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Exposure Matters: Examining The Physical And Psychological Health Impacts Of Toxic Contamination Using Gis And Survey Data

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EXPOSURE MATTERS:
EXAMINING THE PHYSICAL AND PSYCHOLOGICAL HEALTH IMPACTS OF TOXIC CONTAMINATION USING GIS AND SURVEY DATA

by

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ABSTRACT

In the late 1970s and early 1980s, the grassroots environmental movement brought national attention to the issues related to inequities in environmental quality. Previous research addressing these environmental inequities has progressively increased and advanced methodologically. However, the arguments and focus have been primarily limited to examining the socio-demographics in an ongoing debate of race and class. This thesis extends past the methodological stalemate focusing on the application of Geographic Information Systems (GIS) using survey data in an environmental justice case study of a community in south Florida. This approach examines the social, health and environmental impacts of a Superfund site on a low income, minority community. Using geo-coded survey (N=223) and environmental data (ash deposition patterns), this thesis employs path analysis to test the hypothesis that "exposure matters." The "exposure matters" hypothesis suggests exposure (perceived, self-reported and actual) is a significant predictor of physical and psychological health. Results discuss significant findings, and then compare them with previous disaster and trauma-related research and present directions for future research.

To the Wingate community
and the hundreds of thousands affected by toxic contamination

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INTRODUCTION

Classical sociological theorists, such as Marx and Durkheim, have excluded the environment from consideration in social science research (Parsons 1977; Giddens 1972). During its efforts to establish autonomy, sociology directed the discipline away from the natural environment and its processes (Murphy 1997). Strict social constructionists argue that the natural environment is external to society, or the social world, and is therefore independent from it (Schneider 1985; Spector and Kitsuse 1987; Loseke 2003). However, as a result of classical theory and a strict social constructionist perspective, sociologists were slow to include the natural environment in sociological analyses. Later research concerning society and the natural world had developed into an area called sociology of the environment, where research was focused only on the unidirectional relationship from society to the environment (Murphy 1997). In the 1970s, the sociology of the environment led to the emergence of environmental sociology, which examined the interdependent relationship between society and the environment (Dunlap and Van Liere 1979).

Beginning in the early 1960s with the publication of Rachel Carson's *Silent Spring* (1962) and, later, the first Earth Day in 1970, the second generation of the environmental movement experienced a new wave of concern for the protection of environmental quality (Mertig and Dunlap 2002). The increased concern, vocalized through lobbying and citizen participation, translated into a series of environmentally-related legislation, including the Clean Air Act (1970) and the Clean Water Act (1972) (Humphrey, Lewis and Buttel 2002). Following

the accident at Three Mile Island, Pennsylvania (1979), and the discovery of toxic contamination in Love Canal, New York (1979), attention to environmental hazards and contamination gained national attention. In 1980, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)[1] was passed and the Superfund program was introduced. The mission of the Superfund program is "to clean up abandoned, accidentally spilled or illegally dumped hazardous waste that poses a current or future threat to human health or the environment" (EPA 2003). In 1985, the US General Accounting Office estimated that there are potentially "378,000 sites where toxic materials may have been improperly disposed" (Szasz and Meuser 1997; US GAO 1995). In 1987, an estimated twenty billion pounds of toxic chemicals were released into the air, water and land (Foster 1994).[2]

At the same time the environmental movement experienced its wave of concern for environmental quality, various other social movements, including the anti-Vietnam war movement and the women's movement, were taking place. In the late 1970s and early 1980s, the grassroots environmental movement brought national attention to the issues related to inequities in environmental quality (Cable and Cable 1995). Within environmental sociology, environmental justice research emerged in the mid-1980s in response to the growing awareness of the disproportionate impact of toxic environmental contamination on the poor and people of color (US GAO 1983, Bullard 1983, CRJ/UCC 1987). Environmental justice research at both the micro- and macro-level has brought national attention to this grassroots social movement, while methodologically evolving both qualitatively and quantitatively.

Using data collected in Fort Lauderdale in the Wingate Health and Social Survey (2003) and the application of Geographic Information Systems (GIS) in an environmental justice case study, this thesis seeks to explore the relationships between the biophysical environment and the social psychological and health impacts of environmental inequity. Where previous research has focused on the sociodemographic characteristics of those in close proximity to hazardous waste sites, this research is important because it examines how a community, located within close proximity to a Superfund site, is physically and psychologically impacted by environmental contamination. Legally, inclusion of environmental variables allows researchers to test the causal linkage of contamination and health impacts, a quantitative result that may be used as evidence in court cases. On a broader level, an understanding of how populations are impacted by toxic exposure can lead to the development of more effective public policy and programs to support impacted communities.

This thesis is structured into five sections. The first section examines the history of the site, providing a historical context for the analysis. The second section examines the development of environmental justice research focusing on the methodology, levels of measurement and units of analysis. The third section discusses the methodology employed in this thesis, with a particular focus on the use of GIS as a platform to integrate social and biophysical data. The fourth and final section examines the results, identifying the significant relationships and discussing their relevance in relation to other environmental justice and technological disaster research. In addition, the section briefly discusses the development of more effective public policy and programs to support impacted communities.

HISTORICAL BACKGROUND

The context of events has been found to contribute greatly to understanding the origin of social problems, such as environmental inequity in environmental justice research (Best 1993). The history of the area and site provides a more qualitative understanding and depth to complement the results of the quantitative methodological sections. This section provides a history of the site from the growth of Fort Lauderdale to its current status.[3] (See Appendix A for timeline of historical events.) The chronology is divided into four subsections. The first section examines the conditions prior to and up to the siting of the Wingate Municipal Incinerator and Landfill. The second section reviews the years of operations. The third section discusses the events and activities that followed the closure of the incinerators and landfill. This section also discusses the identification of the site as a Superfund site and the clean-up efforts. The final section presents the site and its surrounding community as characteristic of a "classic" environmental justice case study.

Years before Operation (1912 – 1954)

The city of Fort Lauderdale lies along the eastern Atlantic coast of south Florida. Named after the volunteer Major William Lauderdale, a fort was established in his name during the Second Seminole War (appx. 1840) (Weidling & Burghard 1974). It was not until many years later, after its incorporation in 1911, that Fort Lauderdale experienced a great population and economic boom, which continued through the twentieth century. As a result, the city of Fort

Lauderdale became known as one of the prized jewels of Florida's Gold Coast. Fort Lauderdale is now the "Yacht Capital of the World," renowned for its luxurious real estate properties, lavish yachts and marinas. The economy, historically dependent upon tourism, agriculture, and manufacturing, prospered (Smith 1963).

In 1951, the 61-acre site of the Wingate Road Landfill was purchased by the City of Fort Lauderdale. The site is located northwest of downtown Fort Lauderdale and approximately five miles from the coast. The interstate highway (I-95), which was completed in 1965, runs parallel with the coast less than one mile to the east of the site. It is a quarter mile north from the intersection with Sunrise Boulevard at 1300 NW 31st Avenue/Martin Luther King Drive.

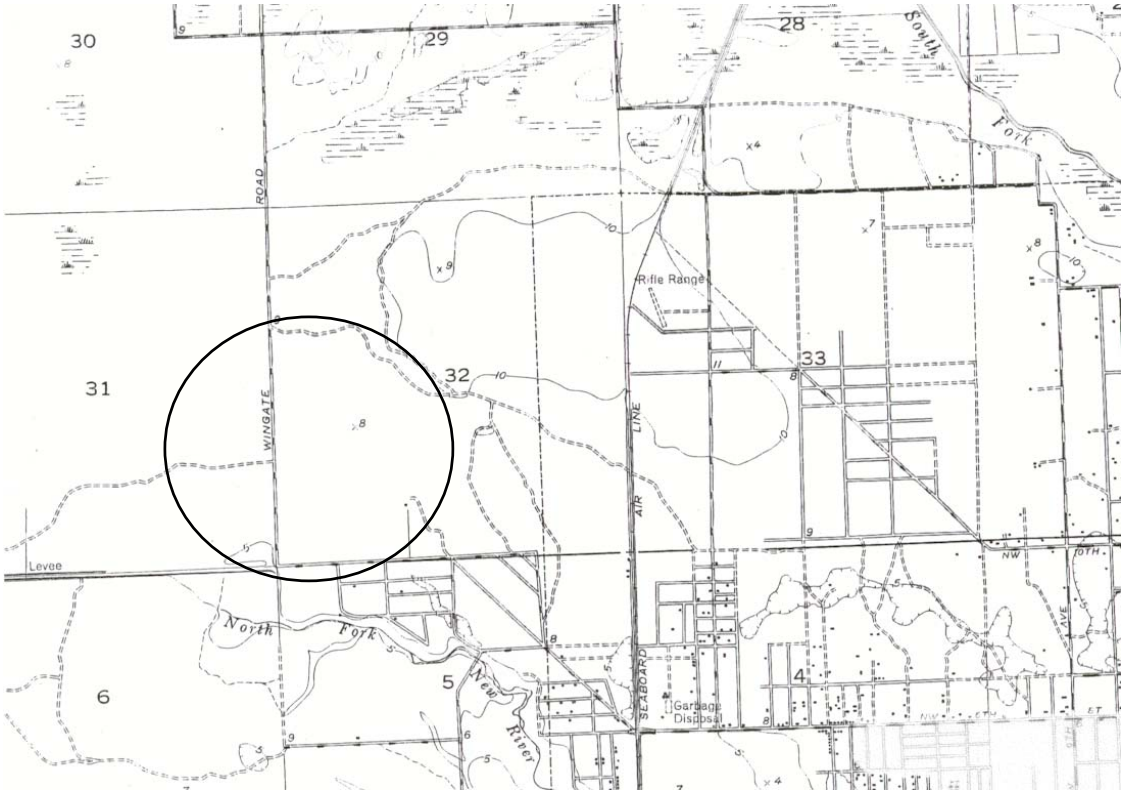

Figure 1: 1949 USGS Topographic Map of Fort Lauderdale North with future site area

Years of Operations (1954-1986)

The first incinerator began operation in 1954. Additional incinerators and a percolation pond, later dubbed "Lake Stupid" by EPA officials, were added by the city in 1966. Because the National Environmental Protection Act (1969) and the Clean Air Act (1970) were not passed until after the incinerators were constructed and began operation, there were no regulatory limits or restrictions on the amount of particulates and pollutants that could be released into the air. In 24 years of operation, the three incinerators burned somewhere between 410 and 560 tons per day and emitted at least 300 tons of particulate (ash) annually (Rogers and Reynolds 2002). Residents who had lived in the area have described the ash from the incinerator as falling like snow in winter and coating everything, including the neighborhood children who would try to catch the ash like snowflakes. The waste from over 1,500 businesses, including large petroleum and chemical industries, was delivered by truck and incinerated on site. At the time, no laws or regulations prohibited the disposal of hazardous waste into the landfill. Hazardous wastes are defined as by-products or waste of industrial production, which are toxic (produces injury if inhaled, swallowed, or absorbed through the skin), ignitable (capable of burning or causing a fire), corrosive (reacts with materials causing deterioration or wear) or dangerously reactive and present particularly troublesome health and environmental problems (EPA 2003). Up until the late 1970s, hazardous wastes were "discarded without consideration of the danger they posed" (CRJ/UCC 1987:3). In 1978, operation of the incinerators ended following violations in clean air standards, but the landfill was not closed until 1986 as a result of the Florida Administrative Code (FACE) requirements (George 2000).

Years after Operation (1986 – 2003)

In the years after the landfill's closure and before the remediation, the site was leased to Production Central Inc., a film production company. Movies such as *Cape Fear* and *Speed 2* were filmed on the site. The overgrown, dense vegetation and deteriorating buildings on site often became a playground for local children. As it had been used over the past 50 years, Rock Pit Lake, a former burrow pit adjacent to the site, continued to be used as the regular swimming and fishing hole for local children and adults alike.

