
| 0-2 | 44.4 |
| 2-4 | 45.8 |
| 4-6 | 77.4 |
| 6-8 | 294 |
| 8-10 | 25.3 |
| 10-12 | 10.1 |

| LG-SB-259 | |
|---|---|
| DEPTH | As (mg/kg) |
| 0-2 | 8.7 |
| 2-4 | 13 |
| 4-6 | 120 |
| 6-8 | 250 |
| 8-10 | 79 |
| 10-12 | 160 |
| 12-14 | 28 |
| 14-16 | 440 |

| LG-SB-256 | |
|---|---|
| DEPTH | As (mg/kg) |
| 0-2 | 13 |
| 2-4 | 11 |
| 4-6 | 4.9 |
| 6-8 | 4.7 |
| 8-10 | 7.2 |
| 10-12 | 510 |
| 12-14 | 860 |
| 14-16 | 2,100 |

| LG-SB-254 | |
|---|---|
| DEPTH | As (mg/kg) |
| 0-2 | 22 |
| 2-4 | 51 |
| 4-6 | 140 |
| 6-8 | 13 |
| 8-10 | 18 |
| 10-12 | 890 |
| 12-14 | 83 |
| 14-16 | 4,600 |

| LG-SB-252 | |
|---|---|
| DEPTH | As (mg/kg) |
| 0-2 | 7.4 |
| 2-4 | 39 |
| 4-6 | 31 |
| 6-8 | 14 |
| 8-10 | 9.7 |
| 10-12 | 1,400 |
| 12-14 | 550 |
| 14-16 | 8,900 |

LEGEND

| | |
|---|---|
| ▨ | EXCAVATION TO APPROXIMATELY 1' BELOW THE WATER TABLE (SEE NOTE 1) |
| 3.61 × | LOCATION OF SURVEY CONTROL POINT AND ELEVATION OF EXCAVATION BOTTOM IN FEET RELATIVE TO MEAN SEA LEVEL |
| 18.01 × | LOCATION OF SURVEY CONTROL POINT AND ELEVATION OF SURROUNDING GRADE IN FEET RELATIVE TO MEAN SEA LEVEL |
| ▲ | GEOPROBE SAMPLING LOCATION (12/09) |
| ● | SOIL BORING COMPLETED DURING ADDITIONAL REMEDIAL INVESTIGATION ACTIVITIES (2/01) |

NOTE

WATER TABLE ELEVATION WAS APPROXIMATELY 13 TO 14 FEET BELOW LAND SURFACE IN THE VICINITY OF AREA 4A DURING THE PERFORMANCE OF THE SOIL IRM.

30' 0 30'

Title:

# SUMMARY OF ARSENIC IN SOIL IN VICINITY OF PZ-10

LAGOON AREA
RENSSELAER, NEW YORK FACILITY

Prepared For:

BASF CORPORATION
FLORHAM PARK, NEW JERSEY

ROUX
ROUX ASSOCIATES, INC.
*Environmental Consulting and Management*

| | | |
|---|---|---|
| Compiled by: N.E. | Date: 31MAR11 | FIGURE |
| Prepared by: J.A.D. | Scale: AS SHOWN | 1 |
| Project Mgr: N.E. | Project: 0251.0011Y040 | |
| File: 0251.0011Y569.01 | | |

