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May 8, 2013

Mary Ann Coogan, Supervisor
Town of Camillus
4600 West Genesee Street
Syracuse, New York 13219

Re: Response to DEC Comments to MSI Report

Dear Supervisor Coogan:

Per your request, we have reviewed the New York State Department of Environmental Conservation's comments to our April 8th report, "Air Contaminant Exposure to Residents of the Town of Camillus from Honeywell's Sediment Treatment and Containment Facility." Our response to these comments is attached.

As air quality consultants, we have been very successful in meeting our clients' objectives over the past 35 years. The cornerstone of our success has been our unwavering commitment to good science, technical thoroughness, and, above all, integrity in all aspects of our business. For this reason, we owe it to all our clients in general, and the Town of Camillus in particular, to remain above the "political fray" at all times. Despite the fallout our firm is likely to incur, there is no way we could compromise our integrity, now or ever.

While our response may appear overly critical of the agency, it is, in fact, rather reserved given the content of their comments. We say this after having gained an understanding of the pervasiveness of DEC's myriad technical misrepresentations, disingenuous and obfuscatory assertions, and circular arguments advanced over the past several years – all carefully orchestrated, with EPA, to circumvent the CERCLA process and deceive the Camillus community about the safety of the air emissions from Wastebed 13. With considerable regret, we find this conclusion inescapable.

Please contact us should there be any questions concerning our response. We sincerely appreciate the opportunity to be of continued service to the Town of Camillus.

Very truly yours,
MINNICH AND SCOTTO, INC.

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Principal

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Response to DEC Review of Minnich and Scotto's April 8, 2013 Report: "Air Contaminant Exposure to Residents of the Town of Camillus from Honeywell's Sediment Treatment and Containment Facility"

SUBMITTED TO

THE TOWN OF CAMILLUS

AND

CAMILLUS CLEAN AIR COALITION

MAY 8, 2013

SUBMITTED BY

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INTRODUCTION

On April 8, 2013, we submitted to the Town of Camillus our report (Report), "Air Contaminant Exposure to Residents of the Town of Camillus from Honeywell's Sediment Treatment and Containment Facility" (Facility). On April 24, the New York State Department of Environmental Conservation (DEC) provided its review (Review) of the Report. This document presents our response (Response) to the Review.

Among the most pervasive of DEC's comments is the insistence that the existing air monitoring program produces data which has shown (and continues to show) compliance with offsite safe levels. We provide compelling evidence to counter this assertion which, of course, is at the heart of the Report.

Another cornerstone of the Report is our well-documented contention that EPA, in its 2010 Supplemental Human Health Risk Assessment (HHRA), effectively and intentionally circumvented the Superfund process, resulting in the failure to demonstrate that the selected remedy for Onondaga Lake was protective of human health. Not surprisingly, both DEC and EPA strongly counter this claim.

We found the transcripts of the February 11, 2010 Camillus public meeting to be particularly enlightening in explaining DEC's continued indifference to the health and well-being of the Camillus residents. From the meeting transcripts (Page 18), Ken Lynch stated:

"It's very important that *this is a DEC and EPA plan* [emphasis added]. This is not [a] Honeywell plan, this is not what they proposed. They were required to do the investigation, they were required to look at a proposed number of different alternatives but they weren't required to come up with the plan. That's our responsibility and *it was DEC and EPA that selected this remedy* [emphasis added]."

The fact that DEC "assumes ownership" of this remediation has set up a grievous conflict of interest, in which the *very same DEC personnel* function simultaneously as the regulator and the regulated. This unfortunate situation goes to the very heart of EPA's Quality Assurance Program which, among other things, is designed to ensure that the quality of data collected always meets established end-user needs. Whenever this "fox guarding the hen house" situation occurs, there can be no unbiased technical oversight and, most importantly, *no accountability*. The lack of objectivity inherent in this management practice invariably leads to poor decision making – in this case, the protection of the health and welfare of the Camillus residents.

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Both general and specific comments are provided. For each of 21 specific comments, the relevant portion of the Review is reproduced in the order presented.

GENERAL COMMENTS

On March 6, in support of the Report, we specifically requested (among numerous other critical pieces of information), all OSHA-related Health and Safety (H&S) data collected from the SCA (sediment consolidation area) during the first year of Facility operation. It was not until April 30, well past the date of Report submission and after numerous followup requests, that DEC finally released this H&S data, but only for the first 31 of the 92 days of operation – before temporary shutdown while DEC and Honeywell attempted to remedy the offsite impacts. The data consisted of PID (photoionization detector) results collected from the breathing zone in the vicinity of the geotubes. When asked for the additional data (via e-mail through the Town Engineer), DEC resisted, replying, "This data collection is not part of DEC's project requirements, but rather worker safety data that Honeywell keeps as part of their work safety requirements." DEC has made similar refusals for virtually all requested data.

Of the 31 days of PID data that we did receive for Year 1, one day showed an onsite concentration of 44.9 parts per million (ppm) of total volatile organic compounds (TVOC) – a level which would certainly have dictated use of full respiratory protection. We have since performed additional air dispersion modeling based on this measured onsite concentration, and found it to be ***fully consistent*** with the dangerously high, short-term safe-level exceedances predicted in the community.

As stated in their introductory paragraph, DEC assigned the Review "top priority," including coordination with a formidable array of environmental experts, engineers, and scientists with the DEC, EPA, and DOH, as well as with consultants retained by DEC. Despite how impressive this sounds, it is clear that DEC's highly competent Division of Air Resources (DAR) in Albany had little or no input beyond validation of our air dispersion modeling results, or, if they did, their input was ignored.*

DEC delegates to the Department of Health, responsibility for air monitoring network design in support of site remediations, and for consultation concerning protection of human health. This raises another serious concern pursuant to the conflict of interest issue discussed earlier, as DAR, which has primary responsibility for both establishment of standards for hundreds of toxic air contaminants and research of innovative air monitoring methods, has, in effect, been "cut out" of the design process for such monitoring networks – which, as evidenced in our comment responses below, employ inappropriate screening methods as a first, and only, line of defense.

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* On April 10, Reggie Parker (DEC) requested that we provide all AERMOD input files so DAR could validate our modeling procedure and results. As the Review contains no criticism of any element of our modeling analysis, we can only assume that DEC agrees with this aspect of the Report. This is not surprising, as DAR respects our work and technical competence. To cite just one example, DAR reviewed and approved a pre-construction Title V air permit we prepared to support a major source cogeneration facility in the Brooklyn Navy Yard. We worked closely with senior DAR personnel to obtain required Permits to Construct within seven months of application submission. Because our performance on this project was recognized as exceptional, the submission package was identified by DEC as a "Benchmark Permit," toward which other applicants are directed.

SPECIFIC COMMENTS

1. ***While modeling is often used to predict potential air emissions during the design and permitting of planned air emission sources, the best way to determine emissions from an existing facility is to actually measure them.***

Despite the fact that the Review was given top priority by DEC, this sentence contains a fundamental error and reflects a serious misunderstanding. The error (first clause) is DEC's erroneous assertion that [air dispersion] modeling is often used to predict potential air emissions during facility design. Actually, the converse is closer to the truth – facility emission rates are used as *input* to an air dispersion model, the purpose of which is to predict compliance with downwind impacts *prior to facility construction*. This is the very basis of DEC's air permitting program under 6 NYCRR Part 201.

The misunderstanding (second clause) concerns the statement that the best way to determine emissions from an existing facility is to actually measure them. While true, this statement is, at the same time, particularly disturbing, as measuring facility emissions is the entire objective of the proposed EPA Method TO-16 monitoring program and, despite what DEC would have one believe, *Facility emissions are not now being, and never have been, measured*.*

In fact, in our April 22 Report Addendum, we derived permissible emission rates (PERs), compliance with which would *ensure* that residential concentrations are continually maintained. This approach for monitoring facility emission rates is similar to the way DEC routinely employs CEM (continuous emission monitoring) systems at permitted industrial plants, also under 6 NYCRR Part 201.

2. ***To date, the actual and extensive air monitoring data demonstrate that the project has always been below the conservative levels established to protect the surrounding community as provided in the Community Health and Safety Plan and the measures incorporated into the project to protect public health have been effective.***

As clearly evidenced in subsequent comments, the current air monitoring program has so many shortcomings that it is of minimal value as implemented. Said another way, the program components to assess compliance with short-term (1-hour) and long-term (annual) safe levels *cannot possibly achieve these goals*.

As for the effectiveness of the [control] measures to protect public health, we will again evidence that these mitigative efforts, while certainly quite expensive to implement, have done little or nothing to mitigate odors and harmful emissions.

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* Although this may seem like a rather inconsequential distinction, this ignorance of basic air pollution meteorology has contributed substantially to the specification of an air monitoring program which, as will become apparent, is of minimal value to the Camillus residents.

3. ***PID instruments are widely-accepted field instruments for collection of real-time data. Their reliability and effectiveness has been consistently proven at remediation sites across New York State.***

PID instruments measure *only* TVOC for which there is no air standard, either State or Federal. Strict air standards do exist, however, for the myriad VOCs comprising TVOC.

We do not dispute that PIDs are widely used during remediation sites across New York State. However, the fact remains that PIDs are *screening instruments*, designed simply to determine whether VOCs exist. Similar to screening data from any other media (e.g., water, soil), data from a PID instrument is neither technically defensible nor legally admissible in a court of law for purposes of evidencing compliance with air quality standards (for air, that is the essential distinction afforded by employment of a Toxic Organic Compendium Method). The individual VOCs comprising a given TVOC measurement cannot be segregated, thus making it impossible to assess compliance with strict air quality standards for individual VOCs.

Another problem is that there is an overall loss factor, on the order of 30 percent, when the PID is operated in moist conditions (as is the case here with the water misters constantly operating). Additional concerns with this instrument are identified in subsequent comment responses.

4. ***The PIDs used for the project have minimum detection levels ("MDLs") below the conservative site-specific short-term health and safety criteria. Protective levels are in the parts per million (ppm) range, and the MDL for the PID is approximately 0.1 ppm. Although PIDs do not identify individual compounds, total VOC threshold action levels were established taking into account protective levels for each contaminant of concern.***

Many hundreds of contaminants emanate from the dredged sediments, most of which were never characterized either during the remedial investigation or subsequent sediment sampling campaigns. It is EPA policy under CERCLA that if remediation decisions are made based on screening instrument results, one must assume that the reported contaminant proxy (in this case, TVOC) is comprised solely of the individual compound having the most stringent safe level.

After nearly a year of SCA operation, *it is totally unacceptable by any reasonable standard* that there has been no effort to perform a complete characterization of the vast array of toxic air contaminants which the Camillus residents are forced to breathe. It is equally appalling that DEC continues to assert that PIDs provide a reasonable means of assessing compliance with short-term safe levels, in light of the fact that the TVOC composition, in this case, is constantly changing and largely unknown.

Finally, it has been strict EPA policy ever since enactment of CERCLA that health-based decisions, remediation-related or otherwise, should *never* be based solely on data from air screening instruments. This is due to the substantial likelihood for the generation of "false negatives."

5. ***While the total VOC data collected to date demonstrate that there have been no exceedances of action levels, people can often smell odors at much lower levels than those which would require action per the Community Health and Safety Plan. Therefore, additional work is ongoing to further address odors.***

The PID deficiencies covered in Comment 4 notwithstanding, we are not convinced there have been no short-term action-level exceedances to date, and remain skeptical for two reasons.

First, it is disconcerting to have an air monitoring program expressly designed to assess 1-hour, safe-level compliance not include the raw data from which the hourly concentrations are derived. DEC has never shared with the community the discrete PID concentrations used to generate the daily TVOC graphs, nor is this raw data available to the public. In fact, according to the community, DEC, in all of their public meetings, has avoided discussion about 1-hour compliance altogether since monitoring program inception, simply asserting that the only legitimate community concern is annual exposure. *At this point, it is important to stress that a lack of achievement of the short-term safe levels in the community was the principal health issue cited in our Report, a concern clearly evidenced as appropriate by the documented symptoms of adverse acute exposure*.

Second, the graphs appear to be much too smoothed to reflect reality, which begs the question as to what averaging times were used for their creation. *At a bare minimum*, a TVOC concentration should be tabularly presented for each hour. Ideally, hourly values should be calculated and presented as moving 10- or 15-minute-averaged concentrations, as protection of public health has precious little to do with whether an unacceptable exposure over 60 minutes begins precisely at the top of the hour.

The remainder of the first sentence is misleading and deceptive for two reasons. First, many toxic air contaminants to which the community is routinely exposed have odor thresholds higher (more forgiving) than their safe levels, and one need look no further than benzene – the most abundant contaminant emitted from the Facility having the designation of "known human carcinogen." With a mean odor threshold of 123 mg/m^3 (milligrams per cubic meter), benzene has a short-term (1-hour) safe level of 1.3 mg/m^3, just *1 percent* of the odor threshold; the long-term (annual) safe level of 0.0019 mg/m^3 is nearly *6,500 hundred times* less than the odor threshold.

