# Perspectives on Nuclear Weapons and Community Health

*A Newsletter of the Community-Based Hazard Management Program*

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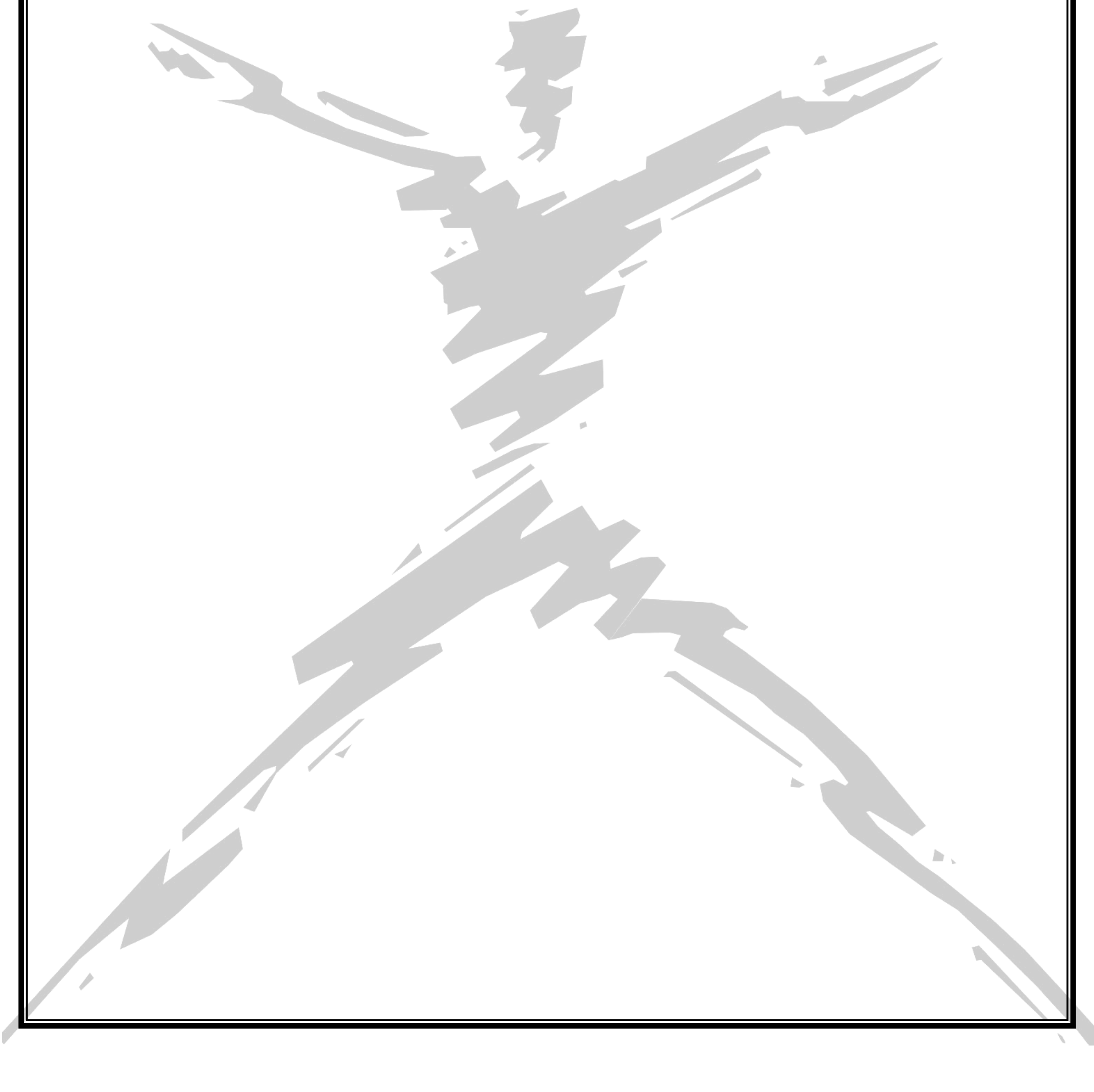

**The Community-Based Hazard Management Program** operates on the principle that the empowerment and protection of a community affected by the US nuclear weapons complex activities are directly dependent upon a community's ability to understand, evaluate, and provide input into the management of the complex health hazards associated with radiological and chemical contamination. We have a strong commitment to community-based research, education, and training activities and to the creation of public participation mechanisms that address the inadequacies of remaining health concerns. Without an informed public, there will be no community pressure or oversight to guide implementation of meaningful government health responses and improve our scientific understanding of these hazards.

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# Geographic Information Systems for Community Environmental Health Applications

By Seth Tuler, Community-Based Hazard Management Program

A Geographic Information System (GIS) is computer software that supports mapping and geographic analysis. A GIS can be used to acquire, store, analyze, retrieve, and display large quantities of data about the environment. While GIS technology has been the object of research projects, applications of the technology can illuminate diverse social-environmental problems. Social statistics from surveys, government records, and maps can contribute to scientific assessment of the problem, and more informed decision-making. While GIS is primarily used in government for planning and implementation of policy, environmental health study methods and opportunities for community involvement are benefiting from the development of GIS.

## GIS as a Health Research Methodology

GIS has been developed for environmental conflict resolution, allocation of resources, and distribution of risk in society. At the U.S. National Laboratories, GIS methods have been developed and implemented characterizing environmental impacts at hazardous disposal sites, pollutants in groundwater and air, environmental clean ups, probabilistic risk assessment, environmental decision making analysis, and global change processes. In health research, GIS is used to support the risk assessment and management process at each stage, i.e. hazard assessment, vulnerability assessment, risk assessment, and decision-making. At the National Center for Geographic Information, there has been an increasing interest in Public Participation GIS (see GIS literature review on page 5).

It is beyond the scope of this article to go into detail of the internal intricacies of the computer system and the differences between softwares (ArcInfo, MapInfo, and Idrisi are examples of software). We focus here on the question: What does it mean to use GIS as a health research method? Notwithstanding the pitfalls of overstating the power of the technology, this summary will end with a note on how GIS can also be used to integrate newly collected community-based data with existing data. A few different applications of GIS are explored to provide examples of how GIS can incorporate environmental monitoring data and can improve communication between the community, the polluting facility owners, and governmental environmental managers and health risk assessors.

## Components of a GIS

Exploring a GIS database requires database management, map processing capabilities, and spatial statistical analysis procedures. As such, it is a research and decision-making tool which can be applied to assist in epidemiology, dose reconstruction, and community-based environmental health planning efforts which require massive data sets and accurate calculations involving many variables (Clarke 1996, Wartenberg 1993). In practice, the variables in a GIS can be complex in origin but simplified in their mapped form.

As shown in Figure 1, a GIS operates around its database. The user must manage the sub-systems of the GIS, such as statistical analysis programs, image and map digitizing systems, and database management programs to control input and output. The users of the system are the most important condition for the use of GIS - the system can only serve those interests that are brought to it, and the GIS cannot answer questions by itself. This point highlights the need and the possibility for training in GIS if communities are encountered with health research using GIS.

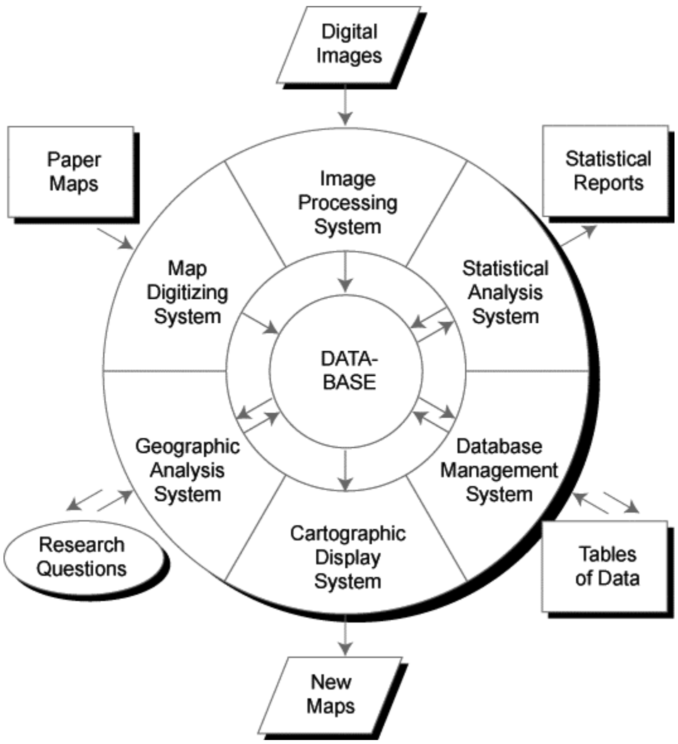
## The Database

GIS use data from a variety of sources. Being data-dependent has its drawbacks and advantages. Drawbacks include, for example, variability, uncertainty, and biases in different data sets. In addition, some data may not be available, and some maybe expensive to buy or produce.

