COMPUTER MODELING OF AIR QUALITY IMPACTS RELEASED FROM AN INDUSTRIAL WASTEWATER TREATMENT FACILITY

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ABSTRACT

Coupling of an appropriate source emissions model and an atmospheric dispersion model represents a cost-effective and environmentally-responsible approach for meeting impact prediction and regulatory reporting requirements, as well as problem analysis and pollution prevention needs, associated with emissions of two chemical depainting agents [phenol and methylene chloride] from a liquid industrial wastewater treatment facility [IWTF]. This coupling study was conducted for the IWTF at Tinker Air Force Base [AFB] in Oklahoma City, Oklahoma. Phenol and methylene chloride are used as chemical depainting agents at the AFB, with the liquid effluent from such uses ultimately subjected to an on-base IWTF. Atmospheric emissions of the depainting agents occur from various unit processes in the IWTF. Use of the coupled model in the predictive mode is illustrated via the development of geographically-based profiles of the ground-level concentrations of phenol and methylene chloride in the surrounding environment of the IWTF. Model validation is demonstrated via comparisons and statistical testing of receptor location predictions with actual air quality data developed from discontinuous air sampling and analysis. Finally, it will be emphasized that the coupled model can be used for: the conduction of site specific health risk assessments; emissions reporting regulatory compliance determinations; and evaluation of the air quality impacts of on-base process change scenarios, pollution prevention activities, and changes in the design or operation of the IWTF.

INTRODUCTION

In production and maintenance operations at the Oklahoma City Air Logistics Center [OC-ALC], industrial wastewater streams are generated which contain organic compounds [*i.e.*, primarily phenol and methylene chloride]. These organic-containing wastewater streams result from both direct and indirect contact with organic compounds via chemical depainting operations, chemical cleaning processes, and electroplating operations. The organic materials in the wastewater are treated at the industrial wastewater treatment facility in open surface impoundments and collection systems. Some of these collection and treatment steps result in the release of volatile organic compounds [VOC] and semi-volatile organic compounds [SVOC] from the wastewater to the ambient air. Because emitted VOC / SVOCs can create potential health problems for treatment facility workers and the general public in surrounding areas, assessment of VOC / SVOC emissions to the atmosphere is necessary for decision makers who must determine the appropriateness of the inputs to and the design and operation of the IWTF. The objective of this effort is to identify potential VOC / SVOC emission sources, estimate emissions from the IWTF, quantify atmospheric air dispersion concentrations surrounding the wastewater treatment

facility, and evaluate computer-generated numerical concentration estimates with respect to field data.

The computer simulation software described in this paper will be used to quantify methylene chloride and phenol releases to the ambient air environment surrounding the IWTF. The chemicals of primary interest are methylene chloride and phenol [chemical depainting agents] because they have historically accounted for over 50 percent of all targeted hazardous materials purchased and released at OC-ALC. The initial task involved estimating emissions [emission rates] from the individual IWTF process units via the use of the WATER8 model. The next task required quantifying / estimating the ambient air chemical concentrations surrounding the IWTF. Computer simulation software developed by the Environmental Protection Agency was utilized for Tasks 1 and 2. The final task [Task 3] involves comparing the estimated computer-generated methylene chloride and phenol concentrations with field data.

THEORETICAL BASIS FOR STUDY

There is concern that release of organic compounds from wastewater collection and treatment facilities poses a public health problem. Such releases can occur because there are competing mechanisms or pathways through which organic compounds can leave such facilities, including volatilization, adsorption, migration, runoff, biological or chemical degradation, hydrolysis, oxidation, and hydroxyl radical reaction. Emission models have been developed by scientific and engineering researchers to predict emission rates for a variety of wastewater collection / treatment facilities. These models are based on diffusion theory and mass transfer principles, whereby the emission rates are calculated by determining the mass transfer coefficient or partition of the chemical of interest. The emission rate potential of VOCs from wastewater collection / treatment facilities is waste-dependent and site-specific.

Diffusion theory and mass transfer principles refers to the movement of individual molecules through a substance of high concentration to one of low concentration on a molecular level. The transfer of a constituent of interest is transferred from one phase to another by the difference in chemical potential [*i.e.*, concentration, etc.] and it is this chemical potential that is the driving force for mass transfer between phases. This interphase transport is typically referred to as two-film resistance theory. Whenever the concentration of a chemical varies between two regions, there is a natural tendency for mass to be transferred across the interface, and to approach equilibrium within the system. As in the case of the surface impoundments and aerated / non-aerated processes, volatilization and biodegradation are potentially significant mechanisms. Based on the use of the WATER8 model for predicting and comparing transfer pathways for collection, treatment, and storage processes, the majority of the organic releases from the OC-ALC IWTF can be attributed to volatilization and biodegradation mechanisms [pathways].