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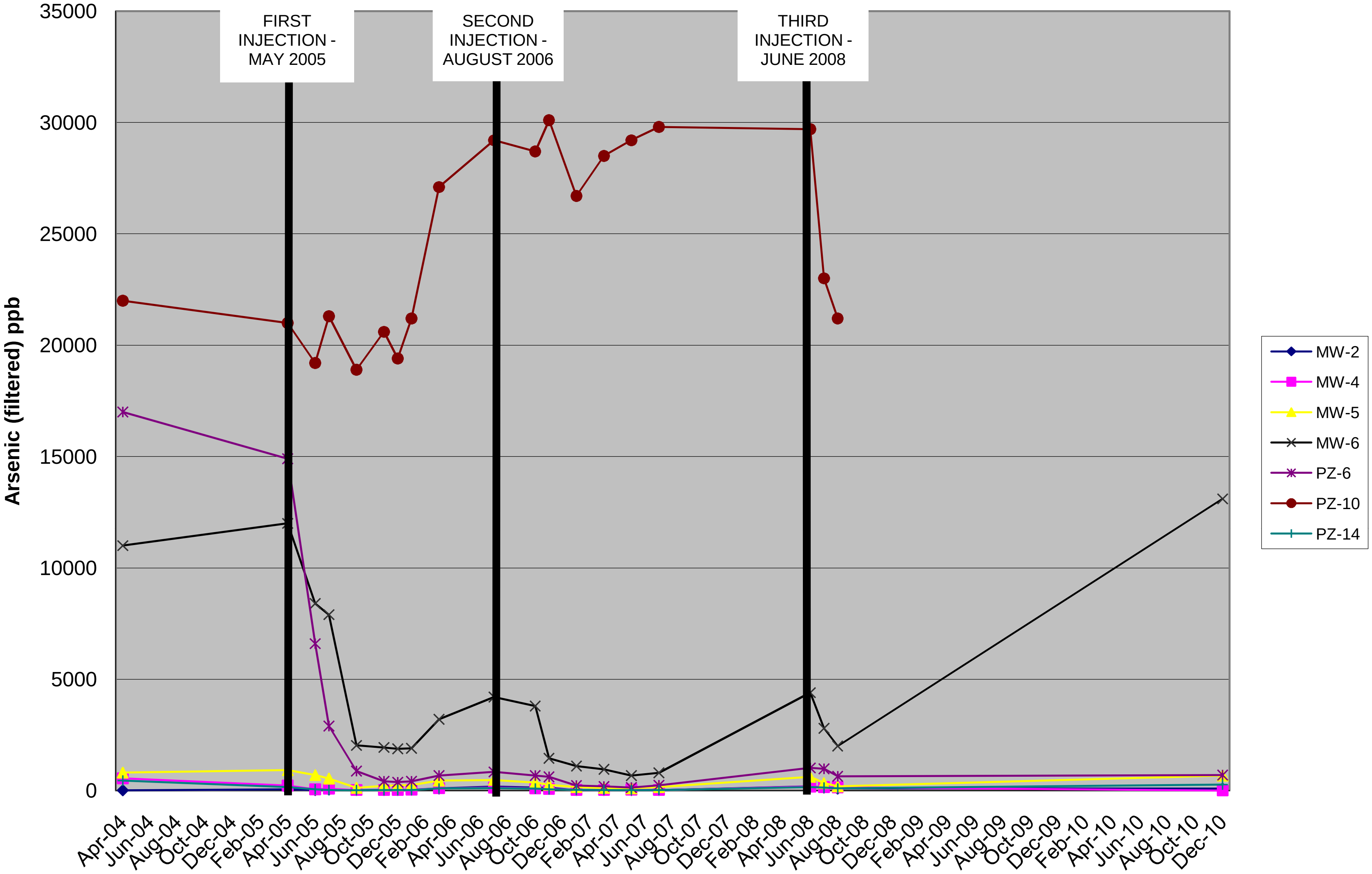
