AECOM

AECOM
2 Technology Park Drive
Westford, MA 01886-3140

978.589.3000 tel
978.589.3100 fax

Letter of Transmittal

Attention:	John R. Strang, P.E.	Date:	May 19, 2011
Project reference:	Hudson River Operable Unit 2 Sediment Nature and Extent Summary Report – Response to Comments BASF Rensselaer	Project number:	60135965.500

We are sending you the following:

Number of originals:	Number of copies:	Description:
2		Dredged Sediment Treatment Pilot Study Report BASF Rensselaer, Rensselaer, NY

Please let me know if you have any questions. Thanks

Sean Crowell

Sean Crowell
AECOM Environment
2 Technology Park Drive
Westford, MA 01886-3140

MAY 20 2011

Get an Electronic Copy.

AECOM Environment

Prepared for:
BASF Rensselaer
Rensselaer, NY

Prepared by:
AECOM
Westford, MA
60135965.500
May 18, 2011

Dredged Sediment Treatment Pilot Study Report

BASF Rensselaer, Rensselaer, NY

MAY 20 2011

AECOM Environment

Prepared for:
BASF Rensselaer
Rensselaer, NY

Prepared by:
AECOM
Westford, MA
60135965.500
May 18, 2011

Dredged Sediment Treatment Pilot Study Report

BASF Rensselaer, Rensselaer, NY

Sean Crowell

Prepared By Sean Crowell, Engineer

John A. Bleiler

Reviewed By John A. Bleiler

Contents

List of Appendices

Appendix A Analytical Reports

Appendix B NYSDEC Fact Sheet

List of Tables

List of Figures and Charts

List of Acronyms

'	feet
"	Inches
"Hg	Inches Of Mercury
BASF	BASF Corporation
BTUH	British Thermal Units/hour
CAMP	Community Air-Monitoring Program
CFM	Cubic Feet Per Minute
CKD	Cement Kiln Dust
CO_2	Carbon Dioxide
COI	Constituents Of Interest
CY	Cubic Yards
Empire	Empire Generating Project
eV	Electron-Volt
FS	Feasibility Study
H_2SO_4	Sulfuric Acid
HDPE	High Density Polyethylene
Hp	Horse-powered
IRM	Interim remedial measure
KW	Kilowatt
LB	Pounds
LEL	Lower Explosive Limit
LKD	Lime Kiln Dust
mg/kg	Milligrams Per Kilogram
mil	Millimeter
NG	National Grid
NYSDEC	New York State Department of Environmental Conservation
O_2	Oxygen
°F	Degrees Fahrenheit
P&ID	Process and Instrumentation Diagram
PCBs	Polychlorinated Biphenyls

PID	Photo Ionization Detector
PSI	Pounds/Square Inch
PVC	Poly-Vinyl Chloride
RI	Remedial Investigation
Roux	Roux Engineers ()
SCFM	Standard Cubic Feet Per Minute
TC	Treatment Cells
TOC	Total Organic Carbon
VGAC	Vapor Phase Granular Activated Carbon
VOCs	Volatile Organic Compounds

1.0 Introduction

This Pilot Study Report has been prepared by AECOM on behalf of BASF Corporation (BASF) to summarize actions that have been performed to evaluate sediment treatment technologies at the BASF Rensselaer Site, in Rensselaer, New York (Figure 1-1). The BASF Rensselaer facility (the "Site") is the subject of an ongoing environmental investigation under New York State Department of Environmental Conservation (NYSDEC) regulatory authority.

The activities described in this report were proposed in a July 2009 Work Plan (Work Plan) (AECOM, 2009) which presented a scope of work for designing, permitting, and operating a series of *ex situ* sediment treatment pilot tests at the Rensselaer Site. This work plan was approved by the NYSDEC on September 16, 2009. The primary objective of the pilot test effort is to evaluate the feasibility and practicality of operating an *ex situ* treatment system to reduce concentrations of volatile organic compounds (VOCs) in dredged Hudson River sediment to levels that may permit on-site re-use and/or reduce the potential costs of off-site disposal. Performance monitoring conducted as part of this pilot test program is presented in this report to assist with a forthcoming feasibility study (FS) evaluation and to provide information to be used should a larger scale sediment treatment system ultimately need to be designed to address the presence of VOCs in Hudson River sediments which are adjacent to the BASF Rensselaer facility. Implementation of the sediment treatment pilot test provides important input to the FS and the remedial design for the Site.

The following background information pertains to the scope of work for the pilot study:

- During the winter and spring of 2008/2009, approximately 1,000 cubic yards (CY) of sediment were dredged from the Hudson River adjacent to the Site to allow for installation of a process water discharge outfall diffuser line. The diffuser line installation was associated with construction of the Empire Generating Project (Empire), a power generating facility recently constructed at 75 Riverside Avenue, Rensselaer, New York. The dredging project was conducted as an Interim Remedial Measure (IRM) by Empire in accordance with a July 2008 IRM Work Plan, which was approved by NYSDEC on September 12, 2008. The dredged sediment was stockpiled in a secure enclosure (here-in-after referred to as the "Containment Cell") in the western portion of the Site (Figure 1-1).
- Based upon prior work conducted by Empire and by BASF, elevated levels of several VOCs were known to be present in the stockpiled sediment, including benzene, chlorobenzene, and dichlorobenzene. The pilot test work discussed in this report was focused primarily on evaluating methods to reduce the levels of these VOCs.
- Sampling conducted by Empire prior to performing the sediment removal IRM found polychlorinated biphenyls (PCBs) in sediments located in the vicinity of the diffuser pipe at concentrations ranging from non-detect to more than 50 milligrams per kilogram (mg/kg). The NYSDEC requested additional PCB sampling of the stockpiled sediment to determine the levels of PCBs in the stockpiled sediment. This report presents PCB analytical data gathered during the course of the pilot study. All available data support the conclusion that PCBs are not Site-related constituents of interest (COI) and are present in Hudson River sediment due to other non-BASF anthropogenic inputs (Appendix A). The PCB data presented in this

- Bench-scale testing was performed by BASF to evaluate treatment technologies in 2008. The results of this bench-scale testing demonstrated that heat-enhanced drying and associated volatilization provided the highest potential to effectively treat the sediments. Therefore, further evaluation of this technology was a primary focus of the pilot study program described herein.
- Prior to initiation of the pilot study program, a Fact Sheet was distributed by the NYSDEC to community stakeholders. A copy of this fact sheet is included in Appendix B.

1.1 Pilot Study Overview

The pilot study program consisted of dividing the 1,000 CY of dredged sediment into four approximately equally sized volumes for placement into independent treatment cells. The four treatment cells were located on a paved and fenced area of the Main Plant site immediately across Riverside Avenue from the Containment Cell location (Figure 1-1). Each of the four piles was treated slightly differently in order to permit BASF to evaluate remedial performance using different treatment cell configurations, treatment technologies, variations in bulking agents/amendments, heating mechanisms, and piping configurations within the treatment cells.

Pilot study activities occurred primarily between August and December 2009, with construction fieldwork commencing during the week of September 21, 2009, and included the following activities:

- Pilot Study Mobilization and Pre-Operational Program
- Sediment Pre-Treatment
- Pilot Treatment Cell Construction
- Pilot Treatment Cell Operations
- Construction and Treatment Cell Monitoring

This report presents and analyzes the data collected during the pilot study and provides conclusions and recommendations for additional activities related to the treatment of VOCs in Hudson River sediments.

2.0 Pilot Study Mobilization and Pre-Operational Program

Prior to initiation of the pilot study, the following mobilization activities took place:

- A variety of equipment and materials were mobilized to the Site during this first phase of work, which also included inspection and mark-out of work areas and access roads, inspection of the Containment Cell area, mobilization of a dumpster for disposal of construction generated wastes, and construction of the temporary Treatment Cell structures.
- Site preparation included installation of a temporary equipment decontamination pad in the vicinity of the Containment Cell. Although the Pilot Study Work Plan indicated that a second pad was to be constructed in the vicinity of the study area, a field decision was made, in collaboration with NYSDEC, that this second pad was not necessary. Decontamination pad construction included grading of an approximate 20-foot by 40-foot area, as required, and construction of a perimeter berm (3-sided berm with access ramp on fourth side) to provide containment within the area. The berm was constructed by installing 2 foot height straw bales to define the perimeter. A vehicle access ramp into the pad was constructed with processed gravel or recycled concrete. The pad was graded to drain to a low elevation established in one corner and was covered with a high density polyethylene (HDPE) liner.
- Attempts were made to obtain electrical service from one of the existing National Grid (NG) power poles in the vicinity of the Treatment Cell area. However, because NG was unwilling to supply more than one power connection to the site address (an existing power connection is already in place for the on-site groundwater treatment system), a 65 kilowatt (KW) generator was rented for the duration of the pilot study operation. The rented generator was supplied with an external 500-gallon fuel oil tank with secondary containment, and a local electrician was contracted to install a power distribution panel, which allowed flexibility for connection of multiple pieces of equipment to be connected to and run-off of the generator.
- Soil erosion and sediment control structures were installed prior to the commencement of work (see Figure 1-1). These structures included stabilized construction entrances/vehicle tracking pads, straw wattle and/or straw wattle/silt fence combination sediment barriers, and storm sewer inlet protection). No inlet or catch basin protection measures were necessary as they were no inlets or catch basins found in the affected areas of construction. Erosion control barriers were monitored on a weekly basis and maintained throughout the duration of the pilot study. Soil erosion and sediment control structures will be removed upon project completion once disturbed areas have been stabilized with either a protective vegetative cover, crushed stone or other approved method.
- Per the request of the NYSDEC, prior to initiation of the pilot study, PCB sampling was conducted on August 7, 2009. The PCB sampling program consisted of visually sub-dividing the sediment in the Containment Cell into three equal areas with the goal of obtaining a single composite sample from each of these areas. Each of the three areas was further broken down into ten separate areas with a PCB sub-sample being collected and properly preserved from each. All 30 sub-samples (1-1 through 1-10, 2-1 through 2-10 and 3-1 through 3-10, respectively from each third of the pile) were submitted to Alpha Analytical of Mansfield, Massachusetts for compositing and PCB analysis via EPA method 3570. The lab analyzed the following three samples: Composite 1 (composite of sub-samples 1-1 through 1-10);

Composite 2 (composite of sub-samples 2-1 through 2-10); and Composite 3 (composite of sub-samples 3-1 through 3-10). Review of the PCB results (Table 2-1) indicated that concentrations of Aroclor 1242 were present in each sample, but that all other PCB Aroclor mixtures were below laboratory detection limits. The PCB results were transmitted to the NYSDEC on August 20, 2009 and on September 9, 2009, the NYSDEC made a determination that the stockpiled sediment would not be regulated as hazardous waste and therefore was suitable for transportation to the Treatment Cell.

3.0 Sediment Pre-Treatment

On August 20, 2009, a series of admixture pre-treatment "bucket-scale" tests were performed to evaluate effects of the incorporation of admixtures (amendments) on samples of dredged material. For the bucket testing purposes, Lime Kiln Dust (LKD), Cement Kiln Dust (CKD), Calciment, and Peat Moss were selected as the four admixtures to be evaluated. The purpose of the bucket scale testing was to evaluate the ability of admixtures at specific percentages to increases sediment permeability, reduce sediment water content, and/or improve sediment material handling properties and compare each of the mixtures to the un-amended sediment. In addition, the admixtures were evaluated for their respective abilities to increase temperature and volatility of the constituents.

During the pre-treatment phase of work, the sediment was determined to be extremely fine-grained, comprised of a mixture of clays and silts that were un-expected, based on the Remedial Investigation (RI) data (AECOM, 2009) that were reviewed prior to commencement of this pilot study. Grain size data evaluated in the RI (as well as historic NYSDEC geophysical data) suggested that the portion of the river from which the sediments were obtained would be expected to be characterized by some finer materials, but also would contain some coarser grained sands and muddy sands.

3.1 Pre-Treatment Testing General Procedure

The following general activities were completed during bucket testing:

- Composite sediment samples from each vessel were collected from and analyzed for percent moisture content on both un-amended and amended sediment.
- Discrete volumes of un-amended and amended sediment were collected and evaluated for qualitative field parameters such as weight, temperature, headspace, VOC head space concentrations and stability (slump).
- Permeability testing was completed on both un-amended and amended sediments. Permeability testing consisted of utilizing a vacuum pump to pull air through a sediment sample with each of two apparatuses. The first method consisted of packing a solid poly-vinyl chloride (PVC) tube with sediment and applying a vacuum on the tube using a vacuum pump, whereas the second method consisted of inserting a 1-foot section of PVC well screen directly into a bucket of the test material and using a vacuum pump to apply a vacuum on the screen. With both test methods, a valve was used to control applied vacuum and resultant flow rates were measured.

The following details the procedure completed during the bucket-scale evaluation:

- Approximately 20 five-gallon buckets were set up (labeled Bucket # 1 through Bucket # 20) and tare weights were collected for each vessel.
- Each of the buckets was partially filled (i.e., 2.5 gallons of sediment per bucket) with un-amended sediment and blended to improve permeability.
- Samples of un-amended material were collected for moisture content.
- A sheet plastic seal was maintained on top of each bucket throughout testing.

- Applied vacuum permeability testing was conducted as specified above on each bucket.
- Slump tests were conducted on material from each bucket (based on ASTM C143).
- Buckets were weighed in order to determine weight of sediment and calculate the amount of amendment to add.
- Desired amounts of amendments were weighed out and prepared. Amendments were mixed on a percent weight basis, as described in Section 3.2.2.
- Pre-mixing headspace readings were collected using a photo-ionization detector (PID) which was calibrated to record total VOCs in parts per million (ppm) as dichlorobenzene and temperature readings were recorded for each bucket.
- Desired amendments were slowly blended with sediments in the bucket.
- PID headspace and temperature readings were recorded periodically following amendment mixing.
- Changes in physical properties of the sediment were noted (e.g., observations were recorded relative to stickiness, free water, friability, expansion, clumping, etc.)
- Buckets were allowed to sit for approximately two hours, and headspace and temperature data were recorded at regular intervals.
- After about two hours, the plastic sheeting was removed and the mixture was visually observed.
- Visual determinations were made on which amendments were most effective based on lower cohesive properties, more friable sediment, no free water, and apparent increase in permeability.
- Applied vacuum permeability testing was conducted as specified above on each amended bucket.
- For those blends that appeared promising, higher or lower doses of amendment were tested.
- Samples of amended material were collected for moisture content from each bucket.
- Slump tests were conducted on amended material from each bucket (based on ASTM C143).

3.2 Pre-Treatment Test Results

The following sub-sections and Table 3-1 summarize the data obtained during the Pre-Treatment testing program.

3.2.1 Un-amended Sediment Results

- No slumping was measureable in any of the un-amended material.
- Headspace readings in un-amended material ranged from approximately 30 to 300 units on a photo ionization detector (PID).
- Temperature readings in un-amended material ranged from 66 to 85 degrees Fahrenheit (°F). The large range in observed temperature readings was likely due to the fact that that the ambient temperatures were in excess of 90°F during the August testing period. Buckets temperatures that were measured later in the day were considerably warmer due to ambient conditions.

- Permeability testing of all un-amended sediment samples yielded no flow: 0 standard cubic feet per minute (SCFM) at a maximum applied vacuum of 20 inches of mercury ("Hg).
- Moisture content of un-amended materials ranged from 33% to 54%.

3.2.2 Amended Sediment Results

- The initial evaluation and field observations resulted in the testing of the following 11 samples with amendment addition:
  - LKD buckets of 10%, 19%, and 35% (Bucket Nos. 6, 1, and 9)
  - CKD buckets of 9%, 24%, and 30% (Bucket Nos. 7, 2, and 8)
  - Calciment buckets of 10%, 16% and 25% (Bucket Nos. 5, 3, and 10)
  - Peat Moss buckets of 30% and 36% (Bucket 4 and 11)

  (Note- all data in percent weight)

- As summarized in Table 3-1, the following observations from the pre-treatment program were noted:
  - The addition of LKD resulted in increased temperature and permeability, and a decrease in percent moisture. Observationally, the addition of LKD resulted in a firmer and drier sediment complex than was observed in the un-amended samples. Based on the tabulated results, LKD at approximately 19% resulted in greater permeability, a decrease in moisture content, and greater increase in temperature than the 10% and 35% mixtures.
  - The addition of CKD resulted in increased temperature, and permeability, while decreasing moisture content, and based on observations created a more firm and dry material. Based on the tabulated results, the addition of CKD at approximately 24% by volume resulted in greater permeability, a decrease in moisture content, and greater increase in temperature than the 9% and 30% mixtures.
  - The addition of calciment resulted in increased temperature, and permeability, while decreasing moisture content, and based on observations created a more firm and dry material. Based on the tabulated results, addition of calciment at approximately 16% by mass resulted in greatest permeability, while both a temperature increase and reduction in moisture content were observed with the 25% mixture. The 10% mixture was the least favorable with respect to permeability, temperature increase, and moisture reduction.
  - The addition of peat moss resulted in increased temperature, and permeability, but also increased the percent moisture. Based on field observations, the addition of peat moss created a less dense and more workable material. Based on the tabulated results, the addition of approximately 36% peat moss resulted in higher permeability, an increase in moisture content and less increase in temperature than the 30% mixture.
- Work was performed outside on a warm and sunny day, which may also have effected changes in bucket temperatures.
- The observed reduction in percent moisture in LKD, CKD and Calciment were based on laboratory analytical results and can be attributed to simple dilution (addition of dry weight amendments), and to moisture being chemically separated from the sediment. Other minor

components of moisture loss were also likely due to evaporation caused by the heating effects of the amendment mixtures and ambient temperatures.

