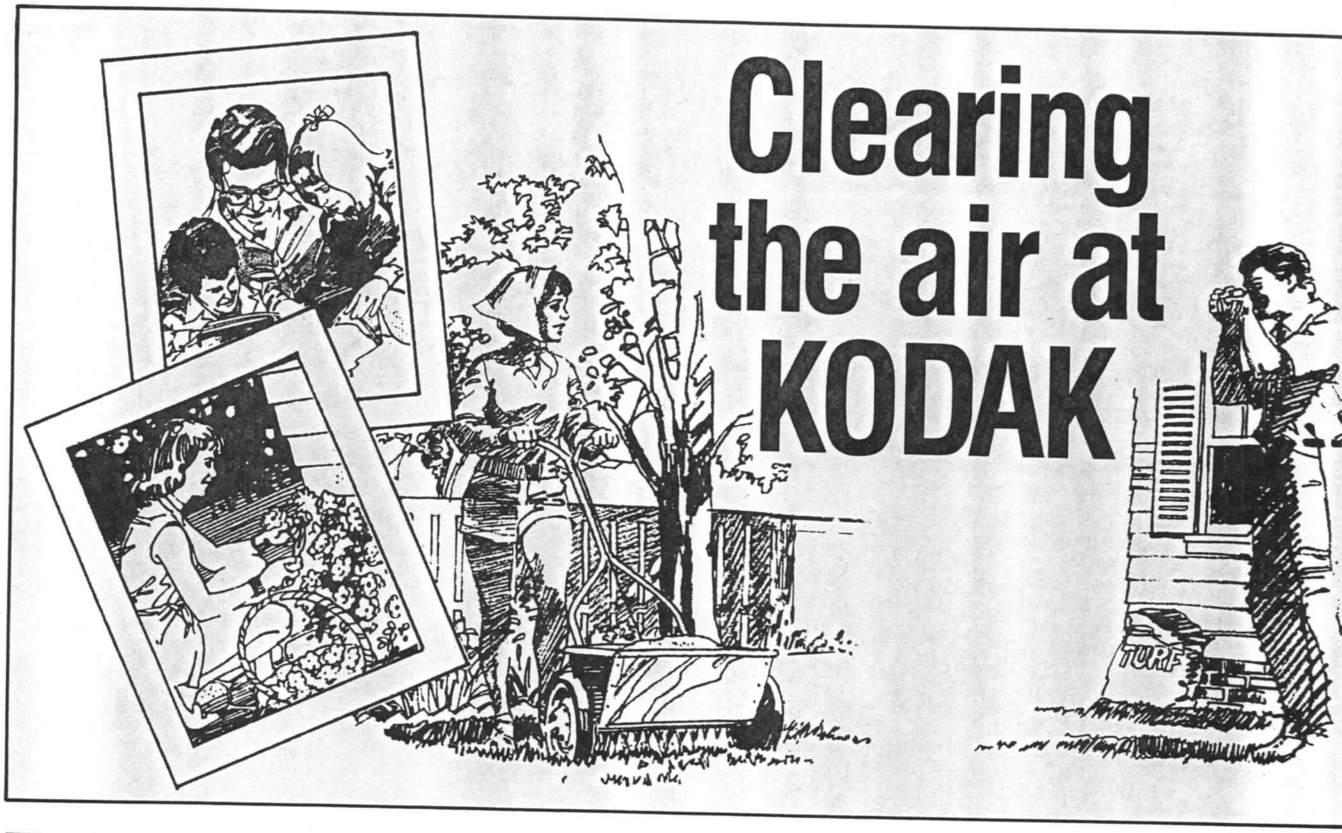
Clearing the air at KODAK



Douglas Muschett and Lee Davis

"Exceptionally clean air," with the lowest number of unhealthy days per year (five) of any metropolitan area in excess of 500,000 population—that's how the Chamber of Commerce describes air quality in Rochester, NY. And it's a perception that most citizens have shared. No belching smokestacks, just corporate headquarters and manufacturing industry with the names of Kodak, Xerox, and Bausch and Lomb. So it came as a shock to the community during the spring of 1989 when two reports on air toxics flooded the media.

One report, compiled by the Natural Resources Defense Council (NRDC) using 1987 industry data reported to the U.S. Environmental Protection Agency under Title III of the Superfund Amendment and Reauthorization Act (SARA Title III), listed Eastman Kodak Company in Rochester as the nation's top emitter of a toxic air pollutant, dichloromethane (other companies also experienced media attention at the same time). The other report, issued by the EPA, listed Monroe County as 12th in the Nation for greatest toxic air emissions. In particular, Kodak data submitted to the EPA indicated that the company emitted 8.9 million lb/yr of dichloromethane, also known as methylene chloride, at its Kodak Park site complex, and much lower amounts of several other air contaminants (Table 1).

According to Kodak spokesman Ronald C. Roberts, "We were thought of as a photographic company—kittens and Christmas and puppy dogs. People never stopped to think that photography is based upon chemistry." Traditionally, Kodak has been regarded as a kindly, nonpolluting employer and as a community benefactor. Has Kodak or the air quality really changed, or is the public perception changing—and reflecting difficulties in interpreting newly available technical information and the scientific issues which have engendered disagreements among scientists and regulators?