DEC must have known the above information about benzene. This would explain their reply to a request to construct a table comparing safe levels and odor thresholds from a member of the Community Participation Working Group (CPWG) in its December 2012 monthly meeting: "[T]his would be very difficult to do because people have differing abilities to detect odors and what constitutes a 'nuisance' is subjective." All CPWG Meeting Notes are available on line at http://onondagalake.info/index.php?/articles_categories/minutes.html.

Finally, DEC has never acknowledged olfactory desensitization, a well-known phenomenon which means simply that people can lose the ability to perceive odors altogether after repeated or continuous exposure.

The last sentence is deceptive and disingenuous, as: (a) it is difficult, if not impossible, to reduce odors from the SCA without reducing the emissions; and (b) the expensive methods DEC has been touting in their press releases – such as the planting of a vegetative barrier, the erection of a 35-foot-high wind screen, and the installation of two tiers of misters (in place since last year) – can do *absolutely nothing* to mitigate contaminant emissions, something DEC's air scientists must certainly know.

Further, had the original air dispersion modeling study been performed as designed in 2008 (and required under CERCLA), or had a pilot-scale demonstration been performed prior to Facility construction, there would be no need for the continued futile search for a "Band Aid" solution.

6. ***Speciated data collected every six days at the site via summa canisters, and other samples collected both onsite and offsite, demonstrate that the M&S predictions for individual compounds are unsubstantiated. These canisters are a widely-accepted means of collecting compound-specific data with very low MDLs.***

As DEC is well aware, we have no qualms whatsoever with EPA Method TO-15 (Summa canister sample collection with GC/MS analysis) *for appropriate applications*. We have employed this method numerous times to analyze individual VOCs at very low concentrations.

The problem here, however, and again *one of which DEC is well aware*, has nothing to do with the analytical capabilities of the method. As shown in the Comment 8 response, the gross "data representativeness" deficiency associated with the Summa canister program as designed (in terms of both time and space) would require operation over a duration *far greater than the remediation itself* before enough data could be collected to facilitate a reasonable assessment of annual exposure. This conclusion would have been obvious if the data quality objective (DQO) process had been followed.

There is another serious issue with the Method TO-15 program. On May 1, we requested, via e-mail through the Town Engineer, the complete analytical Method TO-15 data from the laboratory (Eurofins/Air Toxics). This data should have included analysis results of all TICs (tentatively identified compounds) and unknown compounds – a service highly recommended by the lab for a nominal fee when many compounds are present. We made this request to determine what contaminants were present besides the specified "compounds of concern." On May 5, DEC provided data packages from the lab which were devoid of all TIC and unknown compound results, claiming simply that they "do not have the full data packages." *Apparently, it is policy to either withhold these analysis results, or have the lab not perform the analysis in the first place*.

7. ***The Report alleges that collection of naphthalene in these canisters has a "low bias", apparently because the authors claim compounds like naphthalene attach to the canisters and are not fully available for analysis. Independent certified laboratories today utilize quality control procedures to assure the accuracy of naphthalene TO-15 data. Although past practices may have limited the use of such canisters, today's laboratory practices and further research support use of the canisters to collect accurate data. DEC specifically researched this issue and spoke to our own chemists who have experience with this issue, including the nationally certified lab being used for this project, who verified that current testing protocol eliminates this concern.***

We shall be happy to concede this point upon receipt of field spike analysis results from the lab. Analysis of canister samples for which a known amount of naphthalene is introduced *in the field* (hence the term field spike) is the *only* way that a correction factor can be accurately determined and applied to the measured naphthalene concentration to correct for this systematic low bias. This is the reason that naphthalene is not included in the list of compounds for which EPA Method TO-15 is applicable.

We note that field spike preparation was not included in the monitoring program's Quality Assurance Project Plan.

8. ***The Report also alleges that air emissions "can, and do pass between stations undetected." From its inception, the design of the project's air monitoring system was established to maximize effectiveness. Eight monitoring stations surround the entire SCA perimeter and were strategically located based on extensive site-specific meteorological data. Additional hand-held PID readings taken on site, at the perimeter and in the community, have never indicated that emissions passing between the stations are reaching the community at levels which are not protective.***

DEC completely dismisses guidance developed by EPA over the past 25 years on the DQO process and its use in designing monitoring programs to meet end-user data needs (see, for example, "Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4, U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC, EPA/240/B-06/001, February 2006).

Quite frankly, *we find it inconceivable that DEC could ever defend the existing program as remotely meeting EPA's data representativeness criteria* (whereas EPA defines data representativeness as how well sampling data represent selected characteristics about the media or phenomenon being measured).

For this Facility, we are talking about: (a) highly variable contaminant emission rates; (b) a total of eight perimeter stations to ensure short-term safe-level compliance; (c) a total of four perimeter stations to ensure long-term safe-level compliance; and (d) a total perimeter path length of 18,400 feet (3.5 miles). Therefore, on average, *there is one PID station for every 2,300 feet of Facility boundary, and one Method TO-15 station for every 4,600 feet*!

It is immediately evident that an air monitoring program with such inadequate "sampling densities:" (a) has very little chance of ever capturing the highest 1-hour-averaged concentrations; and (b) would require a duration far longer than the remediation itself before enough data could be collected to facilitate a reasonable assessment of annual exposure.

9. ***The Report asserts that EPA's Method TO-16 is M&S's preferred method of monitoring at this site. As promised, DEC and other experts have spoken with M&S about this method and done further research to determine its effectiveness. Other than as an experimental use of a short duration at one remediation site, DEC is not aware of any use of this methodology for remediation projects in New York.***

No one other than DEC has spoken with us concerning use of this method in connection with this remediation.

As for the DEC conversation, we spent a full 80 minutes on March 7 answering a range of detailed questions covering all aspects of this technology, posed by five individuals who had represented DEC at the January 31 public meeting. Further, we offered to give a comprehensive presentation on our proposed approach at DEC offices, in either Albany or Syracuse, "on our nickel" so to speak. We have yet to hear back on our offer.

Response to DEC's last sentence follows.

Gas Technology Institute Project

As for the so-called "experimental" application of "short duration," DEC was among a dozen project stakeholders in a 26-month, applied R&D (research and development) study by the Gas Technology Institute (GTI) *designed to comprehensively evaluate U.S. EPA Method TO-16* as a means of protecting communities from harmful airborne exposure during the remediation of former MGP (manufactured gas plant) sites. Some 200 of these sites remain to be remediated in New York alone.

Specific project objectives included: (a) comparison of Method TO-16 with typical air monitoring systems (the precise type being implemented at the Facility) at active remediations in Illinois and New York; (b) field evaluation of data-management and reporting software developed by our firm to demonstrate, in real time, offsite compliance across the downwind community; and (c) development of a comprehensive methods application guidance document released in June 2008.

As a project stakeholder from Day 1, DEC had the opportunity to provide formal comment on all aspects of the project, including: the comprehensive Quality Assurance planning document, all field comparison results and conclusions, all aspects of the reporting software, and all drafts of the Methods Guidance Document (leading to a consensus-approved final version).

Field work involved detailed statistical treatment of the two data sets (Method TO-16 vs. the DEC-endorsed method). Analysis results for eleven contaminants of concern (including naphthalene and benzene) were examined, as a function of onsite emissions-effecting activity, for a total of 195 discrete measurement events (105 from the Illinois site and 90 from the New York site).

Results demonstrated the *clear superiority of Method TO-16 in protecting nearby residents from remediation-related emissions*. Method TO-16 was also shown to be significantly less expensive to implement, especially for remediation projects lasting more than six months. Most significantly, *DEC enthusiastically endorsed* GTI's conclusions about method superiority, having actively participated in the entire method comparison testing at the New York site – Coney Island in Brooklyn.

Nepera Chemical Application

Another Method TO-16 application in which DEC played a major role involved their negotiation of a Consent Agreement between a community group and Nepera Chemical Corporation in Harriman, New York in 1998. The Agreement required installation of a permanent Method TO-16-based perimeter monitoring system for the early notification of accidental toxic chemical releases. This was in response to a release of pyridine – an acutely toxic Extremely Hazardous Substance (EHS), pursuant to Section 302 of the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA) – which had forced the evacuation of more than 4,000 students from three nearby schools in the Monroe-Woodbury Central School District.

It is especially relevant that DEC and the community selected a Method-TO-16-based system, as it was deemed the *only* means of assessing, in real time, whether evacuation of downwind students and residents would be required in the event of another pyridine release. It is also especially relevant that *DEC maintained real-time computer access to this system, providing community notification and reporting until Nepera closed the facility in 2005*.

Public Place Former MGP Site Remediation

In January 2012, the Gowanus Canal Community Development Corporation (GCCDC), a not-for-profit neighborhood preservation organization formed in 1978, submitted a written request that DEC require KeySpan – the same company which had been a sponsor of the GTI study and volunteered their Brooklyn, New York site for method comparison testing – to use Method TO-16 during the remediation of the Public Place MGP site, also in Brooklyn. After taking *five months* to respond, DEC flatly refused to consider the request, and even refused to acknowledge participation in the GTI project four years earlier.

10. ***Furthermore, Method TO-16 measures an average of contaminant levels across an extended path. The Method would therefore underestimate maximum contaminant concentrations at any specific point. This underestimation, when compared to the established site-specific protective levels, could well prevent identification of point concentrations at or near protective levels. In addition, the use of this Method as proposed by M&S would again rely on predictive modeling (rather than actual data) to extrapolate concentrations in the surrounding community.***

One can only speculate as to why DEC continues to make assertions and claims about Method TO-16 which they know to be patently false. We are fully cognizant of the charge this makes, namely that DEC is lying; unfortunately we are left with no choice in the matter.

The Report describes in detail (Section 6.2) how Method TO-16, together with data from the onsite meteorological tower, can be employed to: (a) facilitate optimization of emission control processes (via continual, direct emission-rate measurement for individual compounds of concern); (b) present, every 15 minutes, the compliance status with respect to safe residential concentrations for each contaminant; and (c) be accessible online by each resident. We also covered the powerful benefits afforded by this technology – specifically, the generation of a path-integrated concentration – in great detail in our March 7 teleconference, as well as the precise way that the maximum concentration at any point is obtained.

All aspects of our proposed approach have been proven and verified in actual field applications around the country, as DEC is well aware. We have designed and managed well over a dozen Method TO-16 monitoring programs *for regulatory and enforcement application under Superfund and RCRA* (e.g., air pathway analyses, pilot-scale programs, Consent Decree monitoring, permit-equivalency demonstrations) for clients such as U.S. EPA, U.S. Army Corps of Engineers, responsible parties, and numerous other consultants.

One particularly noteworthy project involved an 11-month emergency removal action at the Michigan Avenue Dump Site in Canton, Michigan in 1993. EPA (Region 5) identified an imminent threat to public health due to large volumes of hazardous waste entering the Rouge River, which cut through the center of the site. An emergency removal action was initiated, and wastes were excavated and hauled away for offsite disposal while contractors shored up the riverbank with sheet piling. Because of the proximity of the emission sources to the site perimeter, action-level exceedances occurred frequently over the project duration. EPA has openly acknowledged that if the open-path FTIR technology (soon to become EPA Method TO-16) had not been used to "drive" this highly publicized cleanup, the entire operation would have been performed under a sprung structure at a greatly increased cost to 3M Corporation, the responsible party (see **Attachment A**).

Further, there are many Method TO-16 service providers, each with a wealth of experience in designing similar systems for use during site remediations and for permanent facility application, both domestically and in numerous other countries around the world.

The Report also describes how Method TO-16 can be used, together with onsite meteorological data, to continuously monitor Facility emission rates in much the same manner that CEM (continuous emission monitoring) systems are routinely employed at industrial plants permitted by DEC under 6 NYCRR Part 201. In general, compliance with these facility emission rates (i.e., DEC's PERs) ensures that offsite, residential exposure remains within safe levels.

In the April 22 Report Addendum, we derived Facility-specific PERs, compliance with which will ensure that short- and long-term safe levels for air contaminants are maintained throughout the Camillus community during the treatment of the dredged sediments. Under New York State's air permitting regulations, PER compliance is the sole means of ensuring that emissions from permitted facilities do not cause offsite contravention of ambient air quality standards. Although facilities constructed specifically to support Superfund remediations are exempt from having to obtain air permits *per se*, they are, nonetheless, required under CERCLA (Superfund) to: (a) control emissions such that all air quality standards and thresholds are complied with; and (b) demonstrate that compliance is maintained at all times. (This point is re-visited in the context of Comment 19.)

In general, facility-specific PER values are derived using air dispersion models which predict offsite impacts for all combinations of meteorology and facility operating conditions. For industrial sources, PER compliance is typically demonstrated using CEM systems from which stack emission rates (e.g., pounds per hour) are calculated and displayed. In this case, the CEM system is implemented at the source perimeter, as emissions are not routed up a stack.

