ASSESSMENT OF THE ENVIRONMENTAL IMPACTS PRODUCED BY THE TRANSPORT OF RADIOACTIVE MATERIALS THROUGH URBAN AREAS*

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ABSTRACT

Sandia Laboratories is performing an environmental assessment for the Nuclear Regulatory Commission to ascertain the impacts produced by the transportation of radioactive materials near and through a large, densely populated area. Radiological, nonradiological and economic environmental impacts due to the transportation of all radioactive materials are considered, excepting those related to weapons, weapon components, or shipments on military vehicles. Although New York City is being studied initially to execute the methodology as a function of a real, complex urban environment, the assessment model developed is general in its basic content and is suitable for application to any urban area.

Radiological consequences are being computed for cases involving "normal" and accident conditions. In the "normal" case, nothing unusual takes place, but small radiation doses are still received by nearby people. In the accident case, dispersion of possibly released material away from the accident site is considered. In addition, impacts due to deviations from quality assurance practices, as a result of human error, are being calculated using the assessment model in a special manner. Certain aspects of sabotage and diversion are also being investigated for an urban setting. Radiological consequences are being quantified in terms of human health effects and decontamination costs.

A basic feature of this study is that special aspects of an urban environment are treated to obtain a more precise determination of the environmental impacts produced by the transportation of radioactive materials. High population densities and diurnal variations in these populations are considered. Also treated are pedestrian and traffic flow, effects of buildings, and local wind field patterns. An urban-regional meteorological dispersion model is used to study gross effects of observed urban wind flow. A micrometeorological model has been developed to predict transport of any released radionuclides in street canyons and at intersections.

To facilitate consideration of these urban characteristics, a representation was adopted whereby the urban area was divided into basic geographic units or cells, each of which was characterized by those parameters affecting the analysis. Such a grid was then used to establish positions of shipments

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along a route, to predict events such as dispersal of any released radioactive material, and to sum up environmental impacts on a cell-by-cell basis.

A task group was formed by Sandia early in this study to help in the development of the environmental assessment model. The members, who are associated with federal, state, and local governments, industry, public interest groups and universities, were selected for their expertise and to provide a wide, balanced viewpoint. They have assisted in the study by supplying comments, suggestions and information with respect to the scope, objectives, and development of technical programs involved in the environmental impact analysis. The meetings of the task group are open to the public. This has allowed for very early public input to this study.

This assessment forms part of the technical basis for NRC consideration of possible rule changes in 10CFR71 and -73, which contain the NRC regulations pertaining to transportation and packaging of radioactive materials.

BACKGROUND

An estimated 2.5 million packages of radioactive material were transported in the United States during a recent survey year - (1).* About one-third of these packages contained only small quantities of radioactive materials and were therefore exempt from packaging and labeling requirements of the Department of Transportation (DOT); certain of these items were shipped through the mail. The remainder were subject to DOT or Nuclear Regulatory Commission (NRC) requirements; packages ranged in size from many small, lightly shielded boxes transported on aircraft or trucks to a few massive casks requiring shipment by rail or barge. Because of the nature of the transportation system, many of these shipments pass through or near urban areas.

Transported radionuclides are involved in a variety of medical, research, and industrial applications. Certain non-fissile radioisotopes such as technetium-99m are used in the radiopharmaceutical industry. Other isotopes are involved in well-logging, industrial radiography, as large curie teletherapy and irradiator sources and in the manufacture of certain types of gauges. A smaller number of fissile materials, such as uranium-235, are used as fuel in nuclear reactors; and other isotopes, like plutonium-239, are produced as by-products of reactor operations. Radioactive materials, when shipped, are transported principally by common carriers or via a small number of special-use vehicles.

Potential environmental impacts from the transportation of radioactive materials include health effects, economic impacts, and social impacts. These impacts can result from "normal" (without accident or incident) transport, from vehicular accidents in transit, from human errors in labeling or packaging, or from sabotage or theft.

"Normal" transport of radioactive material exposes the surrounding population to

*Numbers in parentheses designate references at the end of the paper.

X

low levels of radiation. Accidents, human errors, or sabotage can enhance this exposure through reduction of the normal shielding provided by the package or through actual release of radionuclides to the environment. In the latter case, economic impacts involving costs of decontamination of the environment may also be significant, especially in an urban area.