Air dispersion modeling is a technique for calculating concentrations of pollutants resulting from atmospheric emissions. A dispersion model can be used to evaluate gases and particulates, short and long-term concentrations, elevated point sources, ground level point sources, area sources, line sources, urban and rural areas, atmospheric processes, and continuous or discontinuous [puff] releases. A single equation can be used to estimate an air pollutant concentration at a single receptor from a single source. However, when plume rise, multiple

sources, multiple receptors, varying meteorological conditions, building wake effects, and other factors that affect atmospheric dispersion must be considered, a series of equations are needed. A computer model is such a series of equations coded for use and calculated by a computer. Computer modeling is extremely useful for estimating concentrations at a number of receptor locations, from a number of sources, and subjected to a series of meteorological conditions over the length of a simulated time period.

Influencing factors in air dispersion modeling include the meteorological and topographical complexities of the area, the level of detail and accuracy needed for the analysis, the technical competence of those undertaking such simulation modeling, the resources available, and the detail and accuracy of the database [*i.e.*, emission inventory, meteorological data, and air quality data]. One of the most used and convenient methods of estimating pollutant concentrations from various release configurations is the Gaussian model. The name is derived from the Gaussian or normal distribution [bell-shaped distribution] from statistics. Gaussian models are the most widely used techniques for estimating the impact of non-reactive pollutants. The Gaussian model assumes that continuously released material is transported in a direction opposite to the wind direction. It also assumes that time-averaged spreading of the pollutants will result in cross-sections of pollutant concentration, horizontally and vertically through the pollutant plume, that have normal distributions. Refined computer models [*i.e.*, Industrial Source Complex] have the capability of analyzing numerous sources for each hour of a year at a large number of receptors. The ISC model was used in this study.

The alternative to dispersion modeling is to make actual air quality measurements. Measuring the actual level of pollutants is more accurate than modeling. However, if a potential source has not been constructed, there is no way to measure the effects of its emissions, and modeling must be used to estimate these effects. With modeling, concentration estimates can be made at thousands of locations for the price of a single set of measurements. Finally, while modeling does introduce errors into the calculations, these errors are deemed tolerable because the cost of a comprehensive measurement program can be prohibitive.

WATER8 EMISSION MODEL RESULTS

WATER8 requires process unit information [*i.e.*, equipment size, equipment specifications, flow rates, retention times, surface areas, aeration capabilities, etc.] to be input into the software program. In addition to needing the physical dimensions of the process unit, the method of operation is required [*i.e.*, mechanically aerated process, diffused air aeration, non-aerated process, biodegradation, no biodegradation, etc.]. Such input requirements are important because the Tinker AFB IWTF consists of several levels of treatment [*i.e.*, primary, secondary, and tertiary].

Figure 1 illustrates the current OC-ALC IWTF, which is treating in excess of 850,000 gallons per day. The paint stripper effluent accounts for approximately 10 percent of the wastewater flow and is discharged into the stripping waste primary clarifier [PC]. This paint stripper waste stream contains high concentrations of a methylene chloride / phenol-based chemical depainting agent [Toxic Release Inventory listed chemicals]. From the primary clarifier, the paint stripper effluent is discharged to the covered D_1 - D_2 diversionary structure [used to divert flow to either blending tank]. From the D_1 - D_2 diversionary structure [D₁- D_2 DS], flow is directed to the two