As for DEC's assertion that generation of path-integrated data (i.e., concentrations along an entire measurement path up to several hundred meters in length) is not adequate to assess compliance with safe-levels in the community, we again state our position – painstakingly substantiated in the Report and discussed *ad nauseam* in our March 7 DEC conference call: *Method TO-16 is the only practical way to demonstrate, in real time, the causative relationship between Facility emissions and residential exposure*. That was the essence of the GTI project (see our response to Comment 9).

Finally, as for DEC's statement that actual data is superior to dispersion modeling to assess community exposure, we agree. The problem here though, *of which DEC is again very well aware*, is that it is impractical to put a real-time monitoring station at every house, and using dispersion modeling to "extrapolate" actual Facility emission rates is the *cornerstone of DEC's permit program* as discussed above.

11. ***M&S utilized sediment data from Remedial Investigation [RI] work (1992 to 2002) as documented in the 2004 Feasibility Study. The Report does not consider the additional site-specific data collected in multiple pre-design investigations and project design changes that have been developed since the ROD was issued in July 2005. A significant change to the project after the 2005 ROD was the decision to isolate the***

most highly contaminated sediments behind the extended barrier wall. This not only removed a highly contaminated portion of the material from the dredge material to be shipped to the SCA, but would tend to reduce the average contaminant concentration of the material that would ultimately be sent there for treatment and disposal. The additional data and these design changes significantly reduced the quantity of sediment that will be shipped to the SCA from 2.650 million cubic yards to 2.0 million cubic yards. M&S offers the following estimated mass values for the three named VOCs: for benzene (12,131 kg), naphthalene (379,463 kg) and 1,4 dichlorobenzene (57,833 kg). However, taking into account the reduction in the volume and the high concentrations of the material left in place, based on the most current and accurate data, NYSDEC estimates the contaminant mass for these three VOCs in the dredged sediment will have the following values: benzene (3,127 kg), [approximately 74% less than estimated by the M&S Report], naphthalene (92,692 kg) [approximately 75% less than M&S], and 1,4-dichlorobenzene (27,919 kg) [approximately 51% less than M&S]. By not considering current data and design specifications, M&S overestimates dredge volume, contaminant mass and, therefore, emissions from the project.

DEC is correct in that we did not consider additional sediment data (collected to refine the quantity of the lake-bottom sediment requiring dredging). DEC is also correct that we did not consider the extended barrier wall. Therefore, we have re-examined our contaminant mass values for both acute (short-term) and chronic (long-term) exposure. This resulted in only nominal changes, except for 1,4-dichlorobenzene which showed significant mass *increases*: more than five-fold for our acute exposure analysis, and double for our chronic exposure analysis.

Acute Exposure

The concentration (ug/m^3) used to support the acute exposure results for each contaminant considered (naphthalene, 1,4-dichlorobenzene, and benzene) was derived from the highest, depth-averaged sediment mass from the core-sample data (summarized in the ROD) together with the sediment density data (1.4 tons per cubic yard) from the Feasibility Study. After elimination of those core samples which are located within the 650,000 cubic yards no longer requiring dredging, and after including the depth-averaged calculations from the additional sediment data, we have concluded the following.

For naphthalene and benzene, there is no change to our concentration calculations, as the most contaminated core samples fall outside the extended wall boundary. For 1,4-dichlorobenzene, the most contaminated core sample still falls outside the extended wall boundary; however, its magnitude is now superceded by the new (additional) data: 3,026,000 ug/m^3 vs. 553,500 ug/m^3 (Table 5-6) – this represents an *increase* over the concentration we used in the Report for this contaminant by more than 500 percent!

Chronic Exposure

The contaminant masses to be dredged to support the chronic exposure results were similarly derived based on the core-sample data from the ROD, but we opted to base these masses on the mean concentration (instead of the highest concentration used for the 1-hour acute exposure). As presented in Table 5-2, these values were: naphthalene, 379,463 kg; 1,4-dichlorobenzene,

57,833 kg; and benzene, 12,131 kg. However, as alluded to earlier, because the additional sediment data was collected with the express purpose of refining the quantity of sediment to be dredged, we fully agree this should supercede, *in toto*, our original calculations. Based solely on calculations from Appendix B of EPA's HHRA, our new mass values are reduced: naphthalene, 175,198 kg; 1,4-dichlorobenzene, 52,096 kg; and benzene, 5,691 kg.

It was a relatively straightforward exercise to recalculate the new contaminant masses based on the above HHRA data. However, these masses disagree with DEC's contaminant masses as provided in the comment; *DEC does not disclose, nor are we able to reconstruct, how these masses were determined*.

Finally, Appendix F of the HHRA presents detailed statistical analyses of the additional sediment data. During examination of these analyses, we discovered that EPA determined appropriate upper confidence limits (UCLs) to derive individual contaminant masses, as functions of sample distribution and population. Instead of assigning the mean concentration for each contaminant (as we did in the Report), EPA concluded that this smaller data set warranted a much more conservative treatment, and ascribed a 97.5% UCL for each compound of concern. Therefore, incorporating this data treatment precedent, our new (and final) mass values are: naphthalene, 273,747 kg; 1,4-dichlorobenzene, 176,669 kg; and benzene, 9,515 kg.*

The following table compares the new contaminant masses from the HHRA to the original contaminant masses from the Report for the assessment of chronic exposure. Modest reductions are shown for naphthalene and benzene, but a substantial increase is shown for 1,4-dichloro-benzene. These changes to the contaminant masses are directly relatable to the predicted chronic exposure exceedance factors as shown in Table 5-10 and depicted in the related figures.

Scenario	Total Contaminant Mass for Assessment of Chronic Exposure		
	Naphthalene	1,4-Dichlorobenzene	Benzene
Original Mass (Table 5-2)	379,463	57,833	12,131
New Mass (HHRA)	273,747	176,669	9,515
% change	(27.9)	205.5	(21.6)

* The concept of an upper confidence limit can be understood by considering the following example. Suppose we want to find the 95% UCL from a total of 20 measurements with concentrations ranging between, say, 10 and 40. After ranking the concentrations from lowest to highest, suppose the 19th highest concentration is 37 (i.e., only one concentration is higher than 37). The 95% UCL is 37, with only 5% of the concentrations greater than this value.

12. ***The M&S Report (Table 5-3) indicates that the volatilization loss of the three contaminants [naphthalene; 1,4-dichlorobenzene; and benzene] ranges from 79.7 to 82.9% based on Tables 9 through 14 of the Wind Tunnel Testing report (June 2008) prepared by Service Engineering Group as part of the remedial design work. Estimates from the Wind Tunnel Testing report are not relevant to the final design and current operations of the sediment processing area, since the wind tunnel testing was designed to evaluate potential emissions from the open basin disposal/dewatering approach that was included in the July 2005 Record of Decision, but was later eliminated in favor of dewatering using geotubes. Again, the Report fails to recognize that significant design changes were made to the project after the issuance of the 2005 ROD, specifically the change from open lagoon dewatering to the use of geotubes. One of the primary reasons for incorporating geotubes into the project was to reduce emissions and the Report fails to recognize this significant improvement.***

As discussed in the project planning document, "March 2008 Onondaga Lake Pre-Design Investigation: Phase III Addendum 7 Work Plan, Air Emissions and Odors" (Reference 7 of our Report), the June 2008 Wind Tunnel Report, a revision to an earlier version (March 2006), was performed to support SCA operations being considered. From Page 2: "Use of geotubes and operation of the SCA as open basins are both currently under consideration."

The 2008 work was indeed intended to support evaluation of the geotube option (among others), despite DEC claims to the contrary. Said another way, the revised wind tunnel study derived emission factors for the sediment slurry dewatering process, results of which are valid regardless of the precise way such dewatering ultimately came about (i.e., geotubes). We therefore stand by our conclusion that the wind tunnel results provide a reasonable, conservative representation of the current sediment treatment and handling processes.

One question we have, however, is if the 2008 work wasn't relevant to the final design (as DEC asserts above), then why was the 2006 report revised in the first place? We might be able to answer that question ourselves but, unfortunately, the original report was either never added to or has since been removed from the online project document repository. Given these circumstances, we can only conclude that if the emission results were ultimately dismissed by DEC and EPA after this second round of expensive wind tunnel work, *the results were not consistent with the desired outcome*.

It is interesting to note that the contaminant loss to the atmosphere (via evaporation and stripping) could be easily calculated based on mass balance considerations if sampling were performed of the dredged slurry, the cured geotube sediment, and the geotube filtrate prior to entering the onsite wastewater treatment plant. We asked DEC for this data (Table 3-1 of the Report) and were told it doesn't exist.

We understand a similar request to perform a simple mass balance analysis has been made of DEC at least once in the past. The obvious question, of course, is why hasn't this sampling ever been performed?

13. ***Potential emissions from the geotube dewatering approach, including filtrate holding basins were estimated by Honeywell consultants during remedial design. It should be noted that these estimates did not consider the emissions controls that are currently in place for these potential sources. For naphthalene, these estimates were 3,521 gm/day from geotubes (filling, inter-tube streams, cascading water, gravel flow, and perimeter channel flow) without geotube covers and other engineering controls, and 396 gm/day from holding ponds without a cover. Honeywell consultants also estimated emissions from the debris screens and water treatment plant assuming 90% removal of emissions using vapor controls. For naphthalene, these two additional sources were estimated to be approximately 1,209 gm/day, for a total of 5,126 gm/day including the estimated emissions from the geotubes and basins (without controls). Assuming 952 operating days as was used by M&S (see page 5-4 of the M&S report), an upper estimate of the mass of naphthalene released over 5 years would be 4,880 kg, which is significantly lower than M&S volatilized mass estimate (314,575 kg). Similarly, estimates for 1,4-dichlorobenzene (1,826 kg) and benzene (3,485 kg) are also significantly lower than M&S volatilized mass estimates (47,886 kg and 9,668 kg, respectively). Based on these estimates which more accurately reflect actual SCA operations, the estimated emissions over 5 years and annual emissions of these contaminants of concern are much less than the 10 tons/yr Hazardous Air Pollutants (HAP) threshold cited in M&S Table 5-5 (even without engineering controls factored in).***

The wind tunnel work was performed because DEC refused to require construction of a pilot-scale facility to directly measure the air emissions. When the wind tunnel work produced unfavorable results, DEC continued commissioning less defensible studies, regressing into performance of a set of desk-top analyses. We received these results on April 24 (in the form of memoranda dated June 3 and June 29, 2010) from DEC, via the Town Engineer. These memos are not in Honeywell's public document repository, which is accessible online at http://www.lakecleanup.com/publicdocs/.

If the activated carbon control systems in the Screening Building and the wastewater treatment plant were actually removing 90 percent of the contaminants as claimed above, why were we told that the carbon usage records and contaminant "breakthrough" data for the existing carbon systems do not exist (Table 3-1, Item 8 from the Report)? The most likely answer is that these carbon systems have never performed satisfactorily, with breakthrough essentially occurring faster than the activated carbon can be regenerated or replaced.

DEC's entire argument concerning the inappropriateness of the wind tunnel work is baseless and without merit. Further, DEC's continued obfuscatory exercise of discounting the wind tunnel data is absurd based on the following logic.

First, there can be no debate as to our revised contaminant mass calculations as, per DEC insistence (Comment 11), we now follow precisely the approach detailed in the HHRA. Next, as alluded to in our response to Comment 12, besides release to the atmosphere, there can be only three fates for these contaminants: (a) removal via the activated carbon; (b) adsorption onto the geotube sediments; and (c) subsequent dissolution into the filtrate water.

Activated Carbon Removal – The following table shows the maximum contaminant removal rate based on the specifications for the activated carbon system in the Screening Building. Based on these calculations, we conclude that this system can remove *only between 5 and 10 tons of VOC per year*.

Typical VOC Inlet Conc. (ppm)	Mean VOC Molecular Weight	Typical VOC Inlet Conc. (mg/m^3)	Volume Flow Rate		VOC Removal Rate (assumes 100% capture efficiency)		
			(cfm)	(m^3/s)	(g/s)	(lb/yr)	(tons/yr)
40	100	164	4,000	1.9	0.31	12,648	6.3

Geotube Sediment Adsorption – Sampling the cured sediments, together with information on the rate of geotube filling, will allow the VOC removal rate resulting from geotube sediment adsorption to be easily ascertained (tons per year).

Filtrate Dissolution – Sampling the filtrate wastewater immediately prior to entry into the onsite wastewater treatment system will similarly allow the VOC removal from filtrate dissolution to be easily ascertained (tons per year).

Therefore, the contaminant mass released to the atmosphere can be calculated simply by subtracting the mass of the above three VOC loss terms from our revised mass calculations (as was requested by the community). Further, had DEC provided the requisite data as we requested on March 6, we would have done this ourselves. That this data does not exist leads to the inescapable conclusion that *DEC has absolutely no desire to know the true air contaminant emission rate*.

Finally, the extraordinarily high TVOC concentration measured onsite in the breathing zone near the geotubes (discussed in the General Comments section), together with the observed incidences of adverse exposure consistently reported by the residents, serve only to confirm our calculations.