It was not until 1990 that the site was placed on the National Priorities List (NPL), a list ranking contaminated sites in the Superfund program. In 1996, the EPA's Record of Decision assessment of the site stated the "actual or threatened releases of hazardous substances from this site…may present an imminent and substantial endangerment to public health, welfare, or the environment" (1996:2). The EPA has identified 33 companies as Potentially Responsible Parties (PRPs). However, clean up and remedial actions were delayed as a result of pending investigations, environmental sampling and analyses of the site. The final results of the environmental sampling showed known toxic and carcinogenic contaminants, such as benzene, dioxin, lead, mercury and arsenic in the soil, sediment and water samples on site and in Rock Pit Lake (EPA 1996). Additional private soil sampling of the local community found dioxin and furan levels above recommended EPA levels (Ecology and Environmental Inc. 2001). Local health studies conducted in 1999 and 2001 found elevated incidence[4] of and mortality[5] from cancer and increased fetal and infant mortality rates in the local community (Barker 1999; Healthy Mothers-Healthy Babies Coalition of Broward County 2001). Barker's study used

cancer rate statistics from the Florida Cancer Data System with survey data (n = 672) collected in the field from the Wingate community (1999). When these rates were compared with the incidence for the county (Broward - per 100,000) and a control community (Melrose, n = 567), the results were significantly different from the comparison groups (Barker 1999). The rates of cancer (prostrate, stomach, eye, liver, leukemia, pancreatic, bone, breast and skin) were significantly greater than those rates for the county and the comparison community (Barker 1999). These results independently supported findings from an earlier comparison of incidence rates between the community and the state conducted by the Department of Health and Rehabilitative Services (1995). The results of a study of fetal and infant mortality were presented in the fall of 2001 (Healthy Mothers-Healthy Babies Coalition of Broward County 2001). The fetal and infant deaths for the 33311 and 33313 zip codes were compared with the total number of deaths in the same zip codes for 2001 between January and June (Healthy Mothers-Healthy Babies Coalition of Broward County 2001). The fetal and infant deaths in these zip codes were found to represent around 10% of the total deaths in the county. The report found these zip codes were found to account for 39% of the fetal deaths and 60% of the infant deaths for the entire county (Healthy Mothers-Healthy Babies Coalition of Broward County 2001). In 2002, the recommended remedial action was completed with the contaminated landfill material placed under a single-layer synthetic cap dubbed “Cancer Mountain” by residents (Lewis 2002).

A Classic Environmental Justice Case

In the Commission for Racial Justice and the United Church of Christ's 1987 report on Toxic Wastes and Race, Fort Lauderdale was one of 50 metropolitan areas with African-Americans living in communities with uncontrolled toxic waste sites. When ranked by racial inequities, the city ranked sixth with 97% of African-Americans living in a community with uncontrolled toxic waste sites compared to 46.2% for Whites (CRJ/UCC 1987:57). Fort Lauderdale had the highest percentage out of all the metropolitan areas examined with significantly greater black populations living in uncontrolled (unregulated) toxic waste site areas (CRJ/UCC 1987:57).

The Wingate community demonstrates the characteristics of the Environmental Justice (EJ) frame as presented by Stella M. Capek (1993). The EJ frame contains resident's claims including the right to accurate information, unbiased hearings, democratic participation in the future of the community, and compensation from the responsible parties (Capek 1993). Residents, as reported in the *Miami Herald* and *South Florida Sun-Sentinel*, have vocalized all these claims (Bevc 2003a).

With the formation of grassroots organizations, such as the Bass-Dillard Neighborhood Issues and Prevention Inc. and the Team of Exposed Individuals to Contaminants (TOXIC), the residents of Wingate have mobilized in an effort to "clean up" their community (Kelley 1999; Lewis 2002). They serve as yet another example of an African-American community, like Triana, West Dallas, Reveilletown, and Texarkana, impacted by environmental contamination (Bullard 1993).

DEVELOPMENT OF ENVIRONMENTAL JUSTICE RESEARCH

This section reviews and critiques the current state of methodological development in environmental justice (EJ) literature and discusses the potential directions of future research. The review initially focuses on the emergence and influence of early EJ studies. Particular attention is paid to three seminal cases, the US General Accounting Office's 1983 report, Robert Bullard's study of Houston in 1983, and the United Church of Christ research in 1987. In a review of 87 environmental justice articles, the various methods and levels of analysis are discussed. The final section discusses these results with attention to the potential direction of environmental justice research in the future.

Historical Development of Environmental Justice

The emergence of environmental justice as an issue began in the early 1980s, introducing a new body of research examining the convergence of the environmental and civil rights movements. Spurred by a letter by two House Representatives, the U.S. General Accounting Office conducted a study on the correlation of hazardous waste landfills and the racial and economic status of the surrounding communities (1983). Their study of EPA's Region IV (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina and Tennessee) focused on offsite hazardous waste landfills, "those not a part of or contiguous to an industrial facility" (US GAO 1983:1). The Office's review of EPA files identified a total of four sites within the region located in Alabama, South Carolina and North Carolina. Using census

data from 1980, the racial and economic characteristics of people living within four miles of each site was examined along with similar information for the associated counties and states (US GAO 1983). For each site, the review of location standards, public participation and class permit provided summary information on related federal regulations and legislations. Although the results were significant, the generalizability was low due to the limited sample size of four sites. The study served more to raise initial consciousness of the potential correlation between hazardous waste landfills and low income, minority communities.

Over a year before the GAO began their investigation of hazardous waste landfills, Robert Bullard was conducting interviews with personnel from various solid waste companies and examining the demographics of communities around solid waste sites in Houston, Texas. The preliminary results were presented in the spring of 1982 and finalized in "Solid Waste Sites and the Black Houston Community," which was published within months of the GAO's report (Bullard 1983). In his case study of Houston's municipal waste system, Bullard found that there was a significant "relationship between the location of waste disposal facilities (n=13) and the racial composition of neighborhoods," and that there was a difference in siting patterns between the municipalities and the private sector (Bullard 1983:275). Further examination showed that black children were more likely to attend schools located near disposal sites than non-black children (Bullard 1983). Bullard's results argued for further investigation into historical disparities in siting of disposal facilities. Using the term "institutionalized discrimination," Bullard pointed out that the siting practices of solid waste disposal facilities in Houston had established a discriminatory pattern which had not deviated in over 50 years (Bullard 1983:285).

Four years after the General Accounting Office and Bullard released their results, the Commission for Racial Justice (CRJ) for the United Church of Christ followed with the first national study, "Toxic Wastes and Race in the United States," which examined the extent to which minority communities were exposed to hazardous waste, at both controlled and uncontrolled sites (1987). To clarify, uncontrolled hazardous waste sites included "indiscriminately placed dumps, abandoned or closed disposal facilities, accidental spills, illegal discharges or closed factories and warehouses where hazardous materials have been produced, used or stored" (CRJ/UCC 1987:4). Many of these uncontrolled sites were later added to Superfund's National Priorities List (NPL) for clean up. The controlled sites were defined as facilities regulated by the EPA under the Resource, Conservation Recovery Act (RCRA 1976) that were used for treating, storing or disposing of hazardous wastes, also referred to as TSDFs (Treatment, Storage, Disposal Facilities) (CRJ/UCC 1987). The controlled and uncontrolled sites were examined separately, each in a cross-sectional study and the results were compared later.

The information from EPA's Hazardous Waste Data Management System (HWDMS) was used to identify 415 commercial TSDFs. The 18,164 uncontrolled sites were identified through the EPA's Comprehensive Environmental Response, Compensation and Liability Act Information System (CERCLIS). The controlled sites study used residential zip codes to differentiate communities into one of four groups (without TSDF, with TSDF but without landfill, with TSDF landfill not one of the five largest, and with one of five largest TSDF landfills) (CRJ/UCC 1987:11). The number of uncontrolled sites were aggregated to the 3-digit

ZIP codes used to define metropolitan areas. These groups were compared with demographic data from the 1980 U.S. Census. The information was examined at the national, EPA region, state and select metropolitan levels (CRJ/UCC 1987). The statistical analyses tested whether race was the strongest indicator in differentiating communities with TSDFs and whether minority populations were greater in communities with TSDFs than without (CRJ/UCC 1987). The results supported both hypotheses. Communities with TSDFs had twice the average percentage of minorities as those without a TSDF (CRJ/UCC 1987). Income proved to be another significant factor, but not as strong as race. As reflected in later research, the results of the study helped kindle the debate as to whether race or income is the strongest predictor of TSDF locations. Similar to the U.S. GAO report, the results fueled national recommendations, evaluations, and legislation to address environmental inequities.

While the results of these early works helped raise national awareness of environmental inequities, researchers have closely critiqued the methods of analysis of these early studies and later EJ research. The next section looks at the various aspects of EJ research methodology, including the level and units of analysis, as well as the geographic methods of analysis.

Review of Environmental Justice Methodology

Before environmental inequities can be identified, the research technique must be decided and the information must be collected. The research technique refers to the way the data are collected, quantitatively, qualitatively or a combination of both. Qualitative research has frequently been used in case studies to examine specific events and/or issues, such as pesticide

exposure (United Farm Workers 1986), radioactive waste (Schuey 1984), and incinerators (Stults 1988; Russell 1989). Quantitative research has been conducted at various levels of analysis (national, regional, state, county, etc.) to study a multitude of hazard types. This section provides a review of methods used in quantitative studies.

Environmental justice research has examined the distribution of various hazard types including air pollution, municipal landfills and incinerators, Superfund sites, TRI Facilities, and transport storage and disposal facilities (TSDFs). The information about these hazard types has been collected from various sources including the Toxic Release Inventory (TRI), RCRA National Notifiers List, and Superfund's National Priorities List (NPL). Social data are most frequently collected from the U.S. Census Bureau.

Most environmental justice research employs a cross-sectional design, but longitudinal data are increasingly being used to examine historical patterns (Bevc 2003). The collection of longitudinal data is often difficult due to the limited availability of historical data and information, and the consistency in the data and information from year to year, which makes comparisons difficult. Despite these challenges, the results of longitudinal studies are often more powerful, especially in cases concerning the siting of facilities in low-income and/or minority communities (Neuman 2003). The use of longitudinal data allows the researcher to address the class versus race debate by answering the question, which came first, the facility or the minority population? If the facility came first, then it was class. Essentially, early cross-sectional environmental justice research has simply identified environmental inequities, whereas longitudinal research allows researchers to examine the historical developments that lead to these

inequities. This does not mean that researchers should discontinue cross-sectional research. Often the least costly alternative, cross-sectional research can be used for exploratory, descriptive or explanatory purposes to identify certain phenomena (Neuman 2003).

Levels of Analysis

The levels, or scales, of analysis are divided into three levels, macro-, meso- and micro-levels. The results of previous literature at each of these levels were examined for potential similarities and differences. In this review, the macro-level is defined as studies and research concentrated at the national and regional level. These studies have often made broad generalizations about the relationship between environmental inequities and a single demographic characteristic, such as race (see, e.g., U.S. GAO 1983, CRJ/UCC 1987; Been 1994; Hamilton and Viscusi 1999; Mohai and Saha 2003). The amount of research at the macro-level has contributed greatly to raising national attention to the social problem of environmental inequity.

Meso-level studies demonstrate the greatest diversity in the units of analysis, resulting in mixed findings. Some researchers have found race to be the strongest significant predictor of environmental inequity (US GAO 1983; Pollack and Vittas 1995), others have found income to be the strongest predictor (Anderton, Anderson et al. 1994; Yandle and Burton 1996). Harshly criticized for their choice methods, Yandle and Burton's research has raised the debate over race versus income and brought critical attention to the substantive importance of research methodology.

In contrast to the macro- and meso-level research, most studies at the micro-level, defined by a concentrated focus at the city or municipal level, have narrowed their study to a specific problem or site. Much of the research has been qualitative, but there have been a few quantitative studies (Bullard 1983; Maher 1989, 1991, 1993; Mohai and Bryant 1992). At this level, researchers are able to more closely examine the specifics, such as demographic change over time, housing markets, land zoning and the public decision-making. The results have led to a more detailed understanding of the interactions and forces that occur at the local level. With an understanding of forces at the local level, the results are different from the results found at the national level. The use of aggregate data in national studies overshadows the forces that most directly influence the siting and historical inequities at the local level.

Units of Analysis

With critical attention focused on methodology, the units of analysis (the empirical unit that a researcher observes, measures, and analyzes in a study) have become especially important. For EJ research, these units include counties or parishes, MSAs, Zip Codes, census tracts, census block groups, census blocks, and individuals. These units are typically politically or socially defined, rather than geographically determined by watersheds, climate ranges, or topography.

There are several issues directly concerning the selection and use of different units of analysis, specifically variations in population characteristics and the ecological fallacy problem. When using aggregate social data, such as census data, the information does not include the distribution of the population or its characteristics within the aggregated unit. This issue

potentially leads to ecological fallacy. When working with different units of analysis, it is important to be aware of ecological fallacy, which "refers to a poor fit between the units for which a researcher has empirical evidence and the units for which he or she wants to make statements" (Neuman 2003:158). Researchers' attempts to identify populations disproportionately impacted by environmental hazards should be aware that populations, in most cases, are not uniformly distributed in units of analysis greater than the individual. Therefore, the smallest unit of analysis available should be used to most accurately identify potentially affected populations.