dome-covered D_1 - D_2 blending tanks before being blended with the majority of the IWTF influent at the oil-water diversionary structure [OWD]. The IWTF receives 90 percent of the wastewater from the industrial complex [i.e., Building 3001, etc.] via lift station #2. Both streams are blended into the oil-water diversionary structure just upstream of the oil-water separators. From the OWD, flow is diverted to either or both of the oil-water separators [OW-N, OW-S] designed to operate in series or parallel. From the oil-water [American Petroleum Institute] separators, the wastewater passes through two, batch-operated, 1.1 million gallon storage [ST-W, ST-E] tanks and into two equalization basins [EQ-N, EQ-S] to stabilize / equalize the downstream flow. The stabilization basins are large surface impoundments with surface aeration. Following this primary treatment portion of the IWTF, the wastewater enters the metals treatment process [MIX], whereby the hexavalent chromium is reduced [to the less toxic trivalent state], the metal hydroxides are precipitated, and particle flocculation is initiated. From the metals treatment process, the wastewater is directed through a solid contact clarifier diversionary structure into one of two solid contact clarifiers [SCC-N, SCC-S]. The SCCs are operated with a sludge blanket to filter metal hydroxide flocs and clarify the wastewater. From the SCCs, the wastewater is passed through two multimedia pressure filters and into two biological aeration basins *[i.e.*, aerobic biological reactor, BIO] utilizing a step-aeration feed system. The wastewater is discharged into two secondary clarifiers for final clarification [SC-N, SC-S]. Finally the wastewater is passed through additional multimedia garnet pressure filters [polishing] and discharged to a lift station for transport to the Oklahoma City Public Owned Treatment Works [OKC POTW] for additional treatment.



Figure 1. IWTF process flow diagram

Figure 2 was developed from WATER8 output and illustrates the percentage of methylene chloride and phenol released to the ambient atmosphere surrounding the IWTF. For methylene chloride that enters the primary clarifier, approximately 19 percent of the methylene chloride is released to the surroundings, with the majority [83 percent] coming from mass transfer at the surface of the clarifier [relative to the fraction lost over the weir waterfall]. The weir waterfall accounts for roughly 17 percent of the methylene chloride air losses. For the D_1 - D_2 blending tanks, 4.5 percent of the methylene chloride entering the covered tank is lost to the air.

Approximately 73 percent of the methylene chloride losses are attributed to the tank working losses while the remaining emissions are the result of tank breathing. For the oil-water diversionary structure, approximately 0.015 percent of the methylene chloride is released to the air. For the oil-water separator, 56 percent of the methylene chloride that enters the surface impoundment is released to the atmospheric surroundings. The majority [96 percent] of the methylene chloride volatilized is from the oil layer while little is lost from the open surface and weir waterfall. For the 1.1 million gallon storage tanks, 3.9 percent of the methylene chloride is volatilized to the atmosphere. As shown in Figure 2, the majority [94 percent] of the methylene chloride entering the equalization basins is released to the atmosphere. This is not surprising since one of the functions of the surface aerators is to volatilize low vapor pressure organics, thereby removing the contaminant from the wastewater. It is also important to note that the increased volatilization of organics in the equalization basins is not only a function of the surface aerators, but also because of the increased surface area [which promotes volatilization] relative to the upstream process units.



Figure 2. Percentage of methylene chloride and phenol released to the atmosphere

The mixing basins appear relatively the same with approximately 15 percent of the methylene chloride entering each individual basin being lost to the air. Slightly less [13 percent] of the methylene chloride is released in the solid contact clarifiers. The majority [84 percent] of the methylene chloride losses occur at the clarifier surface with the remaining 16 percent associated with the weir waterfall. A total of 81 percent of the methylene chloride is released in the aeration basins while 17 percent is biologically digested. For the secondary clarifiers, 15 percent of the methylene chloride is lost. The clarifier surface losses accounts for roughly 85 percent of the

methylene chloride losses while the remaining 15 percent is related to the weir waterfall.

For phenol entering the primary clarifier, approximately 1.8 percent of the phenol is released to the surroundings with the majority [87 percent] coming from mass transfer at the surface of the clarifier [relative to the 13 percent lost over the weir waterfall]. For the D_1 - D_2 blending tanks and oil-water diversionary structure, a negligible amount of the phenol entering the process units is lost to the air. For the oil-water separator, 0.65 percent of the phenol that enters the surface impoundment is released to the atmospheric surroundings. The majority [95 percent] of the phenol volatilized is from the oil layer while little is lost from the open surface and weir waterfall. For the 1.1 million gallon storage tanks, 0.17 percent of the phenol is volatilized to the atmosphere. A total of 2.4 percent of the phenol entering the equalization basins are released to the ambient atmosphere. The increased volatilization of organics in the equalization basins is not only a function of the surface aerators, but also because of the increased surface area [which promotes volatilization] relative to the upstream process units. The mixing basins appear relatively the same with approximately 0.03 percent of the phenol entering each individual basin being lost to the air. More [0.37 percent] of the phenol is released from the solid contact clarifiers. The majority [98 percent] of the phenol losses occur at the clarifier surface with the remaining two percent associated with the weir waterfall. From Figure 2, 0.01 percent of the phenol is released in the aeration basins while 92 percent is biologically digested. Finally, for the secondary clarifiers, 0.37 percent of the phenol is volatilized to the air.