Major advantages of using GIS, besides speed of computing and ease of multiple tasks, also revolve around the data. By generating new combinations of data, importing new "georeferenced" data, and building new, previously unexplored geographical relationships between data, GIS software can enable you to generate new hypotheses, look at your existing questions in a new way, and allow other users (or non-users) to understand your data, your research questions, and various geographical contexts simply and quickly. Mapping can bridge communication gaps between participants in a study or between participants and non-participants. Mapped results can be viewed at different geographic scales, and even from different physical perspectives (such as with three-dimensional elevation models) or

**Figure 1**

**Uses of GIS. Arrows indicate human actions using the various components of a GIS.** (Adapted from Eastman et al., 1995, Figure 2-1.)




from conflicting philosophical perspectives (which give greater or lesser value to some features over others).

A GIS requires two types of data:

- *spatial data* about position and location, which describe**s** the geography (shape and position) of features on Earth.
- *attribute data* about the characteristics of those locations, which describe the characteristics or qualities of these features. Features may have qualitative attributes (variable by type) or quantitative attributes (variable by amount).

For example, one square meter of land (spatial data) can be characterized by its soil type, the vegetation growing there, its elevation, or its distance from another feature on the map. In our case study, each "polygon" used to organize spatial data was characterized by soil arsenic concentrations. While geographic data allow the user to answer "where" questions, attribute data allow us to address "what" questions. Analysis of complex research questions about environmental processes ("how" questions) can require many sets of attribute data in addition to knowing geographic relationships. This basic organization of a GIS database allows the user to learn about complex geographical processes.

A GIS database contains both types of data, whether in an integrated or rigidly separated fashion, depending on how the digital data is stored. The two types of data are linked by the user who makes inquiries or analyses. Since most of the data analyzed in environmental health research are spatially distributed "patterns" of characteristics, the integrated database is quite useful for finding relationships over space and time. So, as epidemiology is a method for studying the spatial patterns of diseases while considering historical and other temporal dimensions, the GIS data can be used improve the comprehensiveness of epidemiology's spatial, temporal, and statistical needs.

The data used in GIS analyses are often "imported" from existing databases or spatial data from maps can be transformed (digitized) from paper maps. Just as raw data can be imported, users can also import quantitative and qualitative documented history and assessments of that history (values placed on features), such as medical monitoring data, ecological survey data, dose reconstruction data, risk assessment data, epidemiological data, local perceptions, and oral histories (statistical reports, paper maps, or tables of data). Similarly, the United States Geological Survey, the US Census Bureau, and other governmental agencies have digital maps and attributes of basic geographical data (social-demographics, topography, water bodies, towns, cities) ready to load into a system. Importing each of these involves different routines and may require additional hardware, such as a digitizing tablet (to "trace" existing maps) or a magnetic tape reader. Satellite imagery is most difficult to use, as it requires specialized knowledge to enhance, classify, and transform the components of the image into data that are useful for the task at hand.

An important step for any GIS project is to design a base map or series of base maps. The development of a base map is the beginning of any analysis. Users should ask: What important features should always be on the map? What should the scale of the map be? What colors and symbols should be used? Property ownership information, present and past land uses (wilderness, farming, recreation, mining, etc.), water sources, and other spatial and temporal aspects of community can contribute to developing the base map for future research analysis.

Also on this base map might be the community's focal point (or points) of environmental health concern. For example, a focal point may be the location of a nuclear facility or an incinerator. During subsequent analyses, the spatial distribution of different features can be measured, stratified, and compared by distance to these focal points. Typically, health agencies measure effects with concentric circles around the facility at one mile, three miles, five miles, and ten miles. Very large and heavily polluting facilities might require further distances or even at a different geographic scale (local, regional, national, international, global).

As part of early data collection, meteorological data on storms, weather patterns, and wind patterns are easily available for most systems from the National Weather Service. These aspects may be essential to reconstructing a community exposure history. These data would not typically be used on base maps, but would be very useful information for initial environmental health analyses when contamination and ecological interaction are involved. Such data may contribute to process models if meteorological data are necessary. Coupled with emissions data from the Toxics Release Inventory or other routing environmental emissions data, likely environmental deposits of contamination can be estimated such as scientists would do as part of a dose reconstruction.

## Types of Analysis

Many types of analysis can be done as GIS-supported research, including database query, derivative mapping, and process modeling:

D*atabase query* is used to explore a map image by selecting various combinations of data to be highlighted on a map for examination. This can be done for one location or many. For example, one might ask: What is the land use at this location? Or what areas have high levels of groundwater contamination? An inquiry can also be made of an entire map or set of maps based upon user-defined characteristics. For example, what are the locations of monitoring wells with respect to known and suspected groundwater contamination plumes? One could highlight all land below a certain elevation within close proximity to water bodies and rivers to determine which areas are at risk of flooding. The GIS could produce statistics based on your variables, such as number of acres flooded due to different flood stages. Database query does not produce new information, it simply shows us selections from our database in a new way. We can also produce charts, graphs, and lists from database query.

*Derivative mapping* involves combining selected components of the database that can be used in further analysis. If users do not have a map of essential components, such a map can be created by analyzing components of one or more other maps and extracting the necessary features out. With this approach, we can create new data from old data. For example, if we needed slope data and all we had were elevation data, we would map the elevations and calculate slope based upon their distance from one another. This can be done easily with one calculation. What we are doing, by invoking a calculation, is adding our knowledge about the relationships in space between database elements and creating new data. The quality of the new data depends on how we represent that relationship with a calculation.

*Process modeling*, or simulation modeling, offers excellent potential for environmental health research. However, it requires knowledge of processes within the system we model, in the same way that derivative mapping does. In a model we relate various features of a system by defining their relationships. For example, we can simulate how tritium released from a nuclear facility is distributed in the environment by defining the relationships between release of the material into the air, the meteorological patterns that affect its deposition, and knowledge about the rate of uptake into plants or dispersion into groundwater. Using process models we can manipulate the variables in the system, given hypothetical or real events and processes. The distribution of tritium after a release, over time and space, might be calculated using different assumptions about wind and rain patterns, soil characteristics, and vegetation distribution and type. Process modeling is particularly useful for modeling food chains, bio-accumulation of toxic contaminants in the environment, or exposure of humans to hazards. With reliable data and proven knowledge of biological processes, a credible model can be derived. In this way GIS provides a new way of observing what might happen or did happen.

## Community Experience with GIS

In environmental health research, geographical data and their analysis can be useful to generate and test hypotheses. GIS creates an automated environment that can be used to verify historical data, identify gaps in knowledge, and add rigor in terms of uncertainty and vulnerability analysis. The user can also extract specific data for detailed analysis.

GIS has most often been used to meet institutional or private needs. It is obvious why institutional decision-makers are adopting GIS technologies, for its efficiency and adaptability, but desk-top systems are proving attractive for community-based use. Communities face different constraints, among them funding, but there are increasing avenues for community use in forms of grant programs and support for community GIS projects through local, state, and federal government agencies. In fact, with increasing frequency it is being used effectively by and for communities to implement neighborhood planning, make development choices, and track environmental health. Participatory GIS is a promising new approach to making GIS accessible and useful to communities.

In the environmental health risk application of GIS, maps have been presented for community review and CD-ROMs have been used as public participation and public comment tools. For example, a Draft Hanford Remedial Action Environmental Impact Statement was made available to facilitate public comment (USDOE 1996). GIS was also made available to members of the community group FRESH (Fernald Residents for Environment, Safety, and Health, in Ohio) to analyze community-collected data on the incidence of various diseases in their community. GIS research applications for risk analysis and risk management are continuing to be developed. Emphasis is being placed on the value of GIS in determining uncertainty in hazard and vulnerability assessment. It is also being applied in decision-making and conflict resolution procedures where multiple perspectives affect risk evaluation (Emani 1998).

More notably, GIS has been used as a data storage device for on-going environmental monitoring programs at the Three Mile Island (TMI) nuclear facility and the Seabrook Nuclear power plant in New Hampshire. Real-time monitors in people's homes and outdoors are radio signaled directly to a community-controlled GIS system. The use of GIS in a monitoring program are not absolutely necessary, but for a long-term project, storing such data geographically rather than in lists of numerical accounts is a more organized and analyzable foundation for such a project.

There are few examples of community participation in environmental health projects. GIS has typically been associated with top-down, agency-controlled projects. At the same time, GIS shows enormous potential for use to ask and answer questions posed by communities and to help them make decisions. Based on this potential, researchers in Nuclear Risk Management for Native Communities Project are using GIS as a tool specifically to facilitate community participation, capture local knowledge data, perform feasibility analyses for further epidemiological work, build a community environmental health database, and support community risk management decisions for the future (see sidebar, page 6). The Project will have a very complex set of research questions to develop exposure baselines for the more than 100 above-ground nuclear bomb tests of the 1950's and 60's.

The beginning of every GIS project should not only be used to acquire data and prepare for analysis, but also to prepare community members with training and to have group discussions around environmental health issues to determine needs. This is a kind of "needs assessment" to determine the scope of a project. This training-first approach – even if it slows the study down a bit—is necessary for the GIS to be used to its full potential, but also for the tool to be effectively understood by a community. Time spent in training and discussion can also be a productive beginning to an environmental health research project. GIS, as part of a community health needs assessment, can be helpful to: focus thoughts, fund raise; and develop a process for evaluation of other environmental health research.

## Additional Resources

There are many examples of GIS software, produced by both for-profit companies and non-profit organizations. Non-profit software is typically less expensive, requires less high-powered hardware, and is geared toward research questions rather than tasks. Non-profit examples include Clark University's Cartographic Labs "Idrisi for Windows" (www.idrisi.clarku.edu). The most widely-used systems are the for-profit "ArcInfo" and "ArcView" software produced by Environmental Systems Research Institute (http://www.esri.com). Each software is different, and has its own advantages and disadvantages.

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# Literature Review on GIS: Benefits and Barriers to Community Empowerment

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## Background

In recent years, Geographic Information Systems (GIS) has moved away from its traditional clientele of government agencies and private sectors. GIS is now gaining momentum in community organizations and other urban settings. There are many reasons for this increased usage. This literature review is being written to provide current perspectives on the use of GIS in community-based settings. It includes brief descriptions of GIS, Community-Integrated GIS (CIGIS) and Public-Participatory GIS (PPGIS). Lastly it draws attention to the benefits and barriers to implementation.

As discussed elsewhere in the newsletter, Geographic Information Systems is a computer-based mapping system. It is capable of "assembling, storing, manipulating and displaying geographically referenced information" (USGS 2001). In other words, data have to be related to a location in space in order to be used in a GIS (e.g. the location of all dry cleaners in a census block). For the last few decades, "GIS tools have remained in the hands of the technological elite" (Atkins and Stone1998). Those responsible for the development of GIS created a program that was designed based on the "societal and technical conditions in existence [during] the time they were doing their work" (Obermeyer 1998).

More recently, the idea of Geographic Information *Science* has been discussed in the literature. It attempts to bridge the gap where traditional GIS fall short by incorporating a multidisciplinary approach. While GIS must rest on a strong scientific base, it must also incorporate other disciplines. Geographic information science is defined as a research field that seeks to "redefine geographic concepts and their use in the context of geographic information and, more broadly, the digital age. It re-examines some of the most fundamental themes in traditional spatially-oriented fields…, while incorporating more… specialized research themes in such established disciplines as computer science, statistics, mathematics, and psychology" (Goodchild *et al.* 1997).

Traditional GIS created boundaries that have excluded many groups from using this tool. However, with the advent of Community-Integrated GIS (CIGIS) and Public-Participatory GIS, this has slowly, but surely, begun to change. In general terms, "community-integrated GIS seeks to broaden the use of digital spatial data handling technologies with the objective of increasing the number and diversity of people who are capable of participating in spatial decision-making" (Harris and Weiner 1998). Implementing this process begins the daunting task of bringing to the forefront individuals and organizations that have not been able to use GIS for a variety of reasons.

Public-Participatory GIS is quite similar to CIGIS. The term is used to describe a range of topics raised by the infusion of community interests and GIS technology (National Center for Geographic Information and Analysis 1998, Nyerges, *et al.* 1997). The goal of PPGIS is "increased public involvement in the definition and analysis of questions tied to location and geography" (National Center for Geographic Information and Analysis 1996). The vision of PPGIS "includes GIS tools that are easily used and understood by citizens, relevant to public policy issues and available to all sides of public policy debates" (Barndt 1998).

## Benefits and Barriers to GIS

The most apparent benefit that GIS may offer an organization is the ability to help solve some aspect of a particular problem. One problem involves taking spatially referenced empirical information and translating it into a form that allows cartographic representation of patterns and relationships and the analysis of relationships (Obermeyer 1998). The benefit of cartographic representation can be summed up by the idea that a picture is worth a thousand words. A graphic depiction of a problem, be it distribution of monitoring wells, locations of contaminated sites, urban sprawl patterns, preferences for types and locations of retail establishments, can provide a heightened awareness of an issue that may not easily be observed in narrative terms (Barndt 1998).

GIS software is a tool for processing information. As such, a GIS can only be as good as the data collected and available at the time to do an analysis. For the most part, data analysis requires current information, unless a times series analysis is being conducted, where one would need to draw on information from the past in order to link it to present information.

## The Minneapolis Community GIS Project

The Minneapolis Community GIS Project involved a collaboration between faculty and graduate students from the Department of Geography at the University of Minnesota and members of four Minneapolis neighborhood groups (Elwood and Leightner 1998). The four groups were approached and asked if they would be interested in learning more about GIS. The researchers had two objectives in devising and implementing this project: (a) to assess the community groups' access to, needs for, perceived utility of, and concerns about GIS and GIS-based data sources and (b) to facilitate access to and use of GIS and GIS-based information for community-based planning.

Each of the community groups were positive about the capabilities, but also expressed concerns in certain areas. Groups were thrilled at the possibility of being able to graphically represent information. As one community member noted: "GIS would show neighborhood issues and problems in a form that people can understand" (Elwood and Leightner 1998). Community representatives also thought it would be quite beneficial to have the ability to map the amount of toxins released by a company and use it as leverage to encourage producers to reduce releases.

Although groups expressed excitement about using GIS, their excitement was also coupled with concerns. All groups noted apprehension in terms of operating and maintaining GIS software and maintaining databases. There were other issues that occurred in terms of the difficulty in learning computer programs. They found this to be especially true if their organization faced rapid turnover of its employees, which is characteristic of community groups.

This can prove to be a barrier if the researcher is using outdated or incomplete information. For instance, some demographic information from Census 2000 is available. However, if a certain bit of information is not available, a researcher may be tempted to use Census 1990 data to verify certain facts of a community today. This is a thin line to tread because neighborhoods change as does the racial and socioeconomic status of its residents.

PPGIS literature suggests that there is a paradoxical relationship that exists when introducing GIS into community organizations. The belief is that GIS is a "contradictory technology that simultaneously marginalizes and empowers people and communities" (Harris and Weiner 1998). This nexus has the potential to be a major barrier to implementation.

For example, academic researchers, with their good intentions, will often have preconceived ideas for the community that the community members themselves do not hold. Community leaders may feel marginalized by researchers who do not ask them to bring their ideas "to the table" to have an open discussion on how GIS might be utilized within their community. On the flip side, the researcher may become discouraged because the community has not openly embraced their vision for GIS integration. As a result, feelings of exclusion and disappointment may arise from both sides. Proponents of CIGIS and PPGIS "contend that it is necessary to ascertain the communities' perspectives through participatory research in order to determine how GIS might be made more accessible…in a manner which is most appropriate to the communities' needs…and which minimizes the potential for exclusion of less powerful communities" (Elwood and Leightner 1998).

The other side of this dichotomy is empowerment (Atkins and Stone 1999, Harris and Weiner 1998, National Center for Geographic Information and Analysis 1998). Empowerment can be thought of as one measurement of success for a community group. It is believed that GIS may provide the opportunity for individuals and groups who have traditionally been left out of the planning process can now be included alongside the "traditional power structure" (Craig 1998).

One of the most pronounced areas of empowerment is that of the "democratization of data" (Sawicki and Craig 1996). Gaining access to data that were once forbidden, difficult or too expensive to obtain, helps to bridge the gap between the community and political officials that have a vested interest in the community. Access to pertinent information allows the community to "participate [more] fully in planning and policy discussions that affect their neighborhoods" (Sawicki and Craig 1996).

In 1994, President Bill Clinton demonstrated the importance of ensuring spatial data availability to the public by signing Executive Order 12906, which created the National Spatial Data Infrastructure (NSDI). The Order serves to validate the necessity of communities gaining access to pertinent data via hardware and software. However, there are other arguments that say simply accessing the data is not enough if organizations are not taught how to use and analyze the information that they have to influence decisions that directly impact their lives (Elwood and Leightner 1998, Sawicki and Craig 1996).

## Conclusion

From this review, it is apparent that the face of GIS has begun to change. Although this review did not touch upon all of the uses for GIS in community organizations, non-profit groups, and social service agencies, the reader is encouraged to locate the vast amount of information regarding PPGIS and CIGIS via the resources provided here and the Internet. For continued success, organizations must seek the help of local and federal agencies and vice versa in order to develop a holistic approach to implementing and maintaining GIS in community organizations. It is imperative to start any GIS-based effort in a community with first focusing on learning—by researchers, GIS experts, and members of the local community—about what people in a community desire and whether this tool can help them address important concerns. Otherwise, one can spend months teaching a group about GIS, only to later find out that there was no need for it to address critical community concerns or that the interest of the community is not adequate to support the successful implementation of a GIS system.

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# Nuclear Risk Management for Native Communities Project (NRMNC):

## GIS and Community-Based Hazard Management

By Chunling Liu and Stefano Crema

## Introduction to NRMNC

The Nuclear Risk Management for Native Communities (NRMNC) Project is an Environmental Justice program funded in part by NIEHS to strengthen community-based capabilities in addressing and managing the environmental health impacts of nuclear contamination. The project's goal is to prepare community members to make informed decisions regarding the health risks of nuclear hazards by developing and disseminating accessible information on nuclear contamination health hazards, and developing a community-based hazards management infrastructure and plan. Now in its 7$^{th}$ year it has projects at three sites:

1. Southern Paiute and Western Shoshone communities affected by fallout from nuclear weapons testing at the Nevada Test Site;
2. Cherokee and other Native American communities in the vicinity of the Sequoyah Fuels nuclear fuels facility (Oklahoma);
3. The Village of Paguate in Laguna Pueblo (New Mexico) in close proximity to the Jackpile open pit uranium mine.

## GIS and NRMNC

Central to the project's goal is the use of Geographic Information System (GIS). In Nevada and southern Utah, GIS is used to model areas of fallout exposure from nuclear tests with areas that describe the communities' lifestyle. This is accomplished by combining different spatial information. This information includes the physical characteristics of the land, social and economic aspects of the communities and the extent and fallout composition of nuclear test events. The use of GIS facilitates the integration of the multitude of geographic databases created by the multiple research institutes and the native communities involved.

The model developed in the GIS will aid the communities to detect the patterns of nuclear fallout, to identify significant areas for hazard control, and to link the nuclear exposure to their daily activities (e.g., hunting and diet). The creation of maps makes the risk management process more understandable and transparent to native communities.

The GIS process allows the native communities to participate directly in hazard management and decision-making processes. Through interviews and surveys, community members can voice their concerns and needs and they can select and implement their criteria for health-related issues in a participatory GIS process.

## Map Data

To use GIS, we have collected a great deal of information as the basic map layers. These data are stored in a variety of paper and digital formats. For example, some of the nuclear test fallout exposure data are in paper map format, and others in digital (tiff) format. There are a variety of theme maps used: land use cover, fallout (exposure), test site, census, elevation, highway, river, water bodies, rail, reservation areas, native lands, cities and states. These maps are obtained from various sources. The digital (tiff) maps of nuclear test events come from the DOE, state boundary, reservation areas and cities and states maps from the database of Census, the land cover, highway, and water bodies maps come from the USGS website. In terms of structure, these maps include both vector and raster layers, and have different feature types, such as point, line and polygon. We also have established a database of interview data in spreadsheets, such as the diet, mobility, and other lifestyle characteristics of native peoples.

## Technologies Being Used

A wide range of GIS techniques have been employed. Some steps we have taken include:

- Digitizing maps using CartaLinx (a data editing software developed by Clark Labs, Clark University, MA), including the contours and aerial data points showing exposure rate for a number of nuclear test events, cumulative estimated exposure, and the location of the test site.
- Converting all data sets to a common spatial referencing system in the Idrisi GIS analysis software (developed by Clark Labs, Clark University, MA) for the GIS analysis.
- Incorporating the nuclear test events data layers with the native community lifestyle database (such as hunting, diet habits) derived from the interviews.
- Creating 3-dimensional maps combining elevation data with land cover data for each of the reservations.
- Creating continuous exposure surfaces for some nuclear test events using a variety of interpolation techniques. These interpolated maps create an estimated fallout exposure at every location in the landscape.
- Creating a visual picture of native community's livelihood pattern. For example, how far and in which direction does hunting for deer take place?
- Combining the distance, direction and hunting season with the intensity of each test event. We have developed a map that shows areas of high and low risk of exposure to radiation.

Community members and researchers have just begun to tap the power of GIS and how communities can benefit from it. We believe that with continued research, GIS will find more and more potential to contribute to the participatory community-based hazard management program. ✦✦✦✦✦✦

# An Update on the Health Effects of Chernobyl

By Abel Russ, Education Program Director, Community-Based Hazard Management Program

The accident at the Chernobyl nuclear power plant in April of 1986 was the largest accidental release of radiation in history. Approximately 320 million curies of radioactive material were released over the Ukraine, Belarus, Russia, and other countries, including 54 million curies of iodine-131, the radionuclide associated with thyroid cancer (UNSCEAR 2000). Although the accident has caused great suffering, it has improved our knowledge of radiation health effects. Next to the cohort of Atomic bomb survivors in Japan, the populations exposed to this release are the greatest single source of information about the health effects of radiation. The generation and synthesis of information from Chernobyl is ongoing, but the body of literature that has already been created is staggering—a simple search on the National Library of Medicine search engine (http://www.ncbi.nlm.nih.gov/entrez/query.fcgi) pulls up a list of over 2,300 peer-reviewed papers. This article will not attempt to summarize all of this literature, but will be concerned with some key recent findings. These findings are organized into dose reconstruction projects, studies regarding workers at Chernobyl after the accident, and studies regarding children affected by fallout from the accident.

## Dose Reconstruction for Chernobyl Downwinders.

Two groups of downwinders will be considered here: those in the immediate vicinity of Chernobyl and those in surrounding regions of Ukraine and Belarus.

After the Chernobyl accident about 50,000 people were evacuated from the 30-km zone around the reactor. For the 11 days between the accident and evacuation these populations were exposed to significant amounts of radiation. Two recent papers by a European team present estimates of these doses through both inhalation and ingestion pathways (Mück *et al.* 2002 and Pröhl *et al.* 2002). With models that used such input parameters as Cesium deposition, food chain models, and internal dose models of the International Commission on Radiological Protection (ICRP), these researchers have come up with some numbers that we can compare with other 'downwinder' populations. In the case of Chernobyl, early evacuees were exposed externally and through inhalation, and later evacuees were additionally exposed through ingestion of contaminated food and milk. The combined internal doses were found to be 10-13 times greater than the external doses for adults, and 30 to 40 times higher for children. About 40% of the total effective inhalation dose was from Iodine-131 and 60-90% of the total ingestion dose was from Iodine-131, indicating that the thyroid dose should be a major point of concern. The highest exposed settlement in the evacuation zone was Usov, and here the mean thyroid dose from both pathways was estimated to be roughly 200 mSv for adults and 1,200 mSv for infants (Pröhl *et al.* 2002). The adult dose is comparable to the mean dose of 264 mSv received in Hiroshima and Nagasaki (Thompson *et al.* 1994). These doses are higher than doses near the Nevada Test Site[1], but are a small fraction of the adult doses received by Marshall Islanders exposed to testing fallout (3 and 21 Sv on Utrik and Rongelap atolls, respectively; Hamilton *et al.* 1987). The doses received by infants are of special concern because they are so much greater and also because infants have a much greater thyroid cancer risk per unit of dose. Based on an excess relative risk of 7.7/Sv (Ron *et al.* 1995) the infants exposed in Usov experienced a thyroid cancer risk roughly 10 times the background risk. Based on the risk estimate published by Jacob *et al.* (1999; discussed below) these infants would have almost 30 times the background risk.

## Workers Mortality

V.K. Ivanov and colleagues studied 65,905 Russian emergency workers exposed at Chernobyl (Ivanov *et al.* 2001). Although mortality for this group was no higher than for the general Russian population, this is not proof of no effect. This finding can also be explained if the workers were healthier than average and had a lower mortality risk before they were exposed (the healthy worker effect). The authors did detect significant dose-response relationships for malignant neoplasms and cardiovascular disease; they determined that there was an excess relative risk of about 2 per Sievert for cancer and about 0.5 per Sievert for cardiovascular disease. Kurjane *et al.* (2001) studied the immune status of Latvian clean-up workers exposed at Chernobyl. They found evidence of impaired immune systems including a

[1] The mean child (age 9-19) dose in Washington County, Utah, during the peak nuclear testing years of 1951-1958 was 170 mSv (Kerber *et al.* 1993). Child doses would be higher than adult doses and lower than infant doses.

reduction in T cells and neutrophil phagocyte activity. The authors also detected an increased level of IgM, the most efficient antibody in stimulating complement activity (see Pacini 1999, discussed below, for a report on increased thyroid antibodies in children).

## Effects on Children

The most significant health effect of the Chernobyl accident has been childhood thyroid cancer. One 1997 review article commented on the initial skepticism among the scientific community; this eventually gave way to a consensus acceptance of a dramatic increase in thyroid cancer (Schwenn and Brill 1997). In 1998 an international team led by Belarussian Larisa Astakhova reported on a case-control study of Belarussian children. 107 cases were considered with two groups of matched controls, all children aged 0-11 years at the time of the accident. The first group of controls was drawn from the general population and the second group was selected to have had the same opportunity for diagnosis as the cases[2]. In both tests a significant pattern was observed; when using the first group of controls an odds ratio of 5.84 (95% CI 1.96-17.3) was found between the group with thyroid doses lower than 30 rads and the group with thyroid doses greater than 100 rads. A similar odds ratio was found using the second group of controls. Another recent paper described the reconstruction of thyroid doses for 3 cities and 2,729 settlements in Belarus and the Bryansk district of the Russian Federation (Jacob *et al.* 1999). Doses ranged up to just over 200 rads, and an excess relative risk per Gray of 23 (95%CI 8.6-82) was derived. In the most recent piece of evidence, looking at over 20,000 children within a 150-km radius of Chernobyl, a team of Japanese and Russian researchers found increased thyroid cancer incidence by comparing people with different birth dates (Shibata *et al.* 2001). Iodine-131, the fallout component responsible for thyroid cancer, has a half-life of just eight days, so virtually all of the I-131 released from Chernobyl decayed within a few months of the accident. The unexposed control group in this study therefore included 9,472 children born after January of 1987. There were no thyroid cancers in this group. There were two exposed groups analyzed in this study: The first group included 2,409 children who were born between the date of the Chernobyl accident and December of 1986; one cancer was found in this group. Second, 9,720 children were born between January of 1983 and April of 1986. These subjects were all infants and toddlers at the time of the accident. There were 31 cases of thyroid cancer in this group, a highly significant result.

[2] This second control group was selected to address the idea that intensive screening after the accident may have turned up more cancer cases than would have been detected normally, thus artificially increasing the cancer rate.

The rate of thyroid cancer has clearly increased, and it may also be the case that these radiation-induced cancers are characteristically different than background thyroid cancers. Ukrainian surgeon Stanislav J. Rybakov and colleagues (2000) operated on over 339 children between 1981 and 1998; 330 of the operations were done after the Chernobyl accident. They report that cancers in children who had been exposed to high levels of radiation were more extensive, more highly invasive, and more likely to be accompanied by nodal metastases. Similar findings had been reported by Pacini *et al.* in 1997. They found that post-Chernobyl thyroid cancers in Belarus were more likely to affect younger subjects, were less influenced by gender, were more aggressive, and were more frequently associated with autoimmunity when compared to naturally occurring cancers in Italy and France.

When Schwenn and Brill wrote their review in 1997, it appeared that this increase in thyroid cancer was the only significant health effect of the accident. Since that time, a few new findings have suggested that other health effects have developed. One effect is thyroid autoimmune disease, particularly hypothyroidism. Pacini *et al.* (1999) looked at 287 children from the village of Hoiniki who were up to 10 years old when they were exposed to radiation from the Chernobyl accident (13 children were *in utero* at the time of the accident). When compared to a control group from Braslav, Vitebsk province, a significant elevation of circulating thyroid antibodies was found. This is thought to indicate a higher probability of disease development, although at the time of the study disease rates were similar. In 1996 a team led by Yuri Dubrova published a paper claiming that increased germline mutations were observable in Belarussian children, but this paper was widely challenged on the grounds that the control group (British families) was too different from the experimental group, that several potentially confounding factors were not accounted for, and that the A-bomb survivor research was not detecting a genetic effect (Stone 2002). Schwenn and Brill described the Dubrova results as "highly suspect." In February of this year, however, Dubrova *et al.* (2002) published new results that seem to validate the earlier findings. The newer study looked at the germline mutation rate in families around the Semipalatinsk nuclear test site in Kazakhstan, all with effective doses greater than 1 Sv (in this case the control group consisted of unexposed families also from Kazakhstan). Germline mutations increased 80% in the exposed generation and 50% in the children of the exposed, and although the health effects of these particular mutations are unknown, these results strengthen the evidence for low dose genetic effects.

Another health effect that may be reopened to debate is leukemia. Schwenn and Brill (1997) had seen no evidence of Chernobyl-related leukemia in 1997, but

Andrey Noshchenko and colleagues have recently published two papers that describe a link between Chernobyl and leukemia in the Ukraine. The first paper (2001) found an increase in all leukemias, and in lymphoblastic leukemias specifically, when comparing the Zhitomir (exposed) and the Poltava (unexposed) regions of the Ukraine. The exposed and unexposed groups in this study were comprised exclusively of the 1986 birth cohort in order to focus on effects of exposure *in utero*. Although these results are merely suggestive, they follow on a 1996 report of similar results in Greece (Petridou *et al.* 1996). The second Noshchenko paper (2002) reports on a case-control study based in Zhitomir and Rivno regions. 272 cases of leukemia were identified in people that had been age 0-20 at the time of the accident (72 more cases than predicted based on pre-accident leukemia rates). Bone marrow doses were estimated for these cases and for controls matched by age, gender, and type of settlement. Increased risks of leukemia generally, and acute, acute lymphocytic, and acute myeloid leukemias specifically, were observed for males and for both genders combined. The authors found their risk estimates to be similar to the estimates of Stevens *et al.* (1990) with residents downwind of the Nevada Test Site[3].

## Summary

In summary, researchers have detected increased cancer, increased cardiovascular disease and impaired immune systems in emergency and clean-up workers. A dramatic increase in childhood thyroid cancer has been seen in addition to evidence of an increase in leukemia, an increase in thyroid autoimmune disease, and an increase in germline mutations in the children of exposed parents. It seems clear that the health effects of the Chernobyl accident are still being discovered. When we consider that the process of learning from the atomic bomb survivors' experience is continuing more than 50 years after those disasters, we can see that the Chernobyl research project is just beginning.

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[3] Noshchenko et al found an odds ratio for acute lymphocytic leukemia of 3.1 (1.5-6.4) when comparing bone marrow doses >10 mSv to doses <2 mSv. Stevens et al found an odds ratio of 1.69 (1.01-2.84) when comparing marrow doses of 6-30 mGy to doses <3 mGy.

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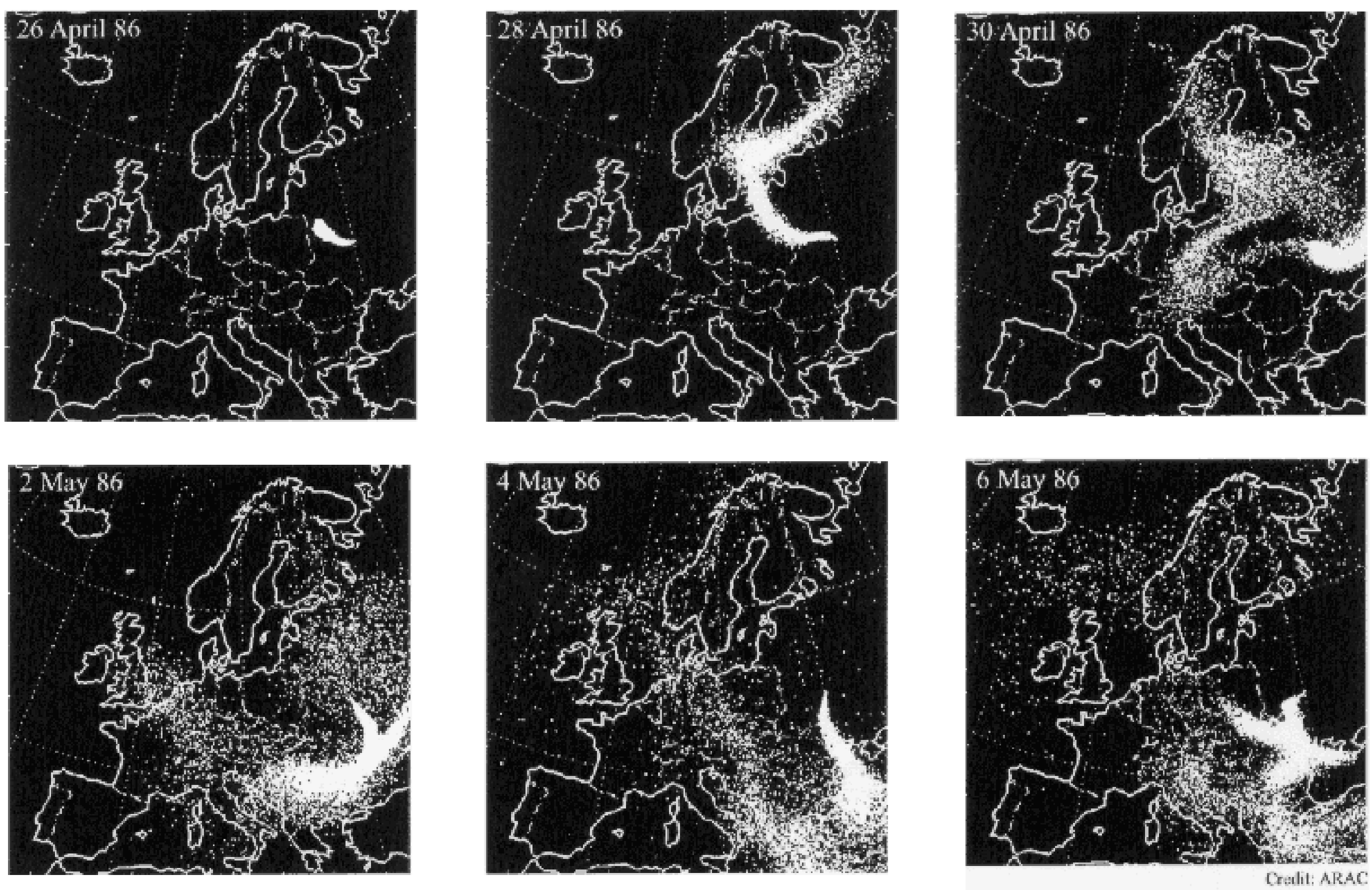


Chernobyl fallout cloud 4/26-5/6 1986 (OECD Nuclear Energy Agency: http://www.nea.fr/html/rp/chernobyl/chern6.gif)

# An Overview of the Radiation Exposure Compensation Act (RECA)

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## Background

In the early Cold War years the United States, like a few other nations, was engaged in a determined effort to produce nuclear weapons. Many people were exposed to radiation through the extraction and processing of radioactive materials and weapon production and testing. Native communities were hit especially hard as they worked in the mines and saw, at close range, their ancestral homeland bombed over and over again. In an attempt to rectify some of these injuries the US government passed the Radiation Exposure Compensation Act (RECA) in 1990 and amended it in 2000 to correct some flaws. This article reviews the effectiveness of this legislation to date (a separate bill to compensate nuclear workers was discussed in our previous newsletter).

RECA was initially intended to partially restitute individuals who worked at test sites or in uranium mines and who had developed serious illnesses, primarily cancers. Three initial categories of claimants included uranium mine employees, residents downwind of the Nevada Test Site, and veterans who actually participated onsite in above ground nuclear weapons tests.

## Statistics on Applications and Costs

The RECP (Radiation Exposure Compensation Program) had received 7,819 applications for compensation by the end of the 2000 fiscal year. Program statistics show that there were an equal number of applications approved and denied- roughly 46% of applications were denied, 46% were approved, and 8% at the time were still pending.

The cost of the RECP changes year to year, but through the end of the 2000 fiscal year the program had awarded $241.1 million in compensation to 5,150 victims and their survivors. At this point the established Trust Fund for the program had run dry, thus putting a temporary stop of payments on awards.

All the claims filled with the Justice Department are the responsibility of the Justice's Civil Division. Processing the data takes approximately 12 months, the maximum time allowed by law, according to an analysis performed by The General Accounting Office (GAO). Some claims have taken more than 12 months to process following the decision of the Attorney General to allow claimants extra time to come up with sufficient documentation to defend their claims.

If a claim is approved, then the Treasury Department makes the appropriate payment from the Trust Fund. If a claim is denied, the program will notify the claimant and inform him or her of the reasons for the rejection. Claimants have two chances to resubmit their claim and a chance to appeal a final rejection with the Justice of Appeals office. If the appeals officer confirms the denial, claimants can file a petition with the US District Courts. In cases of deceased victims, payments are awarded to the victims' eligible survivors (e.g., spouses, children, and in some cases grandchildren).

## The 1990 RECA

The 1990 version of RECA was criticized on several grounds, including internal inconsistencies, the diseases covered, amounts of compensation, and a slow and burdensome process. Facing pressure from communities and legislators, the President's Advisory Committee on Human Radiation Experiments investigated the RECP, issuing a final report on October 3, 1995. Among the recommendations included in the report was a comment on compensation for uranium miners, where RECA had been characterized as unfair and inconsistent with current scientific information[4]. The Committee agreed that published studies, including epidemiological studies on uranium miners, had revealed a causal relationship between exposure to radon and development of lung cancer below RECA's original minimum exposure threshold of 200 working level months.

The other recommendations, which played a considerable role in the RECA Amendments of 2000, included that amendments should:

1. incorporate in the Act a new set of compensation criteria for lung cancer based on minimum levels of radon exposure instead of using probability of causation calculations. The latest epidemiological data have suggested that exposure information is not adequate to calculate these probabilities; the

[4] http://dinecare.indigenous.org/reca-cover.html

minimum levels are intended to give the claimants the benefit of the doubt.

2. incorporate an alternative set of criteria conditioning compensation on minimum duration of employment, because the previously used measurements were not reflective of miners' true exposures.

3. integrate new criteria for compensation in cases of nonmalignant respiratory diseases (NMRD includes pulmonary fibrosis, corpulmonale relate to fibrosis, etc). The old criteria required that any claimant prove that he or she was exposed to a minimum level of radon, but research has shown that other particles exist in the mining environment that can also cause NMRD.

4. include compensation for silicosis or pneumoconiosis to all miners. All of the mines were in silica-bearing rock, suggesting a risk to all miners.

5. change the Act to presume that Native Americans are nonsmokers. The original criteria of evaluation set minimum exposure levels depending on the status of the claimant (smoker or nonsmoker). Someone who smoked a pack of cigarettes a day was considered a smoker. Since most Native Americans smoke on special occasions, and some of them assume that they are smokers, the RECP had been treating many nonsmoking Native Americans as smokers.

6. change the definition of nonsmoker to include ex-smokers. Scientific evidence has shown that lung cancer risk in ex-smokers decreases over time.

7. change the regulations to allow proof of Nonmalignant Respiratory diseases by High-Resolution Computed Tomography scans. Other methods do not always show evidence of disease.

8. modify regulations to allow proof of disease process by biopsy from all miners. The biopsy process is only allowed to be submitted as proof when surviving beneficiaries are trying to submit this kind of proof for deceased miners[5].

9. modify regulations to establish a random audit procedure for B reader reports. B readers are physicians who interpret chest radiographs; the diagnosis of fibrosis or pneumoconiosis by chest radiograph is not reliable and different technicians can have different interpretations. People had also become skeptical of the reports of readers who were selected by the government.

10. modify the pulmonary function standards to define impairment in a manner consistent with recommendations of The American Thoracic Society (ATS). The ATS defines impairment as 20% reduction in lung function while the original RECA used 25% reduction.

[5] This process is considered dangerous and the government believed that people could be putting their lives at risk.

## US Congress Findings (Sec.2. of RECA 2000)[6]

After reviewing the RECA 1990, reports from the Atomic Energy Commission, Committee on the Biological Effects of Ionizing Radiation, testimony of the National Institute for Occupational Safety and Health, and scientific data presented by the President's Advisory Committee, Congress found that:

1. there exists a responsibility of the US government to compensate individuals harmed by the mining of radioactive materials or fallout from nuclear arms testing;

2. the original Act did not provided adequate and clear information and made it difficult for individuals to be fairly compensated;

3. there was a need to extend the eligibility to all states where mining and milling was sponsored by the US government form 1941 through 1971;

4. there was a need to extend the list of eligible radiogenic pathologies;

5. the same criteria of compensation for underground uranium miners and millers should be applied to above-ground miners, millers, and ore transporters;

6. it is the responsibility of the US government, with state and local governments and appropriate health care organizations, to initiate programs on risks of radiation exposure, early detection, and prevention in the approved states.

## Revised RECA of 2000

On July 10th, 2000 the President signed into law new RECA provisions that would expand the criteria for compensation. The major changes were[7]:

- inclusion of aboveground uranium workers, uranium mill workers, and individuals who transported uranium ore to qualify for $100,000 compensation;
- increasing the geographic areas included for eligibility and extending the time period considered for radiation exposure for uranium mine employees;
- decreasing the level of radiation exposure necessary to qualify for compensation for uranium mining workers from 200 to 40 working level months;

[6] http://thomas.loc.gov.

[7] Radiation Compensation Report by GAO, September of 2001.

- making certain medical documentation requirements less stringent for potential claimants;
- eliminating distinctions between smokers and non-smokers pertaining to diseases such as lung cancer and NMRD;
- requiring the Attorney General to ensure that a claim is paid within 6 weeks of approval; and
- inclusion of Native American Laws into the program when determining eligibility.

Another very significant change was to expand the list of compensable diseases in different groups:

- *Uranium Miners* - Lung cancer (including any physiological condition of the lung, trachea, or bronchus that is recognized as lung cancer), pulmonary fibrosis, fibrosis of the lung, silicosis, corpulmonale related to fibrosis of the lung, and pneumoconiosis.
- *Downwinders* - Leukemia, but not chronic lymphocytic leukemia, multiple myeloma, lymphomas other than Hodgkin's disease, primary cancer of the thyroid, primary cancer of the female breast, primary cancer of the esophagus, primary cancer of the liver, lung cancer, primary cancer of the urinary bladder, primary cancer of the colon, primary cancer of the stomach, primary cancer of the pharynx, primary cancer of the small intestine, primary cancer of the pancreas, primary cancer of male breast, primary cancer of the bite ducts, primary cancer of the gall bladder, primary cancer of the salivary gland, primary cancer of the brain, and primary cancer of the ovary.
- *Ore Transporters* - Lung cancer (including any physiological condition of the lung, trachea, or bronchus that is recognized as lung cancer), pulmonary fibrosis, fibrosis of the lung, silicosis, chronic renal disease (including nephritis and kidney tubal tissue injury), corpulmonale related to fibrosis of the lung, pneumoconiosis, and renal cancers.
- *Uranium Millers* - Lung cancer (including any physiological condition of the lung, trachea, or bronchus that is recognized as lung cancer), pulmonary fibrosis, fibrosis of the lung, silicosis, chronic renal disease (including nephritis and kidney tubal tissue injury), corpulmonale related to fibrosis of the lung, pneumoconiosis, and renal cancers.
- Onsite Participants - (same as downwinders)

## Analysis of Processed Claims From 1992 to 2002

Between 1992 and 2002 the RECP received over 13,000 claims. With 3,000 still pending roughly two thirds of claims have been approved. Table 1 describes the claims through May, 2002.

## Reasons for denials (Before the 2000 Amendments)

The Committee investigating the RECP identified 13 reasons why claims were denied. The most common reason was that the diseases contracted by the victim were not specified in the criteria for compensation. Among uranium miners 56% of the claimants did not meet the minimum exposure to radiation requirements and 36% did not contract an eligible disease. Among downwinders 49% did not contract an eligible disease, 21% did not qualify due to non-presence in areas during the established time frame, and 17% did not meet the requirement for age at exposure. Among onsite participant claims 64% did not meet the disease criteria and 17% of the claimants were not eligible as onsite participants.

## Strengths of the RECA Program

My analysis revealed that RECA was in many ways imperfect, but one has to acknowledge that a lot has been accomplished. The introduction of the original bill by Representative Wayne Owens (D-Utah) in 1989 and its enactment in 1990 were significant symbols of apology to Native communities and other victims of nuclear weapons production. To a significant extent, complaints and criticisms responding to the original bill were taken seriously. The findings and recommendations of the President's Committee and of Congress were accepted and became part of the amended RECA of 2000. Among the changes was Section 6(c)(4), an impressive acceptance of Native law in determinations of eligibility.

Another positive element of the RECA program is the re-filing process, which allows a claimant to re-file his/her application twice in the event of a rejection and then appeal a rejection. Although the RECA dissemination process is not perfect, some credit can be given to the Justice Department for establishing a web site for the program, including program statistics, and a telephone information service to inform potential claimants about the program.

The change in maximum lawyer's fees from 10% to 2% of an awarded claim is another well-meaning amendment, although some see it as a drawback in light of the possibility that lawyers may be unwilling to work on these cases, making it more difficult for claimants to receive compensation.

**Table 1**
**Awards Through May 22nd, 2002**

| | Pending | Approved | Denied | Total | % Approved | $ Approved |
|---|---|---|---|---|---|---|
| **Childhood Leukemia** | 0 | 23 | 19 | 42 | 54.8% | 1,150,000 |
| **Other Downwinders** | 1,887 | 3,954 | 1,463 | 7,304 | 73.0% | 197,670,000 |
| **Onsite Participant** | 278 | 402 | 848 | 1,528 | 32.2% | 28,672,847 |
| **Uranium Miner** | 608 | 2,189 | 1,646 | 4,443 | 57.1% | 218,291,500 |
| **Uranium Miller** | 138 | 116 | 9 | 263 | 92.8% | 11,600,000 |
| **Ore Transporter** | 40 | 23 | 3 | 66 | 88.5% | 2,300,000 |
| **Total** | 2,951 | 6,707 | 3,988 | 13,646 | 62.7% | 459,684,347 |

Source: Radiation Exposure Compensation Act – www. usdoi.gov/civil/torts/const/reca/about.htm

## Road Blocks

*"If they weren't going to stand good with the program, they never should have started it […] It's for sure that if we owed the government, they wouldn't wait this long on us" (Helen Story – husband died waiting on compensation)*

Although the RECA process has some positive elements, it has not been as successful as hoped and a few significant problems have persisted through the amendment process. Although the amendments include the section on Native law, other cultural barriers still exist. A vivid example is language. Approximately one-third of the Navajo population speaks little or no English, meaning that language is a barrier in the RECA filing process[8]. Documentation is another persistent problem. RECA requires a set of documents and assumes that records are going to be found. Some claimants and survivors are still battling to find medical records, social security records, and work history. The record of documentation in Native communities is also unique. The irony of the story is that poor record-keeping in the government has also slowed down the process. Processing time has not improved. Some claims have taken more than the legal maximum of 12 months to be decided, and the six week payment window for the Treasury Department was violated when IOUs were issued; 255 IOUs had been issued by May 2001. This leads us to the Trust Fund, another major roadblock of the RECA process. Statistics show that the Justice Department asked for $13.9 million for FY 2001 when it needed $90 million. For FY 2002 they anticipated 1,767 awards totaling $137.8 million, and only sought $10.8 million. The government proposal to move RECA from the Department of Justice to the Department of Labor created some concern. This merger, according to Melton Martinez, a representative of the Western States RECA Reform Coalition, would not bring advantages to the claimants seeking compensation or the ones that have already applied. Rather it would delay the process, cause confusion, and may even entail loss of data.✦✦✦✦✦✦

[8] http://dinecare.indigenous.org/reca-cover.html

# Dr. Alice Stewart Dies

Dr. Alice Stewart played a leading role in showing that exposure to radiation causes cancer. She also played a key role in the establishment of the Childhood Cancer Research Institute, the precursor to the Community-Based Hazard Management Program at Clark University and our work on assisting communities and the general public in protecting their health from radiation contamination. She died at the age of 95 on 23 June, 2002.

In her honor we are reprinting an article by Dianne Quigley on her work originally published in the CCRI Newsletter in 1999.

### The Marginalization of Dr. Alice Stewart: Radiation Epidemiologist, 1956 - present

By Dianne Quigley (former Director of the Childhood Cancer Research Institute, Worcester, MA)

One of the first radiation epidemiologists to suffer the unexpected fate of being marginalized as a scientist because of the unpopularity of her findings was Alice Stewart, M.D. We owe much to the courage of Alice Stewart as both a medical doctor and a scientist. The following discussion of Alice Stewart's experiences as a researcher focus primarily on two of her most famous findings: (1) the childhood cancer risk of a pre-natal x-ray and (2) the cancer risk of occupational exposures to low-level radiation for nuclear workers. A third area of her investigations that we cover briefly is related to her review of some of the data from the follow-up of the Japanese A-Bomb Survivor Study. Quotations of Dr. Stewart are from various articles and private interviews with the author, as Director of the Childhood Cancer Research Institute.

In the early 1950's, Dr. Alice Stewart was an assistant professor at Oxford University. She had been a very successful physician for much of her career but recently had been pulled into solving epidemiological problems related to World War II, such as an outbreak of a plastic anemia and jaundice among TNT shell fillers. She was appointed the head of the brand new Department of Epidemiology but was struggling to keep it alive and funded. The University believed that since the war was over, the Department was no longer needed. She and her colleagues set out to find funding and a disease problem needing further investigation.

Dr. Stewart remarked,

> "I said to the statistician, David Hewitt, go put a wet towel around your head and find out from health statistics research what the problems are that we could tackle to bring in some funding. So we looked around at various problems of the day and discovered poliomyelitis, lung cancer, myocardial infarctions, and leukemia.... The leukemia, however, was considered to be too rare for epidemiological methods. You couldn't collect enough cases to make a sufficient study so no epidemiological study of leukemia existed. We decided to go ahead with the leukemia."

Dr. Stewart was only able to raise one thousand pounds for her study but it was enough for her and her colleagues to interview 1400 case and control mothers of children, matched by age, sex and location.

> "It was my opinion that if we wanted to discover the reason why children between the ages of 2 and 4 were suffering more from a worldwide increase in leukemia mortality, without any clues to go on except that this was happening after the war, we could do a great deal worse than to ask the mothers what they know about the children...."

Dr. Stewart and her colleagues began their investigation in 1953 and by 1956, they solved a piece of the puzzle.

> "The first set of 50 pairs of completed questionnaires that came in showed the live and dead child to be alike in every respect except for one thing - the mothers of the dead children had been x-rayed twice as often as the live controls. These mothers had been given chest x-rays, abdominal x-rays, hands and head x-rays. That was the only difference that stood out. Even more surprising was that it was not only running 3:1 for leukemia vs. the live controls but for leukemia and other childhood cancers vs. the live controls. We eventually succeeded in tracing 82% of the cases and this early finding stayed constant. We turned up the totally unexpected discovery that pre-natal x-rays were in-

creasing the risk of an early cancer death. This was the very first demonstration of a cancer risk from a low dose of radiation. It was such a surprising finding that nobody believed us. It couldn't possibly be true. This was implying that there was no such thing as a safe dose of radiation whereas everybody had the impression that you could escape with a little exposure but you'd need a dozen exposures to have an effect. As it turned out from our later work, only one in 2000 of the abdominal x-rays (delivered to both the mother and the fetus) ever went wrong (resulted in a cancer death). In Great Britain, this meant that one baby would die each week from a pre-natal x-ray."

So what was the impact of this finding on Dr. Stewart?

"When this finding was published, it was immediately squashed. The doctors couldn't believe that something they were doing was causing harm to a child. There were many attempts to discredit the survey. The most vocal critics were the radiation biologists whose experiments proved no cancer risk at low dose levels and obstetricians who insisted that the benefits of obstetric radiography far out-weighed the risk. Other epidemiologists criticized the survey for going backward and relying on the mothers' collective memory. 'You don't go backward, you go forward!' they said.

Well, if we had gone forward, to the present day, there would be no awareness of a cancer risk from low-level radiation. To go forward, you would need to follow up 100,000 x-rayed children and non-x-rayed children for a period of ten years or more. That's quite impossible. By going backwards, we only needed one x-ray case out of ten. To meet the opposition, we thought that if we continued the survey for the next three years, catching the last sample of x-rayed children, we could establish our proof. We needn't have hurried. X-raying went on - keep in mind, it took twenty years or more for our finding to be accepted. So we kept on monitoring the situation. To the present day, we've collected over 23,000 cancer deaths from 1953 - 1981. We've now been able to establish many more findings on children's cancers."

Although the x-ray finding was confirmed in subsequent investigations by other researchers, and for the most part, obstetric radiography has been replaced by sonography, such international agencies as United National Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), which oversee and guide radiation protection standards will not confirm that very low doses of radiation carry significant risk of health effects. Many of these radiation scientists will admit that there is concern about an association between pre-natal x-rays and childhood cancer, but they still insist that there is no definitive proof of a cause and effect relationship. In current campaigns of hormesis, some of these scientists are actually trying to disprove that pre-natal x-rays cause childhood cancer.

Dr. Stewart became increasingly marginalized as a scientist after her discovery and received very little funding for her continued investigations. She was not invited onto advisory committees nor given access and acknowledgment in Britain's medical and scientific societies. She was never awarded a full professorship at Oxford University. Despite this treatment, Dr. Stewart intuitively felt that further analysis and investigation into the relationship between radiation exposures and cancers could provide the key to unlocking the deepest mysteries of cancer induction. As she has said publicly,

"I really become quite cross when roadblocks, such as commercial interest, not even so much commercial interest as those of national security and supremacy, continually obstruct the search for scientific truths about childhood cancers."

In the mid-1970's, Dr. Alice Stewart and her colleague, George Kneale, were invited by Dr. Tom Mancuso, one of the leading occupational epidemiologists in the world, to solve yet another radiation puzzle. Dr. Mancuso had been conducting a ten-year study of cancer mortality among 35,000 Hanford nuclear workers. Initially, he had seen no increase in cancer rates, but Dr. Samuel Milham, a Washington state health official, complained to Mancuso that death certificates were showing a 25% increase in the cancer rate among nuclear workers compared to workers in other industries. When the Atomic Energy Commission (AEC) had heard about Milham's report, they wanted Mancuso to publish his findings right away to give assurance that were no cancer excesses. Mancuso refused to do this and called up Alice Stewart and George Kneale to come and take a look at the data. The Mancuso, Stewart, and Kneale (MSK) team were able to demonstrate a healthy worker effect which was masking the true increase in the cancer rate for workers receiving cumulative doses considerably less than 5 rads over the whole of their working years. They argued that current standards for workers and the public were underestimating the risk of low dose radiation exposures by 10-20 times.

When the AEC became aware of these findings, they begged Mancuso to keep quiet as they feared lawsuits and compensation claims from workers and those exposed to nuclear testing. When Mancuso refused to keep quiet, the Hanford data were confiscated, and Mancuso was fired. All nuclear worker studies from then on were conducted internally within the Department of Energy under their tight control. The MSK team eventually published their findings in *Health Physics* in 1977, and Dr. Stewart was caught again in another storm of controversy, character assassinations and attempts to debunk her work and her integrity as a scientist.

Stewart and Kneale went back to England to continue their Oxford Survey investigations with meager funding. They retained a tape of the Hanford data and published several other papers on Hanford occupational exposures and cancer mortality. Not having the financial backing she needed for the Oxford Survey research, Alice Stewart spent the latter part of her career at Birmingham University, carrying out her research in a pre-fabricated trailer on the grounds of the medical school. She also secured a tape of some data from the follow-up of the Japanese A-Bomb Survivor Study to understand why that story was in such contradiction to her own findings. With George Kneale she has published numerous papers on the "healthy survivor effect" which exists within the cohort of A-Bomb Survivors. Stewart and Kneale have shown that many of the sick, the elderly, the weak, and children were killed off in the first five years after the bomb. The surviving population was not a normal population, but a highly-selected population. Radiation standards for the world have been set according to studies on a healthy survivor population whose cancer death rates will be lower than the general population. In particular, findings from the A-Bomb Survivor study on the effects of low doses of radiation to children and the elderly will be quite inaccurate as many in those age groups were killed off. Needless to say, Stewart and Kneale's work on the A-Bomb Survivor data was brushed aside and they were consistently refused access to additional data by the Radiation Effects Research Council.

In reflecting on the marginalization she has experienced because of her pursuit of the truth about low-level radiation effects, Alice Stewart has said

> "the biggest single deprivation I have suffered is never having been able to have a successor, never having a team of researchers to teach and train to spread my methods. I was good at teaching, I truly regret this. Right now, I can't even find the funds to keep a younger assistant going. So often I have tried to get papers published or to obtain funding for my research, to explore avenues of research closely related to radiation, but I have had no backers in high places to help with this."

Alice Stewart's loss is a loss to the whole world and our scientific understanding of childhood cancers and the health effects of low-level radiation. It is the year 2000, and just now, the Department of Energy is beginning to admit that nuclear workers are at increased risk of cancers from their exposures. In turn, this means that the public exposed to nuclear testing and nuclear contamination from nuclear facilities have also been at increased risk for cancers. We could have dealt with this in 1956 or in 1977 if our scientific institutions had the integrity to deal with the truth. How many children died of cancer between 1956 and 1979 before pre-natal x-rays for pregnant women were banned? Let us hope that these needless deaths will count for something, that we can put protections in place for researchers who discover unpopular truths and not keep repeating the mistakes of the past. Let us not continue to allow our children to pay with their lives for scientific dishonesty and cover-ups.

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# End of the Advisory Committee to CDC on Radiation Health Studies

By Seth Tuler, Community-Based Hazard Management Program

This spring the federal Advisory Committee on Energy Related Epidemiologic Research (ACERER) met its formal end. The charter for the committee that advised CDC on its radiation health studies program was not renewed by the Department of Health and Human Services—hence there is no longer a committee.

ACERER was established in the early 1990's when the radiation epidemiology activities at DOE were moved to the Centers for Disease Control and Prevention's National Center for Environmental Health (NCEH) and National Institute for Occupational Safety and Health (NIOSH). The studies were moved out of DOE because of a lack of credibility in their independence. ACERER provided advice to the health agencies about health studies. It made important recommendations about the need for better public involvement, better risk communication, and better designs that could provide meaningful results. ACERER made key recommendations about the need for follow-up to the study on iodine-131 fallout from the Nevada Test Site, led by former member Tim Connor who also established the Subcommittee for Community Affairs. All along, there were tensions over the purpose of ACERER and the limits of its scope. There also appeared to be growing ambivalence (and sometimes opposition) to the clamoring of the Subcommittee on Community Affairs and some members for more accountability and closer attention to the need for programmatic activities that went beyond health studies.

The last meeting of ACERER was held in June 2000; the meeting ended with uncertainty over whether its charter would be renewed, revised, or allowed to expire. There was general agreement that ACERER was not working well. Some called it dysfunctional. Many of the discussions were pushing the boundaries of its charter. There were lots of issues coming before us that begged the question of follow-up care to exposed populations, but the agencies were not able to deal with them given their mandates. In February 2001 the DHHS hosted a Roundtable discussion with some current and former members, agency staff, and others about the future of the advisory process. It ended with what appeared to be consensus about the need for an advisory committee on the CDC's radiation studies program.

Move forward more than a year, and the news is that the charter was allowed to expire and that the agencies do not want an advisory committee. After a series of phone calls to agency staff I learned that this change of stemmed in large part because Dr. Copeland (Director of CDC) was told by DOE that a) funding under the MOU would continue to decrease and that CDC/ATSDR should expect it to dry up completely sometime in the near future, b) so, don't start any more work at the DOE sites, and c) wrap up what they are doing.

Without funding to do any more work, the need for an advisory committee disappears The MOU between DOE and DHHS is based on the "availability of funds." DOE is saying there are no more funds. In the end, the radiation health studies program of the federal government was never made independent from DOE. DOE continued to hold strong sway over the program by controlling the flow of funds for work. While the MOU appeared to shift responsibility for epidemiologic studies to a more credible agency, there was not truly independence.

This news does not bode well for people who think that additional studies should be done to characterize the health legacy of nuclear weapons production and testing in the US. I was told that there have been no discussions within CDC to seek funds through its own appropriations for continuing work at DOE sites. A smaller Radiation Studies Branch, I am told, will shift away from DOE site studies to radiological terrorism issues.✦✦✦✦✦✦

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