14. ***The following table compares projected emissions:***

Total Projected Emissions (kg)

Contaminant	*M&S*	*DEC*
naphthalene	*314,575*	*4,880*
1,4-dichlorobenzene	*47,886*	*1,826*
benzene	*9,668*	*3,485*

Our revised emissions for these contaminants are presented in the Comment 11 response. Our argument for rejecting the DEC emissions is presented in the Comment 13 response.

15. ***With respect to the June 2010 Supplemental Human Health Risk Assessment (HHRA), the M&S report is critical of how air contaminant concentrations in the residential areas, which were used to evaluate potential risks to people residing in the vicinity of the SCA, were developed. Specifically, the report finds fault with deriving offsite air estimates based on modeled dispersion of air contaminants assumed to be at the "safe level" criteria established for the work zone perimeter, in lieu of modeling facility emission rates to obtain residential area air contaminant concentrations. The Report also states that control measures should have been implemented prior to the start of operations with the implication that criteria were exceeded. EPA disagrees with these assertions for the reasons stated below.***

First EPA notes, the M&S report offers no evidence that air criteria established for the project were exceeded other than its own projected air emission rates and residential air contaminant concentrations. An important omission in the report is that it does not discuss the fact that both short- and long-term monitoring results indicate that, to date, the SCA work perimeter air criteria have not been exceeded.

The argument that air monitoring data can justify the blatant disregard of the Feasibility Study process – the sole purpose of which is to ensure that the selected remedy *and its implementation* is fully protective of human health – is utterly ludicrous. Never mind the fact that, in this case, such data is shown to be hopelessly deficient for any of myriad reasons cited in our response to Comments 2 through 8.

The sordid history leading up to this situation – most unfortunate for the Camillus residents and extremely embarrassing for EPA – has been carefully reconstructed in Section 4.1 of the Report.

16. ***In addition, the emission rates used in the M&S report for its projections are based on a questionable assumption regarding the application of one set of test results reported in a wind tunnel study conducted in 2008. Specifically, the M&S report provided no information to support the use of measured volatile losses for an actively mixed slurry (10% solids) in the 2008 study to represent chemical emission rates from the geotubes. At the time of the 2008 study, both operation of the SCA as a large gravity settling lagoon as well as dewatering with geotubes were under consideration as methods to dewater the dredged material piped from the lake to the SCA. The 2008 study was conducted to verify previous wind tunnel test results, to evaluate potential emissions and odors from exposed sediment at the SCA over a long period of time, and to evaluate potential mitigation techniques to control air emissions and odors from ponded and exposed sediments. The study's stated objectives did not include quantifying emissions specific to the use of geotubes. It is important to note too that, based on information and experience with geotubes at other sites and applications, emissions and odors from geotubes would be less than what would be expected if a large settling lagoon were used for dewatering. This is one of the primary reasons geotubes were incorporated into the advanced design.***

This comment is fully addressed in our response to Comment 12. It is DEC who provides no information in support of their contention that the wind tunnel study results are not representative. The mass transfer of VOCs from the sediments to the water is totally relevant, as a key objective of the revised (2008) wind tunnel work was to reasonably simulate this release

during the slurry pumping and geotube filling processes. Again, we stand by our results.

Ironically, and ultimately much to the community's dismay, Facility emissions would be *significantly less* had the open-basin option been selected rather than the geotubes (a finding which would have been apparent had a pilot-scale program been performed).

As evidenced by our response to Comment 13, we have concluded that the Facility is currently operating essentially as an uncontrolled source; the water cover would allow at least a reasonable portion of the VOCs to bind to the sediment, thereby preventing their volatilization. The water cover would also act to buffer, or "smooth out," the air emissions whenever pockets of extremely high contaminants are encountered in the lake-bottom dredging. **Attachment B** describes just such a circumstance in which water cover was used successfully to contain open-basin emissions.

Under present Facility operations, there is no means to regulate these short-term emissions – hence the "spiking" phenomenon so problematic to the community (and evidenced by the 44.9 ppm onsite TVOC concentration discussed in the General Comments section). Further, instead of remaining bound to the sediments, the VOCs are mechanically stripped while being pumped into, and draining from, the geotubes.

In summary, the net result of the geotube option is that the annualized emissions are somewhat greater, owing to the overall opportunity for greater volatilization; short-term emissions, however, are *substantially greater*, as there is no buffering mechanism to mitigate emission spikes. For this reason we recommended, in our Report, erecting a sprung structure over the geotubes, with a mechanism to remove the VOCs such as thermal destruction.

17. ***Secondly, facility emission rates were not used in the Supplemental HHRA to model air concentrations in the residential areas due to the complexities in estimating emission rates resulting from the use of geotubes. A methodology for estimating volatile emissions from geotubes, which were believed to be the principal source of volatile emissions from the SCA, was nevertheless developed by consultants prior to the release of the Supplemental HHRA. The methodology included developing estimates for the five main flow components associated with geotubes. The components included, (1) water weeping from the surface of each tube as it is being filled, (2) water coalescing into streams between adjacent tubes, (3) cascading of the streams off the tube ends to the gravel bed or to other tubes, (4) streamflow through the gravel bed to the sumps, and (5) streamflow along the perimeter channel to a drain leading to the wastewater treatment plant. Subsequent to this submission and after the Supplemental HHRA was completed, separate emission estimates were developed for the SCA holding ponds, debris screens and wastewater treatment plant. The combined estimated emission rates from all of these sources would result in lower modeled air contaminant concentrations in the community than offsite air concentrations derived from the work zone perimeter criteria as was done in the Supplemental HHRA. This provides an additional line of evidence that the approach taken by EPA in the Supplemental HHRA was conservative (i.e., health-protective). It is also an indication that the methodology for estimating emission rates and offsite air concentrations taken in the M&S report, which resulted in much higher rates and concentrations than the***

approach taken by Honeywell's consultants, is likely to result in a gross overestimate of air impacts from SCA operations.

This comment is fully addressed in our response to Comment 13.

Additionally, since results from this desk top study were not used in the HHRA, its existence here is irrelevant. However, it is interesting to note that EPA recognizes the "complexities in estimating emission rates resulting from the use of geotubes." Again, the question is posed: *"Why wasn't a pilot-scale program performed?"*

18. ***Thirdly, the approach taken by EPA in the Supplemental HHRA assumed that all 27 potential volatile contaminants identified either in wind tunnel tests or in sediment samples collected from the lake would be simultaneously present and be at the maximum allowable concentrations at an exposure frequency of 350 days/year for the assumed five-year duration of the project. It is highly unlikely that every volatile chemical would be simultaneously present and be at the maximum allowable concentrations at the SCA perimeter for any extended period, especially since air monitoring is being conducted during operations and the results are being regularly evaluated to assess compliance with the air criteria established for the project. Furthermore, if monitored air concentrations indicate a trend towards chemicals reaching the work perimeter criteria for a sustained period of time, site operations can be modified to reduce these concentrations. As noted above, the short- and long-term SCA work perimeter criteria have thus far not been exceeded, with most contaminants detected at levels well below criteria. This provides further confirmation that the use of the SCA work perimeter air criteria to derive offsite air contaminant concentrations for use in the Supplemental HHRA was a conservative approach.***

All issues raised in this comment are addressed in our response to Comment 15.

19. ***The Report incorrectly claims that emissions exceed the major source threshold which would elicit regulation pursuant to National Emission Standards for Hazardous Air Pollutants [NESHAP] under the Clean Air Act.***

As discussed above, emissions estimates from the sediment processing area (even without accounting for engineering controls) would be much less that the 10 tons/yr NESHAP threshold cited in M&S Table 5-5. In addition, applicable federal regulations [40CFR63.7881(b)(2)] state that site remediation performed under the authority of the Comprehensive Environmental Response Compensation and Liability Act [CERCLA] as a remedial action is not subject to NESHAPs program. The reason for this exemption is that remedial activities performed under the strict requirements of CERCLA are considered at least as protective, if not more, than emission control standards developed under the NESHAP program. CERCLA's site-specific ROD decision and design process extensively evaluates the contamination and remedial processes at each individual site; provides public involvement; and includes an evaluation of site-specific impacts of the remedial alternatives to air, soil, surface water and groundwater, as appropriate. In short, the CERCLA process involves an equal, or more comprehensive review of site-specific impacts than would be conducted under NESHAP, if applicable.

We have performed revised HAP calculations based on: (a) the revised contaminant masses derived for each of ten HAP identified in Appendix B of the HHRA (using the additional sediment data as discussed in our response to Comment 11); and (b) the contaminant-specific UCL data from Appendix F of the HHRA.

Following is a revised Facility HAP compliance table (after Table 5-5 from the Report). The total HAP emissions are 187.9 tons per year, as compared to a maximum allowable of 25.

Compound of Concern	Revised Contaminant Mass (kg)	Loss Through Sediment Dewatering Step (% of Mass)	Total Mass Emitted		Annual Mass Emitted (Tons/Year)
			Kilograms	Tons	
naphthalene	330,214	82.9	273,747	301.8	60.4
1,4-dichlorobenzene	213,369	82.8	176,670	194.7	38.9
benzene	11,938	79.7	9,515	10.5	2.1
1,2-dichlorobenzene	96,524	82.8	79,922	88.1	17.6
chlorobenzene	132,085	77.4	102,234	112.7	22.5
ethyl benzene	30,481	90.5	27,585	30.4	6.1
1,2,4-trichlorobenzene	43,182	93.2	40,246	44.4	8.9
hexachlorobenzene	16,257	58.4	9,494	10.5	2.1
xylenes	114,305	84.2	96,245	106.1	21.2
mercury	38,102	96.1	36,616	40.4	8.1
Total	**1,026,457**		**852,273**	**939.5**	**187.9**

It is true that 40CFR63.7881(b)(2) does indeed exempt a site remediation if it is performed under CERCLA authority. And it is equally true that this exemption is provided because emission-abatement activities performed under the strict requirements of CERCLA are considered at least as protective as those performed under NESHAP.

However, DEC's argument here is specious, as we have shown that *the CERCLA process has clearly been circumvented*. Therefore, while we concede there is a legal issue concerning explicit compliance with this provision, there can be no disagreement about Congress' *intent* of the provision – namely the protection of human health and welfare.

20. ***VI. Conclusion***

Review of the Report suggests that the authors do not fully understand or appreciate the very significant and comprehensive investigations, scientific studies, and engineering analyses conducted in relation to the design, construction and operations of the Onondaga Lake dredging project. The Report is based on flawed assumptions and inaccurate information. Most importantly, the Report's allegations that the

project is not protective of community health are neither supported by the available data, nor reflective of the project as currently operated. The Report incorrectly predicts that exceedances of protective public health guidelines will occur, when actual measurements have shown no such exceedances, refuting the authors' predictive methodology.

We respectfully submit that we understand every element of this project all too well.

All DEC allegations levied in this comment have been adequately refuted in the preceding comment responses.

21. ***Based upon years of data collection and design, including air quality monitoring data collected during the first year of dredging, DEC, DOH, and EPA are confident that the project is protective of the community.***

Given our response to the preceding comments, this confidence can be only small consolation to the Town. This is especially so given the frequency with which Camillus residents continue to be sickened by exposure to these airborne contaminants.

* * * * *

ATTACHMENT A

Invited Article Published in "Remediation," Summer 1999

Use of Open-Path FTIR Spectroscopy to Address Air Monitoring Needs During Site Remediations

Timothy R. Minnich • Robert L. Scotto

Although open-path Fourier-transform infrared (FTIR) spectroscopy has been a USEPA Toxic Organic Compendium Method since 1996, it has been underutilized as a means to assess exposure to gaseous contaminants during the remediation of hazardous waste sites. This might be considered surprising in light of the myriad benefits that proper application of this technology can offer. In this paper, we provide an overview of the technology and the principle of operation, describe the nature of the data generated, discuss the benefits associated with its use in site cleanup, present emission-rate estimation techniques, and examine the reasons why it has not gained more support over the years. Finally, we present a case study in which the technology was used to drive an 11-month emergency removal action under the direction of the U.S. Environmental Protection Agency.

INTRODUCTION

Assessment of the air migration pathway represents a significant aspect of many hazardous waste site remediations. Compliance with pre-established health-based action levels must be demonstrated in order to protect onsite workers and nearby residents. This can be an especially difficult task based on use of traditional point monitoring.

The nature of atmospheric plume dispersion, in conjunction with the need to consider acute health impacts arising from short-term contaminant exposure, has often resulted either in the implementation of ineffective remediation air monitoring programs which, unfortunately, are not protective of human health or, conversely, in the performance of site remediations at a painstakingly slow pace due to an excessive level of conservatism in the air monitoring results. This over-conservatism arises directly from an inability to adequately address the need for real-time data or the need for spatially representative data, or both. Analytical methods which require

sample collection and subsequent offsite laboratory analysis cannot meet the requirements for real-time data. Similarly, point monitors (or samplers) which can characterize the air only at a single point in space cannot meet the requirements for spatially representative data, unless many such monitors are employed at a considerable cost.