Figure 3. Amount of methylene chloride and phenol released to the atmosphere

Another benefit of the WATER8 emission model [utilized in TRI reporting] is the ability to determine the mass of constituent that is released to the atmosphere over a given time period, as

illustrated in Figure 3. From WATER8 output, approximately 6.14 million grams [6.76 tons] of methylene chloride is released to the atmosphere in the area surrounding the IWTF. As expected, the majority [93 percent] of methylene chloride emissions are discharged from three process units: the API oil- water separators [44 percent], equalization basins [30 percent], and primary clarifier [19 percent]. There is roughly 3.41 million grams [3.76 tons] of phenol released annually to the atmosphere. The majority [95 percent] of phenol emissions are discharged from four process units: the API oil-water separators [13 percent], equalization basins [46 percent], primary clarifier [29 percent], and solid contact clarifiers [6.8 percent].

What is important to note from Figures 2 and 3 is the obvious difference in driving mechanism [volatilization versus biological degradation]. For the more-volatile methylene chloride, volatilization is the primary removal process, with the majority being released in the initial six process units with little biological digestion occurring in the bioreactor. For the less-volatile phenol, the driving mechanism is biological digestion occurring late in the treatment process [bioreactor], with very little volatilized to the ambient environment. Also, Figure 2 infers differences in component volatility's. Even though there is approximately ten times more phenol in the influent, less of the phenol is volatilized. This illustration confirms that the WATER8 software is accounting for the difference in chemical and physical properties between individual components.

Figure 3 also identifies which process units are driving the release of each constituent and how this will impact the air dispersion modeling. For methylene chloride, the majority of the releases will originate from the primary stripping-waste clarifier, oil-water separators, and equalization basins. Intuitively, the air dispersion model predictions should show three major concentration peaks in close proximity to these three process units. Since the wind in central Oklahoma originates from the south-southwest to south-southeast 40 percent of the year, the concentration peaks are expected to be centered to the north of the three process units. This is illustrated in subsequent figures. For phenol, the majority of the releases will originate from the primary stripping-waste clarifier, oil-water separators, equalization basins, and solid contact clarifiers. With the dominant southerly winds, the air dispersion model predictions should present three major concentration peaks and a fourth smaller peak just north of these three process units. This is also illustrated in subsequent figures.

INDUSTRIAL SOURCE COMPLEX [ISC-ST3] DISPERSION MODEL RESULTS

Air dispersion modeling of methylene chloride and phenol emissions from the IWTF was conducted using the U.S. EPA Industrial Source Complex Short-Term [Version 3] model. The model requires inputs related to source types, locations, and emission strengths; receptor grid coordinates; and hourly-average meteorological data consisting of surface conditions and mixing height parameters. For this modeling effort, a nested Cartesian receptor grid covering a 150,000 m² area of approximately 300 meters by 500 meters and centered about the IWTF was used to determine the impact region boundaries. Within this area, a grid system consisting of receptors spaced ten meters apart from each other in both the west-east [*x*-coordinate] and south-north [*y*-coordinate] directions was used. The methylene chloride and phenol emissions from the IWTF were modeled using eight years of meteorological data [1984 through 1991]. The ISC-ST3 air dispersion model was used two-fold: [1] to determine compliance with the State of Oklahoma's Maximum Allowable Ambient Concentration [MAAC] for methylene chloride and phenol, and [2]

for comparison between predicted computer-generated methylene chloride and phenol concentrations with field data. The maximum 24-hour average concentrations for the VOC at each receptor were selected for comparisons between the short-term maximum concentrations and the corresponding State of Oklahoma's MAAC for that specific pollutant, which is also expressed as a 24-hour average concentration. The maximum 24-hour concentrations obtained for each receptor in a modeled year reflect the worst 24-hour period of meteorological conditions in that year with respect to the dispersion of emissions of methylene chloride from the IWTF. Annual-average concentrations were compared to field canister data for both methylene chloride and phenol.

The 24-hour maximum ground-level concentrations for methylene chloride are illustrated in Figure 4. The contours indicate concentration gradients at specific locations within the impact region and are similar to a topographical contour map except that elevations have been replaced with chemical concentrations in parts per billion [PPB]. There are three prominent peaks positioned north of the primary clarifier [PC], oil-water separators [OW-N, OW-S], and positioned between the storage tanks [ST-W, ST-E] and equalization basins [EQ-N, EQ-S]. The peak surrounding the primary clarifier rises to a concentration of approximately 70 PPB. The highest peak occurs north of the oil-water separators and rises to a concentration of 80 PPB. The broadest peak is positioned between the storage tanks and equalization basins rising to 80 PPB. This concentration peak is the widest of the three to incorporate the north-south equalization basins and east-west storage tanks. Note that this trend was anticipated from the WATER8 emission model output. It is also important to note that the other process units $[D_1-D_2]$ blending tanks, mixing basins, solid contact clarifiers, bioreactors, and secondary clarifiers] also contributes to the overall emissions, but at a smaller level. Finally, the methylene chloride concentrations at the fenceline falls between 25 and 30 PPB, and this is well below the Oklahoma methylene chloride MAAC of 500 PPB.

The 24-hour maximum ground-level concentrations for phenol are illustrated in Figure 5 as averaged over the same eight years of weather data. There are three prominent peaks positioned north of the primary clarifier [PC], oil-water separators [OW-N, OW-S], and between the storage tanks [ST-W, ST-E] and equalization basins [EQ-N, EQ-S]. There is also a smaller concentration peak over the solid contact clarifiers. The peak surrounding the primary clarifier rises to a concentration of approximately 50 PPB. The oil-water separator peak rises to a concentration of 50 PPB. The broadest peak is positioned between the storage tanks and equalization basins rising to 58 PPB. This concentration peak is the widest of the three to incorporate the north-south equalization basins and east-west storage tanks. The smaller SCC peak is roughly 30 PPB. This pattern was also anticipated from the WATER8 emission model output. It is also important to note that the other process units [D₁-D₂ blending tanks, mixing basins, bioreactors, and secondary clarifiers] also contributes to the overall emissions, but at a smaller percentage. The phenol concentrations at the fenceline are between 20 and 25 PPB, and this is well below the Oklahoma phenol MAAC of 100 PPB.

FIELD VALUE COMPARISON RESULTS

The final task [Task 3] of the project involves comparing the estimated computer-generated



Figure 4. Methylene chloride concentration [PPB]



methylene chloride and phenol concentrations with field data. One part required that the computer-generated predictions be compared to field-collected sample canister data. For methylene chloride, there are three major field data sources including a Resource Conservation and Recovery Act [RCRA] facility investigation, OC-ALC Bioenvironmental sampling data, and a 1993 Battelle study. Ambient air samples were collected from thirteen locations as illustrated in Figure 6 [A1 through A13]. Field locations A1 through A11 were chosen to represent the fencelines or boundaries of the IWTF, while A12 and A13 were located on base property northwest of the IWTF to monitor on- and off-base migration. In the RCRA facility investigation, three methylene chloride concentrations were measured using 24-hour canisters in September through November 1993. The Battelle data collected in October 1993, was for three locations used in the RCRA facility investigation [A1 through A3]. Along with the RCRA investigation and Battelle study, there is an additional data source from the OC-ALC Bioenvironmental department. Samples were collected at locations A1, A2, and A3 for three days in 1993. As mentioned, the computer simulations were used to predict concentrations predicted at the same ambient air field sample sites. The computer predictions were determined over the eight years [1984 through 1991] and the average calculated. The results are shown in Figure 7, along with field sample values.



Figure 6. Field data sample sites [A1 through A13] relative to impact area

Figure 8 illustrates the methylene chloride ambient air sample data [from Figure 7] after statistical manipulation of the data. The black points represent the field data while the gray data

represents the model predictions. The shaded boxplot area should theoretically contain 50 percent of the data. The vertical lines in either direction should include one standard deviation or 68 percent of the data points. Note that the model appears to slightly over-predict for sample locations A1, A2, A3, and A11, when compared to the concentrations measured in the field. For A4 through A10 and including A12 and A13, the model appears to be in good agreement with field concentrations.