3.3 Pre-Treatment Conclusions

A review of the un-amended pre-treatment test results indicates that moisture content and/or grain size present significant permeability limitations relative to the un-amended sediments. Although PID readings indicated that significant levels of VOCs were present in the un-amended sediment, vacuum pump permeability testing resulted in no flow in any of the tested un-amended sediments.

Based on a review of the pre-treatment testing results, LKD, CKD, and calciment were determined to all be capable of increasing the permeability of the sediment, while decreasing the apparent moisture content. In all cases, vacuum pump permeability testing resulted in substantially higher permeability in amended (versus un-amended) sediments. Furthermore, the addition of LKD, CKD, and calciment all appeared to increase temperature and therefore likely increased the potential for volatility of the VOCs and aided in reducing the moisture content via enhanced evaporation. Based on known materials properties, LKD and CKD were expected to be the most capable of creating an exothermic reaction and thus increasing temperature. The pilot test results indicate that the addition of LKD did produce slightly more favorable results with respect to increased permeability, moisture reduction, and the two amendments are very similar in terms of cost. Therefore, LKD at approximately 19% by volume was selected as one of the amendments to be used for the pilot study.

The pre-treatment studies suggest that the addition of peat moss increased both permeability and moisture content, while not substantively affecting the temperature of the tested materials. Peat moss was tested, in part, to evaluate potential bioremediation scenarios due to its high concentration of organic carbon. Since moisture is necessary for biological activities to occur, and the increase in permeability is necessary to allow for aeration of the pile, 30% peat moss addition (by weight) was selected as an acceptable amendment to use for construction of a biological treatment test cell.

Based on these results and in accordance with the approved work plan, a determination was made to construct four pilot treatment cells (TC), as described in Section 4.

4.0 Design and construction of pilot treatment cells

The pilot treatment cells were constructed as indicated in the July 2009 Work Plan (AECOM, 2009) and subsequent internal technical design memorandum .The following test cells were constructed:

- ***Treatment Cell 1*** was constructed using un-amended sediments and vertical extraction and injection piping. Treatment Cell 1 was designed to be heated by recycling treated hot air into the sediment from a blower system.
- ***Treatment Cell 2*** was constructed using un-amended sediments and vertical extraction and injection piping. This cell was heated by injecting treated hot air into the sediment from a blower system and through the use of a thermal water heating system designed to increase the temperature in the sediment pile through use of a hybrid solar and propane energy-fueled hot water piping system.
- ***Treatment Cell 3*** was constructed by adding approximately 19% LKD to sediment and was designed to evaluate the use of horizontal extraction and injection piping. This cell was heated by recycling treated hot air into the sediment from a blower system
- ***Treatment Cell 4*** was constructed by adding approximately 30% peat moss to the sediment and was designed to evaluate biological treatment using vertical extraction and injection piping in the more permeable material. This treatment cell used an aerobic approach including amendment of microbes and nutrient additions (e.g., use of peat moss which was supplemented with manure), as well as vertical extraction and injection piping.

The following sections detail the design and construction of the cells and equipment installed at the site for the pilot testing operation. The attached figures present details on site layout and process equipment employed in the test.

4.1 Baseline Sampling

Immediately following construction of the cells, composite baseline samples were collected from each cell to determine the concentrations of VOCs and other relevant parameters within the cell. Sampling was conducted on October 15, 2009.

The sampling program consisted of visually segregating each of the four TC into four quadrants (A, B, C and D). Samples were collected from the center of each quadrant at four different depth horizons (1 feet ('), 2', 3', and 4' below the top of the cell). The depth horizons were composited at each sampling location, resulting in a total of four samples/test cell. Each of the 16 (4 test cells/4 samples per cell) samples were submitted to Alpha Analytical, of Mansfield, MA and analyzed for VOCs and Total Organic Carbon (TOC) via EPA Methods 8260 and 9060 respectively, and moisture content. Table 4-1 presents the baseline sampling results, and Figure 4-1 presents the sampling locations.

4.2 Air Monitoring/Emission Controls during Construction

The previously completed community air-monitoring program (CAMP) on the Site, developed by Roux Engineers (Roux) was amended to incorporate study activities. The CAMP included direct measurement of VOCs and total suspended particulate during all activities that involved moving or mixing of the sediment. The air-monitoring program was implemented by Roux with the following objectives:

- To ensure concentrations of VOCs and total suspended particulates were minimized to protect human health and the environment.
- To provide an early warning system so engineering controls could be enacted to prevent unnecessary exposure of emissions resulting from project activities.
- To measure and document the concentrations of VOCs and total suspended particulates for determining compliance with the established air-monitoring limits.
- To provide baseline air monitoring data for consideration in the feasibility study for the BASF Rensselaer Hudson River OU

In conjunction with the CAMP, Exclusion Zone air monitoring was completed in order to establish a safe work environment for employees involved in the construction. The air monitoring included real time data collection, which was observed and logged during all construction activities. Points of data collection were located upwind, downwind, and at the nearest receptor to the construction site. The air monitoring programs were incorporated by Roux and no work stoppage or events requiring additional attention were reported..

4.3 Emission Controls during Construction

Materials management was completed in a controlled manner with air monitoring for VOCs (PID readings) and dust (visual). The high moisture content of the sediments minimized emissions during test cell construction. Sediments were covered with HDPE for the entirety of time during construction and odor observations were recorded to develop the optimal materials management approach should a large scale ex situ sediment management strategy need to be developed,

Engineering controls for odors, dust and fugitive vapors that could potentially emanate from remedial activities were actively managed during all phases of work. The most substantial vapor release was created during sediment mixing with amendments. Throughout the activities involving moving or mixing of the sediment an employee dedicated to misting the sediment with a Biosolve® water mixture. During periods where the sediment was being moved into the Treatment Cells, a second employee was employed for misting at the Treatment Cell area. During transport of the sediments from the Containment Cell to the Treatment Cells, the dump trucks utilized covers to guard against the release of fugitive vapors.

During periods of extended inactivity, any exposed sediments were covered with polyethylene sheeting. Once the sediment piles were constructed and covered, CAMP monitoring was discontinued. No odors were observed while the piles were covered and in treatment mode.

4.4 Cell Design / Construction Details

The following sub-sections present a summary of the pilot-study cell construction effort.

4.4.1 Treatment Cell 1: Un-amended, Unheated, with Vertical Piping

Treatment Cell 1 was constructed without addition of amendments to sediment and was designed to evaluate the use of vertical extraction and injection piping. The temperature build-up and the associated VOC removal rate in Treatment Cell 1 was designed to solely rely on heat buildup from recycling of vapors through a blower (i.e., Treatment Cell 1 employed a system that relied on heat of compression from the blower and heat enhancement and retention of cover material). However, the low permeability of the un-amended sediment precluded the effective injection of recycled air into the pile. Figure 4-2 presents as-built construction details for Treatment Cell 1.

- The cell was constructed using concrete blocks on three sides to measure approximately 40-feet by 40' by 4' high. The cell was lined with filter fabric and 20 millimeter (mil) HDPE.
- Un-amended sediment was mixed and transported from the Containment Cell to Treatment Cell 1 and was mixed again when placed within the cell in 12" loose lifts.
- The fourth side of the Treatment Cell was finished with a single 2-foot high course of concrete blocks, and covered with a 20-mil HDPE liner. The top liner and bottom liner were sandwiched together and anchored on all four sides of the cell to the blocks with wood strapping.
- Vertical injection/extraction pipes were installed within the cell. Points were direct driven into the piles by hand. Installed points consisted of 20 galvanized steel points spaced equally throughout the cell. Of the 20 points installed, 10 consisted of 2' of screen and 2' of riser, and 10 consisted of 4' of screen and 6" of riser. Each point was sealed at its HDPE penetration point with heavy-duty tape and spray adhesive.
- Six thermocouple type temperature-monitoring points were attached to rebar and direct driven into the cell at various locations and depths. The thermocouples were equipped with wire leads, which allowed technicians to measure temperature at each location with a handheld instrument. The penetration point for each thermocouple point was sealed with heavy-duty tape and spray adhesive.
- Steel piping and hoses as per the design were connected to each of the injection/extraction pipes and extended to injection or extraction manifolds which were installed on the side of the cell. Manifolds were configured with individual valves and sample ports for each leg such that technicians could monitor and control applied vacuum or pressure and resultant flow from each point independently. The final connection for each leg was completed with a quick connect fitting such that technicians could easily switch any leg from the injection to the extraction manifold, and thus have maximum flexibility to use any legs as either injection or extraction points.
- Piping was extended from the manifold location to the high-pressure blower system, which is further described in Section 4.4.3.

4.4.2 Treatment Cell 2: Un-amended, Heated, with Vertical Piping

Treatment Cell 2 was constructed in an identical manner to Treatment Cell 1 with the exception that an 800' coil of 1" HDPE pipe was placed in the bottom to supply non-contact heating of the sediments. The 1" HDPE pipe was installed as a coil and spread out such that it covered the entire area of the 40' by 40' cell, and bedded in a 6" thick layer of sand. The 1" HDPE pipe was extended through the top of the HDPE liner and connected to a Burderas forced hot water heating system. Process piping from Cell 2 was installed identically to Cell 1 and was extended from its injection/extraction manifolds to the high-pressure blower system.

4.4.3 High Pressure Blower System (Cell 1 and Cell 2)

- Treatment Test Cells 1 and 2 shared a high pressure blower system, as described below and presented in the Process and Instrumentation Diagram (P&ID) (Figure 4-3):
- Two 4" steel pipes each were run from Cell 1 and Cell 2 back to the high pressure blower system and connected to the blower set-up such that the blower could inject/extract from either cell separately or from both cells simultaneously. The high pressure system consisted of the following elements:
  - A 25 horse-powered (Hp) Rotary Claw capable of delivering and removing approximately 200 CFM of air at a maximum design pressure (total dynamic head) of 30 pounds/square inch (PSI) from Cell 1 or Cell 2. The blower package was designed to either operate at 200 cubic feet per minute (CFM) through either cell at a time or 100 CFM through each cell when operating simultaneously.
  - A moisture separator package with integral high-level alarm and transfer pump which was designed to deliver recovered water through liquid phase carbon to an on-site storage tank, for ultimate discharge to BASF's on site groundwater treatment system.
  - A vapor phase granular activated carbon (VGAC) and piping package complete with two (1,000 LB) VGAC units, a high temperature alarm switch, and a dilution valve which the operator used to introduce ambient air so that the temperature of air entering the VGACs remained below 150°F.
  - Valving, sample ports, and measurement equipment necessary to measure vacuum/pressure, flow, temperature, and VOC concentrations at various points throughout the system.
  - A solar powered (propane gas backup) water heater system (Burderus GB142/45) with integral control panel and solar package (BUDSK4.0-3) and surge tank (BUDERUS SM400) capable of providing up to 158,000 British Thermal Units/hour (BTUH) was installed and provided in order to heat Cell 2.
  - The closed-loop water heater system in Cell 2 was installed and plumbed such that hot water was injected and circulated through the HDPE coil starting in the center of the pile and flowing towards the outside before being circulated back through the heating tank.

4.4.4 Treatment Cell 3: LKD Amended, Heated, with Horizontal Piping

Treatment Cell 3 was constructed by adding approximately 19% (calculated by mass) LKD to sediment and was designed to evaluate the use of horizontal extraction and injection piping. The temperature build-up and the associated VOC removal rate in Treatment Cell 3 (i.e., heating) was designed to rely upon heat generation through the exothermic reaction created by adding LKD and through heat buildup from recycling the vapors through a blower. Figure 4-4 (attached) is the P&ID for Cell 3.

- The cell was constructed using concrete blocks on three sides to measure approximately 40-feet by 40" by 4" high. The cell was lined with filter fabric and 20-mil HDPE.
- Sediment was excavated from the Containment Cell and thoroughly mixed with the appropriate quantity of LKD prior to being transported from the Containment Cell to Treatment Cell 3 and was mixed again and placed within Cell 3 in 12-inch loose lifts.

- The fourth side of the Treatment Cell was then finished with a single 2-foot high course of blocks, and covered with a with a 20 mil HDPE liner. The top liner and bottom liner were sandwiched together and anchored on all four sides of the cell to the blocks with wood strapping.
- Trenches were excavated within the sediment in the cell in order to install two separate layers of nine horizontal screened PVC pipes. Screen sections were installed at approximately 3" and 1" below the top surface of the cell and each section consisted of a 2" diameter, 30' length 10 slot screen. Each individual screen was fitted with a coupling, straight section of solid pipe, a 90°F elbow and an appropriate length of solid pipe to extend the leg out of the cell material. Each point was sealed at its HDPE penetration point with heavy-duty tape and spray adhesive.
- The fourth side of the Treatment Cell was then finished with a single 2' high course of blocks, and covered with a 20-mil HDPE liner. The top liner was pre-cut as necessary to allow pass through of the individual PVC pipes. The top liner and bottom liner were sandwiched together and anchored on all four sides of the cell to the blocks with wood strapping. Each point was sealed at its HDPE penetration point with heavy-duty tape and spray adhesive.
- Six thermocouple type temperature-monitoring points were attached to rebar and direct driven into the cell at various locations and depths. The thermocouples were equipped with wire leads, which allowed technicians to measure temperature at each location with a handheld instrument. The penetration point for each thermocouple point was sealed with heavy-duty tape and spray adhesive.
- Steel piping and hoses as per the design were connected to each of the injection/extraction pipes and extended to the injection or extraction manifolds which were installed on the side of the cell. Manifolds were configured with individual valves and sample ports for each leg such that technicians could monitor and control applied vacuum or pressure and resultant flow from each point independently.
- Piping was extended from each of the manifolds to the Cell 3 Blower System.

4.4.5 Treatment Cell 3 Blower System

- The system connected to Treatment Cell 3 piping consisted of the following components:
  - A 10 Hp Second Generation Regenerative Blower capable of delivering and removing approximately 100 CFM of air at a maximum design pressure of (total dynamic head) of 5 PSI.
  - A moisture separator package with integral high-level alarm and transfer pump which was designed to deliver recovered water through appropriately sized liquid phase carbon to an on-site storage tank, for ultimate discharge to BASF's on site groundwater treatment system.
  - A VGAC and piping package complete with two (1,000 pounds [LB]) VGAC units, a high temperature alarm switch, and a dilution valve which the operator used to introduce ambient air such that the temperature of air entering the VGAC's remained below 150°F.
  - Valving, sample ports, and measurement equipment necessary to measure Vacuum/Pressure, Flow, Temperature, and VOC concentrations at various points throughout the system.

4.4.6 Treatment Cell 4: Peat Moss-Amended, Unheated, with Vertical Piping

Treatment Cell 4 was constructed by adding approximately 30% peat moss to the sediment and was designed to evaluate biological treatment using vertical extraction and injection piping in the more permeable material. The following details the design/construction of cell 4, which are presented in the Figure 4-5 as-built:

- The cell was constructed using concrete blocks on three sides to measure approximately 40-feet by 40" by 4" high. The cell was lined with filter fabric and 20-mil HDPE.
- Sediment was excavated from the Containment Cell and thoroughly mixed with the appropriate quantity of peat moss prior to being transported from the Containment Cell to Treatment Cell 3 and was mixed again and placed in 12" loose lifts.
- The fourth side of the Treatment Cell was finished with a single 2' high course of blocks, and covered with a 20 mil HDPE liner. The top liner and bottom liner were sandwiched together and anchored on all four sides of the cell to the blocks with wood stripping.
- Vertical injection/extraction pipes were then installed within the cell. Points were direct driven into the piles by hand. Installed points consisted of 20 galvanized iron points spaced equally throughout the cell. Of the 20 points installed 10 consisted of 2' of screen and 2' of riser, and 10 consisted of 4' of screen and 6" of riser. Each point was sealed at its HDPE penetration point with heavy-duty tape and spray adhesive.
- Six thermocouple type temperature-monitoring points were attached to rebar and direct driven into the cell at various locations and depths. The thermocouples were equipped with wire leads, which allowed technicians to measure temperature at each location with a handheld instrument. The penetration point for each thermocouple point was sealed with heavy-duty tape and spray adhesive.
- Appropriately sized steel piping and hoses were connected to each of the injection/extraction pipes and extended to the injection or extraction manifolds which were installed on the side of the cell. Manifolds were configured with individual valves and sample ports for each leg such that technicians could monitor and control applied vacuum or pressure and resultant flow from each point independently. The final connection for each leg was completed with a quick connect fitting such that technicians could easily switch any leg from the injection to the extraction manifold, and thus have maximum flexibility to use any legs as either injection or extraction points.
- The piping was initially set-up to extract from the deeper screened points while leaving the longer screened points open to the atmosphere, such that ambient air and oxygen would enter the pile and increase/maintain higher levels of oxygen to facilitate aerobic biodegradation of the VOCs.

