ANL/EA/CP--79944
Conf-931095--19

MODELING EMISSIONS AND DISPERSION OF CONTAMINANTS FROM CLEANUP ACTIVITIES AT A MIXED WASTE SITE TO ESTIMATE AIR IMPACTS AND RISKS

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September 1993

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ABSTRACT

The transport and dispersion of contaminants via the air pathway is a major concern during cleanup of contaminated sites. Impacts to air quality and human health during cleanup were evaluated for the Weldon Spring site by using site-specific information for source areas, activities, and receptor locations. In order to ensure protection of human health and the environment, results are being used to focus on those cleanup activities for which release controls should be emphasized.

BACKGROUND

The Weldon Spring site is a U.S. Department of Energy (DOE) mixed waste site located about 30 mi west of St. Louis. The site consists of a 217-acre chemical plant area and a separate 9-acre quarry. Both areas are radioactively and chemically contaminated from activities that occurred during the 1940s through the 1960s. The chemical plant was first used to produce explosives and then to process uranium, and the quarry was used as a disposal pit. The chemical plant area includes about 40 acres of buildings with underground sumps and pipes, 25 acres of sludge pits, and 15 acres of combined dump areas (Fig. 1); other areas of contaminated soil are scattered across the site. About 900,000 yd^3 of waste are expected to be generated by site cleanup.

PLACE FIG. 1 HERE.

Possible impacts to air quality and human health are major concerns associated with cleanup activities at a contaminated site. A number of human receptor locations are within 3 mi of the Weldon Spring site, including several residents and a high school (within 1 mi) with an enrollment of 1,600 students (Fig. 2). Thus, the community considers airborne releases and subsequent exposures one of the most important issues for cleanup. For this reason, a detailed site-specific evaluation of potential impacts was included in the assessment of cleanup alternatives for the project.

PLACE FIG.2 HERE.

A number of interim actions are under way at the site, including dismantling the buildings and hauling waste from the quarry to the chemical plant area; all material generated by these actions is being stored on-site pending the overall treatment and disposal decision. The major cleanup activities currently planned for the chemical plant area address these stored materials, in addition to the highly contaminated sludge in the waste pits and the contaminated soil across the site. Various engineering activities were assessed for managing this material — including excavating the contaminated soil, dredging sludge from the waste pits, treating the highly contaminated material (with either grout technology or vitrification), transporting and staging both the supplies and the contaminated material, and placing all waste in an engineered disposal cell.

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* Work supported by U.S. Department of Energy, Assistant Secretary for Environmental Restoration and Waste Management, under Contract W-31-109-Eng-38.

Although no impacts to human health or air quality are occurring under current site conditions, both uncontaminated and contaminated emissions will be generated during the major cleanup activities planned for the site. Ambient impacts of these emissions were evaluated separately to allow comparison with ambient air quality standards and to address potential health effects for workers and the local public during the cleanup period. Because of the proximity of the high school and nearby residents, the community expects releases from site activities and subsequent contaminant transport to be assessed as realistically as possible. However, because there are no "typical" cleanup sites, no standard methodology was available for such an analysis.

SITE-SPECIFIC AIR QUALITY MODELING APPROACH

A conventional modeling approach could have been be used if (1) a limited number of emission sources with similar contaminants (types and concentrations) were involved; (2) potential receptors were located a considerable distance from the source areas; and (3) the same cleanup activities were conducted year-round, such that the emission rates were constant. This approach would have involved combining sources in close proximity into a manageable number of representative sources and conducting standard air dispersion modeling calculations. Unfortunately, these factors did not represent conditions for cleanup activities at the Weldon Spring site or many other environmental restoration sites. These sites are located in various land-use settings, have different contamination problems, and are often divided into operable units with several interrelated activities occurring at the same time. Also, the sites usually contain a number of emission sources, unique source/receptor configurations, and cleanup schedules that vary according to factors such as regional climate and the availability of receiving facilities or funds.