Open-path Fourier-transform infrared (FTIR) spectroscopy can be used together with onsite meteorological data to provide ongoing assessment of action-level compliance, in real time, for a virtually unlimited downwind receptor field, thereby overcoming the limitations associated with use of point monitors. As discussed in detail, this method involves, first, the continual back-calculation of site-specific emission rates, and second, the prediction of downwind concentrations (and, thus, assessment of action-level compliance) along the site perimeter and at all identified "sensitive receptors."

THE TECHNOLOGY

Open-path FTIR spectroscopy is able to provide real-time, simultaneous analysis of up to several dozen gaseous contaminants. The technology is identical in principle to classical laboratory FTIR spectroscopy, except the cell into which a sample would be injected is extended to the open atmosphere. A beam of light spanning a range of wavelengths in the near-IR portion of the electromagnetic spectrum (approximately 2 to 14 microns) is propagated from the transmitter portion of the instrument. In the most common configuration, a "retroreflector," comprised of an array of corner-cubed mirrors, is positioned to intercept this radiation and redirect it back upon itself to the receiver portion of the instrument.

As described by Grant, [1] an interferometer splits the returning beam of radiation into two paths, and then recombines them in a way to generate an interference from the phase differences. The phase difference, and thus the interference, is dependent on the wavelengths present in the beam. In one of the paths, the radiation is reflected off of a moving mirror, resulting in an intensity variation which is measured at the detector as a function of the path difference between the two mirrors. The result is an interferogram.

The interferogram obtained from a monochromatic beam is simply a cosine wave. The broadband interferogram is a sum of cosine waves (the Fourier series) for each spectral component as a function of mirror pathlength separation. A spectrum in the optical frequency units, cm^{-1}, is obtained by performing a Fourier transform on the interferogram.

Contaminants of concern are identified and quantified via a computer-based spectral search involving sequential, compound-specific analysis and comparison to the system's internal reference spectra library. The most widely employed technique for analyzing FTIR spectral data is the multicomponent classical least squares (CLS) technique developed by Haaland and

Easterling. [2] Any gaseous compound which absorbs in the IR region is a potential candidate for monitoring using this technology.

One-way pathlengths can range from less than 10 meters (as in the case for combustion source stack monitoring) to several hundred meters or more (as may be required for many ambient air applications).

PATH-INTEGRATED DATA

Gaseous contaminant concentrations are generally reported in units of mass of contaminant per volume of gas, such as micrograms per cubic meter (ug/m^3), or volume of contaminant per volume of gas, such as parts per billion (ppbv) or parts per million (ppmv). Path-integrated concentrations, however, are usually reported in units of parts-per-million-meters (ppm-m). For reasons which will become apparent, it is often desirable to convert path-integrated concentrations (ppm-m) to units of milligrams per cubic meter times meter (mg/m^3 x m), or mg/m^2.

For an open-path FTIR spectrometer, the total contaminant burden is measured within the approximate cylinder defined by the finite cross-sections of the light beam at each end and the length of the beam itself. This contaminant burden is then normalized to a pathlength of 1 meter. If, for example, a path-integrated concentration of 30 ppm-m is reported, no information concerning the contaminant distribution within the beam can be directly inferred, and the instrument response would be identical whether there was a uniform concentration of 30 ppmv over a distance of 1 meter, 3 ppmv over a distance of 10 meters, 300 ppbv over a distance of 100 meters, or 30 ppbv over a distance of 1 kilometer.

It is immediately evident that the integrated concentration reported is directly proportional to the total pathlength for a given uniform contaminant concentration. It also follows that for a site from which contaminants are emanating in a plume of narrow width (e.g., 10 meters), the same path-integrated concentration will be reported regardless of pathlength, as long as the narrow plume remains contained within the observing pathlength and there is no upwind (or background) contaminant contribution. [3]

The generation of a path-integrated concentration yields contaminant information along the entire pathlength, and not just at a single point (or collection of points) in space as with traditional point-monitoring methods. This solves the issue of spatial data representativeness, as a non-buoyant ground-level plume cannot pass through the beam path undetected.

One may divide the path-integrated concentration by the pathlength to obtain an average concentration along the pathlength, but this concentration representation is of limited value when dealing with action-level averaging times typical of acute exposure assessment.

BENEFITS

The following benefits are identified for use of this technology in site cleanup:

- cost-effectiveness
- speed and versatility
- data quality
- documentation of contaminant exposure
- community relations

Cost-Effectiveness

A general perception exists that open-path FTIR spectroscopy is an expensive alternative to traditional air monitoring methods for site-cleanup applications. This is a misconception arising from what turns out to be an "apples and oranges" comparison. When compared to a traditional air monitoring program which is able to meet the necessary site cleanup data quality objectives, an open-path FTIR-based program is far less expensive. A typical cost for a 1-month program involving a single open-path FTIR unit with full upwind/downwind coverage would be on the order of about $45,000. This includes all mobilization and demobilization activities, labor and equipment, and QC activities to ensure the technical validity and legal admissibility of the data.

The same program based on an automated gas chromatography network consisting of one upwind and eight downwind monitors would cost on the order of $85,000. However, even with this number of downwind monitors, data representativeness is only marginally achievable, even for a small site. It would be difficult, if not impossible, to ensure the plume does not migrate offsite undetected, especially under stable atmospheric conditions. By way of illustration, even at a downwind distance of 100 meters, one needs only to move 12.8 meters away from plume centerline (i.e., normal to the wind direction) to see a full 90% reduction in concentration (point-source release) when the atmosphere is stable.

Speed and Versatility

Library spectra exist for several hundred compounds, and new ones can be created within a few days for virtually any gaseous compound which exhibits IR absorption. Today, more than 40 compounds can be monitored simultaneously, with quantitation available within 30 seconds of data collection. Offsite contaminant exposure, via back-calculation of emission rates and subsequent modeling of downwind concentrations, can be assessed within about 1 minute.

Data Quality

As discussed earlier, information is obtained along an entire pathlength instead of at a single point in space. Because of this, data representativeness and comparability are unequaled when compared to point monitoring.

Path-averaged minimum detection limits (MDLs) are generally in the single-digit-ppb range based on a pathlength of 100 meters. This is usually more than sufficient for assessment of action-level compliance for acute exposure.

An infinite "sample holding" time exists, as analysis information is stored as an electronic document. This means that the data can be reexamined at a later date for evidentiary reasons, or even reanalyzed should an additional target contaminant be later identified.

Any sample collection error is eliminated, as there is no "sample" per se; the media is unaffected by measurement method.

Finally, no calibration is required as the instrument is intrinsically calibrated. Only daily precision and accuracy assessments need to be made in accordance with procedures set forth in Toxic Organic Compendium Method 16 (Compendium Method TO-16).

Documentation of Contaminant Exposure

The ability to generate a continual assessment of action-level compliance for an unlimited downwind receptor array can be important in reducing responsible-party or government liability associated with unsubstantiated future claims involving exposure (worker or public) to unknown contaminants during site cleanup.

Another benefit of exposure-documentation capabilities concerns personal protection. For example, field decisions to downgrade personal protection levels (e.g., from Level B to Level C) can be supported by generation of real-time action-level compliance data.

Community Relations

It has been our experience that the "high-tech" nature of the open-path FTIR technology invariably leads to community appeal and positive public perception. Total fenceline coverage (the "eye which never sleeps") allays public fear. Such community appeal, in turn, benefits regulatory agencies, as there is less opposition to the selected cleanup remedy.

EMISSION-RATE ESTIMATION TECHNIQUES

The inability to assess acute exposure based on the direct use of path-integrated data would, on first thought, seem to be a drawback. However, when coupled with onsite meteorology, this type of data is actually unparalleled, as all of the limitations associated with traditional point-monitoring approaches are eliminated. Action-level compliance can be assessed, in real time, for a virtually unlimited downwind receptor field.

The cornerstone of this methodology is the back-calculation of contaminant emission rates. Rather than relying on receptor monitoring for a direct assessment of action-level compliance, having an accurate emission-rate estimation facilitates application of traditional dispersion modeling to predict action-level compliance for any locations of concern (e.g., site perimeters and sensitive offsite receptors such as residences and schools). Because 5 minutes of coadded spectra are more than sufficient from a precision and accuracy perspective, it is a straightforward task to generate a new, site-specific emission rate – and a corresponding assessment of action-level compliance – up to 12 times each hour.

To estimate the health impacts to downwind receptors, reliance upon some type of conservative dispersion model offers the only practical alternative.

Actual concentrations could be continuously measured at each receptor of concern, but this activity is generally both cost- and labor-prohibitive. All dispersion models rely upon accurate estimates of emission rates. The ability to provide accurate emission-rate estimates continually and in real time is the key to the power of the path-integrated concentration. [3]

Three specific back-calculation techniques appropriate for action-level compliance are discussed below.

Point-Source Technique

Within classical Gaussian dispersion theory, the general equation for concentration calculated at ground-level (z = 0) for a continuously emitting point source is given as follows: [4]

$$\chi\,(x,y,0;H) = Q\,(\pi\sigma_y\sigma_z u)^{-½}\exp\left[-½\,(y/\sigma_y)^2\right]\exp\left[-½(H/\sigma_z)^2\right] \quad \textbf{(Eq. 1)}$$

where:

χ	=	concentration, g/m^3
x	=	downwind distance to a receptor, m
y	=	crosswind distance to a receptor, m
z	=	vertical distance to a receptor, m
H	=	effective height of contaminant emission, m
Q	=	uniform emission rate of contaminant, g/s
σ_y	=	standard deviation of plume concentration distribution in the horizontal direction at the distance of measurement, m
σ_z	=	standard deviation of plume concentration distribution in the vertical direction at the distance of measurement, m
u	=	mean wind speed, m/s

This relationship forms the basis for many of the USEPA atmospheric dispersion models currently employed for estimating downwind air quality impact.

Examination of this relationship shows that the downwind concentration at a given location increases with increasing source strength, but decreases with increasing wind speed and horizontal and vertical dispersion (as determined via σ_y and σ_z). The standard deviations of the plume concentrations in the horizontal and the vertical are, in turn, functions of atmospheric stability and the distance downwind of the source. Nomographs which define σ_y and σ_z as a function of downwind distance for each of six stability classes are frequently used to estimate these parameters. Larger σ_y and σ_z values are associated with unstable atmospheric conditions (greater dispersion) and greater downwind distances. [3]

If one integrates Equation 1 in the y (cross-plume) direction, the resultant representation is a crosswind-integrated concentration instead of a point concentration. Performing this integration with respect to y, from $y = -\infty$ to $+\infty$, yields:

$$C(x,0;H) = 2Q\,[(2\pi)^{1/2}\,\sigma_z\,u]^{-1}\exp[-\tfrac{1}{2}(H/\sigma_z)^2] \quad \textbf{(Eq. 2)}$$

where:

C = ground-level crosswind-integrated contaminant concentration at distance x, g/m^2

Equation 2 has historically been employed in diffusion experiments to determine vertical dispersion coefficients (standard deviations of the plume concentration in the vertical direction), σ_z, from ground-level data where the source strength, Q, was known and the ground-level crosswind-integrated concentration was determined from a crosswind line or arc of point-sampling measurements made at some predetermined downwind distance. [3]

The effective height of emissions, H, is defined as the sum of the actual height of emissions and the buoyancy-induced height increment arising from an elevated effluent temperature. Because most site remediation activities occur at ground level and without elevated effluent temperatures, H generally equals zero and Equation 2 reduces to:

$$C(x) = 2Q\,[(2\pi)^{1/2}\,\sigma_z\,u]^{-1} \quad \textbf{(Eq. 3)}$$

Rearranging, Equation 3 may be written as:

$$Q = \tfrac{1}{2}(2\pi)^{1/2}\,C(x)\,\sigma_z\,u \quad \textbf{(Eq. 4)}$$

Equation 4 is the general emission-rate equation for a point source involving path-integrated measurement data. For a measured crosswind-integrated concentration at some specified downwind distance, the emission rate, Q, depends only upon σ_z at that distance and on wind speed, u. The point-source emission-rate technique is applicable for those site disturbance activities which may be approximated as point sources (e.g., excavations).

Tracer-Ratio Technique

The tracer-ratio technique is appropriate for estimating emission rates from any type of site disturbance activity (i.e., point source or area source) and, in contrast to the point-source technique, does not rely on the contaminant distribution in the plume being Gaussian.[5] The tracer-ratio technique involves the release of an appropriate tracer gas (such as sulfur hexafluoride) at a known, controlled flow rate from locations which adequately simulate the source geometry. Assuming that the tracer and source plumes are fully contained by the downwind FTIR beam, the following ratio applies:

$$C / Q = C_T / Q_T \qquad \textbf{(Eq. 5)}$$

where:

C_T = ground-level crosswind-integrated concentration of tracer at distance x, g/m^2
Q_T = uniform emission rate of tracer, g/s

Equation 5 simply states that the ratio of the path-integrated concentration of the contaminant to its emission rate is equal to the ratio of the path-integrated concentration of the tracer to its emission rate. (It is important to note that all concentrations must be expressed in units of g/m^2 or mg/m^2, as use of ppm-m units will yield erroneous results owing to the fact that molecular weights are unaccounted for.)