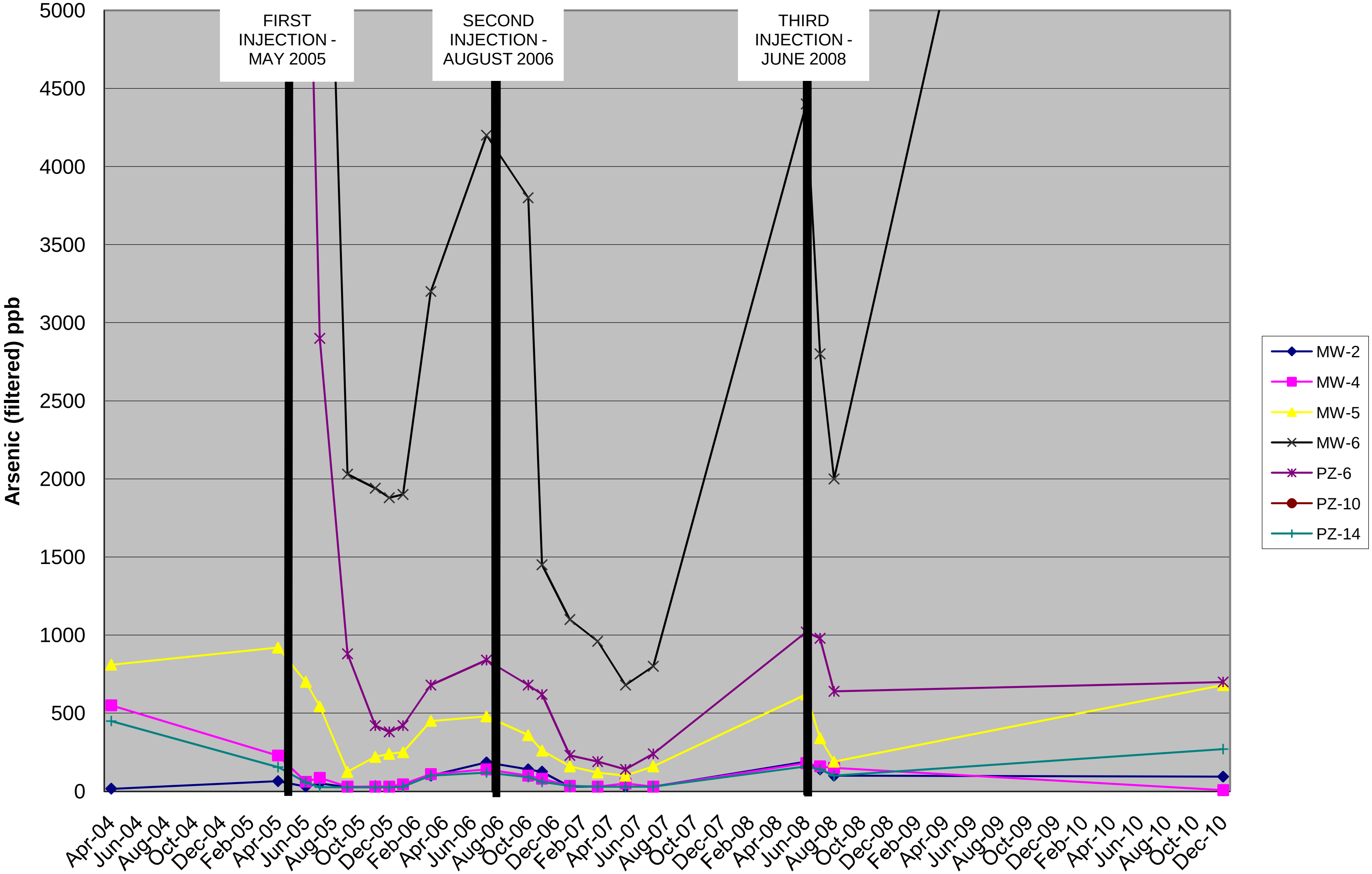
# Figure 2A. Arsenic in Groundwater  During MRC Treatment, Lagoon Area, Rensselaer, NY