For these reasons, the most useful analysis of air pathway impacts during cleanup is one tailored to site-specific conditions. A site-specific modeling approach was developed for the Weldon Spring site to provide the assessment information needed to refine conceptual engineering plans during the detailed design phase of the remedial action, as well as to help ensure responsiveness to public concerns. Information on contaminant data, conceptual engineering plans (including numbers of workers; numbers and types of equipment; and the location, duration, and sequencing of activities), meteorology, topography, and distances to the nearest receptors (also considering hypothetical boundary receptors) were combined to develop a reasonable representation of potential impacts during the cleanup period.

The proposed cleanup activities being considered for the Weldon Spring site are characterized by a variety of emission sources, a complex array of source-receptor relationships, several components of material transport and handling, and a complicated work schedule. The project-specific methodology used to assess air quality and potential health impacts considered the following factors:

- Source areas are widely scattered across the site, with varying levels of chemical and radioactive contamination.

- Cleanup activities for these source areas are conceptually scheduled to occur at different times over the entire remedial action period — ranging from a few days to a few years.

- Both contaminated and uncontaminated emissions are relevant because the modeling results provide important input to both the air quality assessment (i.e., the comparison with environmental standards) and the health risk assessment.

- Source-receptor relationships, which address the contributions of all emission sources to estimated airborne contaminant levels at each receptor, are needed to assess human health risks.

- To assist in evaluating the most appropriate alternative from the standpoint of air quality and short-term exposures and health risks, several alternatives with different emission sources and work schedules must undergo a comparative analysis.

The site-specific approach involved (1) identifying emission sources by type (point, volume, area, and line), size, and activity and developing unit emission rates for each; (2) generating concentration matrices for unit emission source-receptor relationships; (3) projecting integrated cleanup activities over a seven-year period and estimating particulate emission inventories for each activity; (4) modeling 24-hour and annual average particulate concentrations at each receptor for comparison with ambient air quality standards; and (5) combining the results with source-specific contaminant concentrations for input to the human health assessment. A schematic diagram of the general process developed for the site-specific air quality modeling is presented in Fig. 3. Generally, conservative assumptions were used to ensure that the results would bound potential impacts.

PLACE FIG. 3 HERE.

For air quality modeling, emission factors for respirable particulates (PM-10), which would constitute the major emission sources associated with cleanup activities, were estimated from standard reference sources (1), (2); equipment specifications in the *Caterpillar Performance Handbook* (3); and professional engineering judgment. A total of 1 point source, 3 volume sources, 21 area sources, and 29 line sources were evaluated for this analysis. Thirty-six receptor locations were evaluated. Ten locations represent existing human receptors (Fig. 2), and the remaining 26 locations represent hypothetical receptor locations around the site perimeter. Surface meteorological data collected on-site and mixing height data from a nearby station (at Salem, Illinois) were used for the air quality analysis. To estimate the 24-hour and annual average concentrations for PM-10, the Industrial Source Complex, Short Term model (ISCST version 88348 [4], [5]) was used to model point, area, and volume sources. (Recently, restructured and reprogrammed versions of the original ISC models were released as the ISC2 model [6], [7]. The original ISC version was used at the time this analysis was made.) The Industrial Source Complex, Long Term model (ISCLT version 88348 [4], [5]) was determined to be inappropriate for this analysis because of the nature and scheduling of projected cleanup activities for the site. Although the ISCST model is able to model line sources, its use would have been inefficient for this application (e.g., it would require dividing the haul routes at the site into over 300 volume sources). Because it was better adapted to the line source modeling needs for this analysis, the third-generation California Line Source Dispersion model (CALINE3 [8]) was used instead of the ISCST model for these sources (such as haul segments).