Geographic Methods of Analysis

After the data from the desired level and unit of analysis are selected, the geographic method of analysis is selected. These methods vary from the crude unit-hazard coincidence and the distance-based methods to the more precise plume-based analyses.

The unit-hazard, or spatial, coincidence method involves the selection of pre-defined geographic units of analysis, such as census tracts or zip codes, and the identification of units containing the hazard (McMaster et al. 1997; Mohai and Saha 2003). Once identified, the "host" unit's demographic characteristics are compared to the non-host units. If the difference is found to be statistically significant, then the hazard or locally unwanted land use (LULU) is considered to be disproportionately distributed (Mohai and Saha 2003). In an earlier review of EJ research, a strong majority (83%) of the studies conducted between 1972 and the present have used this method of analysis (Bevc 2003b). A majority of national studies have used this method to

determine disparities, including the United Church of Christ's Commission for Racial Justice study in 1987.

The problem with unit-hazard coincidence is that it does not take into consideration the exact location of the facility or the sociodemographic variation in the "host" unit or the surrounding "non-host" units. As illustrated in Figure 2, Mohai and Saha point out that unit-hazard coincidence assumes "that populations in large host units necessarily live as near to the potential environmental hazard or locally unwanted land uses under investigation as populations in small host-units" (2003:5). In addition, this method assumes that members of the population are equally exposed to equal levels of contamination from the point source. This assumption is further discussed in later sections.

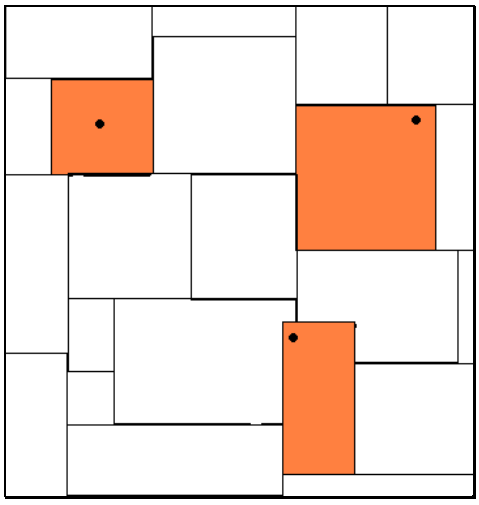

Figure 2: Unit Hazard Coincidence

Distance-based, or buffer analysis, methods use the precise location of an environmental hazard and "their distances to nearby populations are controlled" (Mohai and Saha 2003:5). Similar to the unit-hazard coincidence, the demographics or characteristics of the pre-defined geographic units are compared to determine disparities. Previous research found 13 studies utilizing the distance-based method (Bevc 2003b). In these studies, the distance/proximity/buffer was somewhat arbitrarily pre-defined by the researcher, resulting in concentric circles (Bevc 2003b).

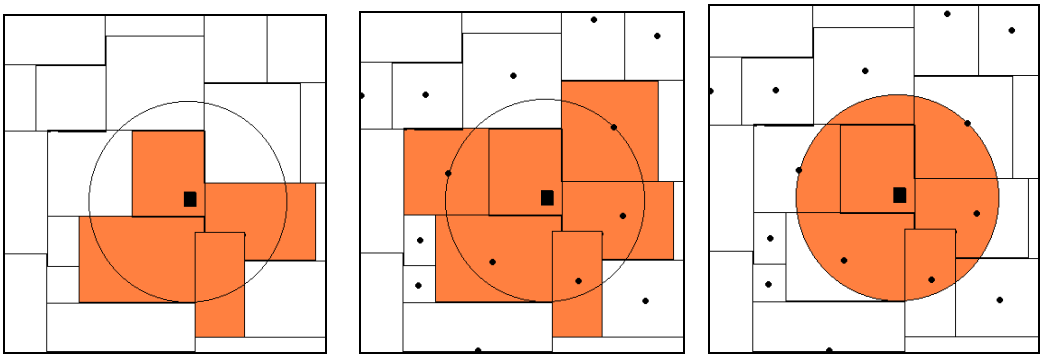

Figure 3: Distance-Based Methods

As illustrated in Figure 3, Mohai and Saha have identified three distance-based methods, 50% areal containment, centroid containment and areal apportionment (2003). These methods assist researchers in determining which units or what portion of units are "captured" by the arguably arbitrary distance. With 50% areal containment, "at least 50% of the unit's area is captured by the resulting circle" (Mohai and Saha 2003:6). Alternately, researchers have also

considered the centroid-containment method, where the unit is considered if the centroid (geographic center) of the unit is captured by the circle (Mohai and Saha 1003). Another alternative method is areal apportionment, whereby "each unit's population is weighted by the *proportion of the area* of the unit captured by the circle" (Mohai and Saha 2003:7 italics added). The US GAO report in 1983 used a method very similar to 50% areal containment to identify communities within a four mile radius of the hazardous waste landfills.

To more accurately address issues related to the modifiable areal unit problem (MAUP)[6], researchers are beginning to utilize grid-based, mapping techniques (Mennis 2002; Downey 2003). This GIS-based multi-scale method "uses remotely sensed imagery and dasymmetric mapping techniques to transform demographic data from a representation based on areal units (e.g. census tracts)…to a representation based on a statistical 'surface' of demographic distribution" (Mennis 2002:285). This method attempts to mitigate the MAUP by creating square grid cells that are smaller than the larger areal unit. The cells are then weighted based upon their proximity to the environmental hazard. The proximity, like distance-based methods, is an arbitrary radial distance determined by the researcher. Cells whose centroid falls within this buffer are considered to be contained by it. However, this technique requires information about population density and sociodemographics of the area. To determine the distribution of sociodemographic characteristics, the characteristics are "distributed to each grid cell in proportion to the distribution of the total population" using a statistical surface generation calculation (Mennis 2002:288). Figure 4 illustrates the population density in relation to a hazardous site (rectangle in the center).

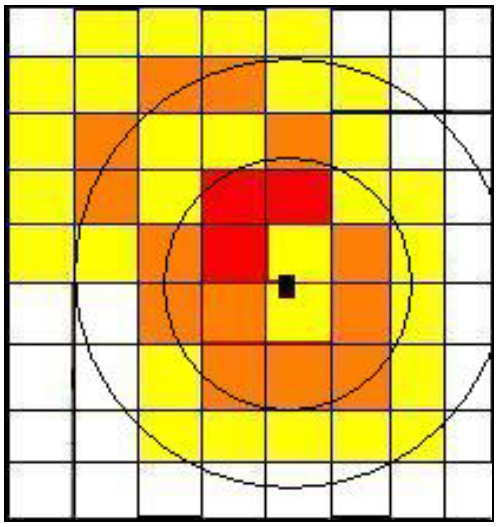

Figure 4: Grid-based Method

This method improves the distance-based method by reducing the areal units to equally sized units, but limitations still exist because the researcher must define the size of the cells and the buffer distance. The problem with the distance-based and grid-based methods is the implicit assumption that contamination emanates from the point source in a constant radius. Thus, it is assumed that proximity to the point source and degree of exposure are linearly related. The degree and nature of actual contamination is, in fact much more complex, dependent on the environmental conditions of the specific location.

In addition, distance-based methods fall victim to the same assumption of unit-hazard coincidence, that the sociodemographics of the population are evenly distributed within the unit of analysis, regardless of its size. This is a potential problem when using any unit of aggregated

social data. The information provides descriptive information, but does not provide information about the distribution of the population and actual exposure. To address these problems, researchers have suggested "geographic plume" analysis.

Geographic plume, or plume-based buffer, analysis differs from unit-hazard, distance-based, and grid-based methods in that it "accounts for the directional biases in the distribution of hazards by using a chemical dispersion model to determine the area that is likely to be affected by a release" (Chakarborty and Armstrong 1997). This integrated approach, using dispersion models and a GIS demographic database(s), "typically combine attributes of the chemical released with site-specific information and meteorological [or environmental] conditions to

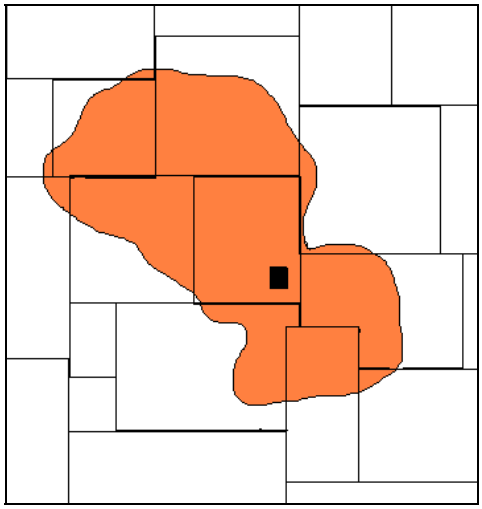

Figure 5: Geographic Plume Analysis

determine the area that would be affected by a spreading plume" (Chakarborty and Armstrong 1997:150). As illustrated in Figure 5, the area of the plume is determined by the Immediately Dangerous to Life and Health[7] (IDLH) concentrations. The GIS database of demographic and

socioeconomic characteristics is used to identify potential populations at risk within this identified area. Studies found using this approach are limited to the research of Charakarborty and Armstrong (1995; 1997).

The problem with Charakarborty and Armstrong's plume "footprint" is that it defines the area of contamination by the IDLH concentrations, but does not consider the chronic exposure to contaminants below IDLH concentrations. To avoid this crude dichotomization, the plume should be operationalized into a continuous, interval variable presenting the range and volume of contaminant dispersion. Like the unit-hazard and distance-based methods, geographic plume analysis also assumes the equal distribution of population characteristics in the unit of analysis, or plume. This is a general problem when using aggregate social data and attempts to disaggregate the information may result in ecological fallacy.

While the dispersion of environmental contamination may be addressed, the issue of aggregate social data is one that is difficult to remedy. In case studies, geocoded survey data at the household level may assist with more accurate analyses.

Future of Environmental Justice Research

Since its emergence in the late 1970s, quantitative environmental justice research has been concentrated largely at the macro-level in national or regional studies. Research at the meso-level has focused primarily on either the state or county level, with few micro-studies examining specific cities, communities and sites. Of the site-specific studies at the micro-level, most have been qualitative (Stults 1988; Russell 1989). Although the number of environmental

justice studies has increased exponentially and advanced methodologically, the arguments and focus have been predominantly limited to determining which socio-demographic variable, class or race, is the strongest predictor of living near a contaminated area. While much of the literature has focused on arguments concerning socio-demographic variables and sought to determine factors significantly related to environmental inequity and risk, the techniques are still evolving and heavily dependent on the most methodologically expeditious approaches, such as unit-hazard coincidence at the macro-level.

While this body of research has contributed greatly to bringing national attention to the issue of environmental injustice and preventing new facilities from locating in the U.S., national awareness has done little to help individual communities already impacted by environmental inequity. Much environmental justice research has sought to determine which populations are disproportionately impacted by environmental inequity. The number of studies examining the effects of environmental inequity, in terms of physical and psychological health, on populations is limited. If environmental sociology is meant to examine the interactions of society and the environment, future research should attempt to include the biophysical variables as independent variables, as well as dependent variables.

The application of Geographic Information Systems (GIS) in environmental justice research is relatively new. However, the methods are still "macro" in their approach, concerned with the broader picture. These previous applications do not help establish cause-and-effect relationship between exposure and health problems. Other areas of research, such as epidemiology, have examined possible causal relationships between environmental contaminants

and human health. In epidemiology, the "classic" epidemiology triangle (see Figure 6) is used to show "the interaction and interdependence of [the] environment, host, agent and time as used in the investigation of diseases and epidemics," where the agent is the "cause of the disease," the host is the "organism, usually human or animal, that harbors a disease," and the environment is "those favorable surroundings and conditions external to the human or animal that cause or allow disease transmission" (Timmerick 1998:7). "Favorable surroundings and external conditions" refer to the pathways of exposure (air, soil, water and food) through which contamination may be passed onto the individual, or host. But this research is also limited because it does not consider the social psychological impacts of contamination. Researchers are beginning to develop theoretical models to examine these interactions between society and the biophysical environment, such as the ecological-symbolic approach (Kroll-Smith 1991, 1993, 1994) and the social epidemiological model (Cwikel, Havenaar and Bromet 2002).

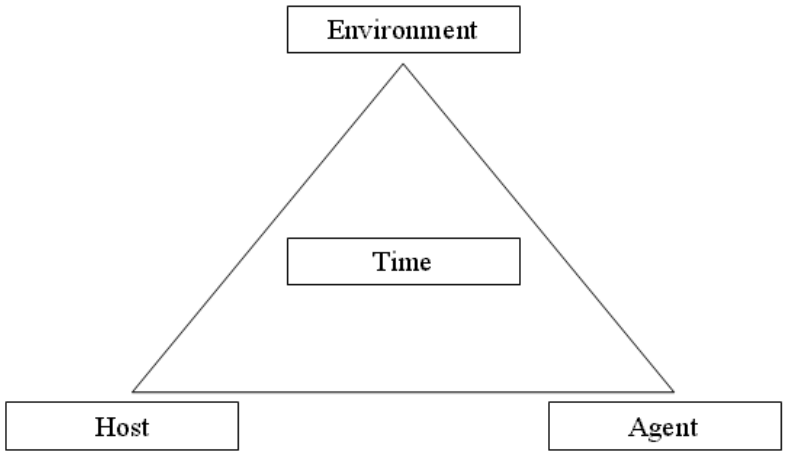

Figure 6: The Epidemiology Triangle

METHODOLOGICAL APPROACH

In this thesis, the case study looks at the effects and interactions of socio-demographics, lifestyle and exposure on the physical and psychological health of survey respondents. Using secondary data collected in the Wingate Health and Social Survey (2003) and the application of Geographic Information Systems (GIS), this thesis explores the relationship between the biophysical environment and the physical and psychological health impacts of environmental inequity. In this research, the units of analysis are not defined by extant political boundaries (i.e. census tracts, ZIP codes, etc.), but defined by the physical and social geography of the unique area. Unlike previous research, which has utilized various GIS approaches and aggregate social data, this research uses biophysical information in a modified geographic plume analysis with geocoded survey data. Rather than create a dichotomous "composite footprint" of the dispersion of the contamination, the model operationalizes the contamination as an interval variable to examine the impact of exposure. The inclusion of geocoded survey data from the Wingate Health and Social Survey will allow an assessment of the physical and psychological health impacts of contamination at the individual/household level using sociodemographic and exposure data.

"Exposure Matters" Hypothesis

Based on previous methodological developments, this hypothesis tests the significant effects of exposure to toxic contamination on the physical and psychological health of a surveyed

community, bringing attention to the importance of examining the impact of environmental factors. While much of the research has examined factors coinciding with existing facilities and sites (e.g. CRJ/UCC 1987; Mohai and Bryant 1992; Anderton et al. 1994; Pollack and Vittas 1995), environmental variables, such as air quality and toxic emissions, have only been considered in a limited capacity (Freeman 1972; Bowen et al. 1995; Chakaraborty and Armstrong 1997). This research argues that the investigation of environmental inequities cannot be limited to social variables, but also must consider environmental variables. This argument is supported by the CRJ and UCC report on toxic waste which recommended the consideration of physical considerations, such as groundwater, soil and topography, in case studies of individual facilities (1987).

Following previous research, we hypothesize that socio-demographics, lifestyle and exposure significantly affect the physical and psychological health of respondents both directly and indirectly (Cwikel, Havenaar, and Bromet 2002). This research suggests that selected sociodemographic variables have an indirect effect, through exposure, and a direct effect on physical and psychological health. Also, we contend that three measures of exposure – perceived, self-reported, and actual – have a direct effect on physical and psychological health. Finally, we argue that physical and psychological health are related, with a stronger causal relationship from physical health to psychological health than vice versa. Where past research has limited their questions to perceived exposure to contamination in their analyses, this analysis includes questions about specific exposure pathways and actual exposure measures.

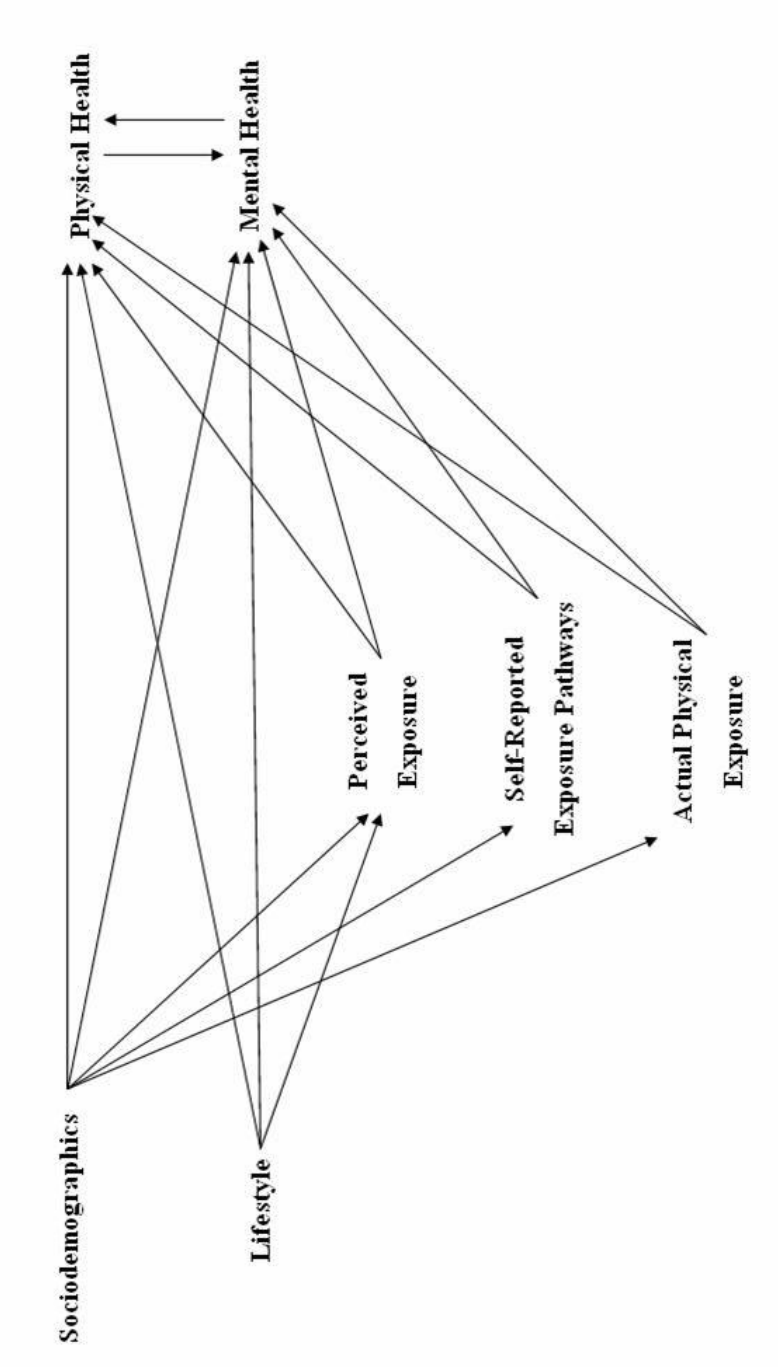

Figure 7: "Exposure Matters" Hypothesis

The “Exposure Matters” hypothesis suggests that exposure (perceived, self-reported, and actual) is a significant predictor of physical and psychological health. Previous researchers have argued that proximity to site should be used to determine potentially impacted population (Mohai and Saha 2003). However, this thesis argues that proximity is only one of many measures of exposure to be considered when examining the impact of contamination on a population. This is important because environmental contamination does not radiate outwards from the point source in perfectly concentric circles. As a result of the unique geography of each site, the pattern of contamination from a specific location, or point source, would not be uniform, but dependent upon the geology of the earth, hydrogeology (water flow underground), air patterns and other environmental exposure pathways. For example, contamination of drinking water from a point source would be dependent upon the direction of the underground water flow, similar to the idea of "standing down wind." Similarly, health effects would not occur in concentric circles because of the varied exposure pathways and the populations within each nested concentric circle are not homogenous.

With measures of perceived, self-reported and actual exposure, this thesis will also determine which is a stronger predictor of physical and psychological health. As previous research suggests (Cwikel, Havenaar, and Bromet 2002), actual exposure and self-reported exposure pathways should affect physical health significantly more than psychological health, which is also affected by perceived exposure.

This thesis also examines the level of psychological health impact among respondents. This is determined by a comparison of the psychological problems of people living in Wingate to

other populations impacted by technological disasters, natural disasters and other traumatic events. This is especially important to explore how the toxic contamination of the Wingate community (a chronic technological disaster) compares with other disasters.

Operationalization of Variables

As presented earlier in Figure 7, a path diagram was created from the social epidemiological model. The independent, exogenous variables (socio-demographics and lifestyle), mediating variables (perceived, self-reported and actual exposure) and the dependent, endogenous variables (physical and psychological health) of the path model were operationalized by questions found in the Wingate Health and Social Survey and related environmental data. The socio-demographic variables include age, gender, marital status, income, education and home ownership.[8] The lifestyle variable is limited to the question on whether or not the person ever smoked cigarettes or used tobacco products. Additional lifestyle variables, such as drinking and drug use, were not included in the original research design and thereby contribute to the weakness of this variable. Future research should include additional lifestyle variables. The exposure variable is divided into perceived, self-reported and actual. The perceived exposure is measured by four questions: the self-reported length of residency in the community, the individual's belief in personal and property exposure to chemicals, and their desire to move.[9] The self-reported exposure pathways include source of potable water (city or well water), homegrown vegetable consumption, and the level of fish from Rock Pit Lake and Lake Stupid.[10] These variables were then used to form a simple additive scale of self-reported exposure

pathways. The scale ranges from 0 to 4 (Cronbach's alpha = 0.64), where a score of zero means that the respondent answered "no" to all questions about potential exposure pathways and a score of four means that the respondent answered "yes" to all questions about potential exposure pathways. The scale was created for purposes of analysis, because dichotomous dependent variables cannot be used with linear regression without violating assumptions.

The actual exposure variables include proximity to the site and the estimated level of ash deposition, which is derived from Florida's Department of Environmental Protection (FDEP) ash deposition model for the Wingate site. For both of these variables, the results represent a measure of exposure, where a lower value represents least exposure and higher values equal highest exposure. The average radial proximity (in miles) was determined using the exact spherical distance between the geographic coordinates of the respondent's residence and the site.[11] Because some respondents lived in multiple locations, the distance was calculated by weighting each measured distance by the number of years at each residence. It is assumed that as the distance between the respondent's location and the site increases, the exposure risk would decrease. To calculate this, the inverse of the distance from the location to the site was multiplied by the years of residence at that location. This was repeated for each location of residency and the totals were added together to represent a cumulative weighted distance.

(1) Cumulative Weighted Distance = $[y_1*(1/d_1)] + [y_2*(1/d_2)] + [y_3*(1/d_2)]$
Where y_n = years of residence at each location, and
d_n = radial distance (miles) from the site to each location

Using Equation 1, the weighted proximity was calculated for each respondent, the results ranged from 0 to 484. Because this variable is used to test the secondary hypothesis of "proximity matters," which is based upon the presumption of radial proximity, the direction of the distance does not matter for this variable.

The average estimated level of ash deposition was determined using the information provided by the air deposition model created by the state of Florida and re-examined by Egan Environmental, Inc. The deposition levels were equally divided into ten intervals. Again, because respondents may have lived in multiple locations, a weighted average was calculated. The number of years at each location was multiplied by the level of deposition determine by the model for each coordinating location. Because the ash deposition level of the model was calculated in g/m^2 for a period of 8 years, the ash deposition value was divided by 8 to determine the annual level of deposition. These values for each residence were added together to represent a cumulative weighted level of ash deposition for each respondent.[12]

(2) Cumulative Weighted Ash Deposition = $(y_1*(x_1/8)) + (y_2*(x_2/8)) + (y_3*(x_3/8))$
Where y_n = years of residence at each location, and
x_n = estimated level of ash deposition (g/m^2) over an 8 year period

Using Equation 2, the results of the cumulative ash deposition ranged from 0 to 134.[13]

The physical health of respondents is determined by the self-reported diagnosed conditions and undiagnosed symptoms. Diagnosed conditions are defined as those conditions that have been diagnosed by a physician. Those undiagnosed symptoms are defined as those that

the respondent have self-reported, but have not been diagnosed by a physician. These diagnosed and undiagnosed variables were used to create a simple additive scale of physical health. The scale has a range of 0 to 31 (Cronbach's alpha = 0.87), where zero means that the respondent answered "no" to all conditions and symptoms and one means that the respondent answered "yes" to all conditions and symptoms. Like the self-reported exposure pathway scale, the physical health scale was created for purposes of analysis due to the dichotomous nature of the individual varaibles.