**ROUX ASSOCIATES, INC.**

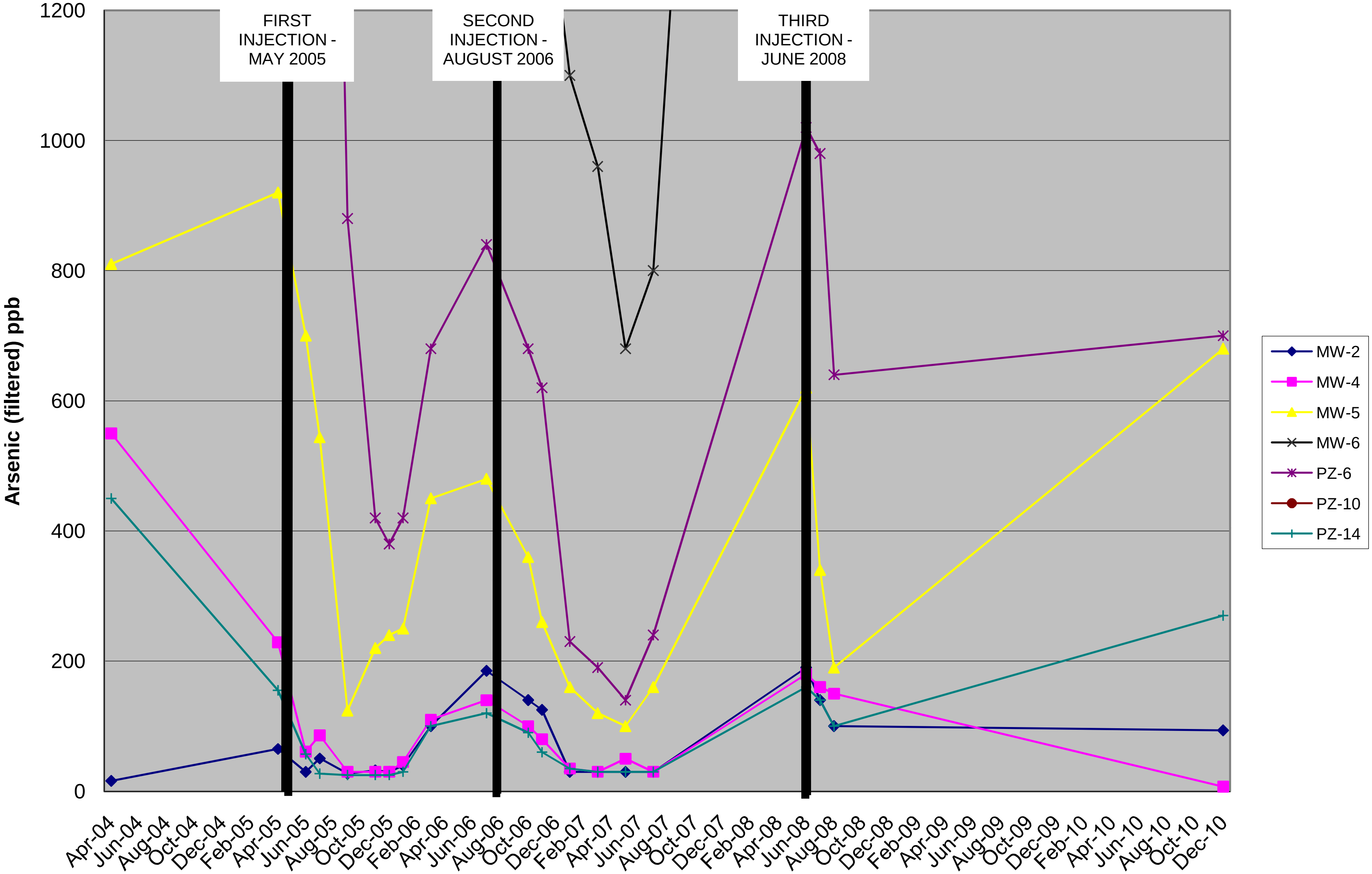
Figure 2B. Arsenic in Groundwater During MRC Treatment, Lagoon Area, Rensselaer, NY