Rearranging Equation 5 and solving for Q yields:

$$Q = (Q_T C) / C_T \qquad \textbf{(Eq. 6)}$$

If the emitting source is not too large, a tracer will typically be released from a single point positioned at the source edge furthest upwind. The simplicity of such a source simulation generally outweighs the resultant increased conservatism (i.e., higher emission rates).

Area-Source Technique

The area-source technique is simple to implement and can be used to estimate emission rates from area sources which are too large for simple treatment via the tracer-ratio technique.

The technique is applicable for both homogeneous and nonhomogeneous sources (i.e., sources which emit uniformly and sources which have "hot spots"). However, for nonhomogeneous sources, some information on the extent and magnitude of the hot spots is required. If no hot-spot information exists, it is possible to generate reasonable bounds upon the site emission rate.

Like the point-source technique, the area-source technique does not involve use of a tracer gas and the plume is generally assumed to obey Gaussian dispersion theory. The following four-step methodology is employed. [5]

1. Identify Source Attribution

This step involves making ground-level FTIR measurements upwind and downwind of the source to identify source attribution. The instrument background will typically serve as the upwind measurement, and site attribution is obtained by subtraction. It is essential that the downwind pathlength be of a magnitude sufficient to encompass the entire width of the plume.

2. Predict Point Concentrations Along the Measurement Path

This step involves use of an appropriate dispersion model, preferably the ISCST (Industrial Source Complex Short-Term) Model, to predict point concentrations along the downwind FTIR measurement path at a nominal receptor spacing of 1 or 2 meters. Relative emission rates are modeled (i.e., unity emissions, with hot-spot subareas represented as multiples of unity) based on actual meteorology and source configuration.

Site-specific σ_z values based on tracer releases are generally preferable to model (textbook) σ_z values, and should be substituted to back-calculate emission rates whenever possible. Equation 4 can be rearranged, as follows, to facilitate site-specific σ_z calculation:

$$\sigma_z = [(2\pi)^{1/2} Q_T] / \pi C_T u \qquad \textbf{(Eq. 7)}$$

By knowing Q_T, C_T, and u, a site-specific σ_z value is calculated directly. However, because σ_z is a function of stability and downwind distance, a curve comprised of σ_z values at several downwind distances should be generated for the range of stability classes expected to be encountered. Similarly, the downwind distances at which σ_z is measured should span the range of downwind distances to be encountered during site-disturbance activities. All tracer work should be carried out in advance.

3. Integrate the Function Defined by the Point Concentrations Along the Measurement Path

Some type of rudimentary numerical technique will generally be required to integrate this function (e.g., Simpson's Three-Point Rule, in which the line representing the value of the

function is replaced by a second-order equation, $y = ax^2 + bx + c$). The resultant path-integrated concentration is what the FTIR is predicted to "see" based on the relative emission rates used in the dispersion modeling.

4. Scale Modeling Results to Estimate Area Emission Rate

The actual contaminant emission rate, Q, is estimated in a manner which is conceptually similar to the tracer-ratio technique:

$$C_M / Q = C_P / Q_R \qquad \textbf{(Eq. 8)}$$

where:

C_M = measured ground-level crosswind-integrated contaminant concentration at distance x, g/m^2

C_P = predicted ground-level crosswind-integrated contaminant concentration at distance x, g/m^2

Q_R = relative emission rate of contaminant, g/s

Equation 8 simply states that the ratio of the measured path-integrated concentration to its emission rate is equal to the ratio of the predicted path-integrated concentration to its emission rate. Rearranging Equation 8 and solving for Q yields:

$$Q = (Q_R C_M) / C_P \qquad \textbf{(Eq. 9)}$$

REASONS FOR UNDERUTILIZATION

We identify at least three reasons why open-path FTIR spectroscopy has been underutilized as a means to assess exposure to gaseous contaminants during remediation of hazardous waste sites. These are:

- Lack of USEPA Headquarters support
- Resistance from the air monitoring community
- Poor marketing of the technology by the manufacturers

Lack of USEPA Headquarters Support

Lack of support from USEPA Headquarters for the use of open-path FTIR spectroscopy (and all optical remote sensing technologies) as a preferred means to assess gaseous contaminant emissions is, in general, perhaps the single biggest reason for its underutilization in the hazardous waste site remediation arena.

It should be pointed out, however, that this lack of support does not exist in all ten USEPA regions, but lack of programmatic support and policy directives on a national level has had a substantial effect. It should also be stated that the national Environmental Response Team (ERT) is one Agency group which has been very proactive in use of this technology, and it is under their direction and support that much of the applied research in developing emission-rate estimation techniques has been conducted.

Factors leading to the lack of programmatic and policy support on a national level are many and complex, but can generally be traced back to the early 1980s when government budget issues forced a fundamental change in the way the Agency operated. Over the span of several years, the USEPA underwent a difficult transition from being a highly proactive agency with arguably unparalleled scientific resources, to one largely relegated to the management of outside technical contractors. This transition resulted in the replacement of retiring senior atmospheric scientists – who had pioneered the design of innovative air measurement programs and the entire field of atmospheric dispersion modeling since the Agency's inception – with either existing individuals of unrelated technical background or new hires having little or no prior professional experience. Compounding the situation at the time was low morale and less-than-competitive pay which resulted in many highly competent technical/management personnel at mid-levels also leaving the Agency for better positions in industry and consulting.

Headquarters' support of open-path FTIR spectroscopy took a step further backwards in 1995 following a series of stakeholders meetings and workshops held around the country as part of the Agency's "Common Sense Initiative." Created by the Clinton Administration to protect public health and the environment more effectively and less expensively, the goal of the Initiative was to look at pollution on an industry-by-industry (vs. pollutant-by-pollutant) basis. All aspects of environmental policy were examined for a total of six pilot industries, and stakeholders ranging from industry to environmental consultants to community organizations were involved.

Based on our participation in the compliance assurance monitoring (CAM) portion of these meetings, it was evident that the Agency was "outmatched" against the industry interests whose goal was to keep the status quo of the state-of-the-art of the air monitoring field and maintain use of indirect means to characterize facility emissions. Also apparent was the fallout from an audit of CERCLA program activities performed by the Inspector General's office several years earlier, which concluded that some contractors were being used – inappropriately – to help create Agency policy.

So, not only was the Agency unable to stand up technically to the industry advocates during the CAM meetings, they were also unable to have consultant assistance in the negotiations because of internal directives to keep consultants and policy making "at a safe distance."

Even though open-path spectroscopy received a lot of support as a means to monitor total facility emissions, in the end, lobbyists for the petroleum refining industry (one of the six pilot industries) were successful in keeping this technology out of the Initiative. The stated reason for the refining industry's rejection of the technology was that it was "too good," as there was fear that proprietary formulations would be revealed because of the creation of a permanent electronic record of the absorbance spectra.

Even today, the Office of Air Quality Planning and Standards, which is responsible for development of both MACT (Maximum Available Control Technologies) standards and guidance concerning the assessment of "residual risk" following MACT application, is divided on acceptance of the technology. Some of the individuals support its use and others believe it has little value or has been oversold (a point to be addressed later).

Within the USEPA, we believe the utility of the path-integrated concentration is still not fully appreciated, and that there continues to be misunderstanding concerning application of the technology for assessment of emission rates. This, in turn, stems from an inability or unwillingness to consider atmospheric dispersion theory and meteorology as part of the "formula" for addressing the fundamental deficiencies of point monitors as relating to data representativeness and comparability.

Resistance From the Air Monitoring Community

Resistance to change from the air monitoring community has also inhibited acceptance of open-path FTIR spectroscopy. There are at least three reasons why such resistance occurs: (a) the technology poses an economic threat to the suppliers of traditional air monitoring equipment and associated analytical services; (b) individuals who have been doing traditional air monitoring for years still do not understand the FTIR technology and would rather resist it than admit their lack of understanding; and (c) many air monitoring decision-makers do not have a background in atmospheric dispersion and, because the open-path FTIR technology is truly revolutionary in terms of the data generated, there is simply an entrenched mentality which requires a significant effort to overcome.

Poor Marketing of the Technology by the Manufacturers

As a rule, manufacturers of open-path FTIR spectrometers have had very poor success in marketing the technology, as can be evidenced by the number of times open-path FTIR product lines have been sold over the past 10 years. Market research has repeatedly demonstrated an enormous potential for instrument sales, and this has often been sufficient to attract outside capital. However, vendors have consistently realized actual sales below those projected.

We have worked with most of the open-path FTIR vendors, and can point to a single factor for this lack of success: an overly simplistic view of what is necessary to achieve sales in a field which is simultaneously complex and immature. Until the market becomes mature – which may take another 10 or even 15 years – the focus must be on selling a service as opposed to a selling a "black box." This latter approach has, in several unfortunate instances, led to overselling the technology to the USEPA and other regulators.

It is a natural tendency for instrument manufacturers to become myopic as they struggle to perfect their product (and, indeed, the instruments on the market today are very good); however, there is a serious problem when the potential customers are, in general, not sophisticated enough to fully understand how it should be used to solve their problem. Add a price tag on the order of $100,000, and it's easy to see why sales have not met projections.

The correct approach is the one consultants have always employed: solve the client's problem. There are two reasons why manufacturers might choose to resist this, however. The first is that the best solution to the client's problem often will not involve sale of an instrument. Perhaps an instrument lease (on the order of a week to a month) might be optimum. The manufacturer needs to structure itself so that instrument leases are desirable.

The second reason is that the requisite expertise to solve the client's problem is generally not found within a manufacturer's organization. Essential to the successful marketing of this technology is a thorough familiarity of regulatory laws such as the Clean Air Act and CERCLA, as well as a strong technical background in meteorology and atmospheric dispersion. Unless such expertise is acquired, strong alliances with consultants are essential.

Keeping in mind the earlier discussion on lack of USEPA support, it is now easy to see why manufacturers trying to deal directly with USEPA have often been counterproductive to the advance of this technology.

CASE STUDY

The Michigan Avenue Dump Site, a 1.8-acre hazardous waste site located in Canton, Michigan, was used by 3M Corporation during the 1960s to dispose of industrial wastes. In 1993, an imminent threat to public health was identified by the USEPA, Region 5, due to large volumes of waste materials entering the Rouge River, which cut through the center of the site. In July of that year, an emergency removal action was initiated, and wastes were excavated and hauled away for offsite disposal while contractors shored up the riverbank with sheet piling.

The USEPA identified a potential for significant offsite exposure to airborne gaseous contaminants generated during excavation and stockpiling of contaminated waste materials. After

extensive Agency review of available monitoring methods and based upon ongoing consultation with USEPA-ERT, open-path FTIR spectroscopy was selected as the technology to "drive" the action.

While working for Blasland, Bouck and Lee, we were retained by 3M's consultant, Roy F. Weston, to design and implement the air monitoring program. The objective was to ensure that emissions generated during the excavation and offsite transport of waste materials did not exceed the health-based property-line exposure levels established by the USEPA for this site, and to support the application of vapor suppressants whenever action levels were approached.

Exhibit 1 identifies a total of 15 target contaminants and associated 30-minute action levels developed specifically for this emergency removal action.

Exhibit 1. Target Contaminants and Associated 30-Minute Action Levels

Contaminant	Action Level (mg/m^3)	Contaminant	Action Level (mg/m^3)
benzene	1.60	ethylbenzene	21.70
chloromethane	5.15	hexane	8.80
dichloromethane	15.00	methyl isobutyl ketone	10.25
1,2-dichloroethane	2.00	octane	70.00
acetone	89.00	toluene	9.40
2-butanone (MEK)	29.50	1,1,1-trichloroethane	95.50
cyclohexane *	5.00	xylenes	21.70
1,2-dichloropropane	17.35		

* As approximated by the sum of n-octane and iso-octane.

Open-path monitoring was performed, using a single FTIR unit, in such manner as to provide full coverage of the site perimeter, regardless of the wind direction. The instrument was positioned at the NW corner of the nearly rectangular site and could pivot to monitor along either the W or the N leg of the site. Flat mirrors were placed in the NE and SW corners to "bend" the beam along the E and S legs, respectively, and retroreflectors were positioned in the SE corner

to send the beams back upon themselves to the FTIR for analysis. Up to six 5-minute-averaged (70 coadded spectra) path-integrated downwind measurements were made each hour.

The tracer-ratio technique was used to back-calculate emission rates for the 15 target contaminants. The source (area of site disturbance) was represented as a virtual point conservatively positioned at the upwind site perimeter.

A proprietary plume dispersion model software package (SPECTRAMET) was used to assess action-level compliance based on the back-calculated emission rates and on meteorology supplied by a portable 3-meter meteorological tower equipped to generate 5-minute averages of wind speed and wind direction.