4.4.7 Treatment Cell 4 Blower System

- The system connected to Treatment Cell 4 piping consisted of the following components:
  - A 3 Hp Regenerative Blower capable of delivering and removing approximately 100 CFM of air at an applied vacuum of 20 inches water column.
  - A moisture separator package with integral high-level alarm in order to shut the blower down in the event that too much water/condensate was recovered.

- Two 200 VGAC units were plumbed in series and installed on the blowers effluent to treat discharge air.
- Valving, sample ports, and measurement equipment necessary to measure Vacuum/Pressure, Flow, Temperature, and VOC concentrations at various points throughout the system.
- A timer was installed in order to allow the Cell 4 blower to be operated only as determined necessary based on the need to maintain aerobic conditions in the cell.

5.0 Field Design Modifications

The original design allowed for as-built variability during construction and during pre-treatment testing based on field observations. This built in flexibility allowed engineers to discuss observations and results with BASF and NYSDEC during the construction phase of work and provided maximum flexibility to meet project needs during the process. The above sections discuss in detail the system as-built information, which did not significantly differ from what was presented in the original design. In general, the systems were constructed as designed, with the following relatively minor differences between the design and the as-built project. Many of these field modifications were made due to the late season construction/operation of the pilot test system and associated colder ambient temperatures.

- Water was not automatically pumped from the system moisture separators through LGAC into BASF's on-site treatment system. Since ambient temperatures during testing were below freezing during a large portion of the test, each moisture separator was heat-traced and winterized, and water was manually pumped through carbon to a 55-gallon drum, which was then transported to BASF's on-site treatment system for additional treatment and discharge. This manual operation resulted in limited system down time when technicians were unable to respond to high moisture separator levels, but allowed BASF to avoid system failures associated with freezing and breaking pipes.
- The original design indicated that test cell piping would use a combination of steel and CPVC for manifold materials. During installation it was determined that the desire to use manifolds as either injection or extraction manifolds dictated that all manifolds should be constructed of steel because of concerns regarding the use of CPVC materials in elevated temperature and air pressure applications (CPVC design limit is 200ºF which might be exceeded with the auxiliary propane fired heater).
- The original design indicated that steel injection/extraction points consisting of 2" of screen and 4" of riser and 4" of screen and 2" of riser would be installed, respectively. Actual riser lengths were modified to make the total pipe length just over 4" to accommodate for the fact that less sediment material was available than originally expected and the overall cell height was 4" instead of the expected 5".
- Vertical pipes were driven at an angle where necessary in order to ensure that the entire length of the screened pipes could be within the sediment material.
- The initial discussions/designs for installation of the heating coil piping indicated that copper tubing would be installed and spread out both vertically and horizontally throughout the pile. During construction it was determined that HDPE pipe installed within a sand layer at the base of the pile would be adequate in terms of adding heat to the pile and would result in far less risk to potential piping damage during installation of the vertical injection/extraction piping.
- Due to late season construction and operation concerns, a number of design details were added to assist with insulating the system and to permit system operation despite the cold weather conditions. These activities included insulating the operational treatment cells with hay bales; winterizing all exposed water conveyance piping with self-regulating heat trace

tape and pipe wrap; installation of thermocouple extensions; installation of boiler, effluent tank, carbon vessel, and moisture separator insulation; adding 60 gallons of Cryolock 100 antifreeze to the closed loop non-contact heating system; and providing a weather-tight enclosure for the control panel.

6.0 Operation of Treatment Cells

In general, operation of the Treatment Cells began as soon as possible after construction was completed. However, an unanticipated and protracted NYSDEC approval process resulted in construction commencing later in the season than initially expected, and ambient temperatures were lower than desirable during the operational phase of this pilot study. A summary of operational highlights is provided below. Please refer to Tables 6-1, 6-2, 6-3 and 6-4 for operational data from each cell, and Tables 6-5, 6-6, 6-7 and 6-8 for a summary of temperatures collected within each cell during the operational phase of work.

6.1 Treatment Cell 1

Treatment Cell 1 was operated for at total period of 3 days between 11/9/09 and 11/13/09. During this period of time, a vacuum of 7.5"Hg was applied to the deep-screened vertical pipes within the cells, and a re-injection pressure of between 0 and 2 PSI was recognized at the full length screened vertical pipes within the cell. The flow rate obtained based on field measurements was consistently between 90 and 120 SCFM, and VOC concentrations of the circulated air ranged between 18 and 24 units on the PID. Approximately 30 gallons of water were removed from the cell and treated and discharged at the standing pump and treat system on the property.

During the initial phases of operation, attempts were made to inject air in the deep screens while extracting from the full-length screens, but this resulted in short circuiting of injected air directly up the borehole of the points. Short-circuiting was also observed at the extraction points, with air discharging in the interstitial space between the HDPE liner and the top of the sediment pile. The average temperature in Cell 1 during the final stages of operation was approximately 50°F.

After 72-hours of operation, it was determined that the pilot study at Cell 1 should be terminated because PID data and pressurization of the cover indicated that vapor flows were completely bypassing the sediment matrix. There was no likelihood that the treatment method could produce significant mass or moisture removal in a reasonable amount of time. This finding is likely related to the unexpectedly fine-grained material that was provided to AECOM by Empire as part of the IRM effort.

6.2 Treatment Cell 2

Treatment Cell 2 was operated for at total period of 16 days between 11/9/09 and 11/25/09. During this period of time a vacuum of approximately 10"Hg was applied to the deep screened vertical pipes within the cells, and a re-injection pressure of between 0.5 and 5 PSI were recognized at the full length screened vertical pipes within the cell. The flow rate obtained based on field measurements was consistently between 40 and 140 SCFM, and the VOC concentrations of the circulated air ranged from 27 to 566 units on the PID. In addition, approximately 260 gallons of water were removed from the cell, treated and discharged at the standing pump and treat system on the property.

Based on a review of the results from the initial trial operation of Treatment Cell 1, Treatment Cell 2 was operated only with a vacuum on the deep points and pressure on the full-length screen. Observations during operation indicated that over time the sediment materials immediately around the extraction points was becoming dried out and shrinking up. The result of this was that short-circuiting developed around the points and technicians had to periodically manually compact the materials around each point in order to maintain system vacuums.

The cover for treatment Cell 2 was insulated with approximately six inches of straw, and the boiler system was continuously operated on this cell and resulted in an average cell temperature of 60°F during the final stages of operation (ambient temperatures during this time period were approximately 30°F on average).

Ultimately it was determined that the pilot study at Cell 2 should be terminated based on the fact that the estimated time to produce significant mass or moisture removal under the available operational conditions was too great to warrant continued operational efforts, and because ambient temperatures and weather conditions prohibited successful and cost-effective operation of the system.

6.3 Treatment Cell 3

Treatment Cell 3 was operated for a total period of 48 days between 10/21/09 and 12/8/09. During this period of time a vacuum of approximately 3 inches water column was applied to the shallow level of horizontal screened pipes within the cell, and a re-injection pressure of between 1.5 and 2.5 inches water column was established at the full deep horizontal screened pipes within the cell.

The flow rate obtained based on field measurements was consistently between 100 and 140 SCFM, and VOC concentrations of the circulated air dropped from an initial 1410 PID units to 60 PID units during the latter stages of operation. In addition, approximately 64 gallons of water were removed from the cell and treated and discharged at the standing pump and treat system on the property.

As PID readings dropped, attempts were made to modify/optimize cell operation by pulsing points and promoting cross flow and mixing. These operational modifications did not significantly change PID readings; therefore, for most of the test, Cell 3 was operated to maintain a balanced vacuum/flow from the upper screens and the deeper points, with an overall slight negative pressure on the cell as a whole.

The sediment-LKD matrix was initially warmer than other cells and ambient conditions (65° F when other cells were between 59°F and 60°F and ambient was 44°F), likely from the exothermic reaction of lime hydration with the wet sediment. During the course of the test, the temperature of the cell decreased to 50°F with ambient temperatures correspondingly dropping from 70°F to 35°F.

The pilot study at Cell 3 was terminated based on the significant decrease of PID vapor concentrations and because sediment and ambient temperatures were continuing to decrease indicating that no significant additional treatment could be attained and because ambient temperatures and weather conditions prohibited continued cost-effective operation of this system.

6.4 Treatment Cell 4

Treatment Cell 4 was operated for at total period of 34 days between 10/29/09 and 12/2/09. The operating technology for this cell was aerobic bioremediation.

An auto-timer was utilized to operate the blower for approximately 1 hour per day. When the blower was operating, a vacuum of between 1 and 12 inches water column was applied to the deep-screened vertical pipes within the cell and air was discharged through vapor phase carbon to atmosphere. The manifold connected to the full-length screens was left open to the atmosphere such that ambient air was drawn into the cell. Flow rate measurements were consistently between 80 and 120 SCFM. PID readings of the recovered air ranged between 21 and 65 PID.

Throughout the period of operation, oxygen levels were monitored in the air stream recovered from the cell and it was determined that the 1 hour of operation per day was adequate to maintain the level of oxygen in excess of 20.4%. In general, oxygen contents in the cell ranged from approximately 19.9% after the blower had been inactive for 23.5 hours to a maximum of 20.9% after 1 hour of operation.

The average temperature in Cell 4 during the pilot test operation dropped from 60 degrees to below 50 degrees F. During the test period approximately 17 gallons of water were removed from the cell, treated, and discharged at the standing pump and treat system on the property.

The pilot study at Cell 4 was terminated based on the anticipated lack of significant biological activity with temperatures below 50°F. and because ambient temperatures and weather conditions prohibited successful and cost-effective operation of the system.

6.5 Data collection

Flow rate and vacuum measurement were collected manually by moving instruments to the test points shown in the P&IDs and site plans. Pressures were measured using digital manometers and liquid filled pressure and vacuum gauges. Vapor flow, temperature and humidity were measured using a hot wire anemometer.

Vapor field concentration measurements were collected at sampling locations using a five-gas meter and a PID unit. The five-gas monitor capable of monitoring H_2SO_4 (sulfuric acid) O_2 (oxygen), Carbon Dioxide (CO_2), lower explosive limit (LEL), and VOC's with a 10.6 electron-volt (eV) lamp.

Sediment temperatures were measured at six locations within each cell using a previously installed type K thermocouple and digital reading instrument. The thermocouples were installed as shown on the drawings and the data are presented in separate tables. These data were used primarily to determine shutdown criteria for the individual cells, but were also used in Treatment Cell 2 to determine the effectiveness of the heating system.

6.6 Close Out Sampling

The final composite sampling of each Treatment Cell was completed on December 16, 2010, approximately one year following termination of test cell operation. On December 16, 2010 composite samples were collected from each of the treatment cells in order to determine the concentrations of VOCs present in the treatment cells after completion of the testing activities. Additional laboratory analysis was completed on the samples in order to characterize the material for disposal. . Please refer to Table 6-9 for evaluation of post-treatment VOC results relative to pre pilot testing results. The laboratory analytical report is provided in Appendix A.

The sampling program was completed in a similar fashion to the baseline sampling with the exception that samples were not collected from all four quadrants in each cell, and composite depths were segregated to more discrete depths). In order to get a better representation of VOC concentrations based on depth in the respective piles approximately half of the samples were composited between 0 and 2', and the other half were composited between 2' and 4'. Samples were submitted to Columbia

Analytical Services, of Kelso, WA and analyzed for VOCs and TOC via EPA Methods 8260 and 9060 respectively, moisture content, and other parameters associated with waste disposal characterization. Tables 6-9 presents the close out sampling results, Table 6-10 compares pre- and post-treatment sampling results, and Figure 6-1 presents the sampling locations and composite depths.

7.0 Performance

Data collected from the four Treatment Cells was analyzed to develop performance curves, which could be used to compare treatment technologies and predict performance beyond the duration of the pilot study. Overall, data shows that this technology could be effective given the proper circumstances, however the presence of PCB's, and the high silt content of the sediment represent significant obstacles.

7.1 Vapor Concentration Decay Modeling

Graphs of vapor concentrations and sediment bulk temperatures for each of the Treatment Cells are provided in Charts 7-1, and 7-2. A regression analysis was performed for all Treatment Cell data to fit a first order lag-rate model as follows:

$$C_t = C_0 e^{-kt}$$

Where C_0 = initial vapor concentration

C_t = vapor concentration at time t

K = inverse of the time constant for contaminant removal via heat enhanced volatilization

Given the kinetic limitations of the low permeability and moist sediment, the regression analysis cannot be considered indicative of absolute treatment times required to achieve certain levels of mass removal. However, it can be an indicator of how robust the removal rate is and at what level asymptotic and kinetic limiting conditions may prevail, and this analysis allows relative comparison of the results from one treatment cell with another. Correlation data are indicated on the graphs for Treatment Cells 2 and 3. Data correlations for Treatment Cells 1 and 4 were poor and the model was considered not applicable for these two cells.

The time constant for Treatment Cell 2 is approximately 20 days indicating, without regard to the kinetic limitations discussed above, that 95% of treatment would be completed in approximately 15 days. Cell 2 was heated by the combination solar-propane non-contact heating system. The heating system initially increased bulk sediment temperatures but as ambient temperatures dropped, the system was reaching a point where sediment temperatures would soon not be sustained, as indicated by decreasing temperatures at the perimeter of the cell. Although Cell 2 performance could improve significantly were the system operated in warmer months with more optimal ambient conditions, the lack of sufficient permeability is expected to be a substantial obstacle to useful treatment or mass reduction irrespective of heating considerations.

The time constant for Cell 3 was approximately 20 days, indicating that, without regard to the kinetic limitations discussed above, 95% of treatment would be completed in approximately 60 days. However, the simplistic first order decay model does not incorporate slower mechanisms, which would dominate at this point in the treatment, and several months are likely to be necessary to achieve reuse standards for VOCs.

7.2 Vapor concentrations and mass removal details

Chart 7-1 presents a VOC versus time graph for all four TCs, and Tables 6-1 through 6-4 detail mass removal rates throughout the course of the test. Table 7-1 details initial conditions and provide a mass removal summary with a predicted endpoint for each cell based on the an assumed linear removal rate and without regard to potential kinetic limitations that would assuredly be encountered as the concentrations and mass removal rate decreased with further time. Time 0 data results were averaged on a per cell basis and utilized to calculate the initial mass balance presented in Table 7-1. The mass of contaminant in moisture for Table 7-1 was estimated based on condensate samples which were collected from the moisture separators at each cell and submitted to the lab for analysis via EPA method 8260 (See Appendix B, Tables B-1 through B-3 for condensate data). As described below, Treatment Cell 3 was the only treatment cell showing significant reduction in extracted VOC concentrations and resulted in a total mass removal that was an order of magnitude higher than for any other cells:

- In Test Cell 1, vapor concentrations dropped from 24.4 units on the PID during the first day of operation to 18.8 units at shutdown. At the flow rates measured, and assuming the entire mass as dichlorobenzene with a molecular weight of 147 grams/mole, it is estimated that mass removal rates during operation ranged between 1.2 and 1.3 lbs/day, and it is estimated that a maximum of 3 lbs/VOC (approximately 0.1% of the estimated mass) may have been removed from the cell during operations. In addition, approximately 30 gallons of water/condensate were removed from Cell 1. Based on the analytical data collected from the condensate, the mass of VOCs present in the 30 gallons of water recovered from Cell 1 was less than 1 lb and therefore is relatively insignificant.
- In Test Cell 2, vapor concentrations dropped from 566 PID units during the beginning stages of operation to around 27 units at shutdown. At the flow rates measured and assuming the entire mass as dichlorobenzene, an estimated mass removal rate during operation ranged from 35 lbs/day at test initiation to approximately 0.6 lbs/day at termination. It is estimated that a maximum of 58 lbs of VOCs or approximately 2% of the estimated total mass were removed from the cell during operation. In addition, approximately 260 gallons of water/condensate were removed from Test Cell 2. Based on the analytical data, the mass of VOCs present in the 260 gallons of water recovered from Cell 2 was less than 1 lb and is therefore insignificant. Overall, operation of Treatment Cell 2 provided significantly better moisture and VOC removal when compared with Treatment Cell 1, but still insignificant relative to the mass necessary to achieve compliance with onsite reuse concentrations.
- In Test Cell 3, vapor concentrations dropped from 1410 PID units during the beginning stages of operation to around 60 units at shutdown. At the flow rates measured and assuming the entire mass as dichlorobenzene, it is estimated that mass removal rates during operation ranged between 3 and 80 lbs/day. Based on these values, it is estimated that a maximum of 886 lbs of VOCs or approximately 64% of the total estimated mass were removed from the cell during operations. In addition, approximately 64 gallons of water/condensate were removed from Cell 3. Based on the analytical data collected, the mass of VOCs present in the 64 gallons of water recovered from Cell 3 was less than 1 lb and therefore is relatively insignificant in comparison to the vapor phase removal of VOCs. Overall, operation of Treatment Cell 3 provided significantly better VOC removal when compared with removal rates from Cells 1 and 2 and represented significant progress relative to the mass necessary to achieve compliance with onsite reuse concentrations.