Historically, Kodak has engaged in a number of environmentally sound activities—perhaps as a forerunner to the now widely-accepted "pollution prevention pays" philosophy. Dating back to the 1920s, the company has engaged in cogeneration in order to satisfy its strong demand for process steam, as well as electricity, and to promote energy self-sufficiency. (During the 1970s the company supplemented this activity with a site trash separation and incineration program that provides supplementary steam.) In addition, the company has been practicing materials recovery and recycling for many years, including the recovery of silver from manufacturing operations, the recycling of polyester scraps from the manufacturing of film base and other company

Table 1. Selected Air Toxics Emissions at Kodak Park

Chemical	NYSDEC Air Guide 1 Rating	Total 1988 Emissions (10^3 lbs)	Emission Reductions By 1991 (10^3 lbs)
*Dichloromethane	Moderate	8900	3300
*Methanol	NC**	5700	380
*Acetone	Low	3470	340
Toluene	Low	590	—
Hydrogen Chloride	Low	552	—
*1,2-Dichloropropane	NC	335	60
*Cyclohexane	Low	310	96
*Butyl Alcohol	Low	300	86
*1,1,1-Trichloroethane	Moderate	250	16
Methyl Ethyl Ketone	Moderate	170	—
Xylene	Moderate	153	—
Acetonitrile	Low	144	—
Methyl Isobutyl Ketone	Moderate	119	—
*2-Methoxyethanol	Moderate	110	46

* Included in Kodak's emissions reduction program.
**NC = Not Classified

operations and the recycling of process solvents. In fact, solvent recycling has been an integral part of Kodak's film manufacturing for over 60 years.

But perhaps what is most surprising is the nature of the air quality activities which took place at Kodak during the 1970s. This was a period which saw increasing federal and state activities directed towards the "criteria" pollutants, such as particulates and volatile organic compounds. During this period the Rochester Air Quality Control Area was in compliance, and the needs to address "criteria" pollutants were rather minimal. According to Jeffery Mathews, Air Quality Coordinator at the Kodak Park site, the company did bring on-line a new chemical waste incinerator in response to tightened standards for particulate control and did reduce process emissions of volatile organic compounds as part of the total oxidant implementation plan. In addition, however, most of Kodak's environmental activities during this period were related to air toxics. Mathews notes that, "In 1972 Kodak, along with the New York State Department of Environmental Conservation (NYSDEC), developed initiatives that addressed the toxicity of some of the major compounds that Kodak used; at that point Kodak proposed and NYSDEC agreed with air quality guideline values for 14 of the most widely used solvents at Kodak Park." Thus, there were ambient guidelines for one-hour and 24-hour concentrations established for those 14 compounds. Sources of emissions were inventoried; and, based upon preliminary dispersion modeling, Kodak identified appropriate sources and reduced emissions.

In 1974 the company established an ambient monitoring program and observed concentrations above measurement thresholds for about half of the 14 compounds. By 1980, as Kodak expanded its testing for different families of chemicals, the list of 14 grew and Kodak proposed additional ambient concentration guidelines at sensitive receptors. It should be noted that Kodak has corporate Health and Environment Laboratories in Rochester with about 200 research toxicologists, chemists, engineers and environmental science personnel to support its operations.

At the same time, NYSDEC was developing a statewide air toxics policy. The policy was unusual (at the time) in that it was based upon guideline ambient concentrations, as well as emissions and a case-by-case determination of control technologies, and was potentially applicable to all facilities in the state. NYSDEC developed a guideline for ambient concentrations for specific compounds, "Air Guide-1," that defined "acceptable ambient levels," intended as "guidelines" not ambient standards. Mathews observes that New York State, during the development of its air toxics program and issuance of its "Air Guide-1" document in 1981, "took the concept of safe ambient exposure levels which had been derived from work at Kodak, and adjusted them for equivalent annual average concentrations, rather than short-term concentrations, in order to evaluate chronic exposure." For Kodak, the next several years revolved around developing analytical modeling tools, and evaluating potential ambient concentration levels and required source reduction levels for some 1200 separate permitted sources and 300 chemical compounds emitted at Kodak Park.

The Site and Emission Sources

It is difficult to convey the overwhelming feeling that a visitor to Kodak Park experiences (perhaps not unlike a first visit to the U.S. Environmental Protection Agency in Washington, DC). The Kodak Park site is primarily a large, integrated manufacturing plant producing photographic films, papers, and chemicals. Opened initially on 16 acres of land on the outskirts of Rochester in 1891, the site now stretches for more than 3 miles, occupies over 2200 acres and includes more than 200 major manufacturing buildings (aerial photo and Figure 1). Kodak Park employs approximately 22,000 people engaged in manufacturing, research and business-unit activities.

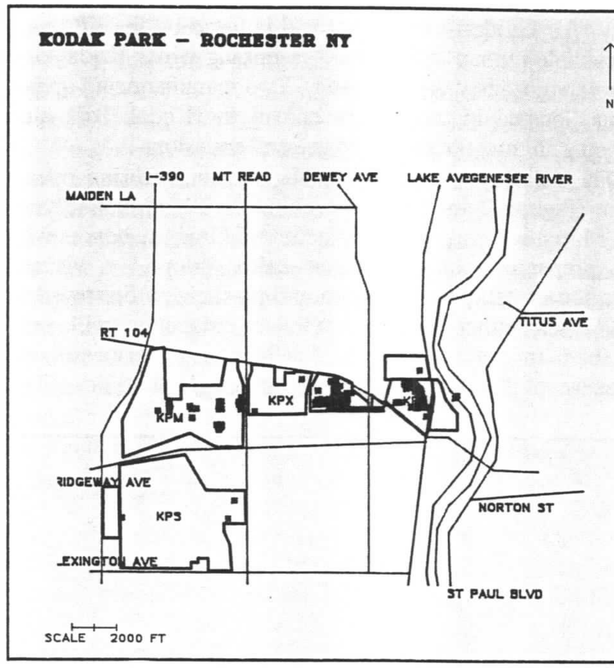


Figure 1. Kodak Park and source locations for dichloromethane (DCM).