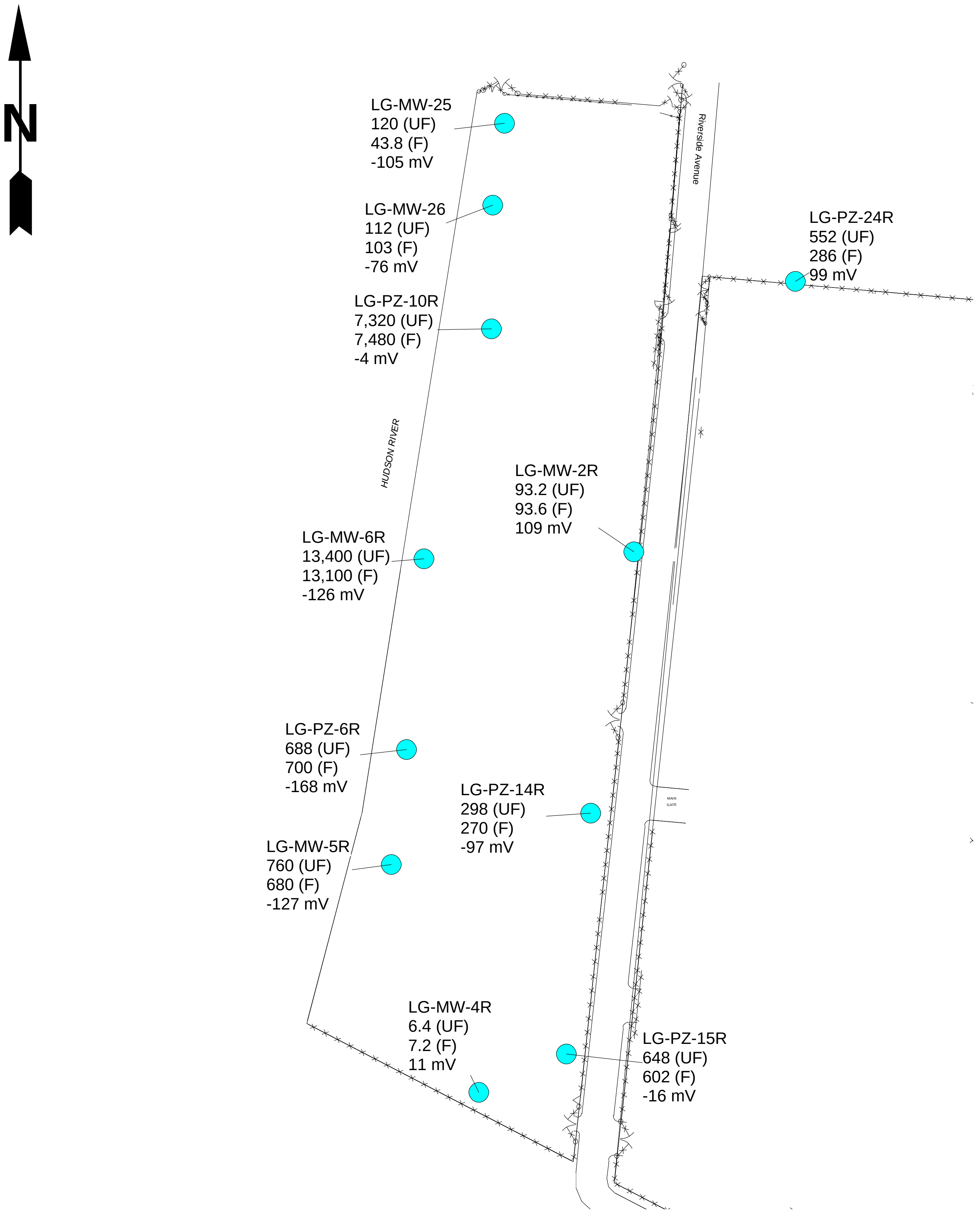


**ROUX ASSOCIATES, INC.**

BF0251.0011Y042.569/WKB-F2A-2C

Figure 2C. Arsenic in Groundwater During MRC Treatment, Lagoon Area, Rensselaer, NY





| | | |
|---|---|---|
| LG-MW-25 | ● | LOCATION AND DESIGNATION OF LAGOON AREA MONITORING WELL |
| 120 (UF) | | ARSENIC IN GROUNDWATER (UNFILTERED SAMPLE) |
| 43.8 (F) | | ARSENIC IN GROUNDWATER (FILTERED SAMPLE)<br>ALL CONCENTRATIONS IN MICROGRAMS PER LITER |
| -105 mV | | OXIDATION REDUCTION POTENTIAL IN MILLIVOLTS |

Title:

# ARSENIC IN GROUNDWATER
# DECEMBER 2010

Prepared For:

BASF CORPORATION
FLORHAM PARK, NEW JERSEY

ROUX
ROUX ASSOCIATES INC
*Environmental Consulting*
*& Management*

| | | |
|---|---|---|
| Compiled by: NE | Date: 4/15/2011 | FIGURE |
| Prepared by: NE | Scale: 1"=150' | 3 |
| Project Mgr: NE | Revision: | |
| BF1156903.WOR | 0251.0011Y041 | |

| LG-SB-133 | |
|---|---|
| 0 – 2 | 177 |
| 2 – 4 | 49.3 |
| 4 – 6 | 181 |
| 6 – 8 | 88.7 |
| 8 – 10 | 98.4 |
| 10 – 12 | 53.0 |

| LG-SB-101 | |
|---|---|
| 0 – 2 | 43 |
| 2 – 4 | 29.4 |
| 4 – 6 | -- |
| 6 – 8 | -- |
| 8 – 10 | -- |
| 10 – 12 | -- |

| LG-SB-100 | |
|---|---|
| 0 – 2 | 10.7 |
| 2 – 4 | 14.8 |
| 4 – 6 | 21.4 |
| 6 – 8 | 22 |
| 8 – 10 | 18.2 |
| 10 – 12 | 12.1 |