- In Test Cell 4, oxygen levels increased each day following cell aeration to approximately 20.9% and decreased on a daily basis to as low as 19.9%. Based on this, the dimensions of the cell, and an assumed porosity of 35% it is estimated that approximately 2.02 lbs/O_2 was consumed on a daily basis. It can be estimated that approximately 3 lbs of O_2 are necessary to degrade 1 LB of VOCs (US EPA 1999). Therefore, mass removal due to bioactivity in Cell 4 can be estimated at a total of 23 lbs (approximately 1% of the estimated mass) in total. However, it is possible that the observed oxygen depletion is due at least in part to consumption of organic matter in the peat moss itself.

7.3 Temperature considerations

Due to delays in the regulatory review cycle, operation of the Treatment Cells commenced in November 2009, and as a result, system operators contended with increasingly colder ambient temperatures throughout the test program. Refer to Table 7-2 and Chart 7-2 for a summary of maximum and bulk average temperatures with reference to ambient temperature on a per cell basis.

- In Cell 1, the average temperature at the start of operations was 59°F, and the maximum temperature in the deepest point in the center of the cell was 62.5 degrees F Sediment temperatures were observed to drop during the course of the pilot study to an average of 49.5 and a maximum of 53.2.
- In Cell 2, the average temperature during the beginning stages of operation was 60 degrees F, and the maximum temperature in the deepest point in the center of the cell was 64 degrees F. These temperatures were observed to rise during the course of the pilot study to an average of 68°F and a maximum core temperature of 79 °F. However, perimeter sediment temperatures indicated that the pile was starting to cool despite the heating system and although several hundred gallons of water were removed from the sediment in Treatment Cell 2, it was apparent that additional moisture loss was required for permeability to increase. Cell 2 treatment or at least mass reduction could conceivably be significant if sediment temperatures could be elevated sufficiently (say 150 °F) to allow significant evaporation of moisture with a resulting increase in sediment permeability. With the solar and propane configuration in place, these temperatures could only be achieved with more amenable ambient conditions and better insulation of the sediment pile.
- Treatment Cell 3 had an initial average and maximum temperatures of 64°F and 70°F, respectively. The warmer initial temperature of this cell is likely due to the exothermic reaction that was generated when the sediments were mixed with LKD in mid-October. Cell average and core temperatures decreased throughout the study to final values of 51°F and 57°F, respectively. Treatment for this cell would be expected to improve with temperature generally following the general relationships of the Antoine vapor pressure correlation and Raoult's Law:

$$P_{vp} = K - e^{B/(T+C)} = y \bullet P$$

$$y = k \bullet x$$

- Temperatures in Cell 4 followed a pattern very similar to Cell 1: initial average and maximum temperatures of 59°F and 61°F respectively, decreasing throughout the test program to 50°F and 54°F, respectively. Bioactivity in general decreases significantly at 50°F so any chance of biological treatment decreased significantly when the test was stopped.

8.0 Conclusions and recommendations

The pilot study conducted at the BASF Rensselaer Site documented the feasibility associated with operating an *ex situ* heat-enhanced treatment system to reduce concentrations of VOCs in dredged Hudson River sediment. In addition, although not described in detail in this report (which focuses on the ex situ management of sediment), the earlier portions of the Empire IRM provided BASF with valuable information relative to the challenges associated with in-water management of sediments in this portion of the Hudson River.

8.1 Pilot Study Conclusions

The pilot study provided several key findings with regard to the ability to use heat-enhanced volatilization to remove VOCs from sediment:

- Neither the sediment received nor the operating conditions were optimum for conducting the ex-situ heat-enhanced treatment of sediment.
  - Because the pilot studies were conducted in the fall and early winter of 2009,low ambient temperatures were encountered, which limited the volatilization potential of the VOCs from the sediment. Even the solar powered indirect heating with water was limited by the low temperatures.
  - The sediments treated during the pilot test were comprised primarily of fine-grained silts and clays, which unexpected based on the historic results of the Hudson River RI program. The fine-grained materials required amendments to support heat-enhanced vapor extraction.
- Despite the challenges encountered, the pilot test demonstrated that heat-enhanced volatilization is a viable technology for removal of VOCs from sediment:
  - VOC levels in Treatment Cell 3, where the sediment was amended with LKD, were reduced by almost two-thirds. Although LKD is a costly amendment and a considerable volume of LKD was required to increase permeability, other amendments are available that can accomplish the same objective without a commensurate cost.
  - The peat used in Treatment Cell 4 provided a degree of permeability enhancement almost equal to that of the LKD. Although there was little measurable VOC removal in Treatment Cell 4, this was in large part a result of operating the cell as a biological treatment unit and not a vapor extraction cell. The addition of the peat, which is a low cost, lightweight amendment, provided an increase in porosity of sediment in the test cell supporting the conclusion that peat could be used in place of the LKD in a full-scale treatment program.

In summary, heat-enhanced volatilization can be an effective method to remove VOCs from the sediment if:

- Fine-grained sediment is amended to improve the permeability and allow air flow or the sediment is suitably coarse-grained to allow for air flow; and

- The system is operated during warmer months, or a heat source capable of maintaining elevated temperatures is used.

Under these conditions, which were represented in Treatment Cell 3, significant reductions in VOC concentrations can be predicted.

However, the non-Site related PCBs present in the sediment are not treatable with the low temperature VOC extraction technologies evaluated in this program. Therefore, even if the treatment system could be operated such that the treated materials contain levels of VOCs suitable for on-Site re-use, the NYSDEC regulatory guidelines relative to PCBs in soils may preclude on-Site re-use of Hudson River sediment and may necessitate off-site disposal.

8.2 Recommendations

Although the pilot test field observations and analysis of field data support the conclusion that heat-enhanced volatilization can effectively remove VOCs from sediment, the presence of PCBs in the sediment are a significant obstacle to achieving the goal of on-site reuse of the material. Therefore, it is recommended, at this time, that no further evaluation of heat-enhanced vapor extraction technologies be conducted, and other treatment/disposal alternatives be assessed. However, because the addition of peat in Test Cell 4 resulted in several indicators of VOC reduction via biological activity, it is possible that the addition of organic matter may prove to be a valuable management tool for ex situ sediment management at this Site. Therefore, in order to further evaluate beneficial aspects of organic enhancement, it is recommended that peat be mixed in with the remaining un-amended sediments (i.e., the contents of Cells 1 and 2) to further evaluate the potential for warm weather removal of VOCs from the sediment via biological degradation pathways.

BASF may conduct additional characterization of sediment as part of the characterization requirements for the feasibility study. If it is determined, based on this additional characterization, that sediment can be segregated in a manner such that the presence of PCBs does not prevent on-site reuse or interfere with efforts to reduce ultimate disposal costs, additional testing activities could be considered to further refine the design of a treatment system:

- The techniques for and effectiveness of sediment dewatering technologies will provide information not only for better refining the heat-enhanced volatilization approach, but will be useful in evaluating other sediment management methods. The evaluation would provide a basis to evaluate whether dewatering alone could sufficiently increase sediment porosity for the heat enhanced drying and volatilization treatment. The evaluation would also provide an understanding of the degree to which the sediment can be dewatered by various means to facilitate easy handling and cost-effective disposal.
- Additional evaluation of alternative amendments would provide a basis to select an amendment provides the positive benefits of LKD (moisture reduction and increased permeability) without the detriments of this amendment (cost and mass). Based on the increased permeability observed in Treatment Cell 4, peat would be a candidate for evaluation. Additionally, sand, sawdust, and corn cob are expected to be potentially suitable for this testing.

However, since the PCBs are present, it is recommended that alternative methods of treating and disposing of the sediment be investigated. These may include higher temperature thermal technologies.

Tables

Table 2-1
Soil Analytical Results - Polychlorinated Biphenyls (PCBs)
Rensselaer, New York

Sample ID	Composite 1	Composite 2	Composite 3
Date Sampled	**8/7/2009**	**8/7/2009**	**8/7/2009**
EPA 3570 PCBs (µg/kg)			
Aroclor 1016	<539	<567	<656
Aroclor 1221	<539	<567	<656
Aroclor 1232	<539	<567	<656
Aroclor 1248	<539	<567	<656
Aroclor 1254	<539	<567	<656
Aroclor 1260	<539	<567	<656
Aroclor 1262	<539	<567	<656
Aroclor 1268	<539	<567	<656
Aroclor 1242	23,000	12,000	22,800

Notes:

µg/kg = micrograms-per-kilogram, equivalent to parts-per-billion (ppb).

< = Below Laboratory Detection Limit

Table 3-1
Pre-Treatment (Bucket) Testing
Rensselear, New York

	Unamended						After Amendment								Permeability	
Bucket ID	Description	PID (ppm)	Temp (°F)	Slump (inch)	Permeability	Moisture	Amendment	Soil (lb)	Amendment (lb)	PID (ppm)	Temp (°F)	Slump (inch)	Moisture	Delta Moisture	Vac for 2 SCFH (inches $H_2$0)	Vac for 20 SCFH (inches $H_2$0)
6	clay/little silt	30.3	80	0	no flow	42	10% LKD	23.4	2.4	183.4	105	0	31.7	-9.8	0.15	0.22
1	clay/little silt	43.7	66	0	no flow	54	19 % LKD	21.8	4.2	750	110	0	27.2	-26.5	0.01	0.06
9	clay/little silt	50.4	83	0	no flow	44	35 % LKD	22.8	8	211	120	0	29.6	-14.3	0.25	0.60
7	clay/little silt	50.5	80	0	no flow	52	9 % CKD	22.8	2	50.5	105	0	36.8	-15	0.12	0.16
2	clay/little silt	59.8	68	0	no flow	54	24 % CKD	26.8	6.5	225	110	0	25.8	-27.9	0.06	0.17
8	clay/little silt	135.2	82	0	no flow	52	30 % CKD	23	6.8	301.3	110	0	29.4	-22.4	0.15	0.21
5	clay/little silt	52.8	78	0	no flow	42	10 % M Calciment	21.6	2.1	250	120	0	25.3	-16.2	0.60	0.75
3	clay/little silt	180.8	68	0	no flow	49	16 % Calciment	25.8	4.2	360	110	0	30	-19.1	0.11	0.18
10	clay/little silt	87.8	85	0	no flow	44	25 % M Calciment	29.5	7.3	215	145	0	23.4	-20.5	3.20	3.50
4	clay/little silt	300.8	76	0	no flow	49	30 % Peat Moss	23.4	6.9	315	110	0	73.9	24.8	0.15	0.21
11	clay/little silt	29.8	82	0	no flow	33	36 % Peat Moss	29.4	10.6	62.9	95	0	46.7	14	0.09	0.20

Notes:
PID - Head space readings in parts per million (ppm) as recorded with a photo-ionization detector calibrated to read total volatile organic compounds (VOCs) as dichlorobenzene.
Temp - Temperature of the sediment recorded in degrees Fahrenheit (°F)
Slump - Material slump recorded in inches based on slump testing as specified in ASTM-C143
Permeability - Aparatus as described in text was used to apply vacuum (measured in inches of water column [IWC]) to the materials. Several vacuums were applied with resultant flow recorded.
"no flow" indicates that zero flow was recorded at the maximum attainable vacuum.
Moisture - Percentage of moisture in soil as determined by laboratory analysis

Table 4-1
Soil Analytical Results - Volatile Organic Compounds (VOCs)
Rensselear, New York

Sample ID	**TC1A**	**TC1B**	**TC1C**	**TC1D**	**TC2A**	**TCB2B**	**TC2C**	**TC2D**	**TC3A**	**TC3B**	**TC3C**	**TC3D**	**TC4A**	**TC4B**	**TC4C**	**TC4D**
Date Sampled	**10/15/2009**	**10/15/2009**	**10/15/2009**	**10/15/2009**	**10/15/2009**	**10/15/2009**	**10/15/2009**	**10/15/2009**	**10/15/2009**	**10/15/2009**	**10/15/2009**	**10/15/2009**	**10/15/2009**	**10/15/2009**	**10/15/2009**	**10/15/2009**
EPA 5035 High Volatile Organics (µg/Kg)																
Chlorobenzene	3,000,000	2,700,000	1,900,000	2,800,000	2,700,000	2,300,000	2,100,000	2,500,000	690,000	2,300,000	730,000	770,000	2,700,000	2,500,000	1,900,000	2,400,000
1,2-Dichloroethane	32,000	37,000	30,000	38,000	39,000	31,000	31,000	34,000	<14,000	<17,000	<15,000	<14,000	39,000	43,000	30,000	38,000
Benzene	91,000	93,000	67,000	95,000	94,000	76,000	76,000	83,000	<14,000	30,000	<15,000	<14,000	100,000	93,000	68,000	90,000
Toluene	<34,000	29,000	<26,000	31,000	30,000	26,000	<24,000	28,000	<22,000	<25,000	<22,000	<22,000	32,000	28,000	<27,000	30,000
1,2-Dichlorobenzene	3,300,000	2,600,000	1,700,000	2,500,000	2,500,000	2,300,000	1,900,000	2,300,000	960,000	2,800,000	1,200,000	1,200,000	3,700,000	2,300,000	1,600,000	1,900,000
1,3-Dichlorobenzene	<110,000	93,000	<88,000	91,000	<95,000	<85,000	<81,000	<95,000	<72,000	110,000	<73,000	<72,000	120,000	90,000	<92,000	<100,000
1,4-Dichlorobenzene	400,000	330,000	220,000	310,000	320,000	290,000	250,000	290,000	120,000	340,000	150,000	150,000	540,000	300,000	200,000	240,000
1,2,3-Trichlorobenzene	150,000	140,000	90,000	130,000	140,000	120,000	120,000	130,000	<72,000	180,000	96,000	82,000	140,000	120,000	<92,000	<100,000
1,2,4-Trichlorobenzene	840,000	790,000	540,000	760,000	880,000	750,000	750,000	790,000	380,000	1,100,000	580,000	520,000	880,000	730,000	550,000	520,000
EPA 9060 Total Organic Carbon (%)	4.69	4.55	4.04	4.02	4.40	4.82	4.09	5.32	3.83	3.57	4.48	3.44	5.74	5.89	6.34	5.08
EPA 8260 Percent Moisture (%)	34	29	31	30	30	26	26	30	24	26	22	24	30	31	32	36

Notes:
µg/kg = micrograms-per-kilogram, equivalent to parts-per-billion (ppb).
< = Below Laboratory Detection Limit

Table 6-1
Cell 1 Field Data
Rensselear, New York

Date	Vacuum (inch Hg)	Pipe Flow Velocity (ft/min)	Flow Rate (SCFM)	PID (ppm)	O_2 (%)	Relative Humidity (%)	Pressure (inch H_2O)	Flow Rate (ft/min)	PID (ppm)	O_2 (%)	Relative Humidity (%)	Mass Removal (lbs/day)	Cumulative Mass Removal (lbs)	Water (gal/removed)	Comments
11/09/09	-7.5	1846	91	24.4	20.9	42.4	2.0	1499	BDL	20.9	42.4	1.2	0	10	Cell Started in morning, vac from deep, water removed prior to starting Cell 2
11/11/09	-7.5	2566	126	19.7	20.6	66.4	0.0	803	0	20.9	59.7	1.3	1	20.0	Water estimated at 20 gal because Cells 2 and 3 were operated simultaneously since end of last visit
11/13/09	-7.5	2500	123	18.8	NM	36.3	0.0	630	0.0	20.9	28.0	1.2	3	0.0	
												Total	***2***	***30.0***	

Notes:

VAC/Pressure - Measured at the inlet/effluent of the to the Blower in units noted

Flow Rate - Measured with a hotwire anemometer at the influent/effluent of the blower in feet per minute and calculated in standard cubic feet per minute (SCFM) based on pipe diameter

PID/O_2- photoionization detection per oxygen concentration recorded in units noted with a calibrated multi-rae meter

Relative Humidity - Recorded at the noted location using a velocicalc hot wire anemometer.