RESULTS

The results of the air quality analysis identified some differences in emissions between the treatment alternatives because of operational differences in the grout and vitrification scenarios. Results also indicated there was little potential for health effects to off-site receptors (e.g., risks would be well below 1 in 1 million), but an unprotected worker involved in certain activities could potentially incur adverse impacts. This information is being used to help identify activities for which respiratory protective equipment would be appropriate to control occupational exposures. The results also indicated that activities conducted near one of the site boundaries could result in temporary exceedances of ambient air quality standards, depending on prevailing meteorological conditions; mitigative measures, such as water sprays, are being incorporated into the remedial design for those activities. These results were presented in the Feasibility Study prepared for the proposed remedial action at the chemical plant area of the Weldon Spring site (9).

PUBLIC COMMENTS AND LESSONS LEARNED

The DOE held a public meeting on the proposed remedial action in December 1992, and several comments were received regarding potential risks via the air pathway. These comments and the DOE responses are included in the DOE document, *Responses to Comments on the Remedial Investigation/ Feasibility Study-Environmental Impact Statement for Remedial Action at the Chemical Plant Area of the Weldon Spring Site (November 1992)* (10), and are summarized as follows:

- A request was made for DOE to commit to a long-term monitoring and maintenance program to verify and maintain the performance of the disposal facility. To ensure the community of long-term health protection, DOE agreed to conduct such a program. The lesson learned from this request was that the feasibility study and proposed plan regarding the long-term monitoring program should be more explicit (to the extent this is possible at the conceptual design stage).

- One individual (a local professor) questioned why the risk for the general public within 3 mi of the site was higher than the risk for an on-site worker conducting the remedial action. This question resulted from a misinterpretation of data representing population risk (for the high school) versus individual risk (for a worker). The lesson learned from this comment was that summary tables in the documents should very clearly explain the risks that are being presented, because it is easy to misunderstand numbers when they are taken out of their normal context.

- The DOE had previously committed to having no measurable impact from site contaminants at the high school (during a public meeting for an interim action). A member of the local community questioned how a measurable impact would be detected. The DOE responded that an intensive monitoring program would be conducted, with the first step being the protection of on-site workers. Because the remedial action workers, the area where cleanup activities are performed, the site perimeter, and the high school would be monitored, any problem would be detected at its point of origin, so that mitigative measures (including work stoppage) could be taken before contaminants ever left the site. Again, the lesson learned from this comment was that information regarding monitoring plans during the cleanup period must be as explicit as possible.

- Another member of the public asked DOE to explain how the students at the high school could be affected by site cleanup work and to comment on possible risks to the high school. The DOE's response reaffirmed the commitment to no measurable impacts at the high school from site contaminants; therefore, any risks would essentially be in the background. The DOE also addressed other aspects of site cleanup that do not involve contaminant emissions, such as truck transport of equipment and materials to the site. The public was assured that scheduling of those activities would be coordinated with the high school to minimize their impact. In this case, the lesson learned was that, in addition to risk, nuisance factors such as traffic are of considerable concern to the local community, and continued coordination with parties that could be affected by increased traffic is an important component of remedial action planning.

- An important concern voiced by the public was the question of whether waste would be shipped from other sites to the disposal facility proposed for the Weldon Spring site. The fear was that the site would become a magnet for waste from other areas of the Midwest, especially if an incinerator were built on-site (the contingency remedy for the Weldon Spring site involves waste vitrification in an on-site melter). The project manager assured the gathering that DOE has no plans to dispose of waste from any other site at the Weldon Spring site. As a result, the lesson learned from this issue was that, to the extent possible, this type of statement should be made in the proposed plan. This issue will be common at most sites, and it should be addressed up front.

In addition to verbal comments at the public meeting, a number of written comments on the air quality assessment were received from one of the technical consultants for a community action group. These comments are summarized as follows:

- Because of the apparently unusual uniformity in wind direction (predominantly from the south), the siting of the on-site meteorological station was questioned with regard to whether it met the siting guidelines of the U.S. Environmental Protection Agency (EPA). The DOE responded that the meteorological data from that station were, in fact, characteristic of the wind patterns for the Midwest, and results of recent wind measurements from the new on-site meteorological tower (which is 0.5 mi east of the original tower) corroborated the earlier results.