| LG-SB-134 | |
|---|---|
| 0 – 2 | 267 |
| 2 – 4 | 71.7 |
| 4 – 6 | 118 |
| 6 – 8 | 45 |
| 8 – 10 | 146 |
| 10 – 12 | 404 |

| LG-SB-129 | |
|---|---|
| 0 – 2 | 16.6 |
| 2 – 4 | -- |
| 4 – 6 | -- |
| 6 – 8 | -- |
| 8 – 10 | -- |
| 10 – 12 | -- |
| 12 – 14 | -- |

| LG-SB-135 | |
|---|---|
| 0 – 2 | 160 |
| 2 – 4 | 159 |
| 4 – 6 | 58.6 |
| 6 – 8 | 10.1 |
| 8 – 10 | 9.1 |
| 10 – 12 | 209 |
| 12 – 14 | 290 |

| LG-SB-128 | |
|---|---|
| 0 – 2 | 112 |
| 2 – 4 | -- |
| 4 – 6 | 9.5 |
| 6 – 8 | 30.1 |
| 8 – 10 | 15.3 |
| 10 – 12 | -- |

| LG-SB-102 | |
|---|---|
| 0 – 2 | 29.6 |
| 2 – 4 | 138 |
| 4 – 6 | 236 |
| 6 – 8 | 154 |
| 8 – 10 | 80.1 |
| 10 – 12 | 44 |

| LG-SB-131 | |
|---|---|
| 0 – 2 | 44.4 |
| 2 – 4 | 45.8 |
| 4 – 6 | 77.4 |
| 6 – 8 | 294 |
| 8 – 10 | 25.3 |
| 10 – 12 | 10.1 |

| LG-SB-103 | |
|---|---|
| 0 – 2 | 91.8 |
| 2 – 4 | 45.2 |
| 4 – 6 | 79.2 |
| 6 – 8 | -- |
| 8 – 10 | -- |
| 10 – 12 | 97.9 |

| LG-SB-132 | |
|---|---|
| 0 – 2 | 177 |
| 2 – 4 | 42.9 |
| 4 – 6 | 8.9 |
| 6 – 8 | -- |
| 8 – 10 | 13.8 |
| 10 – 12 | 90.0 |

| LG-SB-104 | |
|---|---|
| 0 – 2 | 14.6 |
| 2 – 4 | 21.3 |
| 4 – 6 | 165 |
| 6 – 8 | 47.8 |
| 8 – 10 | 21.6 |
| 10 – 12 | 79.2 |

| LG-SB-105 | |
|---|---|
| 0 – 2 | 35.1 |
| 2 – 4 | 33.8 |
| 4 – 6 | 32.7 |
| 6 – 8 | 37.2 |

| LG-SB-106 | |
|---|---|
| 0 – 2 | 9.3 |
| 2 – 4 | -- |
| 4 – 6 | 97.4 |
| 6 – 8 | 79.7 |
| 8 – 10 | 28 |
| 10 – 12 | 53.3 |