Mass - The calculated Mass removal rate in pounds per day, based on the influent concentration, the flow rate, and the molecular weight of

NM- Not Monitored

BDL Below Method Detection Limits

Table 6-2
Cell 2 Field Data
Rensselear, New York

Date	Vacuum (inch Hg)	Flow Rate (ft/min)	Flow Rate (SCFM)	PID (ppm)	O_2 (%)	Relative Humidity (%)	Pressure (inch H_2O)	Flow Rate (ft/min)	PID (ppm)	O_2 (%)	Relative Humidity (%)	Mass Removal (lbs/day)	Cumulative Mass Removal (lbs)	Water (gal/removed)	Comments
11/09/09	-10.0	1119	55	521	NM	NM	5.0	1072	BDL	17.2	66.2	15.44	0	10	Boiler started on 11/4/09 (temperature set at 120 degrees Fahrenheit increased to 140 degrees Fahrenheit on 11/9/09)
11/11/09	-9.5	2368	116	566	20.5	66.1	0.5	686	BDL	20.1	55.2	35.50	15	20	
11/13/09	-9.5	1325	65	47	NM	35.7	0.5	974	2.9	20.9	30.8	1.65	51		
11/13/09	NM	1378	68	23.5	20.9	29.1	NM	887	42.6	20.3	30.6	0.86	51	30	
11/16/09	-3	857	42	23.8	20.9	55.7	4.0	1853	BDL	20.9	50.6	0.54	52		
11/16/09	-10.0	1325	65	47.6	20.9	45.4	2	1470	BDL	NM	47.8	1.67	52	40	
11/18/09	-9.5	1774	87	42.6	20.3	46.0	0.5	1271.0	16.9	20.5	42.9	2.00	54	20	
11/23/09	-9.5	2850	140	27.1	20.5	39.5	0.5	1315.0	BDL	20.5	48.6	2.05	58	80	System Shut Down
11/25/09	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	60	
												Total	***44***	***260***	

Notes:

VAC/Pressure - Measured at the inlet/effluent of the to the Blower in units noted

Flow Rate - Measured with a hotwire anemometer at the influent/effluent of the blower in feet per minute and calculated in standard cubic feet per minute (SCFM) based on pipe diameter.

PID/O_2- photoionization detection per oxygen concentration recorded in units noted with a calibrated multi-rae meter

Relative Humidity - Recorded at the noted location using a velocicalc hot wire anemometer.

Mass - The calculated Mass removal rate in pounds per day, based on the influent concentration, the flow rate, and the molecular weight of Dichlorobenzene.

NM- Not Monitored

BDL Below Method Detection Limits

AECOM

Table 6-3
Cell 3 Field Data
Rensselear, New York

Date	Vacuum (inch Hg)	Flow Rate (ft/min)	Flow Rate (SCFM)	PID (ppm)	O_2 (%)	Relative Humidity (%)	Pressure (inch H_2O)	Flow Rate (ft/min)	PID (ppm)	O_2 (%)	Relative Humidity (%)	Mass Removal (lbs/day)	Cumulative Mass Removal (lbs)	Water (gal/removed)	Comments
10/21/09	-3.0	5101	111	430	NM	NM	NM	NM	NM	NM	NM	25.81	0		
10/24/09	-3.0	4875	106	1410	NM	NM	2.0	NM	NM	NM	NM	80.86	77		
10/26/09	-3.0	4740	103	964	NM	NM	2.0	4870	6	NM	NM	53.78	239		
10/29/09	0.0	4950	108	564	20.0	NM	2.0	4915	8	20.2	NM	32.84	400		
10/30/09	-4.5	4821	105	433	20.0	NM	3.0	5624	0.9	20.1	NM	24.55	433	8	
11/2/09	9.0	5123	112	285	19.2	76	2	5023	5.875	19.8	67	17.19	507	8	
11/3/09	-3.0	4868	106	411	19.7	NM	1.5	5313	BDL	19.7	NM	23.52	524	6	
11/4/09	-3.0	5110	111	322	19.8	NM	1.5	5071	14.1	19.9	NM	19.35	548	6	
11/4/09	-3.0	4946	108	191	20.2	NM	1.5	5149	BDL	20.2	NM	11.10	548		
11/6/09	-3.0	5216	114	202	20.4	55.6	1.5	5221	0.7	20.1	36.5	12.40	570		
11/9/09	-3.0	5191	113	155	20.2	73	1.5	5195	BDL	20.1	36.7	9.47	607	10	Went to 100% recirc
11/11/09	-3.0	6381	139	222	20.1	66.2	2.5	4616	BDL	20.1	52.1	16.69	626		
11/13/09	-3.0	4585	100	301	20.4	42.5	2.0	6047	0.7	20.4	81	16.22	659		
11/16/09	-3.0	5206	114	223	20.9	52.7	2.0	6293	BDL	20.6	56	13.67	708	5	
11/18/09	-3.0	4978	109	92	19.8	41.4		6384	BDL	20.0	80.2	5.39	735	4	
11/23/09	-3.0	5244	114	144	20.4	33.1	2.5	6390	BDL	20.3	66.3	8.87	762	3	
11/25/09	-3.0	5099	111	154	20.6	40.3	2.4	5873	BDL	20.6	75.2	9.25	780	1	
12/2/09	-3.0	5300	116	110	20.4	48.7	2.0	6101	BDL	20.3	58.6	6.89	845	8	
12/8/09	-3.0	5403	118	60	20.3	46.3	2.0	6656	BDL	20.3	43.7	3.79	886	5	
												Total	***886.2***	***64.0***	

Notes:
VAC/Pressure - Measured at the inlet/effluent of the to the Blower in units notec
Flow Rate - Measured with a hotwire anemometer at the influent/effluent of the blower in feet per minute and calculated in standard cubic feet per minute (SCFM) based on pipe diameter.
PID/O_2- photoionization detection per oxygen concentration recorded in units noted with a calibrated multi-rae meter.
Relative Humidity - Recorded at the noted location using a velocicalc hot wire anemometer
Mass - The calculated Mass removal rate in pounds per day, based on the influent concentration, the flow rate, and the molecular weight of Dichlorobenzene.
NM- Not Monitored
BDL Below Method Detection Limits

Table 6-4
Cell 4 Field Data
Rensselear, New York

Date	Vacuum (inch Hg)	Flow Rate (ft/min)	PID (ppm)	O_2 (%)	Relative Humidity (%)	Pressure (PSI)	Flow Rate (ft/min)	PID (ppm)	O_2 (%)	Relative Humidity (%)	Water (gal/removed)	Comments
10/29/09	<1.0	4200	65	20.3	NM	2.75	4636	33	20.2	NM		
10/30/09	0.0	4011	53	20.6	NM	2.5	4566	102	20.6	NM		
11/3/09	NM	NM	NM	19.9	NM	9.0	4708	20.5	19.9	NM	6.0	
11/6/09	-3.0	4312	29.4	20.1	43.0	3.0	5113	NM	NM	20.5		
11/9/09	NM	NM	21	20.5	89.0	13.5	3701	20.5	20.5	NM		
11/11/09	-11.0	4364	32	20.3	62.0	NM	NM	BDL	20.5	NM		
11/13/09	-11.0	4197	30	20.9	34.2	2.0	5816	BDL	20.4	36.2		
11/16/09	-20.0	NM	NM	NM	NM	NM	5563	24.2	20.9	60.4	10.0	
11/18/09	-12.5	NM	NM	20.0	41.4	2.0	5590	11.0	19.9	47.0		
11/23/09	NM	NM	NM	20.3	73.1	NM	4282	14.7	20.9	NM		
11/25/09	-12.9	NM	NM	20.9	76.7	NM	4079	8.0	20.9	NM	0.5	
12/2/09	-11.0	NM	NM	20.1	58.4	2.0	4677	8.8	20.4	NM	0.3	
									Total		***16.8***	

Notes:
VAC/Pressure - Measured at the inlet/effluent of the to the Blower in units noted
Flow Rate - Measured with a hotwire anemometer at the influent/effluent of the blower in feet per minute and calculated in standard cubic feet per minute (SCFM) based on pipe diameter
PID/O_2- photoionization detection per oxygen concentration recorded in units noted with a calibrated multi-rae meter.
Relative Humidity - Recorded at the noted location using a velocicalc hot wire anemometer.
Mass - The calculated Mass removal rate in pounds per day, based on the influent concentration, the flow rate, and the molecular weight of Dichlorobenzene.
NM- Not Monitored
BDL Below Method Detection Limits

Table 6-5
Cell 1 Temperature Data
Rensselear, New York

Date	T1 (°F)	T2 (°F)	T3 (°F)	T4 (°F)	T5 (°F)	T6 (°F)
10/27/09	55.7	56.3	58.6	60.3	61.4	62.5
10/28/09	55.1	55.7	57.6	59.6	60.7	62.0
10/29/09	61.4	54.6	60.2	58.1	59.3	55.1
11/2/09	57.2	56.2	59.7	60.9	61.3	61.4
11/03/09	57.8	59.5	60.2	60.6	55.7	55.9
11/4/09	56.3	56.2	57.9	59.8	60.3	61.0
11/4/09	55.9	55.7	57.3	59.5	60.0	60.9
11/6/09	54.5	54.7	56.3	58.4	59	60.2
11/9/09	53	52.2	55.2	57.0	58	59.0
11/11/09	53.7	54.1	56.6	57.7	58.1	58.1
11/13/09	53.5	54.5	55.5	57.2	58.0	58.6
11/16/09	53.4	53.3	55.9	57.3	57.5	58.0
11/18/09	52.0	52.8	53.6	55.4	55.7	56.1
11/23/09	49.5	51.8	53.3	51.2	53.7	54.6
11/25/09	49.5	52.0	53.4	51.7	53.7	54.5
12/2/09	48.2	51.8	49.8	52.4	52.9	53.8
12/8/09	46.5	49.1	47.5	50.5	51.2	53.2

Notes:

Temperatures are recorded at each thermocouple point

Measurement points are located on Figure 4-2

°F is degrees Fahrenheit

Table 6-6
Cell 2 Temperature Data
Rensselear, New York

Date	T1 (°F)	T2 (°F)	T3 (°F)	T4 (°F)	T5 (°F)	T6 (°F)
10/27/09	55.8	57.7	60.8	63.9	60.7	59.7
10/28/09	56.6	52.2	59.4	60.7	63.7	60.4
10/29/09	58.5	59.4	62.7	59.6	53.7	56.0
11/2/09	57.5	57.4	61.0	60.8	63.3	59.9
11/03/09	60.1	60.0	62.6	59.0	56.0	56.8
11/4/09	56.4	57.4	60.2	63.1	60.2	58.9
11/4/09	55.6	57.0	59.4	62.5	59.7	58.4
11/6/09	56.5	58.1	58.6	63.9	59	57.8
11/9/09	57	57.4	60.1	66.0	60	58.0
11/11/09	59.1	59.4	62.1	67.8	61.7	60.4
11/13/09	58.6	63.0	64.5	71.1	64.0	62.4
11/16/09	62.1	64.8	67.8	74.2	67.8	65.2
11/18/09	60.0	63.2	69.0	75.0	67.7	64.4
11/23/09	58.1	59.7	71.0	78.0	68.7	65.3
11/25/09	59.4	59.5	72.2	79.4	69.7	66.0
12/2/09	53.6	55.9	67.8	74.8	66.5	62.1
12/8/09	50.4	53.2	62.7	71.2	61.9	58.0

Note:

Temperatures are recorded at each thermocouple point

Measurement points are located on Figure 4-2

°F is degrees Fahrenheit

Table 6-7
Cell 3 Temperature Data
Rensselear, New York

Date	T1 (°F)	T2 (°F)	T3 (°F)	T4 (°F)	T5 (°F)	T6 (°F)
10/26/09	57.7	56.7	67.9	67.1	67.3	69.7
10/27/09	54.9	56	62.6	67.1	67.6	70.0
10/28/09	55	56.3	67.1	66.7	67.3	69.0
11/2/09	56.2	56.4	58.6	66.6	67.4	68.7
11/03/09	65.2	65.4	66.8	54.0	55.3	68.3
11/4/09	53.1	54.6	65.8	66.2	67.7	69.2
11/4/09	55.3	52.4	64.5	64.5	66.0	67.7
11/6/09	52	51.8	62.9	63.4	64.7	66.8
11/9/09	53.9	51	60.8	61.3	62	65.1
11/11/09	55.1	54.0	61.0	61.7	62.9	64.7
11/13/09	52.3	50.8	61.0	61.4	62.5	64.3
11/16/09	55.2	54.1	59.5	60.3	61.3	63.2
11/18/09	50.9	50.1	58.8	59.4	60.6	62.2
11/23/09	47.9	48.0	56.2	55.9	57.5	60.1
11/25/09	51.1	50.2	57.0	57.3	58.0	60.4
12/2/09	46.2	45.8	55.0	54.7	55.1	58.1
12/8/09	42.9	43.2	53.5	52.9	53.4	57.3

Note:

Temperatures are recorded at each thermocouple point

Measurement points are located on Figure 4-2

°F is degrees Fahrenheit

Table 6-8
Cell 4 Temperature Data
Rensselear, New York

Date	T1 (°F)	T2 (°F)	T3 (°F)	T4 (°F)	T5 (°F)	T6 (°F)
10/27/09	53.9	57.5	59.9	59.7	59.4	61.2
10/28/09	53.8	57.2	59.5	59.5	59.2	61.1
10/29/09	54.6	59.3	58.6	60.3	58.6	56.1
11/2/09	56.4	57.2	59.5	59.7	59.6	60.6
11/03/09	55.2	59.6	59.6	61.2	59.9	**61.0**
11/4/09	55.1	57.8	60.5	59.7	60.1	61.9
11/4/09	54.0	56.2	59.2	58.7	58.7	60.5
11/6/09	52.6	55.5	58.1	57.7	57.5	59.9
11/9/09	50.5	54.2	57.3	56.2	56	58.8
11/11/09	52.1	54.2	57.5	56.1	56.2	58.0
11/13/09	52.0	54.7	57.2	56.3	56.3	58.6
11/16/09	52.4	53.9	56.6	55.6	55.8	57.8
11/18/09	50.9	53.5	56.2	55.5	55.1	57.4
11/23/09	50.6	51.7	55.2	54.0	54.2	56.1
11/25/09	50.0	52.1	54.4	53.9	53.8	56.4
12/2/09	47.6	50.5	52.5	52.1	52.1	54.7
12/8/09	45.0	48.8	50.4	50.6	50.3	53.9

Notes:

Temperatures are recorded at each thermocouple point

Measurement points are located on Figure 4-2

°F is degrees Fahrenheit

Table 6-9
Post-Treatment Soil Analytical Results - Volatile Organic Compounds (VOCs)
Rensselear, New York