- The use of EPA's ISC model was questioned because of its limited effectiveness for considering the effects of uneven terrain. The DOE advised the group that this limitation had been discussed in the analysis presented in the feasibility study and, because the site is at a higher elevation than the potential receptors, the assumption of a flat terrain for the nearby area would result in conservative estimates. The lesson learned from this comment was to clearly explain the assumptions inherent in the modeling used for air quality analyses, including the conservative effect of the assumptions used.

- The commenter asked why mixing height data collected near the site during EPA's mid-1970 Regional Air Pollution Study (RAPS) were not used. The response from DOE indicated that data from the RAPS program cannot be directly correlated with the on-site meteorological data, and a complete set of data for the entire year is needed for air quality modeling. As a follow-up to this comment, the analyses were recalculated by using mixing height data from RAPS (which were the only data that could be appropriately extrapolated) for comparison. The data for morning and afternoon mixing heights that were evaluated in the original analyses were also graphically compared with the RAPS data. These further analyses indicated all three data sets were very similar, and the results presented in the feasibility study were based on appropriate input data. The lesson learned from this comment was that all possible data sources should be reviewed to ensure that the air quality analyst is aware of potential impacts to the results from other data sets.

SUMMARY

Although the site-specific air quality modeling analysis was extensive and painstaking, it provided a realistic, yet conservative, evaluation of impacts for the cleanup period. This type of evaluation was very helpful toward achieving community acceptance of DOE's ability to ensure their protection during the cleanup period. Also, the results were very useful in flagging potential problem activities, so mitigative measures could be incorporated into the detailed design phase of the remedial action. For example, to ensure that impacts from airborne emissions are minimized, activity scheduling and sequencing are being refined and specific engineering controls are being defined. Having set up the modeling framework on the basis of site-specific conditions, this analysis can be readily adapted to reflect changes in the expected activities as engineering plans are finalized.