Despite the vast, sprawling layout there is a definite pattern to site activities. The older, eastern section, Kodak Park East (KPE), consists of five-to-ten-story buildings which contain the major photographic manufacturing operations—manufacturing of film base, sensitizing and finishing operations for both film and paper. The highest air emissions, about 7.5 million lb/yr of dichloromethane, are emitted in this area of the site, primarily through four sources. The next portion of the site, Kodak Park West (KPW), contains manufacturing of film product components and manufacturing of chemicals for many photographic uses, such as developing and photoprocessing. Silver recovery operations and a large distillation facility are also located in this area. An adjacent part of the site contains more chemical manufacturing operations, manufacturing of photographic paper from pulp, and manufacturing of vitamin and food products and specialty laboratory chemicals. It also contains polyester recovery operations. The buildings in this section are lower and more sprawling and also include considerable warehousing operations stretching down towards the south end of the site.

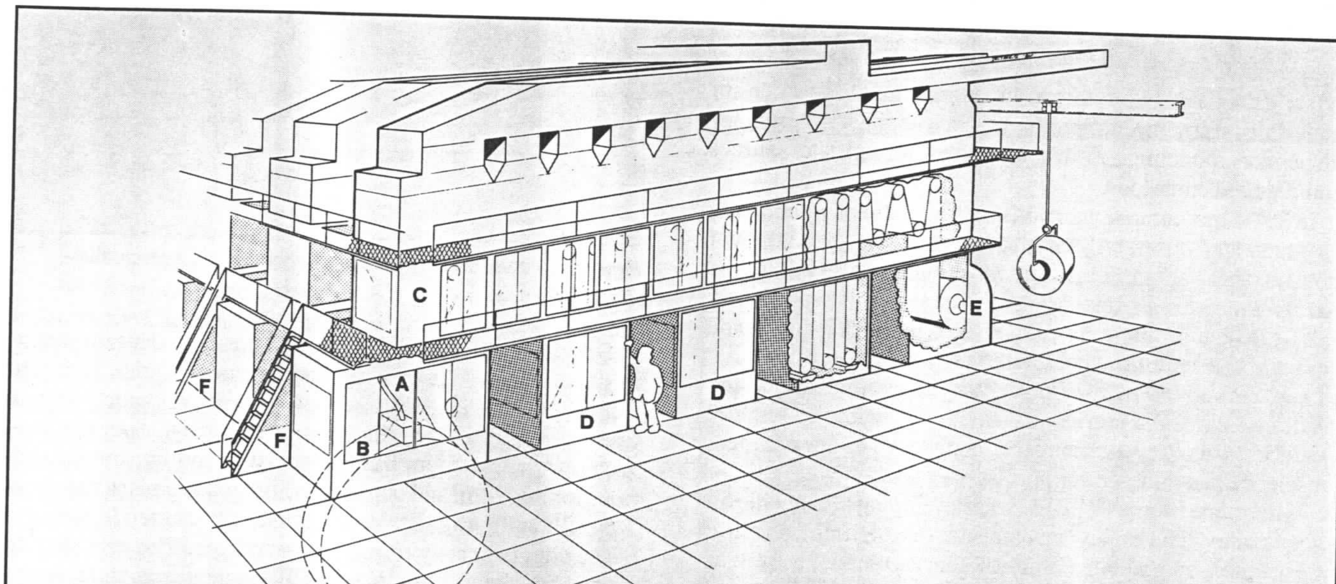
Throughout Kodak Park the physical characteristics of the emission sources vary greatly. Approximately 80% of all emissions are from low-temperature process vents. The majority of emissions come from stacks that are located 5 to 15 ft above the roofs of the buildings, whereas approximately 25% of the sources have emission points below roof level. The four major sources of dichloromethane range from 60 to 80 ft high. The vast majority of emissions can also be characterized as "continuous"—from "continuous" film and paper production, coating, molding, distillation and utilities operations. To a lesser extent, there are some intermittent sources associated with batch manufacturing processes, including organic chemicals, manufacturing developmental work and recovery operations.

Although there are about 300 permitted chemical compounds emitted, Table 1 summarizes information about the many important compounds in terms of emission quantities and toxicity of materials. By far, the single most important air contaminant is dichloromethane (DCM). DCM receives a rating of "moderate toxicity" in the New York State regulatory "Air Guide-1" document and is listed by the EPA as a "probable human carcinogen," a finding which Kodak and others vigorously dispute (later). Two manufacturing operations, located in the eastern end of the Kodak Park site, account for most of the DCM use and emissions.

The cellulose triacetate film base manufacturing operations (Figures 2 and 3) use approximately 211 million lb/yr of DCM as a solvent. The manufacture of film base begins with the preparation of a substance called "dope," a viscous solution of cellulose triacetate and plasticizers dissolved in DCM and other solvents; cellulose triacetate will only dissolve in special solvents. (DCM is a superior solvent because of its low flammability and high volatility.) The liquid dope is coated onto a large, highly polished metal surface; and a soft, pliable film is formed as the solvents evaporate. As indicated in Figure 3, there are additional stages of curing and coating to prepare the film base before it is wound upon large rolls and stored. There are numerous film base manufacturing machines similar to the machine described in Figures 2 and 3. During the manufacturing of film base approximately 202 million lb (96%) of DCM are recovered and recycled annually through low temperature condensation and adsorption equipment (Figure 3). Thus actual air emissions from the film base manufacturing operations are about 7.5 million lb/year. Other processes use and emit smaller amounts of DCM, including solvent coating which after recovery and recycling emits approximately 125,000 lb/yr of DCM. Nonpoint, "fugitive" sources emit an additional 620,000 lb/yr of DCM.