Sample ID	TC-1A	TC-2A	TC-3A1	TC-3A4	TC-3B2	TC-3B3	TC-3C2	TC-3C3	TC-3C4	TC-3D1	TC-3D2	TC-3D4			TC-3	TC-4A1	TC-4A2	TC-4D1	TC-4D2			TC-4
Date Sampled	12/16/2010	12/16/2010	12/16/2010	12/16/2010	12/16/2010	12/16/2010	12/16/2010	12/16/2010	12/16/2010	12/16/2010	12/16/2010	12/16/2010	StdDev	Median	Average	12/16/2010	12/16/2010	12/16/2010	12/16/2010	Std Dev	Median	Average
EPA 5035 High Volatile Organics (µg/Kg)																						
Chlorobenzene	2,300,000	1,300,000	120,000	500,000	47,000	580,000	72,000	30,000	81,000	360,000	83,000	820,000	278,751	101,500	269,300	450,000	2,100,000	1,100,000	800,000	709,900	950,000	1,112,500
1,2-Dichloroethane	12,000	8,800	750	*1,700*	*470*	*1,500*	*480*	*130*	470	1,900	*280*	*890*	626	615	857	6,200	14,000	5,200	5,100	4,279	5,700	7,625
Benzene	47,000	25,000	990	4,100	*290*	2,600	*390*	*210*	660	4,500	*310*	14,000	4,255	825	2,805	2,200	52,000	17,000	13,000	21,559	15,000	21,050
Toluene	18,000	15,000	690	3,300	*230*	2,800	*360*	*130*	*380*	2,100	*250*	9,900	3,009	535	2,014	3,600	23,000	10,000	8,400	8,292	9,200	11,250
1,2-Dichlorobenzene	2,500,000	1,900,000	650,000	1,700,000	780,000	1,600,000	740,000	360,000	440,000	1,800,000	740,000	1,300,000	538,319	760,000	1,011,000	1,000,000	2,800,000	1,400,000	1,300,000	801,561	1,350,000	1,625,000
1,3-Dichlorobenzene	98,000	100,000	20,000	63,000	26,000	64,000	17,000	8,000	14,000	61,000	20,000	52,000	22,638	23,000	34,500	42,000	93,000	59,000	52,000	22,128	55,500	61,500
1,4-Dichlorobenzene	340,000	300,000	63,000	200,000	60,000	210,000	63,000	30,000	45,000	200,000	71,000	150,000	72,155	67,000	109,200	110,000	390,000	180,000	160,000	123,558	170,000	210,000
1,2,3-Trichlorobenzene	150,000	180,000	83,000	140,000	100,000	140,000	120,000	68,000	63,000	120,000	130,000	91,000	28,598	110,000	105,500	86,000	140,000	97,000	85,000	25,910	91,500	102,000
1,2,4-Trichlorobenzene	710,000	760,000	530,000	750,000	56,000	710,000	680,000	380,000	380,000	830,000	660,000	610,000	230,482	635,000	558,600	420,000	700,000	460,000	550,000	124,197	505,000	532,500
Chloromethane	<2,200	<2,100	<420	<1,800	<760	<1,700	<1,700	<400	*220*	<860	<1,600	<930		220	220	<510	<2,600	<2,100	<510	NA	NA	715
Acetone	<88,000	<82,000	*9,100*	<6,900	<31,000	*13,000*	<65,000	*11,000*	*13,000*	*13,000*	<62,000	*10,000*	1,733	12,000	11,517	<21,000	<110,000	<81,000	<21,000	NA	NA	29,125
Methylene Chloride	*970*	*850*	*180*	<6,900	*360*	<6,600	*970*	*150*	*190*	*340*	*890*	*430*	319	350	439	*220*	*1,100*	*1,100*	*200*	514	660	655
2-Butanonoe	<88,000	<82,000	*2,300*	<6,900	<31,000	<66,000	<65,000	*2,000*	*3,200*	*3,400*	<62,000	<38,000	680	2,750	2,725	<21,000	<110,000	<81,000	<21,000	NA	NA	29,125
Chloroform	<2,200	<2,100	<420	<1,800	<760	<1,700	<1,700	*340*	800	<860	<1,600	<930	325	570	570	*80*	<370	<2,100	*91*	8	86	329
Trichloroethene	*570*	<2,100	<420	<1,800	<760	<1,700	<1,700	<400	<430	<860	<1,600	*220*		220	220	*140*	*650*	<2,100	*210*	276	210	460
Tetrachloroethene	*660*	*570*	<420	<1,800	<760	<1,700	<1,700	<400	<430	<860	<1,600	*220*		220	220	*270*	*700*	<2,100	*280*	245	280	505
Ethylbenzene	7,600	6,200	480	*1,700*	*150*	2,000	*190*	*78*	*270*	1,300	*250*	3,400	1,102	375	982	2,200	7,500	4,000	3,400	2,277	3,700	4,275
m,p-Xylenes	22,000	23,000	1,800	6,500	980	7,900	*940*	*350*	1,200	5,600	*980*	13,000	4,197	1,500	3,925	8,900	24,000	14,000	13,000	6,409	13,500	14,975
o-Xylenes	5,800	6,700	520	2,100	*350*	2,600	*320*	*130*	*390*	1,900	*430*	3,400	1,176	475	1,214	2,600	6,600	3,900	3,400	1,735	3,650	4,125
Isopropylbenzene	<8,800	*490*	<1,700	<6,900	<3,100	<6,600	<6,500	<1,600	<1,700	*190*	<6,200	*260*	49	225	225	*220*	<11,000	<8,100	*260*	28	240	2,508
EPA 8260 Percent Moisture (%)	27.4	24.2	25	26.6	20.5	23.9	23.2	22.5	25.7	26.6	21.1	30.5	2.98	24.45	24.56	33.2	33.5	35.1	34.3	1	34	34

Notes:
µg/kg = micrograms-per-kilogram, equivalent to parts-per-billion (ppb).
< = Below Method Reportable Limit
Red Italics = Estimated concentration
NA = not applicable

Table 6-10
Soil Analytical Results Comparison - Volatile Organic Compounds (VOCs)
Rensselear, New York

Sample ID	TC1							TC2							TC3							TC4						
	Pre-treatment			Post-treatment			Percent Reduction	Pre-treatment			Post-treatment			Percent Reduction	Pre-treatment			Post-treatment			Percent Reduction	Pre-treatment			Post-treatment			Percent Reduction
EPA 5035 High Volatile Organics (µg/Kg)	# of sample	# of non detect	10/15/2009	# of sample	# of non detect	12/16/2010	%	# of sample	# of non detect	10/15/2009	# of sample	# of non detect	12/16/2010	%	# of sample	# of non detect	10/15/2009	# of sample	# of non detect	12/16/2010	%	# of sample	# of non detect	10/15/2009	# of sample	# of non detect	12/16/2010	%
Chlorobenzene	4	4	2,600,000	1	1	2,300,000	12	4	4	2,400,000	1	1	1,300,000	46	4	4	1,122,500	10	10	269,300	76	4	4	2,375,000	4	4	1,112,500	53
1,2-Dichloroethane	4	4	34,250	1	1	12,000	65	4	4	33,750	1	1	8,800	74	4	0	900	10	10	857	NA	4	4	37,500	4	4	7,625	80
Benzene	4	4	86,500	1	1	47,000	46	4	4	82,250	1	1	25,000	70	4	1	30,000	10	10	2,805	91	4	4	87,750	4	4	21,050	76
Toluene	4	2	30,000	1	1	18,000	40	4	3	28,000	1	1	15,000	46	4	0	2,500	10	10	2,014	NA	4	3	30,000	4	4	11,250	63
1,2-Dichlorobenzene	4	4	2,525,000	1	1	2,500,000	1	4	4	2,250,000	1	1	1,900,000	16	4	4	1,540,000	10	10	1,011,000	34	4	4	2,375,000	4	4	1,625,000	32
1,3-Dichlorobenzene	4	2	92,000	1	1	98,000	-7	4	0	100,000	1	1	100,000	0	4	1	110,000	10	10	34,500	69	4	2	105,000	4	4	61,500	41
1,4-Dichlorobenzene	4	4	315,000	1	1	340,000	-8	4	4	287,500	1	1	300,000	-4	4	4	190,000	10	10	109,200	43	4	4	320,000	4	4	210,000	34
1,2,3-Trichlorobenzene	4	4	127,500	1	1	150,000	-18	4	4	127,500	1	1	180,000	-41	4	3	119,333	10	10	105,500	12	4	2	130,000	4	4	102,000	22
1,2,4-Trichlorobenzene	4	4	732,500	1	1	710,000	3	4	4	792,500	1	1	760,000	4	4	4	645,000	10	10	558,600	13	4	4	670,000	4	4	532,500	21
Total VOC's			6,542,750			6,175,000	6			6,101,500			4,588,800	25			3,760,233			2,093,776	44			6,130,250			3,683,425	40
Percent Moisture			31			27	12			28			24	14			24			25	-2			32			34	-6

Notes:

µg/kg = micrograms-per-kilogram, equivalent to parts-per-billion (ppb).

< = Below Laboratory Detection Limit

ND = Non Detect

Date
10/26/09
10/27/09
10/28/09
11/2/09
11/03/09
11/4/09
11/4/09
11/6/09
11/9/09
11/11/09
11/13/09
11/16/09
11/18/09
11/23/09
11/25/09
12/2/09
12/8/09

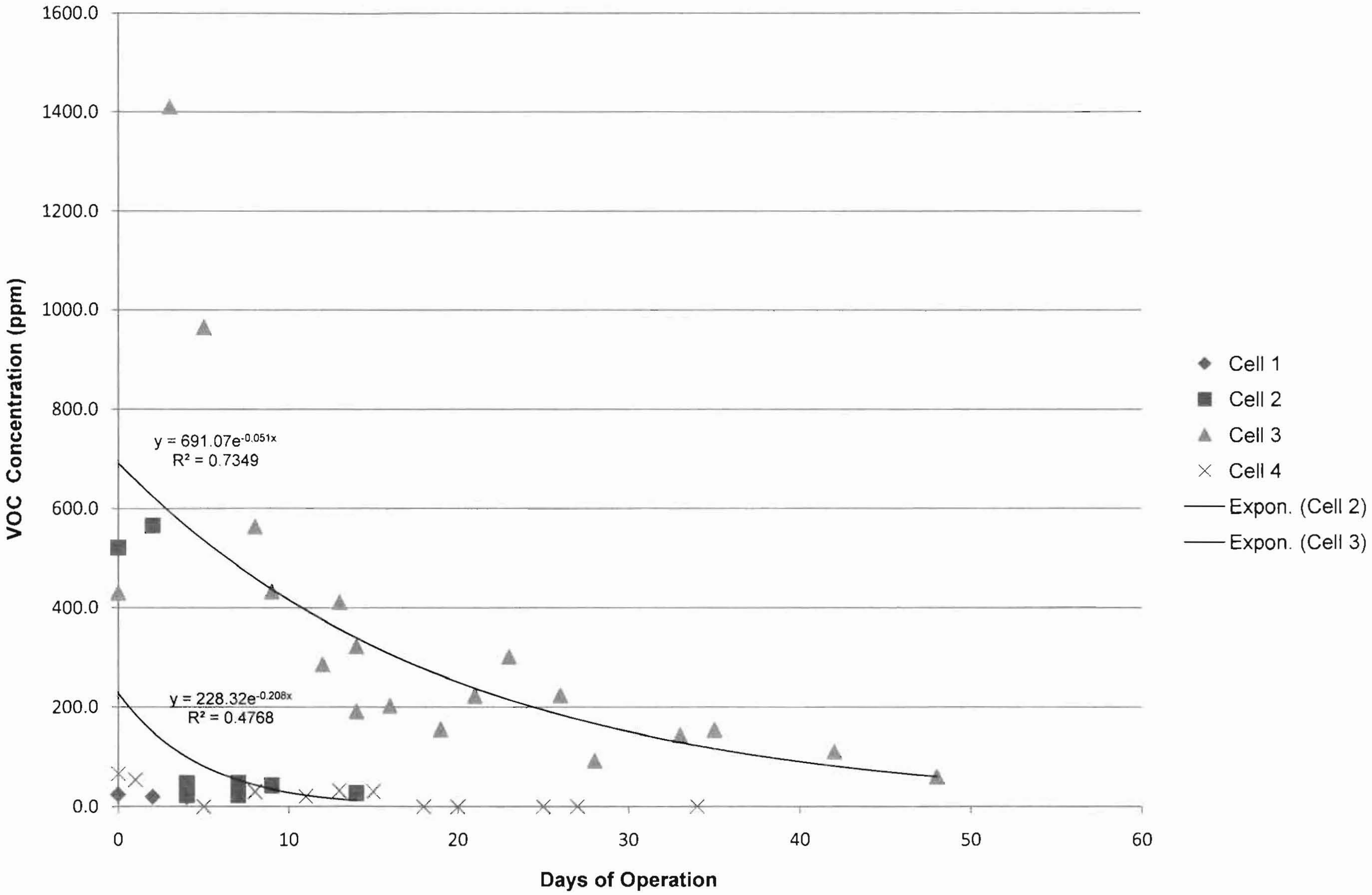
Notes:
Average a
Ambient te
°F is degre

Table 7-1
Summary of Mass
Rensselear, New York

Chemical Name	Cell 1				Cell 2				Cell 3				Cell 4			
	Average Conc. %		Mass (lbs)	% or qty (gal)	Average Conc. %		Mass (lbs)	% or qty (gal)	Average Conc. %		Mass (lbs)	% or qty (gal)	Average Conc. %		Mass (lbs)	% or qty (gal)
MOISTURE	31		137491	16486	28		144883	17372	24		120960	14504	32.25		126420	15158
Soil (Calculated Mass)	NA		306029	NA	NA		372557	NA	NA		383040	NA	NA		265580	NA
TOTAL ORGANIC CARBON (%)	4.33				4.66				3.83				5.76			
Chemical Name	**µg/kg (soil)**	**µg/l (water)**	**(lbs)**	**(%)**	**µg/kg (soil)**	**µg/l (water)**	**(lbs)**	**(%)**	**µg/kg (soil)**	**µg/l (water)**	**(lbs)**	**(%)**	**µg/kg (soil)**	**µg/l (water)**	**(lbs)**	**(%)**
1,4-DICHLOROBENZENE	315,000	4,924	97	4.8%	287,500	4,173	107	4.8%	190,000	3,354	73	5.2%	320,000	3,754	85	5.2%
1,2-DICHLOROETHANE	34,250	535	11	0.5%	33,750	490	13	0.6%	0	0	0	0.0%	37,500	440	10	0.6%
TOLUENE	15,000	1,148	5	0.2%	21,000	1,493	8	0.4%	0	0	0	0.0%	22,500	1,293	6	0.4%
CHLOROBENZENE	2,600,000	140,925	804	40.3%	2,400,000	120,798	902	40.2%	1,122,500	68,705	434	31.1%	2,375,000	96,617	636	38.9%
1,2,4-TRICHLOROBENZENE	732,500	1,509	224	11.2%	792,500	1,517	295	13.2%	645,000	1,501	247	17.7%	670,000	1,036	178	10.9%
1,3-DICHLOROBENZENE	46,000	719	14	0.7%	0	0	0	0.0%	27,500	485	11	0.8%	52,500	616	14	0.9%
BENZENE	86,500	32,436	28	1.4%	82,250	28,641	33	1.4%	7,500	3,176	3	0.2%	87,750	24,697	25	1.5%
1,2,3-TRICHLOROBENZENE	127,500	263	39	2.0%	127,500	244	48	2.1%	89,500	208	34	2.5%	65,000	101	17	1.1%
1,2-DICHLOROBENZENE	2,525,000	39,471	775	38.8%	2,250,000	32,661	840	37.4%	1,540,000	27,185	591	42.4%	2,500,000	29,331	666	40.7%
Mass Removal Summary	**Cell 1 Summary**				**Cell 2 Summary**				**Cell 3 Summary**				**Cell 4 Summary**			
VOCs in Cell (lb @ T=0)	1997				2246				1393				1637			
Mass Removal Vapor (lb to date)	2				44				886				23			
Mass Remaining (lb VOCs)	1996				2202				507				1614			
% removed	0.10%				2%				64%				1%			
Days of Operation to date (days)	4				16				48				34			
Project total days for compliance (days)	4203				825				75				2456			

Notes:
Density is assumed wet density based on bucket testing and reviewed text. Expected to collect samples for lab analysis of bulk density etc during close out sampling.
Calculated mass is based on analytical data collected from 4 points in each cell and averaged for the calculation (see full data set in Table 4-1).
Only volatile organic compounds (VOCs) which were detected above lab detection limits are included in the mass calculation.
Mass removal of VOCs in the vapor phase is calculated based on the vapor flow rate and photo ionization detector (PID) readings, data are calibrated and adjusted based on lab analytical and field observations made during operation.
Cell 1 and 2 vapor phase VOC removal is adjusted to 75% of calculated based on operational down time and lab data.
Cell 3 vapor phase VOC removal is not adjusted because lab data indicated greater removal and no down time was observed.
Removal of VOCs in condensate is neglected based on lab data and qty of water indications of minimal removal.
See Table 6-1 Through 6-4 for operational parameters, quantity of water recovered, and VOC mass removal calculation in the vapor phase.
See Appendix A Tables A-1 through A-3 for summary of air analytical collected on 11/18/09. Data used to verify/adjust PID based calculations.
See Appendix B Tables B-1 through B-3 for summary of analytical results on condensate collected.
Cell 4 mass removal is based on an estimate that we are consuming 2 lb/day of oxygen (O_2), and VOC demand is 3lbs O_2/lb VOC (see "O_2 Consumption" worksheet)