Psychological health variables were comprised of two scales, the Impact of Events Scale and the Depression Scale. The Impact of Events Scale (IES) was introduced by Mardi Horowitz, Nancy Wilner and William Alvarez in 1979 (Seidner, Amick, and Kilpatrick 1988). The questions evaluate the level of intrusiveness and avoidance related to the event, in this case the contamination in their neighborhood. The scale has since been used to evaluate an individual's response to stressful events, including technological disasters. The Depression Scale used is slightly modified from the Center for Epidemiologic Studies Depression Scale (CES-D). Introduced in 1977, the scale is designed "to measure [the] current level of depressive symptomatology, with emphasis on the effective component, depressed mood" (Radloff 1977:385).

Table 1: Comparison of Original and Modified CES-D Scale

Item	Original CES-D	Modified CES-D
1	I was bothered by things that usually do not irritate me	I was bothered by things that usually do not irritate me
2	I did not feel like eating; my appetite was poor	I lost my appetite
3	I felt that I could not get rid of the blues	I felt that I could not get rid of the blues
4	I felt that I was just as good as other people	---
5	I had trouble keeping my mind on what I was doing	I had trouble keeping my mind on what I was doing
6	I felt depressed.	---
7	I felt that everything that I did was an effort	Everything that I did took a great effort
8	I felt hopeful about the failure.	---
9	I felt that my life had been a failure.	I felt that my life was a failure
10	I felt fearful.	---
11	My sleep was restless.	I had trouble falling asleep or staying asleep
12	I was happy.	---
13	I talked less than usual.	---
14	I felt lonely.	I felt lonely
15	People are unfriendly.	---
16	I enjoyed life.	---
17	I had crying spells.	---
18	I felt sad.	I felt sad
19	I felt that people dislike me.	---
20	I felt that I could not get “going.”	I felt that I could not get going
	Cronbach’s alpha ≈ 0.85	Cronbach’s alpha ≈ 0.92

As presented in Table 1, the complete CES-D scale is comprised of 20 items, whereas the Wingate Health & Social Survey only used 10 items (Cronbach’s alpha = 0.9226). The scale represents “a valuable tool to identify such high-risk groups and to study the relationships between depressive symptoms and many other variables” (Radloff 1977: 400). Both scales have been used in previous research and have been found to be reliable measures of psychological health (Horowitz et al. 1979; Shore et al. 1989; Solomon 1989; Picou and Gill 1996).

Social and Environmental Data Collection

This thesis uses secondary data collected from various sources. The information largely originates from the Wingate Health and Social Survey and is supplemented by additional spatial and environmental information. This section provides an overview of the data collected.

The Wingate Health and Social Survey data was collected from April to October of 2003 by trained professionals proctoring self-administered surveys to residents local to the site (See Appendix B for a copy of the survey). The respondents surveyed were selected from a non-random, ad-hoc sample of residents living within close proximity of the site, approximately 1.5 miles (determined by the original research design). As the data was collected over several months, the conditions varied, but the survey remained the same. The first method of data collection occurred in mid-April over a period of 3 days (n = 137). The second method of data collection occurred after the first period of data collection and continued until early June (n = 37). The third method of data collection occurred after the results of the initial period of data collection were presented to the community in early June and continued until the end of October (n = 54). Since the sample is non-random, the results cannot be generalized beyond the 223 respondents who completed the survey. In addition, a response rate cannot be calculated because of the sampling procedure used and the secondary nature of the data. While this analysis uses secondary "blinded" data, which means that the personal identifiers, such as names and addresses, have been removed, for the purpose of geographic and spatial analysis, the addresses were previously geocoded. (See Appendix C for additional information on GIS and geocoding methodology.)

The additional spatial data collected for this thesis include U.S. Geological Survey (USGS) topographic maps, Air Modeling Deposition Model (Rogers and Reynolds 2002) and maps of water and soil monitoring and sampling locations. Historical aerial photos and maps were used for descriptive purposes. As mentioned earlier, this thesis uses a modified plume-based buffer analysis, whereby contamination, specifically the estimated level of ash deposition, is operationalized at the interval-level to examine the impacts of exposure.

Analytic Methodology

The hypotheses are tested through univariate, bivariate and multivariate analyses. First, a univariate (frequency) analysis is used to provide initial descriptions of the sample. Bivariate analyses were used to confirm the relationship between physical health and psychological health variables. A path analysis was used to test the relationship between the exposure variables and health variables. Building on simple multiple regressions, the path analysis allows the examination of the effects of independent variables and on multiple dependent variables. Path analysis also enables the assessment of the indirect effects of the sociodemographic and lifestyle variables on physical and psychological health.

RESULTS

The results of the analyses are presented in the sections below and are divided according to the type of analysis (univariate, bivariate, and multivariate).

Univariate Analyses

This section is subdivided according to the latent variables of the path model, sociodemographics, lifestyle, exposure (perceived, self-reported and actual), physical health, and psychological health.

Sociodemographics and Lifestyle

The results of the frequency analyses of the sociodemographic variables and lifestyle variable are presented in this section. In addition, these results were then compared to those obtained by the U.S. Census Bureau for 2000 to provide a descriptive, reference comparison.

The tables for this section can be found in Appendix D. The racial composition of the sample was entirely African American. The ages of the respondents ranged from 19 to 84 years of age. The average age of the survey respondents was 51. Respondents were more likely to be female (70.4% or n=157) than male (26.6% or n=66). The marital status of the respondents varied with almost half (44.6%) married, followed by those who were never married (22.5%), divorced (20.3%), and widowed (12.6%).

About half of the respondents reported that they had a high school degree (25.5%) or less (27.7%). A small group (12.0%) reported having attended vocational/technical school, but only

half of those or 6.0% of the full reported that they had graduated. Nearly one-fifth (19.9%) of the respondents reported having some college, but did not graduate. A few (6.9%) reported that they had graduated from college, but very few reported that they had attended graduate school (3.2%), received a Master's degree (3.2%) or an advanced professional degree (1.4%).

One third (33.2%) of the respondents reported an annual household income of less than $10,000. Nearly two out of three respondents (64%) own their home, while the remaining third (36%) rent.[14] Around thirty-four percent of the respondents answered that they had smoked cigarettes or used tobacco products, with the average respondent smoking about 17 years.

In a comparison of the sociodemographics and lifestyle variables findings with the 2000 U.S. Census, the results of the Wingate Health and Social Survey are not very similar to those for the zip codes around the site (area of interest). This comparison is not intended to imply generalizability of survey results to that of the census population, but is intended to provide a simple comparative reference of the sociodemographics.

Table 2: Comparison of Sociodemographics

Sociodemographic Variables	Wingate Health & Social Survey	Zip Codes[a]	U.S. General Population
Age	51.05	31.7[b]	35.3[b]
Gender			
Male	29.6%	47.0%	49.1%
Female	70.4%	53.0%	50.9%
Marital Status			
Married	44.6%	37.2%	54.4%
Single, Never Married	22.5%	37.3%	27.1%
Single, Divorced	20.3%	12.2%	9.7%
Widowed	12.6%	7.86%	6.6%
Educational Attainment			
Less than High School	27.8%	35.2%	19.6%[c]
High School Graduate	25.5%	31.4%	28.6%
Some college, but did not graduate	19.9%	17.4%	21.0%
College Graduate	6.9%	12.6%	15.5%
Advance professional degree	1.4%	3.4%	8.9%
Annual Household Income	N/A[d]	$54,256	$41,994
Home Ownership			
Own	64.0%	51.7%	66.2%
Rent	36.0%	48.3%	33.8%

[a] The Zip Codes are defined by those located around the site. They include: 33311 and 33313
[b] This number includes individuals who are under 18 years of age.
[c] This number was computed by adding "Less than 9th Grade" and "9th to 12th Grade, No Diploma" percentages.
[d] Annual Household Income for the Wingate Health and Social Survey did not specify income, but only provided a range.

The data best approximates the zip codes for area of the Wingate Community and the general U.S. population. The information was collected in 2000 by the U.S. Census Bureau.

Exposure

The next section provides the univariate analysis results for exposure. This section is presented in three separate subsections - perceived exposure, self-reported exposure and actual exposure. Although the measures of self-reported exposure pathways are not entirely objective, they are better proxies of objective measures than perceived exposure alone. The results are

segregated into these three levels for methodological and analytical purposes to best test the "exposure matters" hypothesis.

Perceived Exposure

This section presents the results of four questions which gauge the level of perceived exposure to health-threatening chemicals from the Wingate Incinerator and Landfill. The years of residence within the Wingate community were also included to determine if the length of residency affected the physical or psychological health of respondents. The average number of years of residency was 27 years. When respondents were asked to what extent they believed that they had been exposed to health-threatening chemicals (N=219), the results indicate that over three-quarters (77.2%) of the respondents either agreed (24.2%) or strongly agreed (54.3%) that they had personally been exposed. When asked if they believed that their home and personal property were exposed to health-threatening chemicals, a large majority (79.4%) of the respondents either agreed (25.8%) or strongly agreed (55.8%) that their property had been exposed. In addition, the desire to move was also used as an indicator of perceived exposure. When respondents were asked if they would move out of the neighborhood in which they currently reside, a majority of the respondents would not (70.9%).

Self-Reported Exposure

The results of the self-reported exposure questions represent the potential exposure pathways, including water consumption, vegetable and fish consumption. Nearly half (45.7%) of

the respondents reported that they had drunk well water. In response to the question as to whether they grew their own vegetables, 43.2% responded yes. For those respondents that reported they had eaten fish out of Rock Pit Lake (51.8%), most reported consuming the entire fish (77.7%) on average of five times per month over a period of 11 years. For those respondents that reported they had eaten fish out of Lake Stupid (27.7%), most reported consuming the entire fish (83.3%) on average of four times per month over a period of nearly 11 years.

Physical Health

Respondents were asked if they had been diagnosed as having any of the eight conditions. As presented in Table 3, approximately one in four respondents reported being diagnosed with irregular heartbeat (35.9%), bronchitis (29.6%), anemia (26.0%), diabetes (25.6%), or asthma (24.3%),.

Table 3: Frequency of Diagnosed Conditions

Condition	N	Yes	No	Don't Know
Irregular Heartbeat	223	35.9%	63.2%	0.4%
Bronchitis	223	29.6%	69.1%	1.3%
Anemia	223	26.0%	71.3%	2.2%
Diabetes	223	25.6%	73.5%	0.9%
Asthma	223	24.3%	73.1%	2.7%
Other Skin Conditions	223	18.4%	80.3%	1.3%
Cancer	223	12.6%	86.1%	1.3%
Chloracne	223	3.6%	91.5%	4.5%

Table 4: Frequency of Undiagnosed Symptoms

Symptom	N	Yes	No	Don't Know
Headache	222	68.8%	30.5%	0.4%
Muscle Aches/Pains	222	64.0%	34.7%	1.4%
Blurred Vision	222	59.9%	38.7%	1.4%
Soreness of Joints	221	59.3%	39.8%	0.9%
Numbness in Fingers, Toes, and/or Legs	221	56.1%	43.0%	0.9%
Difficulty Sleeping	220	55.0%	44.5%	0.5%
Sneezing	222	53.8%	45.7%	0.5%
Coughing	222	53.4%	45.7%	0.4%
Excessive Tiredness	221	52.9%	46.2%	0.9%
Burning Eyes	221	51.1%	47.5%	0.9%
Eyesight Problems	222	48.2%	51.4%	0.5%
Nausea/Upset Stomach	222	46.2%	51.6%	1.8%
Runny Nose	222	42.8%	56.8%	0.5%
Excess Tearing of Eyes	220	42.3%	56.8%	0.9%
Psychological Problems	222	42.3%	57.2%	0.5%
Difficulty in Concentration	221	41.6%	57.0%	1.4%
Burning Throat	221	38.0%	61.1%	0.9%
Respiratory Problems	219	37.9%	61.2%	0.9%
Digestive Problems	222	29.3%	70.3%	0.5%
Diarrhea	221	27.6%	70.6%	1.8%
Reproductive Problems	219	25.6%	73.5%	0.9%
Kidney Problems	222	17.1%	82.0%	0.9%
Liver Problems	221	8.6%	90.5%	0.9%

Respondents were asked if they experienced any of the 23 undiagnosed symptoms. As presented in Table 4, over half of the respondents reported suffering from headaches (68.5%), muscle aches/pains (64.0%), blurred vision (59.9%), soreness of joints (59.3%), numbness in fingers, toes and/or legs (56.1%), difficulty sleeping (55.0%), sneezing (53.8%), coughing (53.4%), excessive tiredness (52.9%), or burning of eyes (51.1%).