Origin and Development of the AIR-1

So now, if you will, "picture" this situation at Kodak: About 1200 sources and 300 chemical contaminants extending over a large site complex; generally low stack heights, which subject emissions to building cavity and downwash



Roll coating machine environment. Dissolved substrate is piped to dope hopper (A). Cast on revolving wheel (B). Cured by hot, recycled air behind balcony windows (C). Coated with solutions at subhoppers (D). And rolled in windup area (E). Handlers move finished rolls to adjacent rooms for inspection and packing. Aisles (F) separate the coating machines.

Figure 2. Acetate film base manufacturing machine.

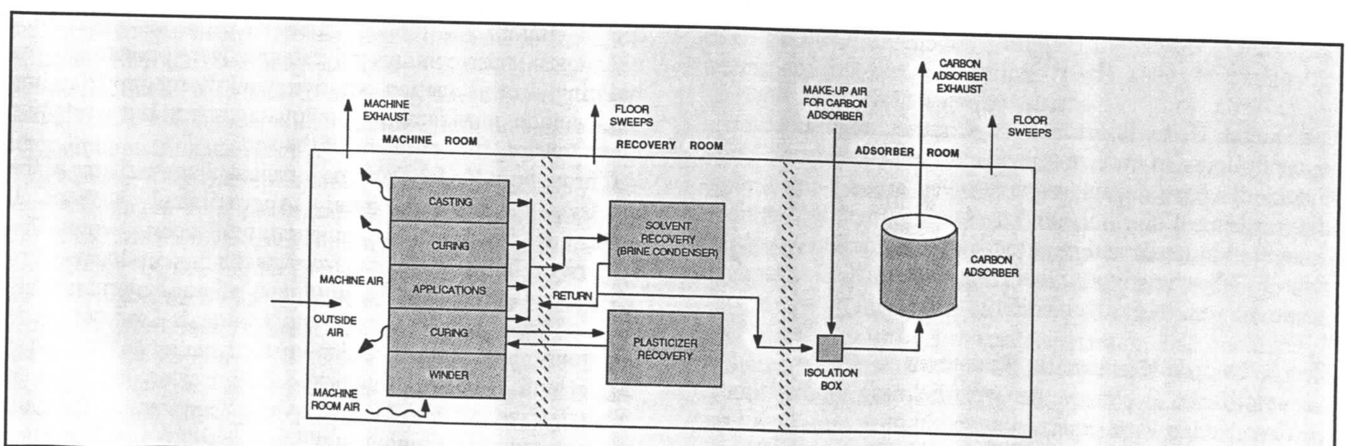


Figure 3. Acetate film base manufacturing operations.

effects and building-enhanced dispersion; and, beginning in 1981 in response to the New York State DEC "Air Guide 1" initiative, a need to evaluate ambient concentrations for all 300 contaminants. Then consider the complicated source-receptor geometry, and the need to determine what each close-by neighborhood receptor "sees" in terms of impact from the plant. Clearly, at that point in time there were no available "off-the-shelf" computer dispersion models to analyze the complex situation that Kodak faced. Moreover, Mathews notes that there was a need to manage and merge the emission inventory, identify compounds of interest and provide modeling output in a "user-friendly" graphical display of air concentration isopleths, as opposed to matrix tables.

The concept for the AIR-1 system for Kodak Park developed out of a telephone conversation between Mathews and Lee Davis of Galson Technical Services. Recalling the original conversation, Davis notes, "The application of the State's 'Air-Guide-1' to Kodak Park presented a unique set of problems due to the sizes, locations and the large number of sources and contaminants at Kodak Park. In developing the AIR-1 system, we discussed such issues as local building effects (wakes, cavities, impingement), receptor grid, intermittent and/or atypical sources, and averaging time, among others."

Davis adds, "We concluded at that time that 'screening' techniques would likely be inappropriate and, although very computer intensive, a source-by-source refined modeling approach was more suitable to resolving the complexity of Kodak Park. However, a simple back-of-the envelope calculation suggested that such an approach would require 20,000 hr of CPU time on a Digital Equipment Corporation VAX 11/780 super-mini computer. That's over 2-1/4 years just to get a snapshot of Kodak Park! And if one of the 1200 sources were to be changed, the entire process would have to be repeated! Thus, we further concluded during that original conversation that an alternative scheme would be needed."

To provide a more manageable system, Galson personnel worked on a series of various pre-/post-processing schemes evaluating normalized concentrations to reduce computer run time to a more acceptable level of just over 400 hours. Gibson Stine, Galson's Technical Director, posed a further refinement of "baseline concentration." This concept involved establishing baselines for each of the 300 air contaminants through an "initialization" step. Thus, once the 400-hr initialization step is completed, the system would track changes to baseline concentrations as emission strengths, processes or source characteristics changed. The result was a powerful, "operational" dispersion modeling system that provides an end user with quick, interactive response (few minutes) to simulate air quality impacts for Kodak Park as opposed to days, or even years, using conventional dispersion modeling techniques.

The conceptualization and actual development of the AIR-1 system took approximately 2.5 worker-years and involved significant contributions not only from the consultant staff, but also Kodak's Air Technology Group, headed by Brian Wirsig. In order to ensure regulatory acceptability, Ed Bennett and Leon Sedefian of the NYSDEC provided continuous review and valuable input during the development, initialization and operating steps of the process.

The development and evolution of the AIR-1 system has continued over a period of several years. Lee Davis notes that there was no comprehensive air toxics management *system* in existence prior to AIR-1. All parties saw a clear need to develop a comprehensive system to respond to *long-term* air toxics management issues involving multiple sources. Because of Kodak's extensive history of compiling, analyzing and reporting information with respect to air toxics, they already had a sophisticated source emission inventory and reporting software in place. Thus AIR-1 was designed to transfer source data from Kodak's existing emission inventory information system to the AIR-1 system (AIR-1 does contain its own emission inventory software component).

After consideration of various dispersion models for the AIR-1 system, Galson used its own CRSGTS dispersion model, a derivation of the EPA "CRSTER" model, which had regulatory approval status. In many instances, the emissions from Kodak Park buildings are influenced by building downwash and building cavity effects. Although there existed generally-agreed-upon procedures to incorporate these effects, prior to the CRSGTS model they had not been incorporated into an existing multiple source and multiple receptor dispersion model (It should be noted that in comparison with extensive wind tunnel testing for the Kodak Park site the CRSGTS dispersion model yielded the best, and somewhat conservative results, among the models tested such as the EPA Industrial Source Complex (ISC) dispersion model).

A schematic description of the AIR-1 system, which is accessed by a series of menus, is shown in Figure 4. The RECEPTOR module is used to maintain the receptor data base, which specifies the locations of interest at which the model calculates ambient concentrations and forms the basis for many reports and graphics. The SOURCE/EMISSIONS module can be used to maintain the source and emission data bases. Emission inventory tracking reports (over time) and

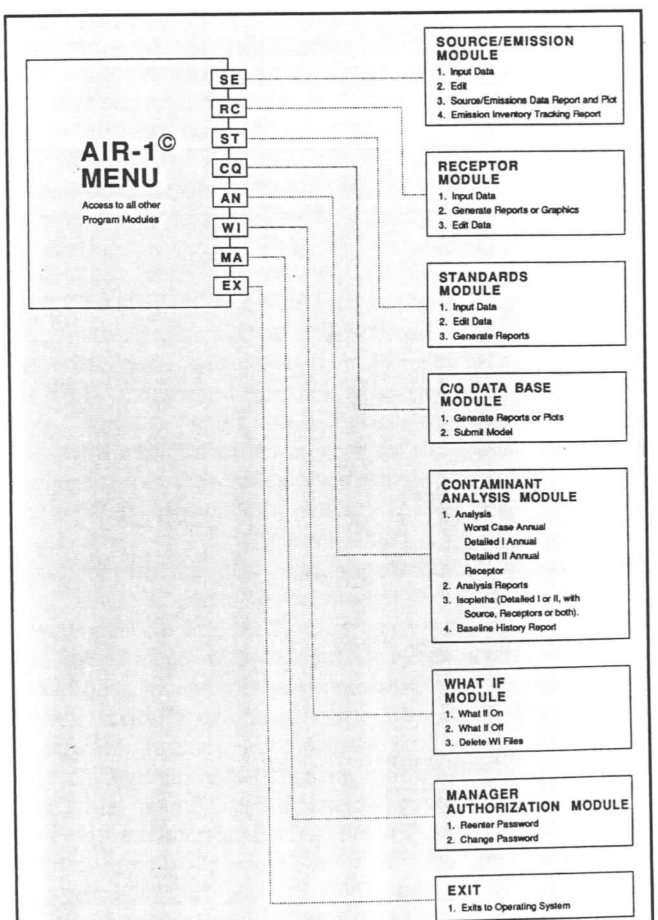


Figure 4. AIR-1 main menus and modules.

various permit reports and forms can be generated (although Kodak's version of AIR-1 enables them to maintain their existing software for these purposes). The STANDARDS module is used to maintain the data base of allowable or recommended levels of ambient concentrations and to generate reports.

The C/Q DATA BASE module contains the matrix of normalized concentrations for sources and receptors, which can be accessed for inspection or specific analyses. The CONTAMINANT ANALYSIS module enables the user to perform three levels of annual average air quality analysis (including a highly simplified screening analysis and two levels of more detailed analysis) as well as a fourth type, a short-term concentration analysis, and to generate graphical concentration isopleths. The WHAT IF module allows the user to model and evaluate potential changes to source parameters and emissions without affecting the permanent C/Q and baseline emission data bases. This module has been used by Eastman Kodak company to evaluate the ambient impacts of the source reduction strategies, such as those discussed below, as well as to evaluate potential responses to additional regulatory initiatives as they occur. Finally, for system security purposes, the MANAGER AUTHORIZATION module controls access to making permanent changes in the data bases.

Once the "initialization" step is conducted with careful selection of the receptor locations and the meteorological data base, the typical user need not necessarily have a detailed knowledge of modeling or computers (some elementary grasp of file management and editing and a working knowledge of dispersion models is helpful). With the AIR-1 system in place, Kodak personnel were able to prepare their own comprehensive report of air toxics impact assessments in support of their permit application to expand capacity for the film base manufacturing at Kodak Park.

Film Base Manufacturing Expansion at Kodak Park

In October 1988 Kodak submitted to the NYSDEC an extensive five-volume set draft environmental impact statement (DEIS) to obtain a construction permit for a proposed expansion of cellulose triacetate film base manufacturing at Kodak Park. Although the material was in the public record, there was little knowledge, interest or reaction in the community at that time. Most likely, the public and media were far more interested in knowing that the expansion was estimated to create approximately 800 construction jobs and 1200 permanent jobs (including multiplier effects) in the Rochester area. To say the least, by June 1989 perceptions changed. The public was concerned not only about the high existing emissions of air toxics and what they really meant, but also that the situation could become worse with the major expansion being proposed by Kodak.

The new film base manufacturing machine will emit 154,000 lb/yr of dichloromethane (less than 2% of the existing total emissions from present film base manufacturing operations). The new machine will reduce emissions by containing and recycling close to 100% of the air within the machine and preventing escape to the machine room and ventilation system. In addition, a new carbon adsorber will provide additional capacity and operate at an improved 98% DCM removal efficiency in comparison to the present 95% removal efficiency. Even with the improved, more-efficient design of the new machine, it is obvious that total site emission levels would increase if no additional measures were taken to reduce other existing source emission levels. Therefore Kodak proposed to reduce emissions of DCM for existing operations by 30% by 1991 (see Table 2). As part of the conditions to receive its construction permit, Kodak pledged to further reduce site emissions of major toxic air emissions, including dichloromethane, by 1995.

Table 2. Summary of Control Alternatives and Ambient Concentrations for Dichloromethane

	Point Sources		Point and Non-Point Sources	
Control Alternative	Total Emissions (lb/yr)	Air-1 Predicted Concentrations (μg/m³)	Total Emissions (lb/yr)	Air-1 Predicted Concentrations (μg/m³)
Existing Conditions (1988)	7,800,000	179	8,900,000	193
New Machine & Existing Major Point-Sources with Emission Reduction Program (ERP)	5,900,000	108	6,500,000	122
New Machine & Existing Major Point-Sources with ERP & Cost-Effective Control	5,600,000	101	6,250,000	115
New Machine & Existing Major Point-Sources with ERP, Cost Effective Control & Add-on Control	590,000	21	1,200,000	85
New Machine & Existing Major Point-Sources with ERP, Cost Effective Control and Enhanced Dispersion	5,600,000	22	6,250,000	85
Permit Conditions: New Machine & Existing Major Point-Sources with ERP, Cost Effective Control; 99% Control at Machine, Enhanced Dispersion + 50% Reduction of Fugitives	2,000,000	25	2,300,000	45-50

*Maximum average annual ground-level concentration at a sensitive receptor predicted by Kodak's Air-1 System.

Outline of Kodak Park in Rochester, NY.

Source Emission Reduction Program at Kodak Park

One cannot overestimate the difficulty in communicating technical information and understanding to the public, especially concerning such an emotional issue as toxic air emissions. However with the help of the AIR-1 Air Toxics Management System, Kodak did prepare a well-defined plan, which it presented in the DEIS, to reduce both source emissions and the ambient air quality impact of its air toxics emissions. Despite the overriding attention being given to dichloromethane, it should be noted that the source reduction program and ambient impact assessments undertaken by Kodak in its DEIS for film base manufacturing expansion also addressed nine other major chemicals: Methanol, acetone, ethanol, 1,2-dichloropropane, n-butanol, cyclohexane, 2-methoxyethanol, 1,1,1-trichloroethane, and propylene oxide. The various emission reduction strategies discussed for dichloromethane also reduce emissions of these other solvents.

A two-phase emission reduction program evolved during negotiations with the NYSDEC after submittal of the Kodak DEIS for the new machine. Thomas Marriott, regional NYSDEC engineer, describes Kodak's participation with NYSDEC as "cooperative" and "open" with respect to sharing information and developing initiatives to ensure strong margins of safety from air toxics. The first phase of the emissions reduction program, originally scheduled for completion by 1991, is well underway and, Mathews notes, will likely be completed during the first half of 1990 at a cost of about $20 million. After this program to reduce emissions from existing film base manufacturing machine sources is completed, and after the new machine is in operation in 1991, there will be a net 30% reduction in DCM emissions from former levels. With respect to the 30% reduction, Mathews observes "We look at how we can continue to reuse and recycle the air within the machine more effectively and how we can contain the emissions within the machine. That involves the hardware that is used in the machines and some of the manufacturing procedures so that there is a total team effort from the maintenance personnel, design engineers and machine operators to identify opportunities to reduce emissions." One important specific strategy has been to prevent leakage of emissions from within the machine by improving the seal integrity for machine access ports, seals on penetrations of machine enclosures and seals on pressure relief vents. Another significant improvement is the replacement of the existing carbon adsorber system with that of the new, higher-capacity, higher-efficiency carbon adsorber system to serve the new machine as well as the existing machines.

During the second phase Kodak agreed to install "best available control technology" (BACT); but the definition of BACT used by the NYSDEC encompassed much more costly alternatives than Kodak had expected when filing its draft environmental impact statement. Nonetheless, Kodak agreed to 99% recovery of the dichloromethane entering the film base manufacturing machines, at an estimated cost of $80-100 million. Stated in other terms, this is another 40% reduction beyond the emission reduction in phase one, or a total of 70% reduction from the 1987 level of 8.9 million lb of emissions.

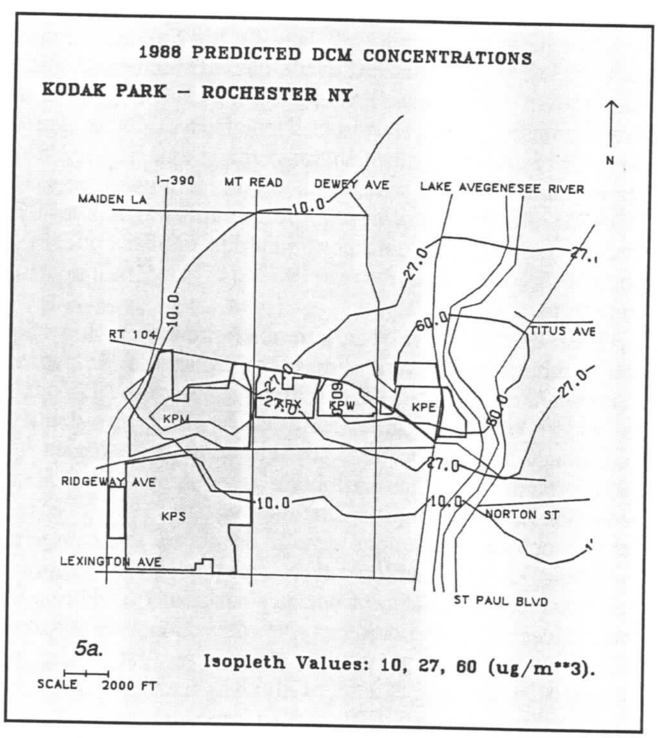
Given the high cost of carbon adsorption technology for the machine room vent emissions, which is a critical component of what NYSDEC characterizes as BACT, Kodak is undertaking a significant research effort to identify additional, potentially more cost-effective technologies by 1991. Kodak would have to obtain an equivalent emissions reduction through implementation by mid-1995. The research includes evaluating several advanced technologies, including energy dechlorination, reaction dechlorination, and new methods of adsorption and absorption, in addition to the conventional technologies of adsorption, absorption, incineration and condensation. After the first phase of emission reductions, Kodak will also construct a Good Engineering Practice (GEP) stack to improve dispersion and minimize the building downwash and building wake effects on emissions from acetate film base manufacturing operations.

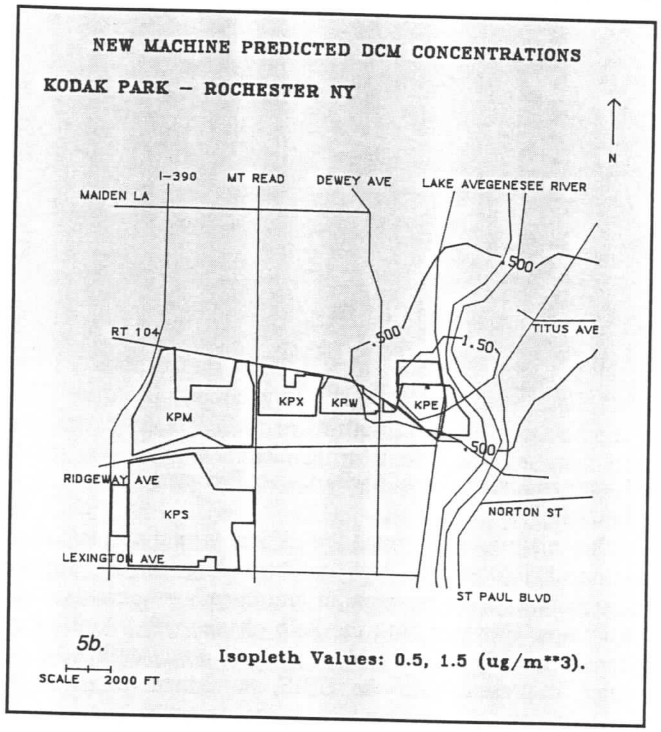
Ambient Analysis and Decision-Making

The AIR-1 air toxics management system was an integral part of providing supporting analysis for the permit expansion and for developing the source emission reduction program. Again, Jeff Mathews: "I think the power of the AIR-1 system became visible during the extensive environmental impact analysis for the manufacturing expansion. In the 1987-1988 time frame the allowable concentration for dichloromethane was proposed to be reduced by a factor of 3000 by the NYSDEC. In the ensuing work to identify the impact of emission reduction alternatives the flexibility, ease of analysis and true effectiveness of AIR-1 was shown. With the target levels for some compounds now being established in the range of 0.05 to 0.5 μg/cu m, AIR-1 provides the source owner with an understanding of whether that target can be achieved through emissions reductions or whether these target concentrations are so restrictive that a compound may no longer be used at a site."

Some representative examples of dispersion-modeled ambient air quality impacts from emissions of dichloromethane are shown in Figure 6 for several different emission scenarios. All of the impacts are presented as annual average concentrations—to simulate long-term exposures and to correspond to NYSDEC guidelines. The higher concentrations tend to be located close to the site boundary; therefore several nearby "sensitive" receptors, including a local school and residential neighborhoods, were included in the analysis. From the "baseline" case (Figure 5a.) for the emissions of DCM (8.9 million lb/yr) prior to the new emissions reduction program, the maximum ambient concentration of DCM was modeled to be 193 μg/cu meter. With respect to DCM emissions from the new film base manufacturing machine alone, the maximum incremental concentration was found to be 3 μg/cu meter (Figure 5b.). Using the AIR-1 "What If" module, Kodak analyzed many different emission reduction strategies. Figure 5c. shows the projected ambient concentrations from all emissions in 1992-93 after the first phase of the source emission reduction program together with GEP stack heights.

A more general summary of source emission reduction alternatives and their ambient impacts for DCM are presented in Table 2. In the last entry, "permit conditions," it is noted that Kodak went beyond its original proposal in the DEIS by proposing additional machine control measures, the application of enhanced dispersion (GEP stacks) and a 50% control of fugitive emissions. These permit conditions are expected to go a long way towards resolving the community concerns, noted earlier, about the impact of emissions from the existing machines and the new machine. One very interesting finding





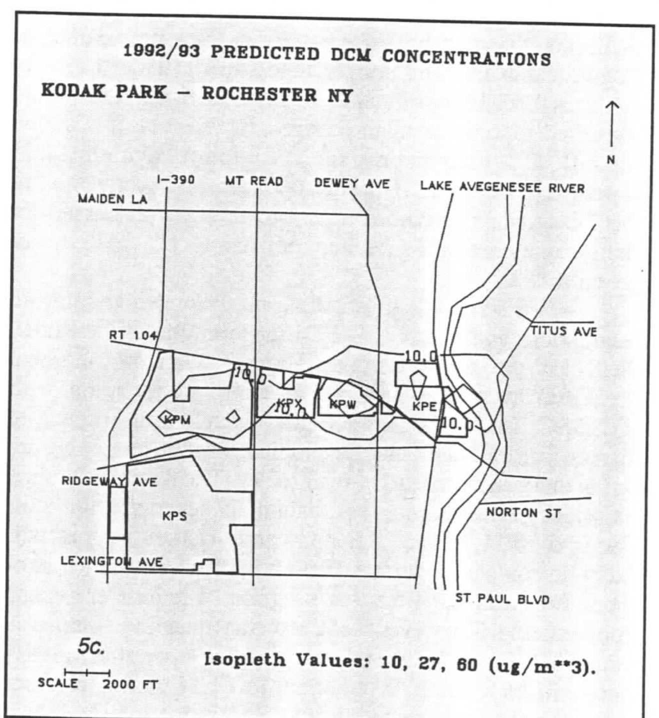


Figure 5. Isopleth values of dichloromethane for (a) 1988, (b) the new film base manufacturing machine, and (c) 1992/93 after the first phase of Kodak's emission reduction program.

from the ambient air quality modeling, which is currently under study by Kodak, is that the "fugitive" sources seem to have a higher, disproportionate impact upon nearby receptors than the quantity of their emissions would suggest; this situation could have far-reaching implications for industrial chemical users as they develop emission reduction programs.

Although ambient air quality dispersion modeling is a powerful and necessary tool, it is not a sufficient one. Actual ambient monitoring is also required. Kodak conducted several studies during the period 1973 to 1981 to obtain short-term peak concentrations of air toxics. However, these samples were not intended to verify long-term concentrations (although some inferences can be drawn indicating very rough agreement with dispersion modeling). In 1983, Kodak undertook an eight-month sampling program at nine receptor locations in the vicinity of Kodak Park. In 1986 Galson conducted an air toxics measurement study for Kodak at 18 nearby receptors for a seven-month period. The maximum mean off-site dichloromethane concentrations at sensitive receptors found during the 1983 and 1986 monitoring programs were 210 and 180 μg/cu m, respectively. These figures compare to the maximum receptor concentration of 193 μg/cu m from the AIR-1 modeling, and seem to indicate agreement between the source emissions modeling and ambient monitoring.

Both Kodak and the New York State DEC have recognized the need for an extensive, long-term ambient monitoring program to (1) determine "baseline" concentrations and (2) track the change in ambient concentrations from lowered emissions. As a result of the permit conditions, Kodak has conducted an ambient monitoring pilot program for air toxics at three receptor locations. This program will be expanded to a seven-station network during the next several months.

Looking Towards the Future

One senses that Kodak's environmental philosophy is to do the right thing in terms of protecting its workers and the community from any questionable air toxic exposures and health risks. Towards this end the company's air toxics management program has been focused upon several approaches. Kodak continuously engages in and evaluates toxicological research in order to determine safe concentration levels; in this effort Kodak is assisted by various outside expert university researchers and panels. Another facet is continued and expanded emphasis upon waste minimization through process improvements. Kodak devoted considerable resources towards further analyzing ambient impacts through the development and utilization of the AIR-1 Air Toxics Management System. And Kodak is maintaining an open dialogue with regulators and the community and is prepared to accept and respond to tightened allowable concentration levels of air toxics. Kodak has been researching, negotiating and is prepared to meet permit conditions for its expansion of film base operations between now and 1995.

Nonetheless, the most difficult and trying times for Kodak and other companies, as well as the regulatory process, seem to lie ahead. Classic, time-honored disputes over how to apply toxicology data from animal studies to human beings are causing widely divergent views as to what concentrations of dichloromethane and other air toxics are safe and should be allowed. Kodak scientists, and many others from academia and industry, insist that to develop a low, safe concentration for humans it is not proper to linearly extrapolate from the high doses given to mice. They argue that humans use a different pathway to metabolize and break down low levels of dichloromethane. EPA scientists argue, however, that because there is some evidence that humans do metabolize through the same pathway as the mouse, albeit at a lower rate, that the more conservative linear dose response data should be used until more conclusive information about human pathways and responses is available.

Kodak also believes that a historical lack of health effects to workers exposed to dichloromethane is further evidence that the current ambient concentrations are safe. In particular, a study of some 1000 Kodak workers exposed over a period of 40 years to concentrations more than one hundred times greater than those found in the community found no evidence of increased incidence of cancer. Because of the relatively small sample size, the regulatory officials categorize this study as "inconclusive."

The bottom line from these uncertainties and differences of opinion is that the regulatory process has adopted a conservative approach and much tougher guidelines than appeared just a couple years ago. At the time Kodak began preparing its draft environmental impact statement in support of its expansion of film base manufacturing, the New York State "acceptable ambient level" (AAL) guideline concentration for dichloromethane was 1167 μg/cu meter. Although the New York State Department of Health has suggested that an annual average concentration for DCM of 60 μg/cu m would be protective of human health, recently the NYSDEC adopted an "ambient guideline concentration" (AGC) of 27 μg/cu m for DCM. This simple change in nomenclature, and removing the word "acceptable," seems symptomatic of the changing regulatory climate. Whatever nomenclature you choose, with this change receptor concentrations which were previously an order of magnitude *below* the previously acceptable levels are now too high.

Mathews underscores the difficulty in trying to meet this guideline concentration: "Even after we meet the 99% reduction target level for the film base machines *and* if we further reduce existing fugitive emissions by 50% *and* utilize enhanced dispersion methods, including taller stacks and greater exit velocities, our ambient analysis indicates that ambient dichloromethane concentrations will still be in the range of 40 to 50 micrograms per cubic meter." However, another related regulatory facet which makes the Kodak situation of general interest is that the "ambient guideline concentrations" are just that—"guidelines", and are not "standards".

NYSDEC engineer Marriott notes that the AGC are "targets" or "goals," but they are not enforceable standards and there is more flexibility to amend them in conjunction with updated health information and feasibility. Thus, there is flexibility in the air emissions permit review process on a case-by-case basis to include socioeconomic factors and feasibility of implementation. It will be very interesting in the months and years ahead to observe how all of the factors, including a comfortable margin of safety, are balanced in the case of Kodak and other industrial chemical users around the nation. The final chapters in this case study have yet to be written. **PE**

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