Chart 7-1
VOC Concentration vs. Time
Rensselear, New York



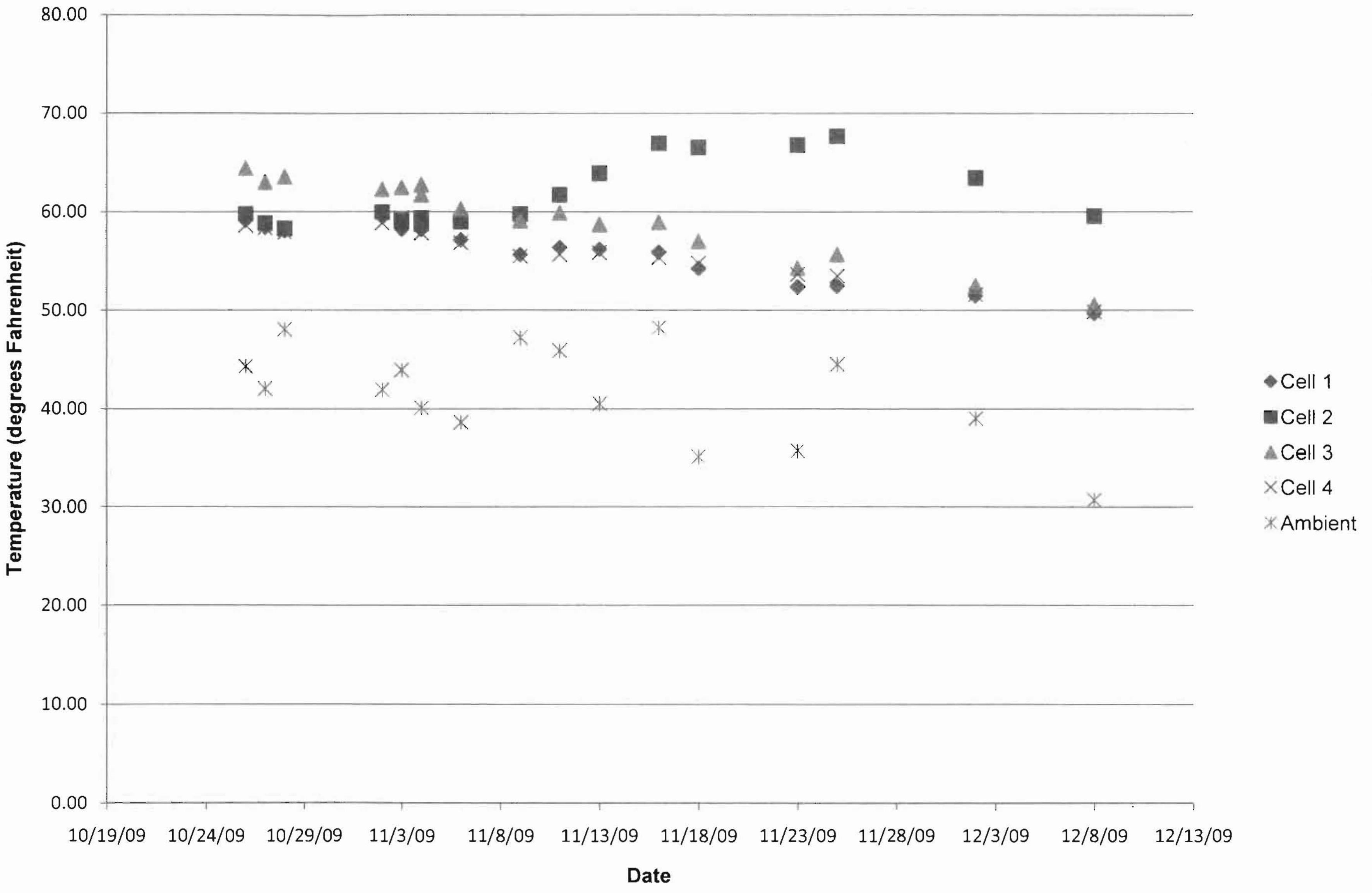


Chart 7-2
Average Temperature vs. Time
Rensselear, New York

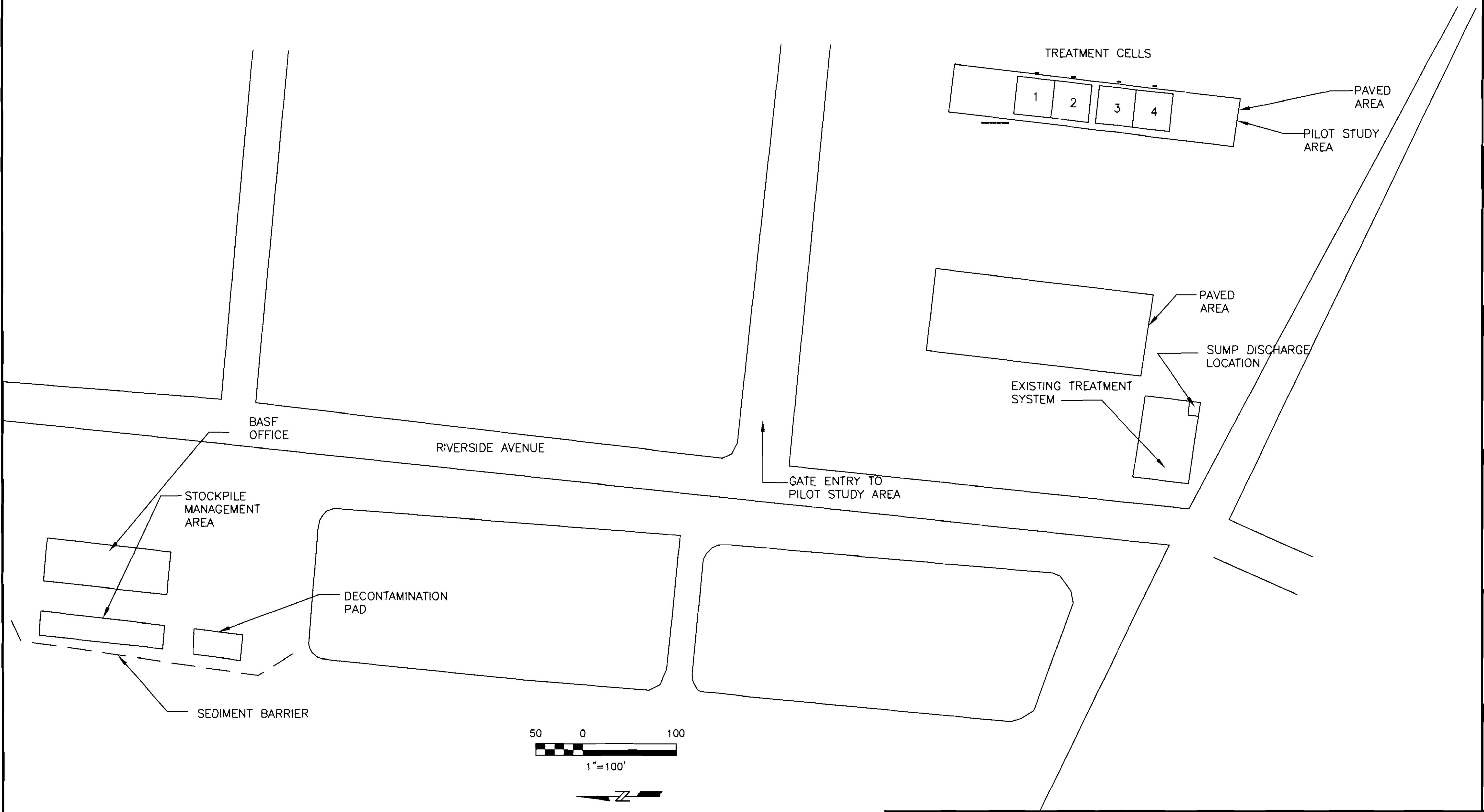
Table 8-1
Economic Analysis
Rensselear, New York

Cell #	Cell Construction ($)	Additional Items ($)	Energy ($/day)	Time To Completion (day)	Total Cost ($) to Complete	$/Ton Sediment	Comments
1	$ 50,000	$ -	$ 38.25	4203	$ 210,749	$ 1,377	No Additional Items
2	$ 50,000	$ 16,200	$ 173.25	825	$ 209,163	$ 1,123	Additional Items Include Sand Layer, HDPE, and Boiler Unit
3	$ 50,000	$ 9,439	$ 30.60	75	$ 61,748	$ 322	Additional Items Include LKD amendment at 19%
4	$ 50,000	$ 7,962	$ 0.38	2456	$ 58,901	$ 444	Additional Items Include Peat Moss at 30%

Notes:
Cell Construction Cost - Based on actual project cost of 200 K to complete construction of cells.
Additional Items - Esimtimated cost for cell specific items such as amendment addition, mixing, and heating equipment.
Energy - Cost of energy based on blower size and electrical cost of 0.17 $/KW-hr, and propane consumption (actual). Cost per day
Time to Completion - # of days to 100% mass removal based on Table 7-1 with linear removal approximate.
Total Cost - Calculated cost to complete test cell based on constuction cost and energy usage.
$/Ton - Total Cost/Mass of Sediment in cell based on estimated mass calculated in Table 7-1

Figures

File J:\Ind. Service\Project Files\BASF-0760\Rensseleer NY\Pilot Studies 2009\Installation\Site layout Rev1.dwg Layout: Site Layout User: CrowellS1 Plotted: Feb 11, 2010 - 10:30pm Xref's:



AECOM

BASF CORPORATION

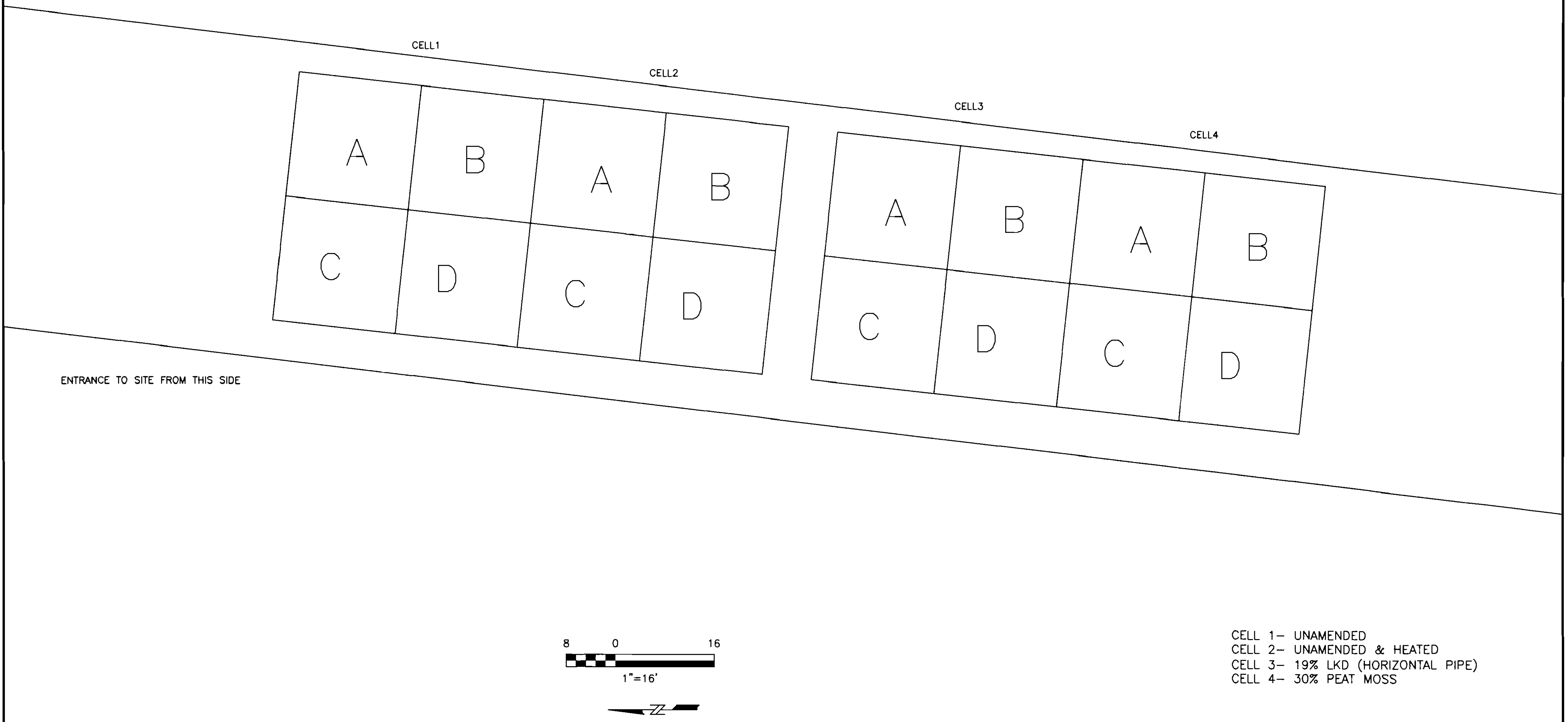
00760271-200

DATE: 08/05/09

DRWN: KS

SITE LAYOUT
DREDGED SEDIMENT TREATMENT PILOT STUDY
RENSSELAER, NY

FIGURE 1-1



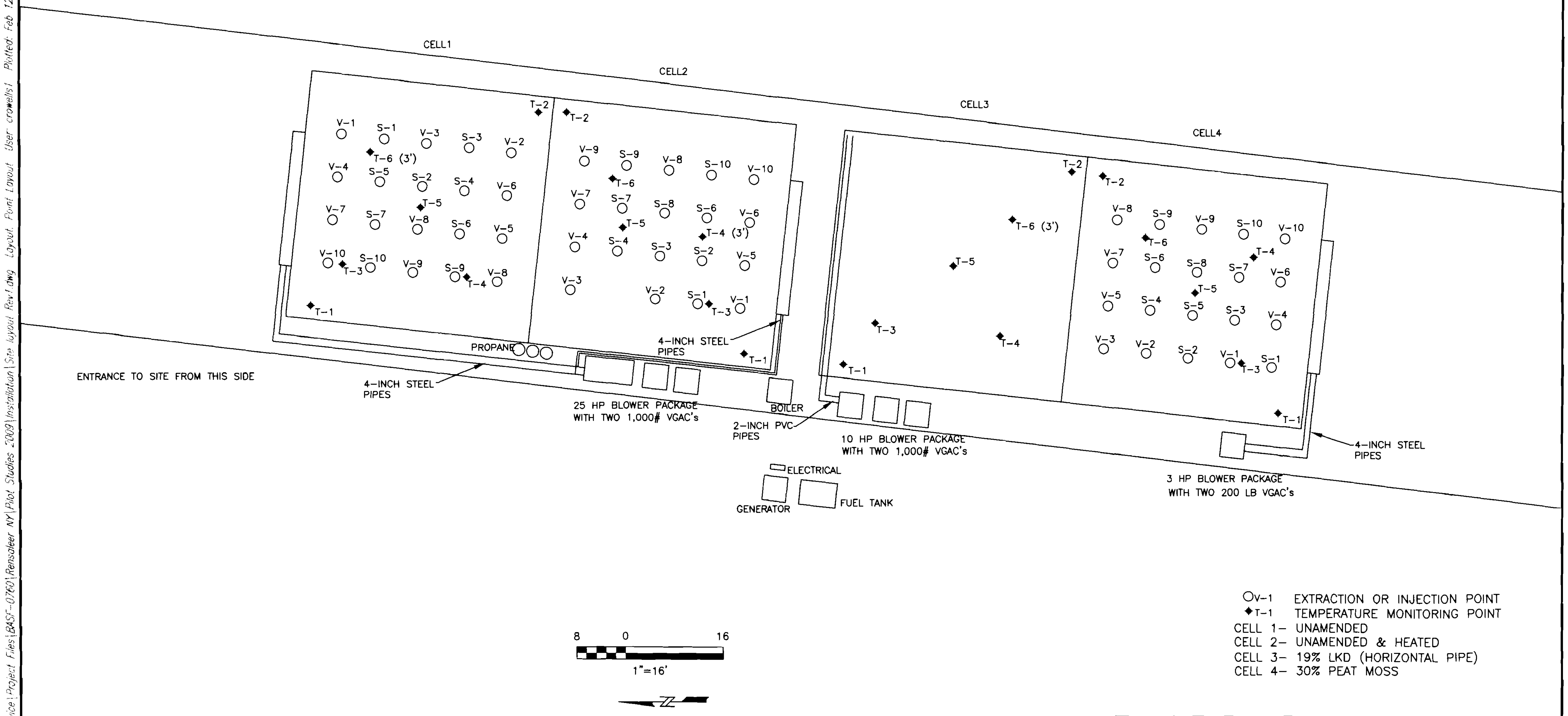
CELL 1– UNAMENDED
CELL 2– UNAMENDED & HEATED
CELL 3– 19% LKD (HORIZONTAL PIPE)
CELL 4– 30% PEAT MOSS

AECOM

BASF CORPORATION			**SAMPLING PLAN** **DREDGED SEDIMENT TREATMENT PILOT STUDY** **RENSSELAER, NY**
DATE: 1/25/10	DRWN: KS		**FIGURE 4-1**

File: J:\Indl_Service\Project Files\BASF-0760\Rensaleer NY\Pilot Studies 2009\Installation\Site layout Rev1.dwg Layout: Sampling Plan User: crowelis1 Plotted: Feb 12, 2010 – 9:09am Xref's:

File: J:\Indt_Service\Project Files\BASF-0760\Rensselaer NY\Pilot Studies 2009\Installation\Site layout Rev1.dwg Layout: Point Layout User: crowells1 Plotted: Feb 12, 2010 - 9:13am Xref's:



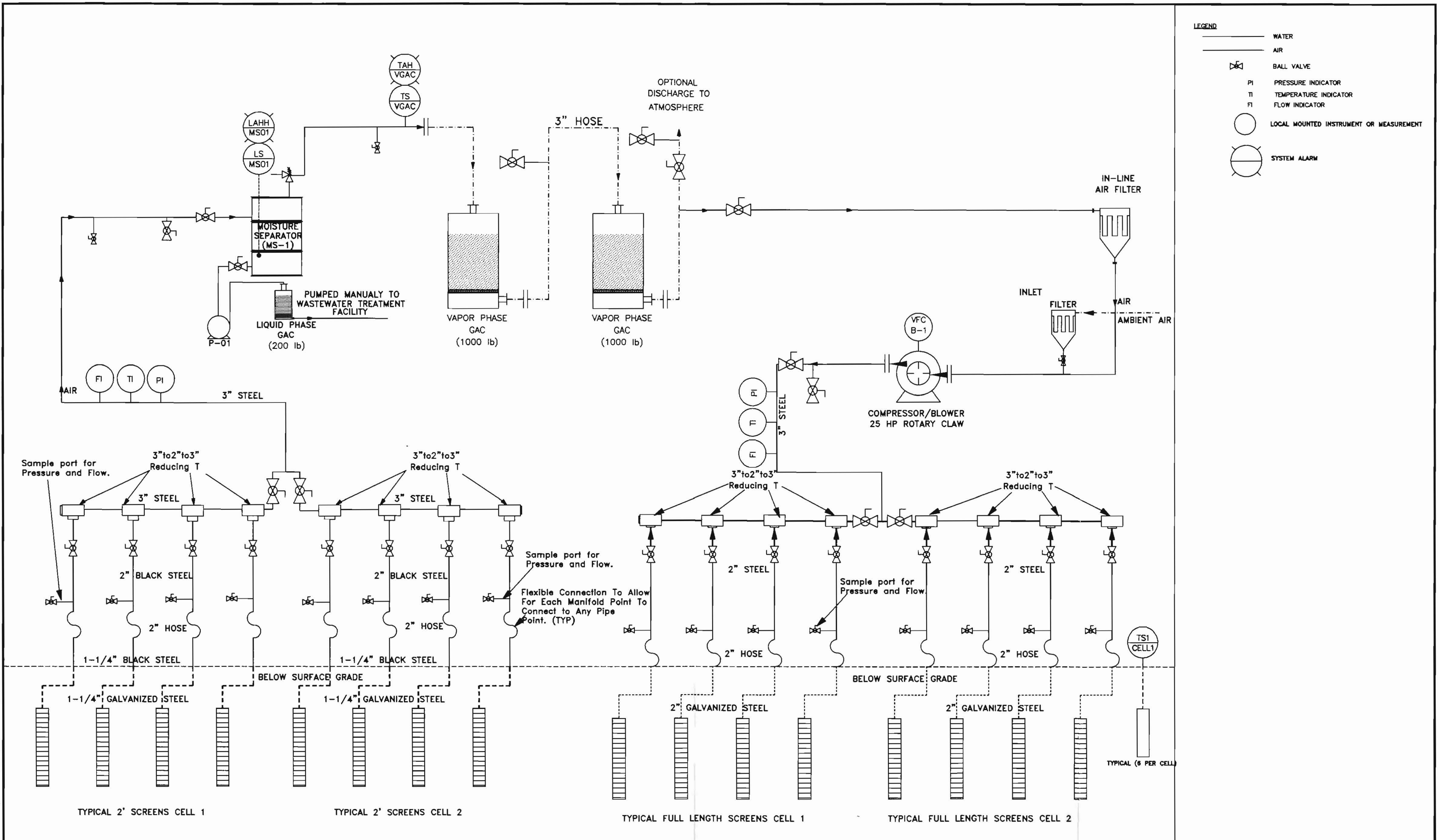
AECOM

BASF CORPORATION

PILOT STUDY AS-BUILT LAYOUT
DREDGED SEDIMENT TREATMENT PILOT STUDY
RENSSELAER, NY

DATE: 1/25/10
DRWN: KS

FIGURE 4-2



AECOM

BASF CORPORATION

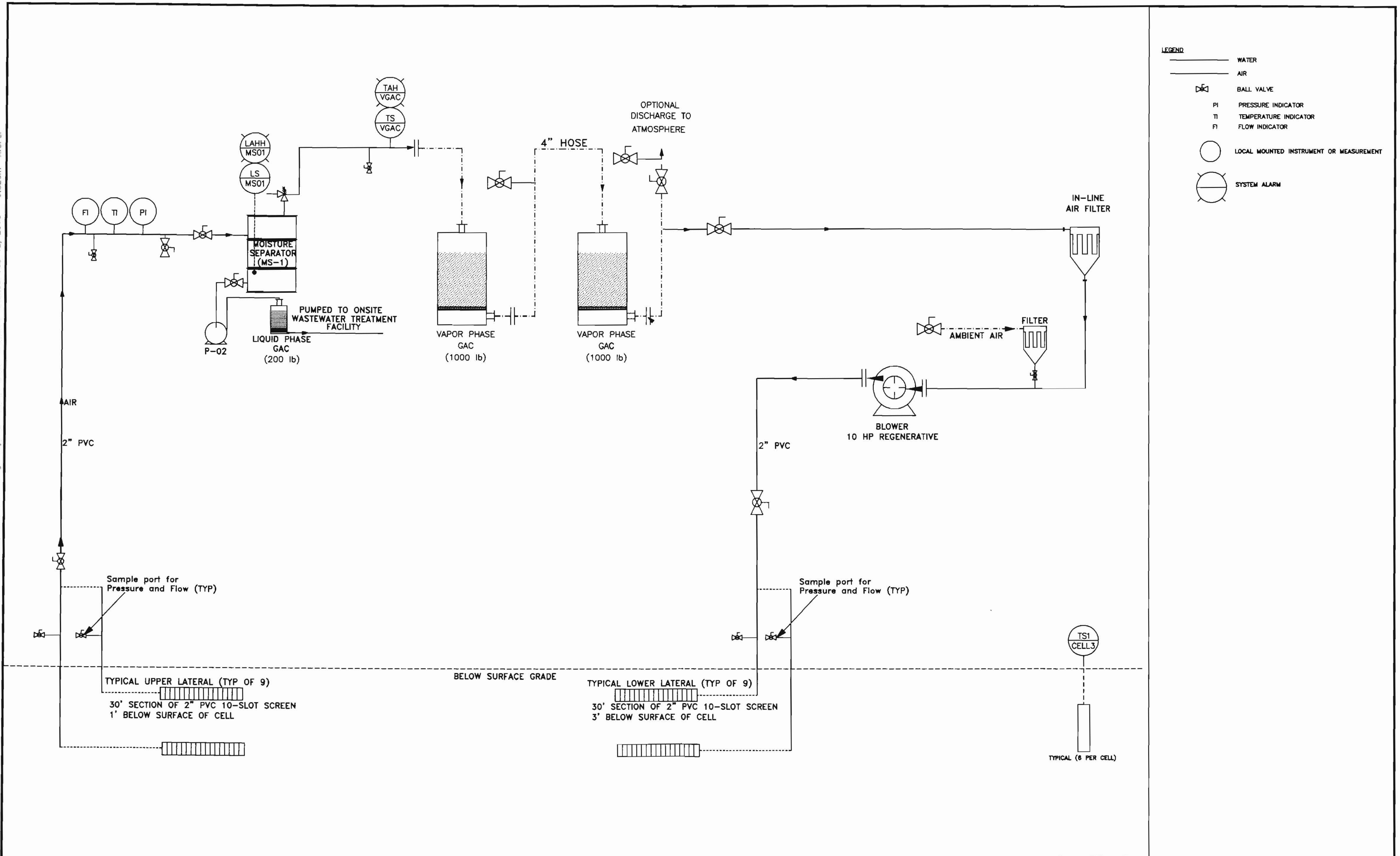
DATE: 1/25/10 | DRWN: PAP

AS-BUILT PROCESS AND INSTRUMENTATION DIAGRAM
SYSTEM CELLS 1 and 2

DREGED SEDIMENT PILOT STUDY
RENSSELAER, NY

FIGURE 4-3

File: J:\Indl_Service\Project Files\BASF-0760\Rensaleer NY\Pilot Studies 2009\Installation\BASF-Cells 1&2.dwg Layout: ANSL_B User: crowells1 Plotted: Feb 12, 2010 - 9:15am Xref's:



File: J:\Indl_Service\Project Files\BASF-0760\Rensselaer NY\Pilot Studies 2009\Installation\BASF-Cells 3.dwg Layout: ANSI_B User: crowells1 Plotted: Feb 12, 2010 - 9:32am Xref's:

AECOM

BASF
Rensselaer, NY

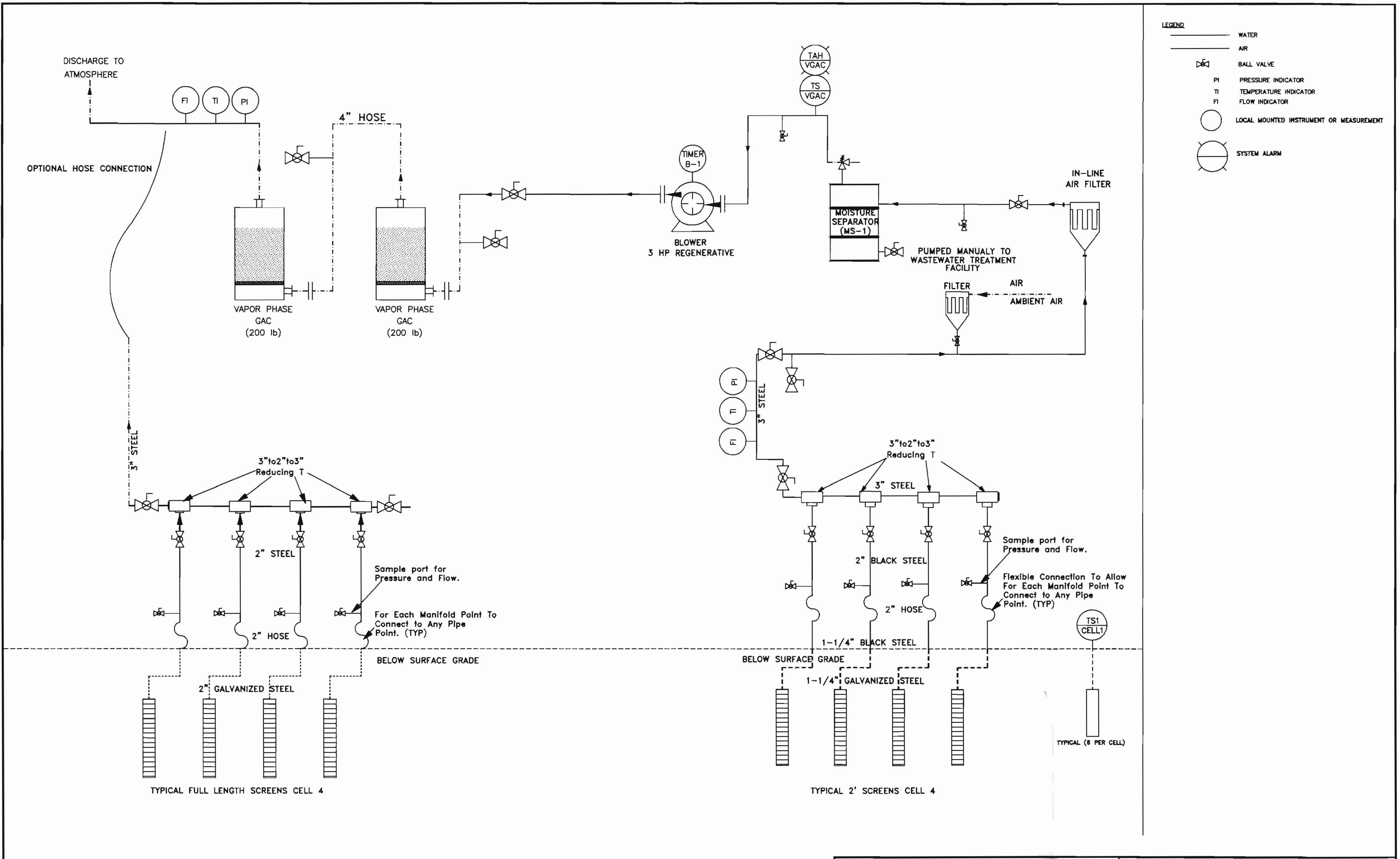
PROPOSED PROCESS AND INSTRUMENTATION DIAGRAM
LOW PRESSURE SYSTEM CELL 3

BASF RENSSELAER
RENSSELAER, NY

DATE: 07/16/09 DRWN: PAP

FIGURE 4-4

File: J:\Indl_Service\Project Files\BASF-0760\Rensaleer NY\Pilot Studies 2009\Installation\BASF-Cells 4.dwg Layout: ANSL_B User: crowells1 Plotted: Feb 12, 2010 - 9:33am Xref's:



AECOM

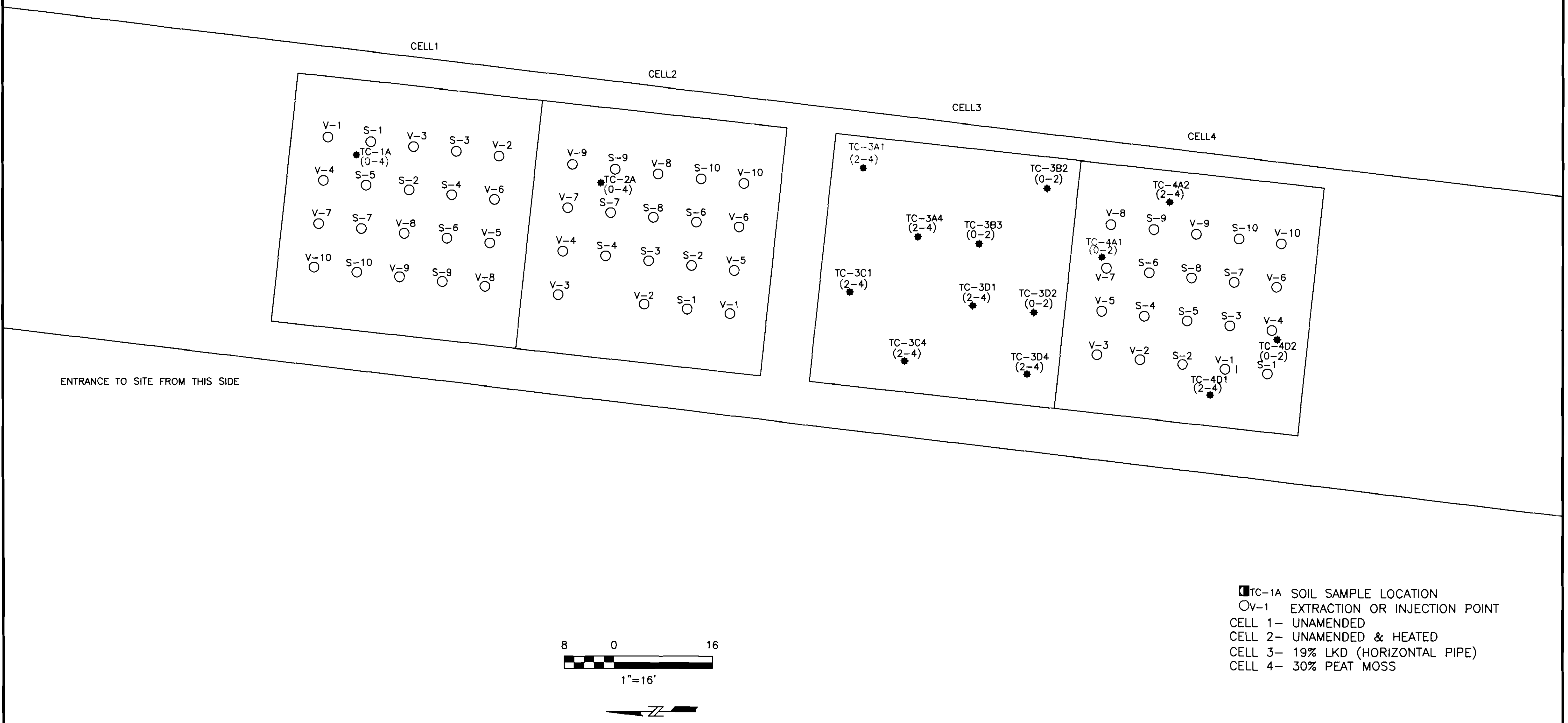
BASF CORPORATION

AS-BUILT PROCESS AND INSTRUMENTATION DIAGRAM
SYSTEM CELL 4

DREGED SEDIMENT PILOT STUDY
RENSSELAER, NY

DATE: 07/16/09
DRWN: PAP

FIGURE 4-5



● TC-1A SOIL SAMPLE LOCATION
○ V-1 EXTRACTION OR INJECTION POINT
CELL 1- UNAMENDED
CELL 2- UNAMENDED & HEATED
CELL 3- 19% LKD (HORIZONTAL PIPE)
CELL 4- 30% PEAT MOSS

AECOM

BASF CORPORATION

PILOT STUDY CLOSE OUT SAMPLING PLAN
DREDGED SEDIMENT TREATMENT PILOT STUDY
RENSSELAER, NY

DATE: 3/1/11	DRWN: KS		**FIGURE 6-1**

File: J:\Indl_Service\Project Files\BASF-0760\Rensselaer NY\Pilot Studies 2009\Installation\Site layout\Site layout Rev1.dwg Layout: CLOSE OUT SAMPLING User: crowellsl Plotted: Mar 01, 2011 - 3:40pm Xref's: