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A New Approach for Environmental Justice Impact Assessment

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A New Approach for Environmental Justice Impact Assessment

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Abstract

President Clinton's Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, calls for the examination of disproportionately high and adverse impacts to minority and low-income communities. Many environmental justice analyses have successfully identified minority and low-income communities through demographic mapping. However, in support of the Executive Order, environmental justice analyses should also include quantitative *impact* assessment to demonstrate the presence or absence of disproportionately high and adverse impacts on low-income and minority communities. This study demonstrates use of a geographic information system (GIS) and a computer model to analyze the potential for disproportionate impacts resulting from a hypothetical facility accident.

One part of an environmental justice impact assessment includes the collection and mapping of demographic data to identify the minority and low-income communities in a study area. GISs have been used as an effective tool for this demographic mapping. The second, and often overlooked portion of a quantitative environmental justice assessment is impact analysis; for which a GIS may also be used.

For this demonstration, a safety analysis report and a computer code were used to develop impact assessment data from a hypothetical facility accident producing a radiological airborne plume. The computer code modeled the plume, plotted dose contours, and provided latitude and longitude coordinates for transfer to the GIS. The GIS integrated and mapped the impact and demographic data to provide a graphical representation of the plume with respect to the population.

Impacts were then analyzed. The GIS was used to estimate: (1) the total dose to the exposed population under the plume, (2) the dose to the low-income population under the plume, and (3) the dose to the minority population under the plume. Impacts among the population groups were compared to determine

whether a disproportionate share of the impacts were borne by minority or low-income populations.

A primary goal of President Clinton's Environmental Justice Executive Order is the prevention of disproportionately high and adverse impacts on minority and low-income populations such that all communities and persons live in a safe and healthful environment. Identification of these minority and low-income communities is an important first step in conducting and environmental justice impact analysis. A more complete assessment, however, includes impact assessment to demonstrate the presence or absence of disproportionate impacts. Some environmental justice studies have combined demographic data with impact assessment data to assess impacts of normal facility operations. A new approach to environmental justice impact assessment considers facility accident scenarios to provide another measure to test for potential disproportionately high and adverse impacts to minority and low-income communities.

Background and Requirement for Impact Assessment

Environmental Justice, as defined by the U.S. Environmental Protection Agency (EPA), is the fair treatment of people of all races, cultures, and income such that no racial, ethnic or socioeconomic group bears a disproportionate share of the environmental consequences of a program or policy (EPA 1994). President Clinton's Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, calls for the examination of disproportionately high and adverse impacts to minority and low-income communities. Many of the analyses prepared thus far for U.S. Department of Energy (DOE) National Environmental Policy Act (NEPA) documents have successfully demonstrated demographic mapping of minority and low-income communities. In support of the Executive Order, however, quantitative impact assessment should also be conducted to identify any disproportionate impacts on minority and low-income communities.

The U.S. Environmental Protection Agency (EPA) has demonstrated effective use of a geographic information system (GIS) to assess potential disproportionate impacts to communities from facility operations (EPA 1995). This paper presents a new approach for quantitative environmental justice impact assessment using a GIS and a computer model to test for disproportionate impacts resulting from a hypothetical accident scenario at an existing facility.

Demographic Analysis

One component of an environmental justice analysis is the identification of population demographics. Demographic data include population composition with respect to minority and low-income communities.

Demographic data were obtained from two sources: (1) the U.S. Bureau of the Census Summary Tape Files (STF), and (2) the U.S. Geological Survey (USGS) Topologically Integrated Geographic Encoding and Referencing System (TIGER)/ Line files. The USGS TIGER/Line files provide political boundaries and STF files provide population data (Census 1990, Census 1991). The two data sources were joined and processed by a commercially-available GIS. For this demonstration, population data were aggregated at the Census Block Group level and assumed to be evenly distributed across the entire Block Group.

For an environmental justice impact assessment, two population parameters are considered: (1) minority populations, and (2) low-income populations.

"Minority" generally includes individuals listed by Office of Management and Budget Directive Number 15 as Black/African American, Hispanic, Asian and Pacific Islander, American Indian, Eskimo, Aleut, and other nonwhite persons (Census 1991a, EPA 1994). A minority population percentage was derived for each Census Block Group by comparing the total population with the derived minority population for each of the Block Groups in the analysis. The data were mapped in the GIS and representative shading applied to show areas with minority populations in concentrations greater than 50 percent, 25 to 49 percent, and less than 25 percent minority population in the Block Group.

"Low-income" generally incorporates EPA guidance (EPA 1994) and other agency poverty guidelines such as those of the Department of Health and Human Services (HHS 1994), and the Department of Housing and Urban Development(HUD 1937 and 1974). A good practice is to apply a definition that most accurately reflects the relative cost of living in the particular area under consideration. Low-income population distribution was based on Federal poverty status guidelines and considered household income, the size of the family, and the number of children less than 18 years of age. A Census Block Group that had 50 percent or more of its population in poverty status was shaded on the map.

Impact Assessment

A Safety Analysis Report (SAR) prepared for the U.S. Department of Energy (DOE) provided data about potential accidents for the impact assessment. SARs are prepared for DOE nuclear facilities according to DOE Orders to establish and evaluate the adequacy of the safety basis of a facility. The facility SAR was used to identify various accident scenarios from which a hypothetical "worst-case" or bounding accident was derived. In the postulated accident scenario, a hypothetical facility explosion would elevate an unfiltered plume of radionuclides into the atmosphere under conditions favorable for transport and dispersion of radionuclides.

The Lawrence Livermore National Laboratory (LLNL) Atmospheric Release Advisory Capability (ARAC) dispersion computer code was used to model the plume and calculate the radiological doses to the people under the plume.[1] The LLNL ARAC computer model calculated the downwind dose and ground deposition values for radionuclides from this hypothetical accident scenario. Radiological dose contours for a 50-year committed effective whole body dose were plotted in contours ranging from 30.0 to 0.003 rem.[2] This plot was then converted to latitude and longitude coordinates and imported into the GIS for processing with the population demographics.

Disproportionate Impact Analysis

Disproportionate impacts were assumed to exist if the proportion of the total dose to the minority or low-income population appreciably exceeded the proportion of the dose to the general population under the plume. Higher impact proportions imply that minority or low-income population groups bear a disproportionate share of the adverse impacts; lower impact proportions imply that minority and low-income populations do not bear a disproportionate share of the adverse impacts. For this demonstration, the population under the plume was used as the study population because those were the people who would be directly affected by the postulated accident scenario.

Results were presented both in graphical and tabular format. Figure 1 shows the integrated distribution of the plume and minority populations. Areas of minority population are shaded in zones of greater than 50%, between 25% and 50%, and less than 25% minority population within the Census Block Group. Radiological dose is presented in graded contours from 30 rem to 0.003 rem. Figure 2 provides similar data for the low-income population distribution with respect to the same plume.

The data were further examined by the GIS and expressed in tabular format for numerical calculations as shown in Table 1.

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[1] Other computer codes could be used to model accident scenarios.

[2] Other dose contours, such as a 10 millirem contour, could be plotted to aid in demonstrating compliance with regulatory dose limits.

Figure 1

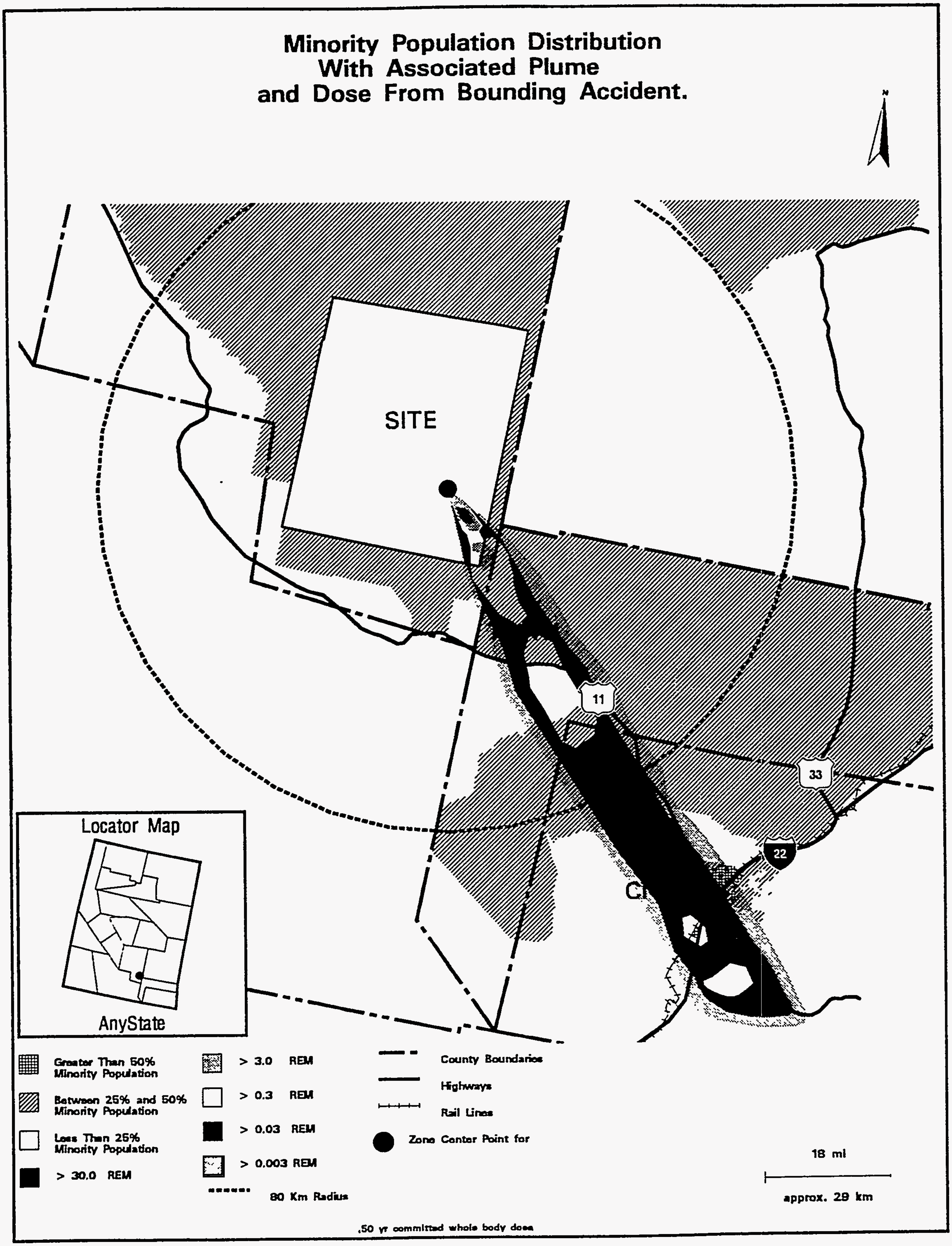
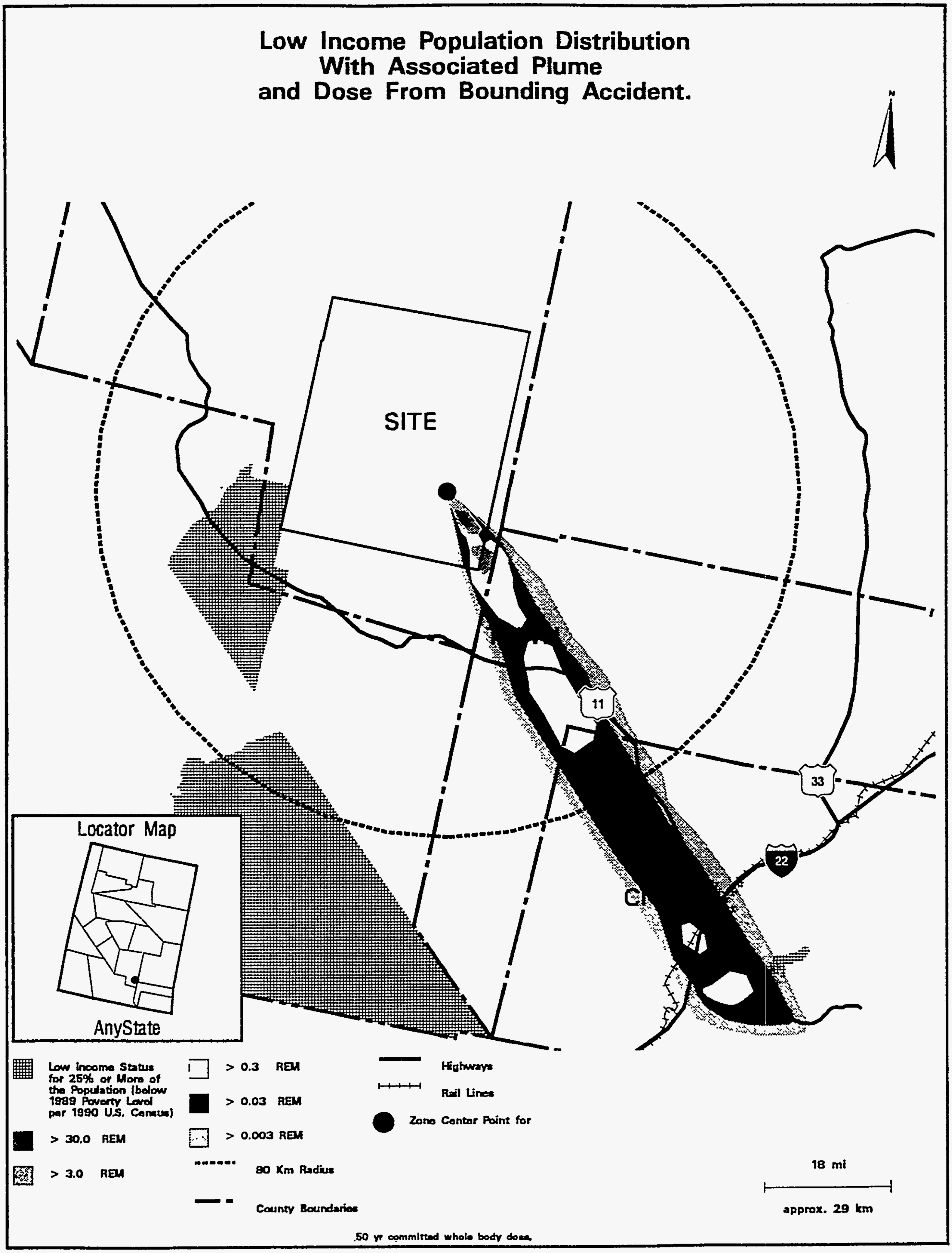

Minority Population Distribution
With Associated Plume
and Dose From Bounding Accident.
N
SITE
11
33
22
Locator Map
AnyState
Greater Than 50% Minority Population
Between 25% and 50% Minority Population
Less Than 25% Minority Population
> 30.0 REM
> 3.0 REM
> 0.3 REM
> 0.03 REM
> 0.003 REM
80 Km Radius
County Boundaries
Highways
Rail Lines
Zone Center Point for
18 mi
approx. 29 km
.50 yr committed whole body dose

Figure 2


Low Income Population Distribution
With Associated Plume
and Dose From Bounding Accident.
N
SITE
11
33
22
Locator Map
AnyState
Low Income Status for 25% or More of the Population (below 1989 Poverty Level per 1990 U.S. Census)
> 30.0 REM
> 3.0 REM
> 0.3 REM
> 0.03 REM
> 0.003 REM
80 Km Radius
County Boundaries
Highways
Rail Lines
Zone Center Point for
18 mi
approx. 29 km
50 yr committed whole body dose.

The first column in Table 1 shows the radiation dose values corresponding to the dose contours shown in the Figures. The second column displays the total population between the contours. For example, the population inside the 0.003 contour and outside the 0.03 contour is 141,811. The third column is the estimated dose to the population between the dose contours, which is obtained by multiplying the geometric mean dose rates of the two bounding contours by the population between the contours. [3] The next two columns provide data for the minority population within the contours, and the last two columns provide data for the low-income population.

Table 1. Minority and Low-Income Population Impacts

Radiological dose contour (REM)	*Population within contour*	*Population Dose (person-rem)*	*Minority Population within contour*	*Minority dose (person-rem)*	*Low-Income population within contour*	*Low-Income Dose (person-rem)*
0.003	141,811	1,345	51,547	489	19,014	180
0.03	452,538	42,932	94,751	8,989	42,522	4,034
0.3	26,106	24,766	4,780	4,535	2,185	2,073
3.0	none	none	none	none	none	none
30.0	none	none	none	none	none	none
total	620,455	69,043	151,078	14,013	63,721	6,287
proportion	--	--	24.35%	20.30%	10.27%	9.11%

The data in Table 1 show that of the 620,455 persons affected, 24.35% are minorities and 10.27% are low-income. One would expect the total dose (69,043 person-rem) to be distributed in similar proportions. However, the minority population receives 20.30% of the total dose,

[3] The geometric mean is appropriate when analyzing changing quantities such as a dose rate applied over a geographic area. The population dose to the people in the area between the 0.003 rem and 0.03 rem dose contours can be estimated using the geometric mean dose as follows:

$$(141{,}811\ \mathit{people})\ x\ \sqrt{(0.003\ \mathit{rem})\ x\ (0.03\ \mathit{rem})}\ =\ 1{,}345\ \mathit{person{-}rem}$$

which is less than their representation (24.35%)in the total population. One can conclude, therefore, that the minority population does not bear a disproportionate share of the adverse impacts. The data also show that 10.27% of the affected persons are low-income, and that this low-income population receives 9.11% of the total dose. Because the proportion of the dose is lower than their representation in the total population, one can conclude that the low-income population is also not disproportionately affected. The application of further statistical tests to estimate disproportionate impacts is not necessary for this example because the data are based on actual population counts rather than statistical sampling.

Other Considerations

This study provided a test for analyzing potential disproportionate impacts resulting from a hypothetical accident an existing facility. A similar method could also be applied to support decisions regarding the siting of a facility considering multiple site locations. Such an approach would require statistical analyses, sampling, hypotheses formulation and testing based on a suitable reference population (such as that of a state or county). The approach taken by this example employs actual population counts combined with computer-modeled impacts to determine potential effects to the public under an accidental release.

Impact data were presented in terms of a plume with radiological doses estimated in regions separated by contours. The impact data might also be presented as an array of points with consequences identified at each point. In such case, the effects on population centers in the region could be estimated by interpolating with respect to the effects identified at nearby points. This approach would facilitate evaluation of economic consequences such as estimated impacts on property values.

This analysis used demographic data aggregated at the Census Block Group level. Other political boundaries could be used depending upon the size of the area under evaluation. In an urban setting, varying degrees of detail may be desirable; data may therefore need to be aggregated at the Census Block level for finer resolution or at the Census Tract level for broader resolution. In non-metropolitan areas, data may need to be aggregated by Block Numbering Areas or Block Groups.

For a more in-depth environmental justice impact assessment, the accident impact data could be further analyzed for cumulative impacts that might occur in conjunction with impacts from normal operation of near-by industrial facilities. For example, the EPA has conducted environmental justice impact assessment studies using a GIS and Toxic Release Inventory (TRI) emission-source data (EPA 1995). Cumulative impact assessment would also consider lifestyles, age, health, habits, or special resource consumption patterns of the minority and low-income population groups.

Conclusion

A primary goal of President Clinton's Environmental Justice Executive Order is the prevention of disproportionately high and adverse impacts on minority and low-income populations such that all communities and persons live in a safe and healthful environment. Many environmental justice assessments have successfully demonstrated demographic mapping capabilities using a GIS. Other studies have also combined these demographic data with impact assessment data for normal facility operations. A new approach to environmental justice impact assessment considers facility accident scenarios to provide another measure to test for potential disproportionately high and adverse impacts to minority and low-income communities.

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