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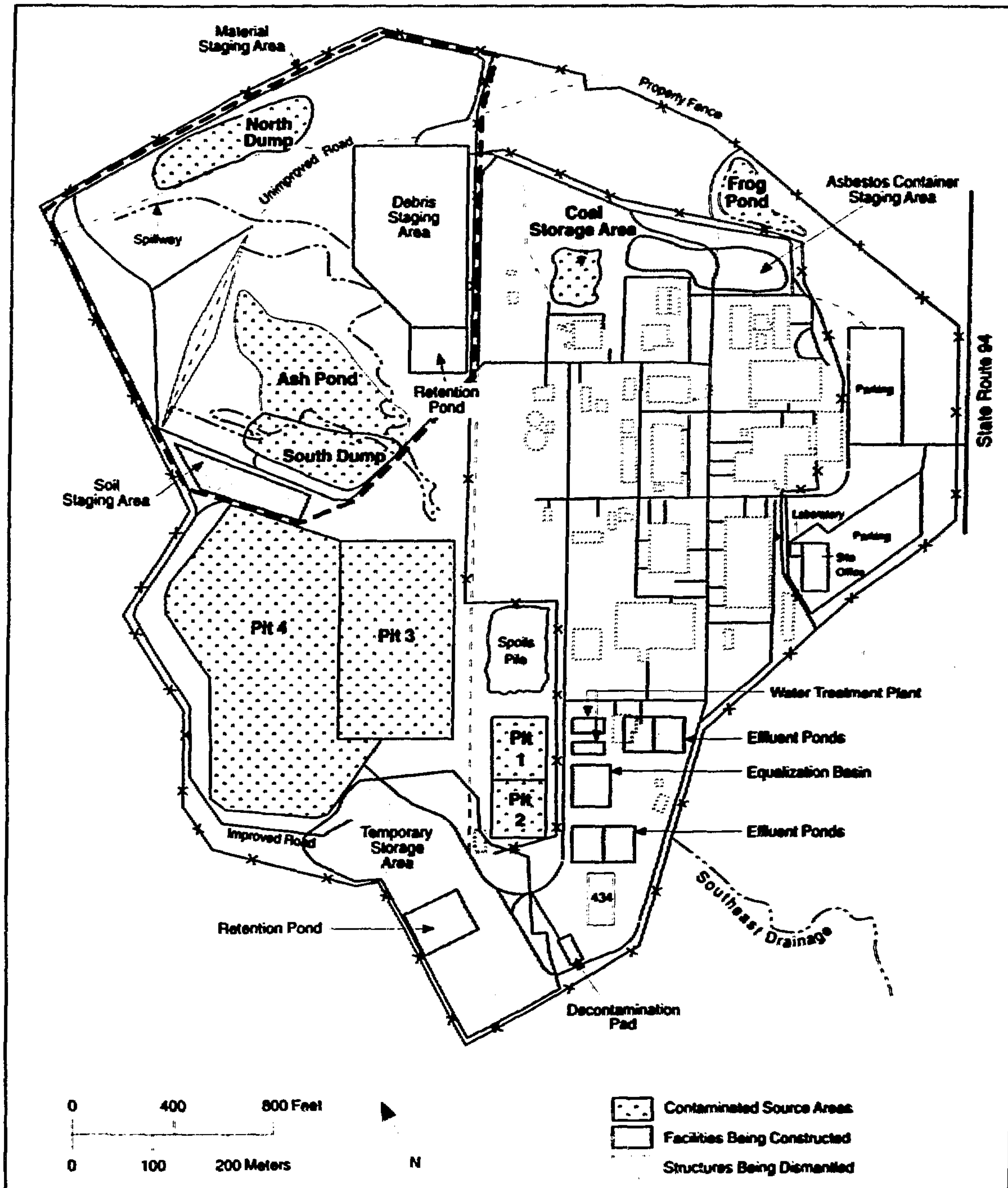

Fig. 1 General Layout of the Chemical Plant Area

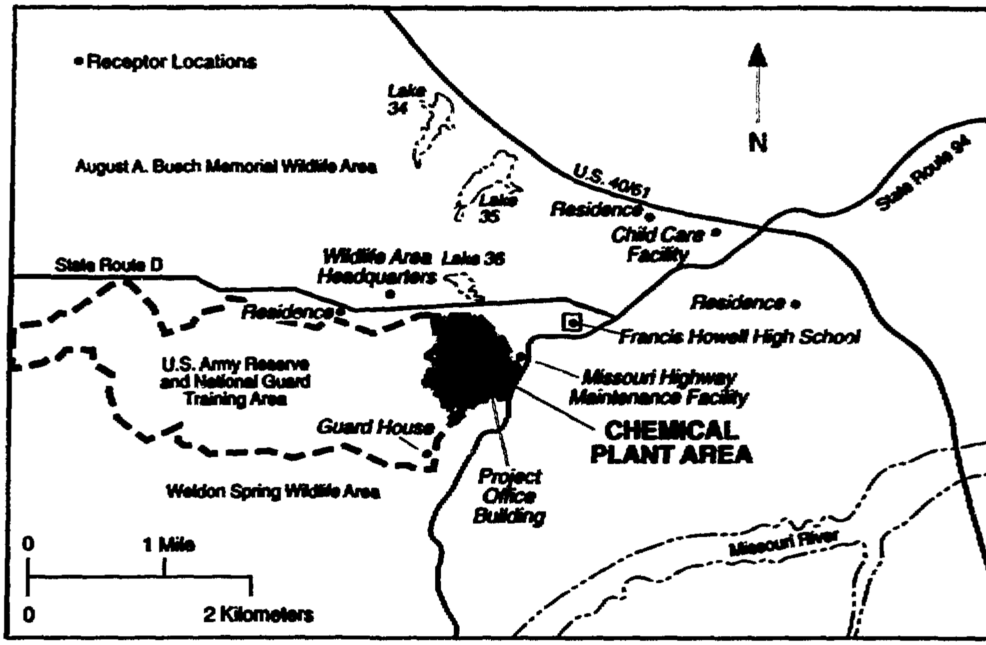

Fig. 2 Locations of Potential Current Receptors

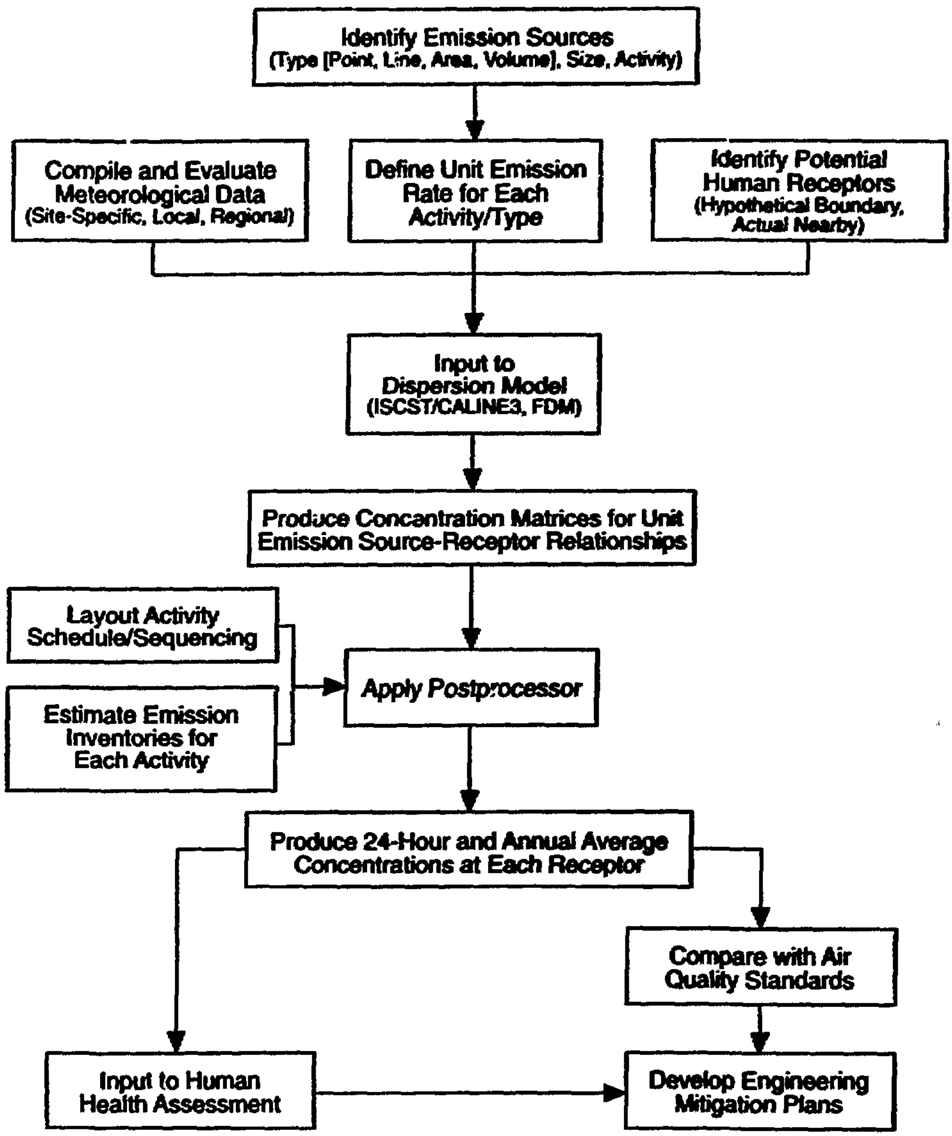

Fig. 3 Schematic Diagram of the General Process for Site-Specific Air Quality Modeling