For phenol, the same three major field data sources were available including the RCRA facility investigation, OC-ALC Bioenvironmental sample data, and the 1993 Battelle study. As mentioned earlier, the computer simulations were used to predict concentrations over the eight-year period [1984-1991] at the same ambient air field sample sites. The results are shown in Figure 9, whereby the predicted phenol concentrations in parts per billion are compared to the field sample values. Figure 10 illustrates the phenol ambient air sample data [from Figure 9] after statistical manipulation of the data. The same color-codes as used in Figure 8 apply. The model appears to slightly over-predict for locations A1, A2, A3, and A11, when compared to the concentrations measured in the field. For A4 through A10 and including A12 and A13, the model appears to be in agreement with field concentrations.

In summary, for both methylene chloride and phenol, there is good agreement between the coupled model predictions and periodically collected canister monitoring data. Trends are similar for all data points, whereby the predicted concentrations are higher for the samples closer to the major sources [A1, A11, A2] and tend to decrease with the major emission sources [A6, A7, A8]. For sample sites downwind and less than 100 meters from the major emissions sources [A1, A11, A2, A3], there is very good agreement between the coupled model predictions and field data for A1 and A2, while the model tends to under-predict for A11 and A3. For sample sites downwind and greater than 100 meters from the major emission sources [A12 and A13], there is relatively good agreement between the coupled model predictions and field data, but the model tends to under-predict for both A12 and A13. For sample sites upwind and greater than 100 meters from the major emission sources [A6, A7, and A8], there is relatively good agreement between the coupled model predictions and field data, but the model tends to under-predict all three points. For sample sites crosswind from the major emission sources [A4, A5, A9, and A10], there is relatively good agreement between the coupled model predictions and field data for all four points [slightly better for A9 and A10], but again the model continues to under-predict all four points. Therefore, qualitatively, the coupled model appears to be adequate for predicting environmental concentrations of methylene chloride and phenol. Further, the coupled model appears to be better for predicting downwind [both less and greater than 100 meters from the major emission sources] and crosswind concentrations.

CONCLUSIONS

The following conclusions can be drawn from this discussion and analysis. Coupling of the WATER8 source emission model and ISC-ST3 atmospheric air dispersion model represents a cost-effective and environmentally responsible approach for neeting prediction and regulatory reporting requirements. For example the coupled model can be used to develop geographically-based profiles of the ground-level concentration of phenol and methylene chloride at specific receptor locations within the impact region of the IWTF under differing meteorological conditions, on-base chemical usage, and pollution prevention practices. The coupled model can also be used to evaluate changes in the design or operation of the IWTF for purposes of minimizing atmospheric emissions of phenol and methylene chloride. Further, the coupled model can be used during the conduction of a site-specific heal risk assessments for chemical depainting agents [phenol and methylene chloride] at the IWTF. Finally, the coupled model approach is effective for generating information for emissions reporting and regulatory compliance determinations relative to maximum ambient air concentrations for phenol and methylene chloride.

The WATER8 model flexible building block approach satisfactorily simulates common industrial wastewater collection / treatment processes. The model represents a cost-effective and environmentally responsible method of generating emissions data from an IWTF for use in an atmospheric dispersion model. For the more-volatile methylene chloride, the volatilization mechanism is the primary removal pathway with the majority of the releases discharged in the initial process units [i.e., primary clarifier, oil-water separators, equalization basins, and storage tanks]. As observed, little biological degradation of methylene chloride occurs in the bioreactor. For the less-volatile phenol, the driving removal mechanism is biological degradation occurring late in the treatment process [bioreactors], with very little volatilized to the ambient air environment. The coupled model can be used to evaluate changes in the design or operation of the IWTP for purposes of minimizing atmospheric emissions of phenol and methylene chloride. The coupled model approach can have direct applicability for air quality management purposes at other similar U.S. Air Force Bases or industrial [private sector] chemical depainting operations. The coupled model methodology is effective for generating information for emissions reporting and regulatory compliance determination relative to maximum ambient air concentrations [MAAC] for phenol and methylene chloride. The coupled model approach is an adequate methodology for modeling both volatile and semi-volatile organic compounds from an industrial wastewater treatment facility. The coupled model methodology can be used to determine compliance with the National Emission Standards for Hazardous Air Pollutants for Publicly Owned Treatment Works [major versus minor source]. The methodology can be used to determine compliance with pollution prevention activities.



Figure 7. Methylene chloride ambient air sample data for A1 through A13 sites



Figure 8. Field data comparison to model predictions for methylene chloride



Figure 9. Phenol ambient air sample data for A1 through A13 sites



Figure 10. Field data comparison to model predictions for phenol