Certain nonradiological impacts may also result from the transportation of radioactive materials. Social impacts such as the formation of interest groups or the passage of restrictive legislation are possible societal consequences involving public perception of the transportation of radioactive materials in urban environs. Other potential nonradiological impacts relate to the additional deaths and injuries that might result from transportation of radioactive material in exclusive-use vehicles.

A recent study provided by the Office of Standards Development of the NRC gives estimates of radiological impacts of transportation of radioactive materials on a nationwide basis - (2). "Normal" transport is estimated to produce no early fatalities, but on a statistical basis to induce 1.2 latent cancer fatalities per year as compared to the existing rate of approximately 300,000 cancer fatalities per year from all causes in the United States - (2,3). Only one latent cancer fatality in two hundred years of shipping at 1975 rates is expected to result from accidents - (2).

Prior studies, however, have not addressed in detail the unique features of an urban environment such as high, rapidly changing population density, micro-meteorology, the presence of concrete/steel buildings, high property values and other factors that might significantly affect the environmental impacts associated with the transportation of radioactive materials in urban environs

The study being conducted at Sandia Laboratories to assess these urban-specific environmental impacts is described in this paper. The approaches being used in the analyses are discussed. Preliminary results for certain facets of the study are presented.

APPROACH

Radiological environmental impacts resulting from the transportation of radionuclides in an urban area are calculated using the grid shown in Figure 1. In this representation, a 100 square kilometer portion of New York City is divided into basic geographic units or cells, each of which is characterized by a large number of parameters affecting the radiological impact analysis. As elaborated in another paper at this conference - (4), detailed routing of radioactive material shipments can be followed through the grid to calculate radiological impacts owing to "normal" transport as well as to accident or incident situations involving potential release of material. Time-dependent parameters assigned to individual cells include those characterizing population density, traffic flow and numbers of pedestrians. In the "normal" truck transportation scenarios, for example, doses are calculated for population groups which encompass people in buildings along the route, pedestrians, people in nearby vehicles and the crew of the transport vehicle.

In the case of a severe accident or sabotage involving vehicles carrying radioactive materials in urban areas, certain dispersible materials, such as plutonium oxide powder, can represent health hazards upon inhalation. Atmospheric dispersion of any material released at the accident site is accounted for in the analysis as explained in another paper at this conference - (5). Two models are used to simulate atmospheric transport and diffusion as a function of short ($<$500 meters) or long ($>$500 meters) distances from the accident site. These models predict concentrations per unit of material released as a function of local wind flow patterns.

The grid and its large associated data base are used to analyze a specific area in, and actual shipment information for, a portion of New York City. The cell-dependent parameters, however, are thought to be characteristic of other urban areas. A combined sensitivity and error analysis is underway in order to produce a generic basis for the study, i.e., to make it applicable to and inclusive of other U.S. urban areas.

The study also covers those environmental impacts, germane to urban areas, produced during transport of radioactive materials owing to nonconformance with quality assurance procedures, noncompliance with the regulations and other factors affecting safety. This facet of the environmental assessment also includes analysis of human errors in procedures such as mishandling and mislabeling of packages. DOT, NRC, state and commercial incident records are being studied to deduce error rates and to relate them to the radiological consequence analysis.

Certain aspects of sabotage, diversion, security and safeguards are also being studied for urban areas. Plausible sabotage scenarios involving presently unprotected shipments, such as spent fuel from nuclear reactors, are being analyzed to estimate radiological consequences. In addition, effects of the urban setting on the level of protection required for presently safeguarded shipments of radioactive material are under investigation.

Social impacts related to the transport of radioactive material in urban areas are being assessed by personnel at the University of Texas Health Science Center at Houston and at Rice University. They are analyzing pertinent features of human conduct as revealed in past records of collective behavior. Their objective is to obtain a sociologically informed interpretation of scenarios involving "normal" transport, vehicular accidents, human errors and sabotage or diversion.

Sandia Laboratories is also receiving the assistance of a twenty-member task group in this work. This group, composed of experts from governmental, environmental, industrial, and university backgrounds, is furnishing comments, recommendations and information on all facets of the study. Four meetings of this task group have been held so far in various cities throughout the United States. These meetings are open to the public and opportunity to obtain local comments and opinions have been provided at these gatherings.