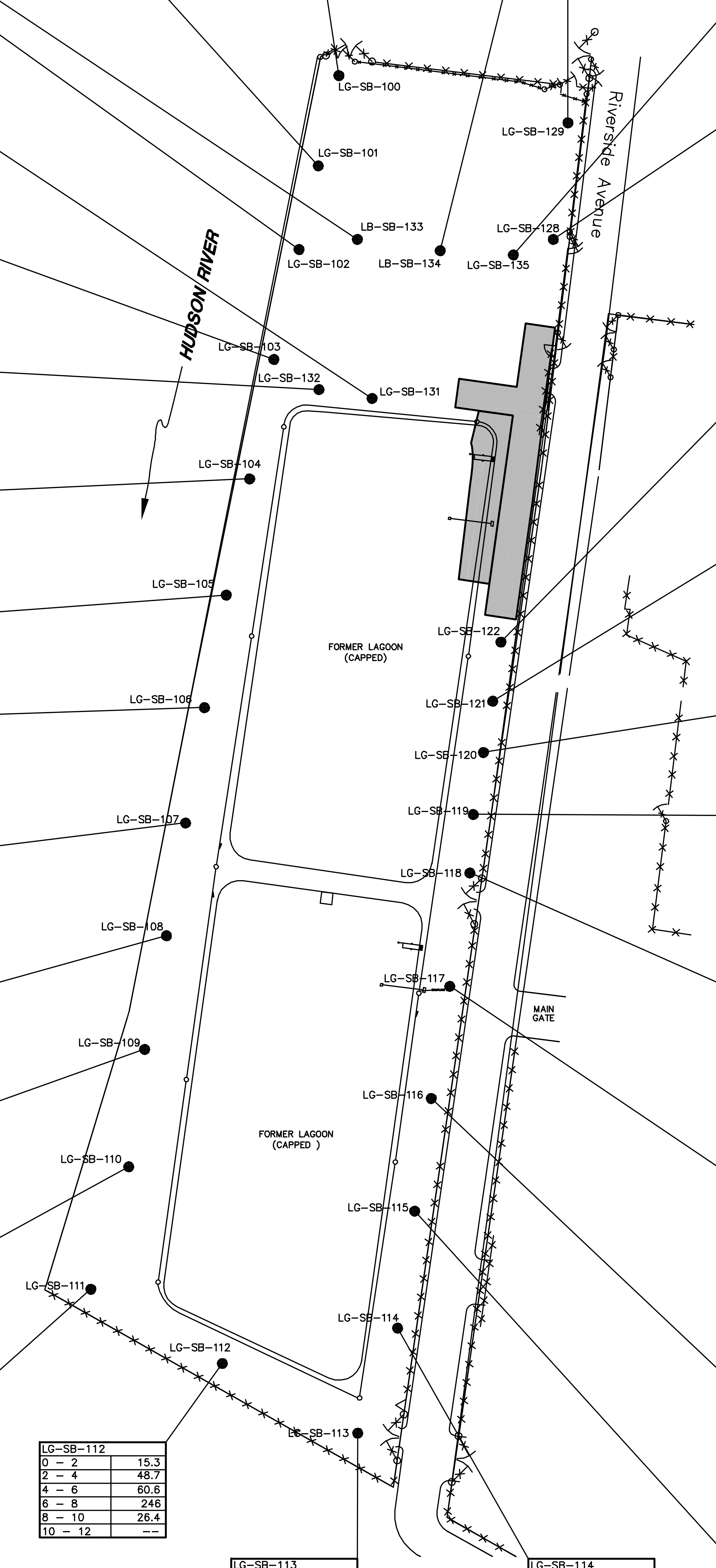
| LG-SB-107 | |
|---|---|
| 0 – 2 | 57.7 |
| 2 – 4 | 55.2 |
| 4 – 6 | 168 |
| 6 – 8 | 25.1 |
| 8 – 10 | 42.7 |
| 10 – 12 | 17.5 |

| LG-SB-108 | |
|---|---|
| 0 – 2 | 15.7 |
| 2 – 4 | 576 |
| 4 – 6 | 524 |
| 6 – 8 | 45.0 |
| 8 – 10 | 143 |
| 10 – 12 | 31.1 |

| LG-SB-109 | |
|---|---|
| 0 – 2 | 150 |
| 2 – 4 | 482 |
| 4 – 6 | 18.4 |
| 6 – 8 | 2.1 |
| 8 – 10 | -- |
| 10 – 12 | -- |
| 12 – 14 | -- |

| LG-SB-110 | |
|---|---|
| 0 – 2 | 22.4 |
| 2 – 4 | 34.6 |
| 4 – 6 | -- |
| 6 – 8 | -- |
| 8 – 10 | -- |
| 10 – 12 | -- |
| 12 – 14 | -- |

| LG-SB-111 | |
|---|---|
| 0 – 2 | 26.5 |
| 2 – 4 | 42.5 |
| 4 – 6 | 48.4 |
| 6 – 8 | -- |
| 8 – 10 | 9.2 |
| 10 – 12 | 12.9 |



| LG-SB-112 | |
|---|---|
| 0 – 2 | 15.3 |
| 2 – 4 | 48.7 |
| 4 – 6 | 60.6 |
| 6 – 8 | 246 |
| 8 – 10 | 26.4 |
| 10 – 12 | -- |

| LG-SB-113 | |
|---|---|
| 0 – 2 | 827 |
| 2 – 4 | 59.8 |
| 4 – 6 | 11.0 |
| 6 – 8 | -- |
| 8 – 10 | 8.0 |
| 10 – 12 | -- |