SPECTRAMET was configured to generate maximum predicted fenceline concentrations (mg/m^3) in near real-time (within 15 or 20 minutes of actual occurrence) approximately twice each hour for the duration of waste disturbance or vapor suppressant activities, or on demand by the Weston field manager. Whenever an action level was exceeded, waste disturbance activities were immediately stopped and a vapor suppressant applied. Activities could not recommence until maximum fenceline concentrations fell to background levels.

The local press was successful in gaining community support for the technology. "Like something right out of the Star Wars defense initiative, the Fourier Transform Infra-Red system has been doing some surreptitious defense work of its own in Canton.

"By quietly and inconspicuously testing the air at a Michigan Avenue dumpsite, the system – introduced by 3M to monitor its cleanup of the site – has been defending residents against the possible inadvertent release of any harmful chemicals." [6]

Because of the proximity of the emission sources to the site perimeter, action-level exceedances occurred frequently and 11 months was required for completion of the entire emergency removal action. However, during the course of the project, the USEPA stated that if open-path FTIR spectroscopy had not been utilized in the manner it was, the whole operation would had to have been performed under an enclosure, at a greatly increased cost to 3M.

REFERENCES

1. Grant, W.B. (1992). Optical Remote Measurement of Toxic Gases. Journal of Air & Waste Management Association. Vol. 42, No. 1, p. 18.

2. Haaland, D.M. and Easterling, R.G. (1982). Application of New Least-Squares Methods for the Quantitative Infrared Analysis of Multicomponent Samples. Applied Spectroscopy. Vol. 36, p. 665.

3. Minnich, T.R., Scotto, R.L., Leo, M. R., and Solinski, P.J. (1993) "Remote Sensing of Volatile Organic Compounds (VOCs): A Methodology for Evaluating Air Quality Impacts During Remediation of Hazardous Waste Sites." Sampling and Analysis of Airborne Pollutants. Chapter 15, p. 237. Lewis Publishers.

4. Turner, D.B. (1994) "Work Book of Atmospheric Dispersion Estimates - An Introduction to Dispersion Modeling." Lewis Publishers.

5. Minnich, T.R., Scotto, R.L., and Kricks, R.J. (1992) "Field Standard Operating Procedure for the Use of Open-Path FTIR Spectroscopy at Hazardous Waste Sites." USEPA preliminary draft.

6. The Community Crier. (1993) "Clean Up Date - 3M Gets EPA Approval; Begins Cleanup of Canton Dumpsite." Alex Lundberg. July 14, 1993.

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ATTACHMENT B

92-11.09

PRESENTED AT AIR AND WASTE MANAGEMENT ASSOCIATION
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Air Pathway Analyses Using Open-Path FTIR Spectroscopy During Waste Dredging Activities At a Large Industrial Lagoon

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INTRODUCTION

The release of volatile organic compounds (VOCs) to the ambient air and the resultant impact upon downwind populations is a major concern during remedial activities at many Superfund sites. The air pathway analyses (APA) process[1] provides the framework within which one can assess this impact. The most common assessment method is through use of an appropriate air quality dispersion model to predict ambient air concentrations at downwind receptors of concern. An accurate source emission rate estimate is the cornerstone of any such modeling study, yet this typically represents the most serious data gap. The complexity of many of these sites generally makes accurate estimation of source emission rates difficult and very costly using traditional sampling techniques.

This paper presents APA results based on measurements made in October 1991 using open-path Fourier-transform infrared (FTIR) spectroscopy during waste dredging activities at a 17-acre inactive industrial lagoon in New Jersey. The air monitoring investigation was the first of several that are planned to be performed during an 18-month waste removal and solidification project. Contaminants of concern are those established or probable human carcinogens that have been previously detected in the waste, and are comprised of benzene, chloroform, 1,1,2,2-tetrachloroethane, tetrachloroethylene, and vinyl chloride.

The objective of the air monitoring program is to demonstrate that health risks associated with the lagoon dredging are insignificant. Although an insignificant risk to off-site residents has already been indicated based on waste characterization data and associated mass balance projections, the potential for odors associated with the dredging process convinced the client to implement a periodic air monitoring program to provide data that demonstrates this insignificance. The basic approach involved sequential open-path FTIR measurements upwind and downwind of the lagoon during reasonable worst-case emission conditions. Although target contaminants were not observed in either the upwind or downwind measurements, upper-limit emission rates were derived by conservatively assuring that each downwind contribution was equal to the instrument minimum detection limit (MDL) response, and that each upwind contribution was equal to zero. These MDL-default-derived emission rates were then modeled based on 5 years of representative meteorological data, and each maximally exposed individual (MEI) was assigned a risk based on a reasonable exposure scenario. In all cases, the maximum demonstrated risk was less than the 10^{-5} level of concern for this project.

The principal advantage of using open-path FTIR spectroscopy to make quantitative air migration measurements lies in the nature of the monitoring data output. A path-integrated measurement provides contaminant information along the entire pathlength, instead of at discrete points as provided by point samplers or monitors. Path-integrated concentrations, when coupled with appropriate meteorological data, can be used to yield accurate estimates of emission rates from ground-level sources as shown in the data analysis section.

METHODOLOGY

Figure 1 presents the site map and the monitoring configurations used for this project. On October 4, 1991, a total of 28 five-minute open-path monitoring events were conducted along two paths west of the lagoon downwind of dredging activities. Five events were collected along a 175m path (Path A) and 23 events were collected along a 230m path (Path B). A background measurement was performed along Path A prior to any lagoon disturbance. Additional background measurements were performed part-way into the program along Path B when the wind shifted to a westerly direction (i.e., Path B became an upwind path) and upon completion of the day's dredging activities.

One set of upwind and downwind Summa canister samples were collected to provide qualitative verification of open-path FTIR monitoring results. The canister samples were collected when, based on the judgement of the on-site meteorologist, worst-case transport and dispersion conditions were occurring. Each canister was equipped with a flow controller to ensure a constant sample collection rate while being walked along the FTIR monitoring path.

The data generated during the air monitoring investigation were used to derive worst-case VOC emission rates during the sludge disturbance. These emission rates were used as input into a long-term Gaussian dispersion model to predict, using on-site meteorological data representative of each monitoring event, ambient concentrations at specific downwind receptors of concern. Positive VOC identification was required, and FTIR MDLs were sufficient to estimate risk to the MEI at least as low as 1×10^{-5} (1 in 100,000). The MEI resident was located approximately 150 meters north-northwest of the lagoon's northwest corner.

Methodologies employed for the FTIR system, the Summa canister sampling system, and the meteorological monitoring system are described below.

FTIR System

The data collection for this project was carried out using an MDA Scientific Model 282080 open-path FTIR system, consisting of an FTIR unit, a corner-cube-based retroreflector, a plane mirror, and a Kontron 386 personal computer. To minimize electromagnetic interference, signal transmission was carried out by using fiber optics cable. The basic software used was Galactic Corporation's Lab Calc software, with enhancements provided by MDA Scientific and Blasland, Bouck & Lee. The spectral library used was provided, through MDA Scientific, by Infrared Analyses, Inc. Some additional library spectra were supplied directly through MDA Scientific and generated by Blasland, Bouck & Lee. The gases used as part of this method evaluation were supplied by Scott Specialty Gases, and analyzed by Scott to within 2% accuracy. The microcomputer and microprocessors incorporated in the open-path FTIR system allowed for rapid and sophisticated data processing. With an appropriate software program, the inverse Fourier-transform calculation of a spectrum represented by up to 32,000 data points took only a few seconds. Interfering spectral features were eliminated from normal atmospheric species (e.g., H_2O and CO_2) by subtracting a representative background spectrum from the spectrum collected downwind of the source. Absorbance spectra were created by dividing the downwind spectra by the upwind spectra (taking into account background sources). A spectral search program, involving a collection of reference library spectra, was employed to identify and quantify species present in the resulting absorbance spectra. Each absorbance spectrum was collected to represent scanning periods of approximately 5 minutes.

A variety of monitoring configurations normal to prespecified wind directions were determined in advance (i.e., orientation of the FTIR beam as perpendicular as practical to the mean wind direction). Actual monitoring configurations employed were based on on-site wind direction measurements and forecasts. The length of the beam (the distance between the FTIR unit and the retroreflector) was determined via an electronic distance meter. Commands and data were transmitted via cable connection from a personal computer located in a vehicle in the clean zone. Information from the on-site meteorological tower was communicated to the field manager and FTIR operator via hand-held interface.

During each measurement event, path-integrated concentrations attributable to both remedial activities and upwind sources were determined. Representative upwind and background measurements were taken so that instrument response due to background H_2O and CO_2, as well as any VOCs originating from upwind sources, could be subtracted from the open-path FTIR measurement made downwind of activities. Background measurements were made at the beginning of the day's activities, when monitoring configurations changed, and at the end of the day to ensure data representativeness.

To verify system accuracy and analytical capabilities, matrix spikes were used during each measurement event and audit gases were used at the beginning and at the end of the day. Appropriate standard gases were introduced via an internal gas cell into the open-path FTIR beam.

Summa Canister Sampling System

As a method of qualitative confirmation of the open-path FTIR results, air samples were collected using 6-liter Summa canisters. The canisters had polished interiors and stainless steel mass-flow controllers and valves. Each mass-flow controller was precalibrated by the laboratory. Each canister was operated in the subatmospheric sampling mode while a constant flow rate from nearly full vacuum to nearly ambient pressure (approximately 13.7 psi) was maintained over a 10-minute period. Each mass-flow controller was preset by the laboratory to yield a sample collection time of 10 minutes. The Summa canisters were walked back and forth at a uniform speed along straight-line paths upwind and downwind of the source. Following sample collection, each canister was shipped to a laboratory for analysis of the contaminants of concern in accordance with USEPA Toxic Organic Compendium Method TO-14.[3]

Meteorological Monitoring System

On-site meteorological measurements were obtained in real time via use of a permanent 10-meter Climatronics meteorological tower located approximately 100 meters west of the lagoon. This system was equipped with sensors to measure wind speed, wind direction, temperature, and relative humidity. Additionally, the system was designed to calculate the standard deviation of the horizontal wind direction (sigma theta or σ_θ). All aspects of the meteorological monitoring system, including tower siting, were in conformance with USEPA guidelines set forth in On-Site Meteorological Program Guidance for Regulatory Modeling Applications.[4]

DATA ANALYSIS

The area source method[5] was used to estimate emission rates from the area of lagoon sludge dredging (see Figure 1). The area source method involves use of an appropriate dispersion model, together with on-site meteorological data, to predict point concentrations of each contaminant at incremental locations along the downwind path, based on a unity emission rate for each monitoring period. For each configuration, the mathematical function defined by the respective predicted point concentrations is then integrated to yield a path-integrated concentration (based on the unity area emission rate). Finally, the unity emission rate is simply multiplied by the ratio of the measured to the predicted path-integrated concentration for each monitoring event. For this study, the PAL Model[6] was used and the meteorology was averaged over each monitoring event.

The numerical method employed to evaluate the integral of the function was Simpson's rule, or the parabolic approximation. In this technique, the line representing the value of the function is approximated by a second-order equation ($y = ax^2 + bx + c$), with unique values of a, b, and c determined for each subregion, and the integral,

$$\int_{\alpha}^{\beta} f(x)\, dx$$

is evaluated as follows:

(a) Break the interval $\alpha \leq x \leq \beta$ into n equal parts of width Δx each, where n is an even number;
(b) Compute $y_k = f(x_k)$, $k = 0, 1, 2, \ldots n$; $x_0 = \alpha$, $x_n = \beta$; and
(c) Then:

$$\int_{\alpha}^{\beta} f(x)\, dx \approx \frac{1}{3} \Delta x \, (y_o + 4y_1 + 2y_2 + 4y_3 + 2y_4 + \ldots + 2y_{n-2} + 4y_{n-1} + y_n)$$

The crossplume location at which the point concentrations were predicted by the PAL Model defined the interval width Δx (5 meters), and the corresponding PAL Model concentration predictions (based on unity emissions) at these points defined the y values.

The orientation and magnitude of the upwind and downwind pathlengths are key factors in ensuring the measurement of representative path-integrated concentrations. For downwind measurements, the path ideally should be normal to the wind direction and of a length sufficient to ensure that the entire plume emanating from the source is contained. Plume capture percentage was estimated based on procedures in the USEPA Field Standard Operating Procedure for the Use of Open-Path FTIR Spectroscopy at Hazardous Waste Sites.[5] Briefly, this procedure is as follows. First, use a unity modeling approach to predict contaminant concentrations for only those receptors represented along the beam path, and then numerically integrate the function even though at least one of the function endpoint values (y_0 or y_n) is nonzero. Second, repeat the first step for receptors extending beyond the FTIR beam so as to capture the entire plume (i.e., y_0 and y_n are both zero). The percentage of plume capture, expressed by mass, is simply the ratio of the path-integrated concentration in the first step over the path-integrated concentration in the second step, times 100.