RESULTS

Partial results are available for the radiological consequences of transporting radioactive material in urban environs. These are exemplified by Figure 2 which shows the dose to surrounding population groups from a "normal" transport situation involving the truck shipment of a unit source through the 100 cell New York City as a function of various time periods. Except at night when lower traffic densities occur, dose to people in nearby vehicles constitutes the largest dose to surrounding populations. Dose to the crew of the transporting vehicle is next in magnitude; the crew dose actually dominates during night-time transport but is lower than the corresponding crew dose sustained during day-time traffic when more time is required to traverse the grid. Pedestrians receive the next largest dose for all time periods. People in buildings are significantly shielded by intervening material and their relatively large separation from the radioactive material shipment; they receive extremely small doses and constitute the least exposed population group.

Preliminary results from the human factors area of the study indicate that less than one in 100,000 packages of radioactive material is involved in a reported incident. The vast majority of these incidents do not involve any release of material or enhanced exposure to the public.

The study of sabotage situations indicates that packaging, especially for large curie sources, is an important factor to consider in estimating plausible releases.

The social impact study is finding that many possible effects on densely populated areas of the transportation of radioactive materials do not lend themselves to quantitative expression, but involve social-psychological impacts such as individually felt but socially expressed values.

The task group assistance has resulted in an expanded scope for this environmental assessment to include a more complete treatment of possible radiological and nonradiological impacts. Individual task group members have provided some of the key data necessary for the analyses.

This investigation, when complete, will also include alternatives to actual transport situations involving radioactive material shipments in urban environs. These findings should be valuable to the NRC in its present review of the regulations.

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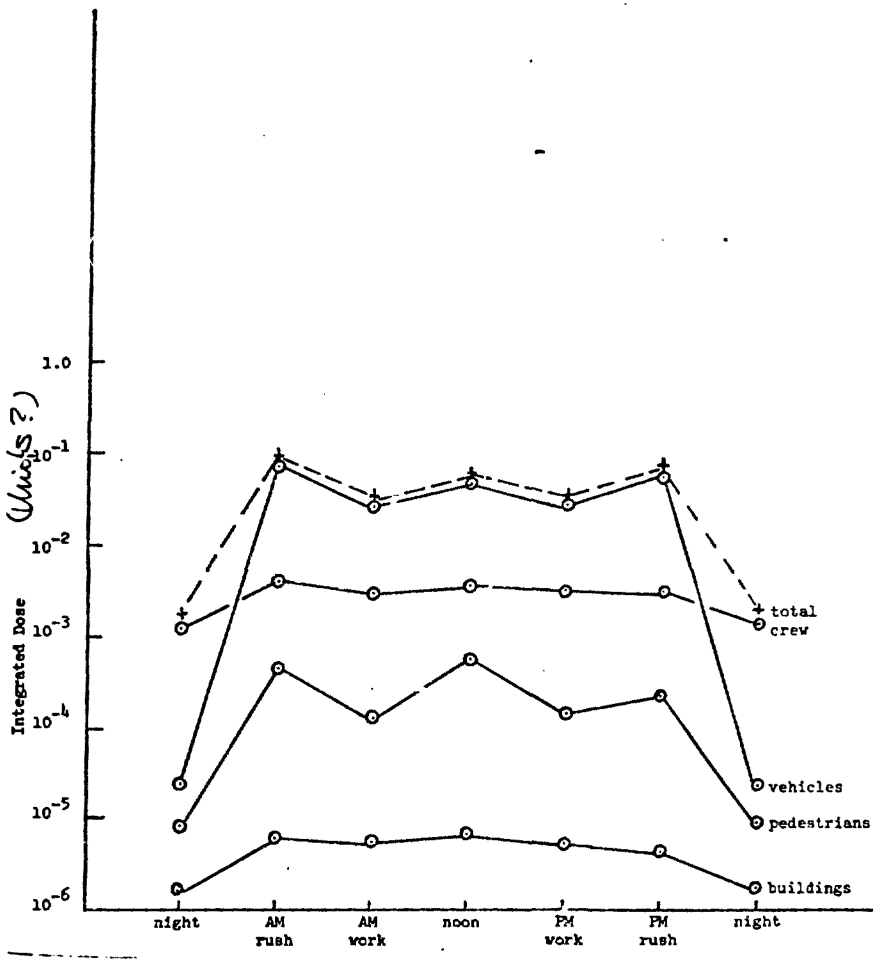

Figure 2.: Dose to surrounding population groups from "normal" transport of radioactive materials on 2-way streets in urban areas.

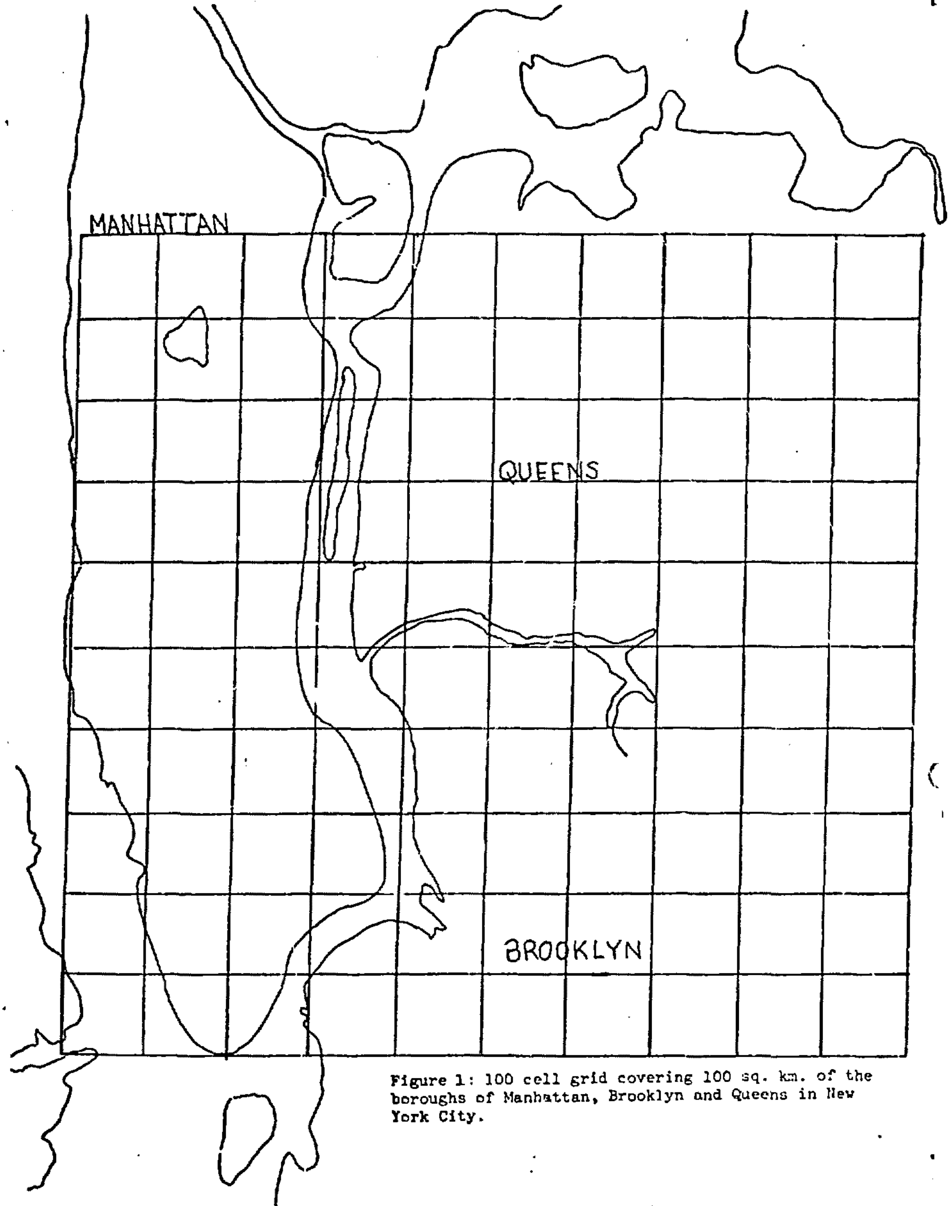

Figure 1: 100 cell grid covering 100 sq. km. of the boroughs of Manhattan, Brooklyn and Queens in New York City.