| LG-SB-114 | |
|---|---|
| 0 – 2 | 11.0 |
| 2 – 4 | 9.4 |
| 4 – 6 | -- |
| 6 – 8 | 9.1 |
| 8 – 10 | 8.0 |

| LG-SB-115 | |
|---|---|
| 0 – 2 | 19.5 |
| 2 – 4 | 9.4 |
| 4 – 6 | -- |
| 6 – 8 | 10.0 |
| 8 – 10 | 46.9 |

| LG-SB-116 | |
|---|---|
| 0 – 2 | -- |
| 2 – 4 | 12.3 |
| 4 – 6 | 16.8 |
| 6 – 8 | 46.0 |
| 8 – 10 | 37.6 |

| LG-SB-122 | |
|---|---|
| 0 – 2 | 146 |
| 2 – 4 | 85.6 |
| 4 – 6 | 79.4 |
| 6 – 8 | 90.9 |
| 8 – 10 | 70.7 |
| 10 – 12 | 20.0 |

| LG-SB-121 | |
|---|---|
| 0 – 2 | 44.0 |
| 2 – 4 | 205 |
| 4 – 6 | 147 |
| 6 – 8 | 86.1 |
| 8 – 10 | 39.1 |
| 10 – 12 | 43.8 |

| LG-SB-120 | |
|---|---|
| 0 – 2 | 16.4 |
| 2 – 4 | 119 |
| 4 – 6 | -- |
| 6 – 8 | 12.6 |
| 8 – 10 | 527 |
| 10 – 12 | 80.6 |
| 12 – 14 | 773 |

| LG-SB-119 | |
|---|---|
| 0 – 2 | 17.2 |
| 2 – 4 | -- |
| 4 – 6 | 7.7 |
| 6 – 8 | -- |
| 8 – 10 | 23.2 |
| 10 – 12 | 328 |
| 12 – 14 | 611 |

| LG-SB-118 | |
|---|---|
| 0 – 2 | 24.8 |
| 2 – 4 | 13.3 |
| 4 – 6 | 12.6 |
| 6 – 8 | 14.9 |
| 8 – 10 | -- |
| 10 – 12 | -- |

| LG-SB-117 | |
|---|---|
| 0 – 2 | 50.4 |
| 2 – 4 | 10.2 |
| 4 – 6 | -- |
| 6 – 8 | -- |
| 8 – 10 | -- |
| 10 – 12 | 20.8 |
| 12 – 14 | 59.7 |

N

LEGEND

LOCATION PREFIXES

LG – LAGOON
MP – MAIN PLANT
LF – LANDFILL
ST – ORGANICHEM PROPERTY (FORMERLY STERLING ORGANICS)

–×–×–×–×–×– CHAINLINK FENCE

▨ EXCAVATION AREA

PRE–DESIGN INVESTIGATION AND OTHER HISTORIC SAMPLING LOCATIONS

MP–SB–61 ● LOCATION AND DESIGNATION OF SOIL BORING

DESIGNATION OF SOIL BORING

CONCENTRATION OF ARSENIC IN MILLIGRAMS PER KILOGRAM (mg/kg)

| LG-SB-106 | |
|---|---|
| 0 – 2 | 9.3 |
| 2 – 4 | -- |
| 4 – 6 | 97.4 |
| 6 – 8 | 79.7 |
| 8 – 10 | 28 |
| 10 – 12 | 53.3 |

DETECTED BELOW NYSDEC RSCOs

SAMPLE DEPTH INTERVAL IN FEET BELOW LAND SURFACE

RSCO – RECOMMENDED SOIL CLEANUP OBJECTIVES

NOTE

NYSDEC RSCO FOR ARSENIC = 7.5 mg/kg

100' 0 100'

Title:

# SUMMARY OF ARSENIC DETECTED ABOVE NYSDEC RSCOs IN LAGOON AREA SOILS

RENSSELAER, NEW YORK FACILITY

Prepared For:

BASF CORPORATION
FLORHAM PARK, NEW JERSEY

ROUX
**ROUX ASSOCIATES, INC.**
*Environmental Consulting and Management*

| | | |
|---|---|---|
| Compiled by: M.R. | Date: 07APR11 | PLATE |
| Prepared by: J.A.D. | Scale: AS SHOWN | 1 |
| Project Mgr: N.E. | Project: 0251.0011Y040 | |
| File: 0251.0011Y569.02 | | |

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