Although it is important that downwind measurements be made using a pathlength normal to the wind direction, it is not essential that the upwind measurements be made in the same manner. Assuming there are no nearby upwind sources, upwind path orientations must ensure only that the presence of any upwind VOCs are attributable to background sources and not to the source of interest.

Once an emission rate was determined, it was used as input into the ISCLT (Industrial Source Complex Long-Term) Model.[7] Modeling was performed using representative meteorological data to predict annual MEI impacts. Modeling results were based on Stability Array (STAR) data from the 5 most recent years of available National Weather Service observations from the closest representative first-order station. The predicted annual concentration at the off-site MEI locations was evaluated using an appropriate exposure scenario to determine a conservative estimate of associated off-site health risk.

RESULTS AND CONCLUSIONS

Table I presents the results of the Summa canister analyses. No target contaminants were present above their respective detection limits, although several nontarget compounds were present in both upwind and downwind samples (not shown).

As expected, FTIR concentrations of all contaminants of concern were below instrument MDLs for each monitoring event. Maximum emission rates were calculated using the conservative scenario in which "actual" downwind concentrations were based on the instrument MDLs. These MDL-default-derived emission rates were then used to estimate annual MEI impacts as discussed above.

Presentation of the entire data set is beyond the scope of this paper. Instead, the results of three monitoring events are presented. These events were chosen because high plume capture percentages were achieved in each, and because they represent conditions during which a range of atmospheric stabilities was achieved. The importance of atmospheric stability is discussed below.

Table II presents the event summary and corresponding meteorological data for each of three events (Events B6, B14, and B17). Also included is the percentage of plume capture by the downwind beam. The Pasquill-Gifford (P-G) stability class provides a measure of how well an atmospheric contaminant will disperse as it is advected along by the mean wind. In this scheme, Stability Class A indicates the greatest dispersion, and Stability Class F the least.

Table III presents, for each target contaminant, the maximum emission rates for each of the three monitoring events. Unit emission rates are presented in grams per square meter per second (g/m^2-s), and total emission rates are presented in g/s. Contaminant-specific MDLs are also provided for the day's measurements. As can be seen from Table III, the MDL-default-derived emission rate depends significantly on the atmospheric stability and wind speed. Under Stability Class A, a much greater emission rate would be needed to yield an FTIR MDL concentration (at some given downwind distance) than would be needed under Stability Class C. This is because of the greater contaminant loss in the vertical under Stability Class A. This dependence of maximum emission rates upon atmospheric stability and wind speed should be kept in mind whenever concentrations are expected to be below the respective instrument MDLs. A greater wind speed for a given stability class will result in a greater MDL-default-derived emission rate, as there will be greater contaminant dilution.

The following example for benzene for Event B6 illustrates how the emission rates in Table III were calculated. The detection limit for benzene was 105.4 mg/m^2. The unity-derived numerically-integrated concentration for this monitoring scenario was 22,806.8 mg/m^2, and the unity emission rate corresponding to that concentration was 1 g/m^2-s; therefore:

$$\frac{Q}{105.4\ mg/m^2} = \frac{1\ g/m^2\text{-}s}{22{,}806.8\ mg/m^2}$$

and

$$Q = 4.62 \times 10^{-3}\ g/m^2\text{-}s$$

where Q is the maximum benzene emission rate based on a detection limit default concentration for the downwind measurement and a zero concentration for the upwind measurement.

Table IV presents theoretical maximum MEI concentration and risk based on ISCLT Model results using MDL-default-derived emission rates (Table II). Five individual years (1984-1988) of STAR data from Newark, New Jersey, were modeled for Event B6. All risk calculations were based on a scenario of 18 months of continuous potential exposure. The highest and most conservative concentrations (from 1988) was 25.06 ug/m^3 of benzene. The benzene concentration, 25.06 ug/m^3, when multiplied by a unit risk number of 8.30 x 10^{-6} (ug/m^3)$^{-1}$ yield a risk of 2.08 x 10^{-4} based on a 70-year exposure. Adjustment of the exposure scenario from 70 years to the 18-month duration of the remediation results in an associated risk of 4.45 x 10^{-6}.

REFERENCES

1. U.S. Environmental Protection Agency, Air/Superfund National Technical Guidance Series, Volume III - Estimation of Air Emissions from Cleanup Activities at Superfund Sites, EPA-450/1-89-003, January, 1989.

2. R.L. Scotto, T.R. Minnich, and M.R. Leo, A Method for Estimating VOC Emission Rates from Area Sources Using Remote Optical Sensing, 1991, EPA/AWMA International Symposium on Measurement of Toxic and Related Air Pollutants, Durham, North Carolina, May 1991.

3. U.S.Environmental Protection Agency, Compendium of Methods for determination of Toxic Organic Compounds in Ambient Air: Method TO-14: The Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using Summa Passivated Canister Sampling and Gas Chromatograph Analysis, EPA600/4-84-017, June 1988.

4. U.S.Environmental Protection Agency, On-Site Meteorological Program Guidance for Regulatory Modeling Applications, EPA 450/4-87-013, June 1987.

5. T.R. Minnich, R.J. Kricks, and R.L. Scotto, A Field Standard Operating Procedure for the Use of Open-Path FTIR Spectroscopy at Hazardous Waste Sites, Internal Draft for review, U.S. Environmental Protection Agency, Environmental Response Team, Edison, NJ, 1992.

6. U.S.Environmental Protection Agency, User's Guide for PAL 2.0, A Gaussian-Plume Algorithm for Point, Area and Line Sources, Office of Research and Development, Research Triangle Park, NC, EPA/600/8-87/009, March 1987.

7. U.S.Environmental Protection Agency, Industrial Source Complex (ISC) Dispersion Model User's Guide - Second Edition (Revised), Office of Air Quality Planning and Standards, Research Triangle Park, NC, EPA-450/4-88-002a, December, 1987.

TABLE I. Results of the Summa Canister Analysis.

Contaminant	Detection Limit (ppb v/v)	Downwind 1 (ppb v/v)	Duplicate Downwind 1 (ppb v/v)	Upwind 1 (ppb v/v)	Downwind 2 (ppb v/v)
Benzene	3	ND	ND	ND	ND
Chloroform	2	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	4	ND	ND	ND	ND
Tetrachloroethylene	2	ND	ND	ND	ND
Vinyl Chloride	2.5	ND	ND	ND	ND

TABLE II. FTIR Event Summary and Corresponding Meteorological Data.

Event	Time	Wind Speed (m/s)	Wind Direction (Degrees)	P-G Stability Class	Plume Capture (%)
B6	1300	1.4	99	A	99.4
B14	1405	2.0	127	D	88.0
B17	1435	3.3	121	C	95.1

TABLE III. Maximum Emission Rates for Three Monitoring Events.

Compound	MDL (mg/m^3)	Event B6 Unit Emission Rate (g/m^2-s)	Event B6 Emission Rate (g/s)	Event B14 Unit Emission Rate (g/m^2-s)	Event B14 Emission Rate (g/s)	Event B17 Unit Emission Rate (g/m^2-s)	Event B17 Emission Rate (g/s)
Benzene	105.4	4.62 E-3	2.31 E+0	2.43 E-3	1.21 E+0	6.00 E-3	3.00 E+0
Chloroform	8.3	4.27 E-4	2.14 E-4	2.25 E-4	1.13 E-1	5.55 E-4	2.78 E-1
1,1,2,2-Tetrachloroethane	43.9	1.80 E-3	9.00 E-1	9.51 E-4	4.76 E-1	2.38 E-3	1.19 E+0
Tetrachloroethylene	18.3	8.94 E-4	4.47 E-1	4.68 E-4	2.34 E-1	1.16 E-3	5.80 E-1
Vinyl Chloride	28.1	1.24 E-3	6.20 E-1	6.47 E-4	3.24 E-1	1.60 E-3	8.00 E-1

TABLE IV. Predicted Theoretical Maximum MEI Concentrations and Risk.

Contaminant	Unit Risk Factor[a] (ug/m^3)	Event B6 Concentration (ug/m^3)	Event B6 Risk	Event B14 Concentration (ug/m^3)	Event B14 Risk	Event B17 Concentration ug/m^3	Event B17 Risk
Benzene	8.30 E-6	25.06	4.45 E-6	13.18	2.34 E-6	32.55	5.79 E-6
Chloroform	2.30 E-5	2.32	1.14 E-6	1.22	6.01 E-5	3.01	1.48 E-6
1,1,2,2-Tetrachloroethane	5.80 E-5	9.77	1.21 E-5	5.16	6.41 E-5	12.91	1.60 E-5
Tetrachloroethylene	9.50 E-7	4.85	9.87 E-8	2.54	5.17 E-6	6.29	1.28 E-7
Vinyl Chloride	4.20 E-5	6.73	6.05 E-6	3.51	3.16 E-6	8.68	7.81 E-6

Note: (a) Unit risk factors presented are based on 70 years of continuous exposure.

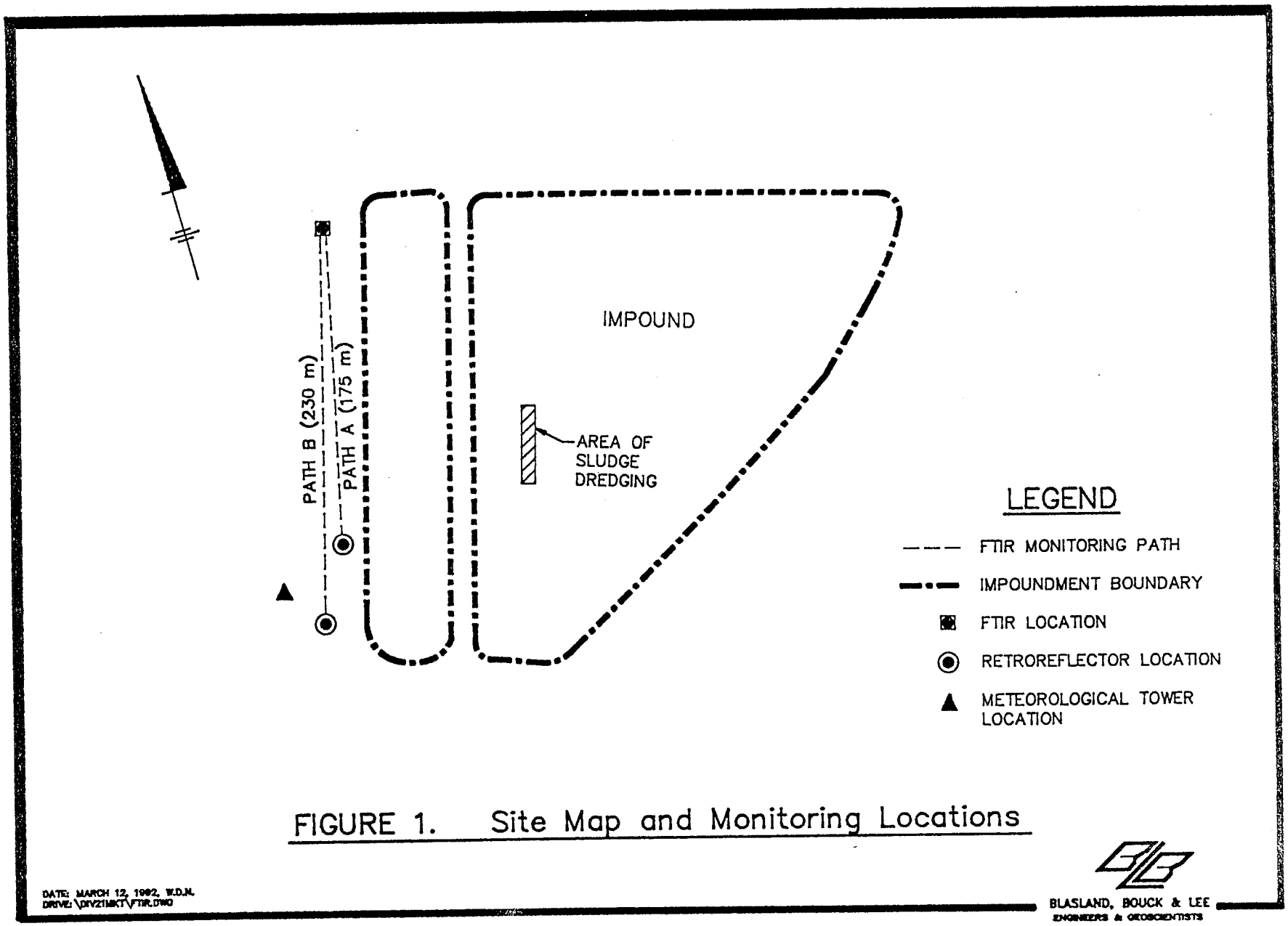

FIGURE 1. Site Map and Monitoring Locations

DATE: MARCH 12, 1992, W.D.N.
DRIVE: \DRV2\MKT\FTIR.DWG

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