Psychological Health

Table 5: Impact of Events Scale

Impact of Events Scale Intrusive Stress Subscale	Mean
I thought about the contamination in my neighborhood when I didn't want to	3.14
Pictures about the contamination in my neighborhood popped into my mind	3.09
Other things kept making me think about the contamination in my neighborhood	3.07
I had trouble falling asleep or staying asleep because of the contamination in my neighborhood	1.99
I had waves of strong feelings about the contamination in my neighborhood	2.93
I had dreams about the contamination in my neighborhood	1.39
Any reminder brought back feelings about the contamination in my neighborhood	2.77
Total (Scale 0 to 35) alpha = 0.90	18.57

Avoidance Behavior Subscale	Mean
I avoid letting myself get upset when I thought about the contamination in my neighborhood or was reminded of it	2.32
I tried to remove the contamination in my neighborhood from my memory	2.44
I stayed away from reminders of the contamination in my neighborhood	2.24
I felt as is the contamination in my neighborhood hadn't happened or wasn't real	1.58
I was aware that I still had a lot of feelings about the contamination in my neighborhood, but I didn't deal with them	2.39
I tried not to think about the contamination in my neighborhood	2.44
My feelings about the contamination in my neighborhood were kind of numb	2.31
I tried not to talk about the contamination in my neighborhood.	2.31
Total (Scale 0 to 40) Alpha = 0.85	18.10

Total IES Scale (Scale 0 to 75) alpha= 0.91	36.51

The results in this section are presented as the Impact of Events (IES) subscales and the depression scale. The IES subscales are designed to measure the levels of stress experienced by the individual. The mean values of the total scale (36.51) and subscales (18.57 and 18.10) indicate a high level of stress among respondents. The internal reliability of the total scale is

quite high (Cronbach's alpha = 0.91). The internal reliability of the subscales, intrusive stress (0.90) and avoidance behavior (0.85), were also found to be quite high. These results are comparable to those found by Horowitz et al. in their original study (IS alpha =0.078 and AB alpha = 0.80) (1979). The Intrusive Stress and Avoidance Behavior subscale will be used as variables in later analyses.

Depression Scale

The scale was comprised of ten items that ask respondents to report the number of times (0 to 7) in the past week that they have thought about each item. The internal reliability of the scale was very high (Cronbach's alpha = 0.92). As presented in Table 6, the mean value of the total depression scale was found to be 16.21 (total scale 0 – 30).

Table 6: Depression Scale

Item	Mean
I felt that I could not get rid of the blues	1.77
I had trouble keeping my mind on what I was doing	1.84
Everything that I did took a great effort	1.96
I felt sad	1.77
I felt that I could not get going	1.83
I lost my appetite	1.19
I had trouble falling asleep or staying asleep	1.78
I felt lonely	1.46
I was bothered by things that usually do not irritate me	1.61
I felt that my life was a failure	0.98
Total Depression Scale (Scale 0 to 30)	16.21
Alpha = 0.9226	

Bivariate Analyses

Bivariate analyses are divided into three sections (sociodemographics, actual exposure and physical and psychological health). These sections are guided by the path model presented earlier, see Figure 7. Pearson's r was used when testing for significance between two dichotomous variables, or a dichotomous variable and an ordinal/interval variable. Kendall's tau-b was used when testing for significance between two ordinal variables, or ordinal and interval variables. These two measures of association were used to more rigorously test for significance between variables.

Prior to conducting any bivariate analyses, a difference of means was conducted to test whether the method of data collection significantly affects the variables used in the analyses. This is important because the method of data collection varies within the sample. Although this is not wholly desirable, due to the research design, it can only be controlled post hoc. To test for differences, the collection methods were dichotomized into the initial data collection, which occurred in mid-April, and all data collected after mid-April. The results found significant differences between the two sample groups for some variables (age, smoking, consumption of vegetables and fish from Lake Stupid, intrusive stress, avoidance behavior, and depression). For the following bivariate analyses, partial bivariate correlations using Pearson's r were conducted for all variables. Only significant results that differ from the initial bivariate results will be discussed.

Sociodemographics

Sociodemographics and lifestyle were correlated with exposure and health variables to determine significant correlations. As presented in Table 7, the results show a significant correlation between age and years of residency within the Wingate community (tau-b = 0.255), whether or not the respondents grew their own vegetables (r = 0.177), and the level of ash deposition (tau-b = 0.135), Intrusive Stress (r = 0.149), Avoidance Behavior (r = 0.149), and depression (r = -0.156). Older respondents, those who lived in the community longer, and those who grew their own vegetables lived in areas with heavier ash deposition. Additionally, significant correlations were also found between gender and years of residency in the community (-0.183), the Avoidance Behavior subscale (r = 0.149) and depression (r = 0.170).

Table 7: Results of Correlations with Sociodemographic Variables

Variable	Age	Gender	Marital	Education	Income	Ownership	Smoking
Residence	0.255**	-0.183**	-0.057	-0.099	0.139**	0.278***	0.002
Self Exposure	0.049	-0.032	0.034	-0.052	-0.030	-0.137	-0.001
Property Exposure	0.039	0.007	-0.007	-0.140*	-0.070	-0.104	-0.047
Desire to Move	-0.081	0.055	-0.105	0.010	0.026	-0.188*	-0.163*
Well Water	0.032	0.061	0.179**	-0.014	-0.013	-0.092	-0.168*
Vegetable	0.177**	-0.036	-0.038	-0.008	0.088	0.151*	-0.123
R.P.L Fish	-0.078	0.053	0.127	-0.102	-0.192**	-0.232**	-0.026
L.S. Fish	-0.038	0.056	0.110	-0.093	-0.116	-0.141	0.027
Proximity	-0.059	-0.109	0.078	0.111*	0.070	0.066	-0.044
Ash Deposition	0.135**	-0.051	-0.083	0.019	0.169**	0.350***	-0.033
Physical Health	0.067	0.078	-0.079	-0.137*	-0.150**	-0.184*	-0.037
Intrusive Stress	0.149*	0.029	0.081	-0.072	-0.041	-0.044	-0.041
Avoidance Behavior	0.149*	0.149*	0.035	-0.182**	-0.144**	-0.111	-0.070
Depression	-0.156*	0.170*	-0.110	-0.082	-0.220**	-0.299**	-0.098

* Significant at p>0.05 level ** Significant at p>0.01 level *** Significant at p>0.001 level

Males are likely than females to have lived longer within the community. Being married was found to be significantly correlated with well-water consumption (r = 0.179). Education was found to be significantly correlated with proximity (tau-b = 0.111), but inversely correlated with the belief that their property was exposed to chemical contaminants (tau-b = -0.140), as well as physical health (tau-b = -0.137), and the level of engagement in avoidance behaviors (tau-b = -0.182). This means as the educational attainment level of respondents increases, their perceived exposure, and physical and psychological health decrease. Annual household income is correlated with years of residency (tau-b = 0.139) and the level of ash deposition (tau-b = 0.169), but is inversely correlated with fish consumption from Rock Pit Lake (r = -0.192), physical health (tau-b = -0.137), Avoidance Behaviors (tau-b = -0.144), and the level of depression (tau-b = -0.220). The positive relationship between income and ash deposition contrasts with previous findings that as annual household income increases, the level of exposure would decrease. Home ownership is found to be significantly correlated to years of residency (r = 0.278) home-grown vegetables (r = 0.151), and the level of ash deposition (r = 0.350), but inversely related with the desire to move (r = -0.163), fish consumption from Rock Pit Lake (r = -0.232), and the level of depression (r = -0.299). Those respondents who had smoked or used tobacco products were also likely to have a desire to move (r = -0.163) and consume well water (r = -0.168).

Physical and Psychological Health

Physical and psychological health variables were correlated along with all variables including actual exposure, and physical and psychological health variables. As presented in

Table 8, physical health was found to be significantly correlated with all variables with the exception of years of residence, the belief that they were personally exposed to chemicals, proximity to the site, the level of ash deposition, and Avoidance Behavior. The beliefs that they (tau-b = 0.199) and their property (tau-b = 0.167) were exposed to chemical contamination were found to be correlated with physical health. All the self-reported exposure pathways were found to be significantly related to physical health.

Table 8: Results of Correlations with Physical and Psychological Health Variables

Variables	Physical Health	Psychological Health		
		Intrusive Stress	Avoidance Behavior	Depression Scale
Residence	0.024	0.096	0.030	0.007
Self Exposure	0.199**	0.172**	0.234**	0.105
Property Exposure	0.167**	0.175**	0.252**	0.137*
Well Water	0.271 ***	0.132*	0.102	0.203**
Vegetable	0.147*	0.151*	0.131*	0.132*
R.P.L Fish	0.287 ***	0.245 ***	0.169*	0.190**
L.S. Fish	0.269 ***	0.212 ***	0.103	0.237**
Proximity	-0.085	-0.059	-0.080	0.022
Ash Deposition	0.009	0.024	-0.012	-0.039
Physical Health	---	0.226**	0.145**	0.321**

* Significant at p>0.05 level ** Significant at p>0.01 level *** Significant at p>0.001 level
Note: Physical and psychological health and sociodemographic/lifestyle correlations can be found in Table 7.

These pathways include well water consumption (r = 0.271), home-grown vegetable consumption (r = 0.147), and fish consumption from both Rock Pit Lake (r = 0.287) and Lake Stupid (r = 0.269). In addition, physical health is correlated with all psychological health variables which includes Intrusive Stress (tau-b = 0.226), Avoidance Behaviors (tau-b = 0.149), and Depression (tau-b = 0.339).

The Intrusive Stress (IS) was found to be significantly correlated to most perceived exposure and all the self-reported exposure pathways. Perceived exposure included the belief that they (tau-b = 0.172) and their property (tau-b = 0.175) were exposed to chemical contamination. The self-reported pathways include well water consumption (r = 0.132), home-grown vegetable consumption (r = 0.151), and fish consumption from both Rock Pit Lake (r = 0.245) and Lake Stupid (r = 0.212).

The Avoidance Behavior (AB) subscale was found to be significantly correlated to most of the perceived exposure variables and self-reported exposure pathways. These include the belief that they were personally exposed to health-threatening chemicals (tau-b = 0.234) and their property was also exposed (tau-b = 0.252). In addition, AB was significantly correlated with the self-reported pathways of home-grown vegetable consumption (r = 0.131), consumption of fish from Rock Pit Lake (r = 0.169), and physical health (r= 0.145).

The level of Depression among respondents was found to be significantly related to some perceived exposure and all the self-reported exposure pathways and physical health (r = 0.321). This includes the belief that their property was exposed to chemical contaminants (tau-b = 0.137). The self-reported pathways include well-water (r = 0.203) and home-grown vegetable (r = 0.132) consumption were correlated as was fish consumption from Rock Pit Lake (r = 0.190) and Lake Stupid (r = 0.237).

However, perhaps most significant, the results of the bivariate analyses for psychological health support a significant relationship with the exposure variables. This means that their perceived exposure and self-reported exposure pathways are related to their psychological health.

This next section more closely examines the relationship between these and other variables on physical and psychological health variables.

Multivariate Analyses

Linear regression with pairwise deletion of missing variables was used in the multivariate analyses. The mediating exposure and health variables were first regressed on all of the sociodemographics and lifestyle. Then, physical and psychological health variables were regressed on all variables. The results of these regressions are presented in the following sections.

Exposure

This section examines the effects of sociodemographics and lifestyles on the exposure variables, including perceived, self-reported and actual exposure, and physical and psychological health. The dependent variables were individually regressed on the sociodemographic and lifestyle variables using OLS linear regression.

Table 9 presents age, education and income significantly predicting years of residency within the community. As age and income increase, so do the years of residency. This is not unexpected: as respondents age, residential mobility decreases which leads to greater years of residency within a particular community. The effect of education on residency indicates that as educational attainment increases, the years of residency decrease, meaning that respondents are

more likely to move away. However, as income increases, the years of residency also increase. Further research should examine additional factors that may influence this relationship.

Table 9: Effects of Independent Variables on Perceived Exposure

Independent Variable	Years of Residence		Belief in Self Exposure		Belief in Property Exposure	
	β	t	β	t	β	t
Age	.313	4.244***	.129	1.562	.086	1.041
Gender – Female	-.125	-1.746	-.026	-.319	-.005	-.064
Marital Status – Married	-.023	-.313	-.008	-.091	.020	.240
Education	-.232	-2.663**	-.035	-.359	-.135	-1.372
Annual Household Income	.224	2.294*	.115	1.050	.076	.687
Home Ownership	.122	1.526	-.220	-2.462*	-.144	-1.607
Smoking	-.119	-1.703	-.021	-.274	-.082	-1.050
R^2	0.238***		0.040		0.035	
N	183		183		183	
* Significant at p>0.05 level	** Significant at p>0.01 level				*** Significant at p>0.001 level	

Table 10: Effects of Independent Variables on Self-Reported Exposure

Independent Variable	Self-Reported	
	β	t
Age	0.073	0.853
Gender – Female	0.057	0.696
Marital Status – Married	-0.071	-0.814
Education	-0.033	-0.324
Annual Household Income	0.047	0.408
Home Ownership	-0.099	-1.059
R^2	0.021	
N	170	
* Significant at p>0.05 level		
** Significant at p>0.01 level		
*** Significant at p>0.001 level		

As presented in Table 10, after regressing the self-reported exposure pathway scale on the independent sociodemographic and lifestyle variables, the model was not significant nor were

there any significant relationships. This means that the degree to which people were exposed through the exposure pathways was not affected by sociodemographics and lifestyle.

Table 11: Effects of Independent Variables on Actual Exposure

Independent Variable	Proximity to the Site		Ash Deposition	
	β	t	β	T
Age	-0.105	-1.294	0.169	2.210*
Gender – Female	-0.158	-2.041*	0.033	0.454
Marital Status – Married	-0.129	1.558	-0.023	-0.295
Education	0.129	1.358	-0.096	1.068
Annual Household Income	-0.156	-1.440	0.180	1.758
Home Ownership	-0.168	1.906	0.249	2.987**
R^2	0.063		0.162***	
N	183		183	

*Significant at p>0.05 level
** Significant at p>0.01 level
*** Significant at p>0.001 level

As presented in Table 11, after regressing the actual exposure variables on sociodemographics and lifestyle, the regression model for proximity to site was not significant. However, the model for ash deposition was significant. Age and home ownership predict the exposure to levels of ash deposition. As the age of respondents increased, the level of ash deposition also increases because it is a measure of cumulative exposure over time. Home owners were also found to have higher levels of exposure to ash deposition. As home owners are less likely to move around, they would have greater length of residency which would then affect the level of exposure to ash deposition.

Physical and Psychological Health

This section examines the effects of the independent variables on physical and psychological health variables. The analysis was divided into four parts (physical health, Intrusive Stress, Avoidance Behavior, and Depression). The significant results of these four regressions are presented in several tables and one figure with the standardized coefficients.

Table 12: Effects of Independent Variables on Physical Health

Independent Variables	β	T
Age	0.150	1.867
Gender	-0.029	-0.397
Marital Status	-0.017	-0.225
Education	-0.137	-1.502
Income	-0.003	-0.030
Home Ownership	-0.048	-0.564
Smoking	-0.048	-0.680
Years of Residence	-0.173	-1.919
Exposure of Self	0.262	1.970
Exposure of Property	-0.122	-0.919
Self-Reported Exposure Pathways	0.221	2.974**
Proximity to Site	-0.150	-2.152*
Level of Ash Deposition	0.131	1.550
Intrusive Stress	0.129	1.414
Avoidance Behavior	-0.143	-1.574
Depression	0.359	4.285***
R^2	0.343***	
N	170	

*Significant at p>0.05 level
** Significant at p>0.01 level
*** Significant at p>0.001 level

As presented in Table 12, when physical health was regressed on the independent variables, several significant predictors were found. The self-reported exposure pathways and proximity to the site results partially support the hypothesis that exposure affects physical health.

As the number of exposure pathways increases, the number of conditions and symptoms a person has also increases. When looking at proximity, people who live further from the site have fewer physical health problems. Of all the variables found to be significant, the level of depression is the strongest predictor of physical health. The findings suggest that the more depressed someone is, the more physical health problems they have.

Table 13: Effects of Independent Variables on Intrusive Stress

Independent Variables	β	T
Age	0.121	1.405
Gender	0.015	0.185
Marital Status	0.136	1.639
Education	0.060	0.599
Income	-0.047	-0.428
Home Ownership	-0.054	-0.578
Smoking	-0.026	-0.338
Years of Residence	0.051	0.511
Exposure of Self	0.037	0.254
Exposure of Property	-0.008	-0.057
Self-Reported Exposure Pathways	0.245	3.002**
Proximity to Site	-0.044	-0.567
Level of Ash Deposition	-0.025	-0.262
Physical Health	0.206	2.494*
R^2	0.189**	
N	170	

*Significant at p>0.05 level
** Significant at p>0.01 level
*** Significant at p>0.001 level

As presented in Table 13, when Intrusive Stress was regressed on all independent variables, several significant predictors were found. As the number of self-reported exposure pathways increased, the level of Intrusive Stress also increased. This relationship is stronger than the effects of physical health on Intrusive Stress. However, the number of conditions and

symptoms associated with physical health also significantly affects the level of Intrusive Stress experienced by residents.

As Table 14 presents, when Avoidance Behavior was regressed on sociodemographic, lifestyle, exposure and physical health, self-reported exposure pathways were found to be significant.

Table 14: Effects of Independent Variables on Avoidance Behavior

Independent Variables	β	T
Age	.126	1.469
Gender	.101	1.254
Marital Status	.128	1.554
Education	-.121	-1.214
Income	-.073	-.665
Home Ownership	-.071	-.764
Smoking	-.080	-1.026
Years of Residence	-.027	-.272
Exposure of Self	.046	.312
Exposure of Property	.118	.808
Self-Reported Exposure Pathways	.181	2.228*
Proximity to Site	-.083	-1.085
Level of Ash Deposition	.008	.084
Physical Health	.056	.683
R^2	0.194**	
N	170	

*Significant at p>0.05 level
** Significant at p>0.01 level
*** Significant at p>0.001 level

As Table 15 presents, age, self-reported exposure pathways, and physical health were found to be significant predictors of depression. Like previous physical and psychological health variables, self-reported exposure is directly related to the level of depression. The effect of physical health variables on the level of depression establishes a reciprocal relationship. The

counter intuitive inverse relationship between age and depression is difficult to explain. Personal correspondence suggests that the area around the site has an elevated level of crime and drug use among juveniles and young adults, which may explain the inverse relationship.

Table 15: Effects of Independent Variables on Depression Scale

Independent Variables	β	t
Age	-.186	-2.406*
Gender	.093	1.287
Marital Status	.077	1.030
Education	.008	.085
Income	-.147	-1.489
Home Ownership	-.160	-1.917
Smoking	-.009	-.130
Years of Residence	.124	1.386
Exposure of Self	-.192	-1.447
Exposure of Property	.135	1.026
Self-Reported Exposure Pathways	.175	2.381*
Proximity to Site	.084	1.216
Level of Ash Deposition	-.013	-.151
Physical Health	.357	4.811***
R^2	0.345***	
N	170	

*Significant at p>0.05 level
** Significant at p>0.01 level
*** Significant at p>0.001 level

For the sake of parsimony, the path model presented in Figure 8 only includes the paths for statistically significant relationships. Path coefficients are standardized regression coefficients.

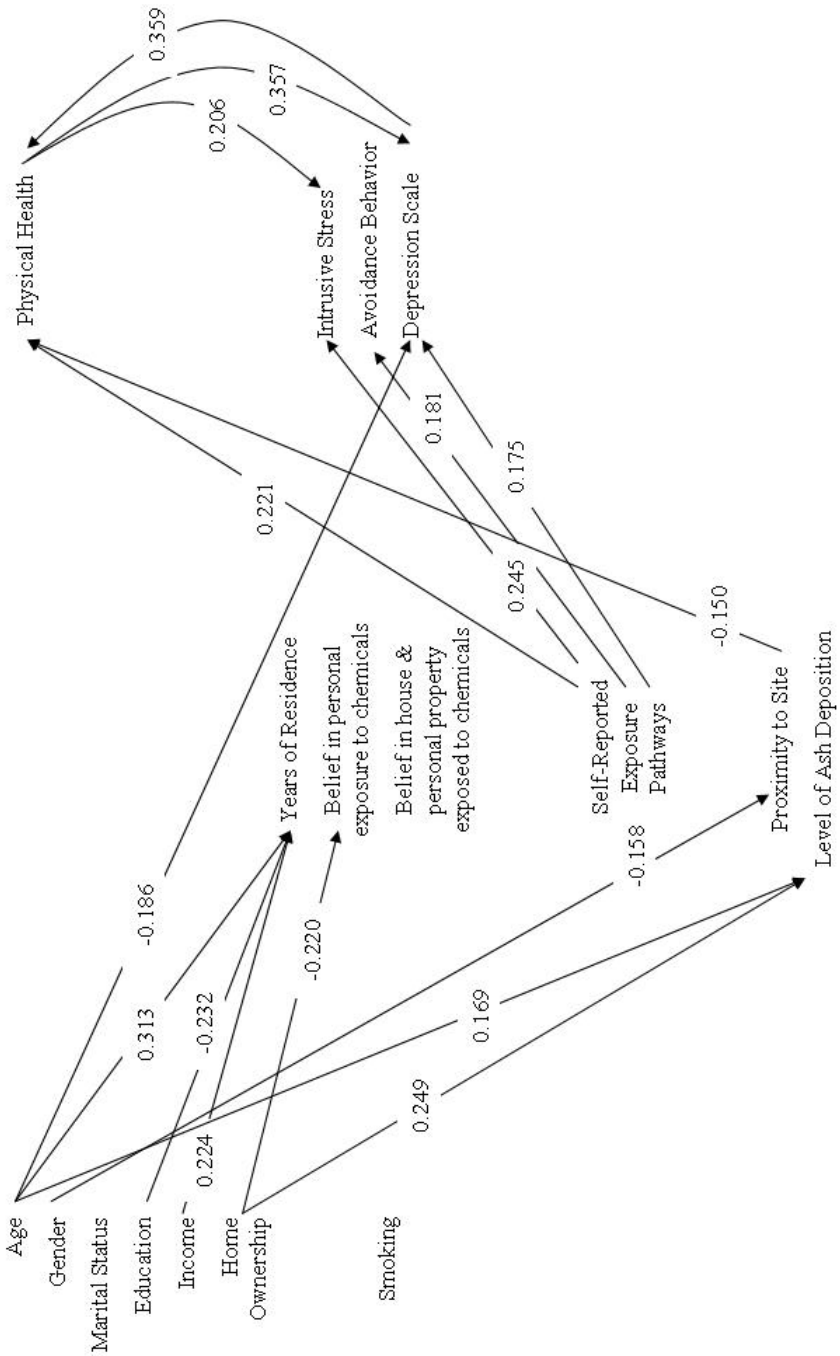

Figure 8: Path Model with Standardized Regression Coefficients

DISCUSSION AND CONCLUSION

The results of the multivariate analyses show that sociodemographic characteristics and smoking are poor predictors of exposure and physical and psychological health. In this case, the degree of exposure to contamination is not affected by sociodemographics or lifestyle. Additionally, in this case, physical and psychological health are not significantly affected by sociodemographics and lifestyle.

Perceived exposure is also a poor predictor of physical and psychological health. Although previous research has found perceived exposure to significantly affect psychological health, they are highly subjective measures of exposure (Crighton et al. 2003; Cwikel et al. 1997). When combined with more objective measures in analysis, the effects of perceived exposure are much weaker. In contrast, the scale of self-reported exposure pathways is a strong predictor of psychological and physical health. When looking at self-reported exposure pathways, they are proxies of known epidemiological exposure pathways. The pathways are the modes of transmission into the body (Timmerick 1998). While the self-reported exposure pathways, while not objective, they are better surrogates for actual exposure than perceived exposure. These represent the physical links between individuals and their physical environment.

When looking at actual exposure, proximity is significant, but not the more sophisticated measure of ash deposition. Self-reported and actual exposure are more objective measures of exposure. Although cumulative ash deposition is not significant, the significance of the more

sophisticated measure of proximity is important. Proximity does matter in this case, but the measurement of proximity differs from previous research. Where previous research has used pre-defined buffers, the cumulative, weighted measure of proximity is a more sophisticated measure. By considering the individual length of residency, mobility, and the exact distance from the site, the measure of proximity is more rigorous.[15]

In this case, the effects of sociodemographics and lifestyle are much weaker due to the significantly greater influence of exposure on physical and psychological health. While perceived exposure is not significant, self-reported and actual exposure are significant. This supports the central hypothesis that "exposure matters." Physical and psychological health are significantly impacted by exposure to contamination. As expected, psychological and physical health are related. The physical health of an individual significantly affects their psychological health and vice versa. In the broader sense, the extent to which a community is exposed to contamination is much more significant than its sociodemographic composition.

Methodologically, this thesis supports the use of environmental variables as independent variables in social impact analysis. Specifically, this thesis encourages the use of more objective measures, including self-reported exposure pathways and actual exposure. The results, in terms of their impact on policy, affect the remediation of past and present sites and the siting of future facilities. In terms of site remediation, the effects of chronic exposure significantly affect psychological as well as physical health of individuals who have lived or currently live within the area of the site. Future siting of the facilities must include not only the consideration of the

sociodemographic characteristics of the area, but the long-term environmental effects and their potential impact on the population.

These bivariate results indicate that actual exposure is significantly correlated with physical health. However, the limitations of linear regression suggest that additional regression techniques should be used to more adequately test the effect of actual exposure on specific physical conditions and symptoms. Other regression techniques, such as the logit model in log-linear regression analysis, also known as logistic regression, may be used to better address these dichotomous dependent variables of physical health. Post hoc bivariate analyses find proximity to be significantly correlated with coughing and muscle aches. Ash deposition was found to be significantly correlated with diabetes and diarrhea. It should also be considered that some medical conditions, such as cancer, may not appear for many years. Therefore, the effects of chemical contamination may not become apparent until later.

Comparison with Previous Research

The psychological health impacts of respondents can be compared with the results found in previous disaster and other trauma-related research. The results of previous studies of psychological health impact are presented in Table 16. These studies included the Exxon-Valdez oil spill (EVOS), bushfires in Australia, victims of rape, and witness of the dissection of a cadaver (dead body).

Table 16: Comparison of Results with Previous Research

Event	Impact of Events Scale			Depression (Range)
	Total	IS	AB	
Wingate Road Municipal Incinerator and Landfill, FL	23.78	11.99 (0–35)	11.88 (0-40)	31.64 (0-70)
Brio Superfund Site	N/A	17.2	16.4	---
2 yrs post-EVOS (1991) - Cordova, AK [a]	N/A	12.46	N/A	---
3 yrs post-EVOS (1992) - Cordova, AK [a]	N/A	11.78	N/A	---
12 yrs post-EVOS (2001) - Cordova, AK [a]	N/A	14.74	N/A	---
EVOS - Native Americans [b]	---	---	---	11.1 (0 – 60)
EVOS - Euro-Americans [b]	---	---	---	6.8 (0 – 60)
Livingston, LA – Train Derailment	N/A	13.7	11.4	---
Australian Bushfires [c]	17.4	10.5	7.5	---
Victims of Rape [d]	N/A	23.8	26.0	---
Victims of Rape (2 yrs after therapy) [d]	N/A	11.4	16.0	---
Cadaver Dissection Pre-therapy [e]	43.7	23.1	20.6	---
Cadaver Dissection Post-therapy [e]	24.3	13.9	10.5	---
Death [f]	15.31	16.93	32.24	---
No Event [f]	7.99	9.12	17.11	---
General Population [g]	---	---	---	10.3 (0 – 60)

[a] Marshall et al. 2004; [b] Palinkas et al. 1992; [c] Gill 1986; [d] McFarlane 1992; [e] Kilpatrick & Veronen 1984; [f] Horowitz, Wilner and Alvarez, 1979; [g] Wilson et al. 1985; [h] Michales et al. 2000

The results indicate that the psychosocial impact of Wingate is greater than that associated with natural disasters (i.e. bushfires), but similar to the level of the stress experienced by rape victims after 2 years of therapy. In addition, respondents are more depressed than the victims of other technological disasters (i.e. EVOS) and the general population. Overall, the results of the Wingate Health & Social Survey indicate a high level of stress and depression among respondents.

Although respondents of the Wingate Health and Social Survey have experienced a chronic, rather than acute, technological disaster, the psychosocial impact is comparable to those of other disasters and traumatic events. Only recently had research begun to examine the psychological health impacts of chronic environmental contamination. Researchers have examined the "impacts associated with multi-sourced, environmental problems" in the Aral Sea region as well as the long-term psychosocial effects of Chernobyl (Crighton et al. 2003; Cwikel et al. 1997). However, the linkage between the physical exposure and psychological health impacts is more contextually referenced rather than included in analyses.

Conclusion

In the past 20 years of EJ research, unit-hazard coincidence is still the most frequently used method in analysis, while the use of environmental variables as independent variables in analysis is extremely limited. This thesis is unique because it is quantitative, but only addresses one community. Methodologically, the use of GIS and geocoded survey data have created unique measures of actual exposure. The cumulative weighted measure of proximity and ash deposition takes into consideration respondents' mobility over time. Although the measures remain dependent on self-reported information, they are more accurate than the assessment of proximity and ash deposition based upon respondent's current residences. Greater understanding of the long-term effects of exposure to environmental contamination is still needed.

In this thesis, the findings are particularly notable. First, the results of the analysis have shown that there is a correlation between actual exposure and the physical and psychological

health of respondents. Second, respondents self-reported pathways of exposure have a direct effect on their physical and psychological health. Third, in comparison with other disaster research, the respondents of the survey are experiencing a high level of stress and depression related to the contamination in their community. For the residents, their perception of risk to contamination is high as indicated by the high level of chronic psychological stress and depression as determined by the Impact of Events and Depression scales. As long as the risk is perceived, the threat is real to the community (Cwikel, Bromet and Havenaar 2002). Overall, exposure, more than sociodemographics, matters when the examining the impact of contamination on a community.

Future Research

With the emergence of GIS, environmental justice researchers have been able to develop more advanced methodological approaches to identify environmental inequities. Using recent and proposed methodologies, the research conducted in this thesis has examined the physical and psychological health effects of environmental inequity and contamination surrounding one site, the Wingate Road Municipal Incinerator and Landfill Superfund site. Methodologically, this research has combined environmental information with social and self-reported epidemiological data to more accurately examine these socio-environmental relationships finding "exposure matters."

With additional information from medical research, future research can more closely examine the connection between contaminants, such as dioxin, and their health effects. Medical

research has already begun to report the long-term impacts of synthetic and toxic chemicals (Colborn et al. 1997; Schettler et al. 1999). However, environmental research should also be included to examine the chemical composition of the incinerator's fly ash to more accurately assess exposure to contaminants via ash deposition. This is especially important because toxins have varying densities which would affect their deposition patterns. It would be expected that toxins with heavier densities, such as lead, would have a smaller area of deposition as opposed to the lighter contaminants, such as dioxin, which would be expected to have a broader area of deposition. By increasing our understanding of these interactions and indicators, social scientists can develop more effective approaches to direct recovery programs and policy revisions to assist populations impacted by environmental contamination.

APPENDIX A:

TIMELINE OF EVENTS

Year	Month	Day	Description
1911			Incorporation of the City of Fort Lauderdale
1951			Site purchased by City of Fort Lauderdale (former agricultural site)
1954			Wingate Road Municipal Incinerator and Landfill begins operation
1964			Civil Right Act of 1964 Enacted
1966			Second "new" incinerator becomes operational
1966			Young lawyer, Alcee Hastings (now Congressman), sues City of Fort Lauderdale to try and stop the installation of second smoke stack (Unsuccessful)
1975			Cooling water treatment system constructed for use by both incinerators
1978	June		Operation of the Wingate Road incinerators ends
1980			Superfund is created
1984			EPA considers adding Wingate to the Superfund list
1985			Hazard Ranking System Report issued
1986			Landfill closed
1989	June		EPA considers adding Wingate to the Superfund list for a second time
1989	September	29	Wingate Road Municipal Incinerator and Landfill added to Superfund's Active NPL List
1990			FL Dept. of Health and Agency for Toxic Substances and Disease Registry conclude the site is not a current public health threat
1991	September	19	Port Everglades Authority agrees to chip in up to $60,000 for a study of pollution
1991			City of Fort Lauderdale and Port Everglades Authority enter into Administrative Order on Consent (AC) with EPA to conduct RI/FeS
1991			Fort Lauderdale and EPA study detects several toxic substances in landfill ash residue
1992	April	7	Fort Lauderdale City Commission agreed to spend $632,091 with the possibility of paying $132,909 later to consultants Brown and Caldwell to study the extent of contamination at the Wingate Landfill and how to clean it up
1992	April	7	City commission agrees to hire consultants to test soil, ground water, sediment and air around site
1992	April		EPA begins its community relations conducting community interviews and public meeting
1993	March		EPA Public Meeting to discuss results of Remedial Investigation
1994	December	5	EPA Proposed Plan Fact Sheet released to public
1994	December	7	Public comment period for proposed remedial action begins
1994	December	12	EPA and Agency for Toxic Substances and Disease Registry (ASTDR) hold public meeting to present results of the RI/FeS
1994	December	14	EPA holds public meeting to discuss recommendation for capping the old Wingate landfill

Year	Month	Day	Description
1994	February		EPA Public Meeting to discuss results of Remedial Investigation
1994			President Clinton issues Executive Order 12898 reinforcing the Civil Rights Act of 1964 and created the National Environmental Justice Advisory Council (NEJAC)
1994			EPA reports that present-day, increased risk of cancer to workers and children playing on the site is within EPA limits
1995	January	4	Fort Lauderdale City Commission approves first rate increase for homeowners garbage bills
1995	January	6	Public comment period for proposed remedial action ends
1995			Agency for Toxic Substances recommends limiting fish consumption to one meal per week from Rock Pit Lake (cite)
1996	August	8	City of Fort Lauderdale holds community meeting to discuss Wingate
1996	July		State Dept. of Health and Agency for Toxic Substances report that nearby residential soil is not a public health threat
1996	March		State Dept. of Health and Agency for Toxic Substances preliminary review of state cancer data finds rates of some cancers may be elevated in 9 Census tracts surrounding Wingate
1996	May		EPA releases Superfund Record of Decision (ROD) for Wingate Road Municipal Incinerator and Landfill ()
1996	October	21	Florida Environmental Equity & Justice Commission Final Report released.
1997	February	20	Public Meeting held to discuss the contaminated landfill
1997	July	26	Public Services Dept. and Bass-Dillard Neighborhood Issues and Prevention, Inc. hold pubic meeting about contaminated landfill
1997	October		EPA announces that they will leave contaminated soil and ash buried on site
1998	April	25	NAACP and Miami-Dade branches of NAACP co-sponsor NAACP Environmental Justice Conference
1998	August		Agency for Toxic Substances awards state $120,000 for two years to study the symptoms and diseases prevalent around Wingate
1998	February	17	Fort Lauderdale City Commission approves $20 million clean up agreement
1998	February		Floyd Johnson becomes Fort Lauderdale's first African-American administrator as City Manager
1998	November		Community representatives reject the proposed symptom and disease study in favor of one that tries to reconstruct what dose of toxins residents might have been exposed to while the incinerator was operating
1998	September	16	State Dept. of Health holds public meeting to discuss proposed health study
1999	April	9	City holds community workshops to discuss future uses for the site

Year	Month	Day	Description
1999	April		Nova Southeastern University survey shows much higher rates of cancer for residents who lived near Wingate than in the demographically similar neighborhood of Melrose Park, five miles away (Barker 1999)
1999	April		In response to residential comments, the Health Dept. and Agency for Toxic Substances report that eating vegetables and fruit grown in nearby soil is not a public health threat
1999	February		State Health Dept. and Agency for Toxic Substances recommend that the EPA suppress dust and monitor the air during the site cleanup
1999	January		State Health Dept. and Agency for Toxic Substances conclude that a dose reconstruction study is not feasible becasuse they don't have enough exposure data
1999			Institute of Medicine issues report addressing environmental justice issues via public health, biomedical research, education, and health policies broadening discussion on disproportionate environmental risks.
2000	October		Broward Gardens Tenant Association files suit against EPA, US Dept of HUD, & City of Fort Lauderdale to protest cleanup plan
2001	May	29	Capping of 36 acres of the 61-acre landfill begins (Completed within a week?)
2001	November	19	Community Advisory Committee meeting discussing status report of health study, "The Relation of Exposure to Lead and Possible Results Effects Among Persons who Live Nearby the Wingate Road Municipal Incinerator Dump"
2002	August	13	Broward County Commission meets to discuss infant deaths and illnesses near Wingate
2002	August	13	County Commission agrees to test for toxins in schools and county lands near site
2002	February		Healthy Mothers-Healthy Babies Coalition of Broward County release study of infant deaths for zip codes 33311 and 33313
2002	January	30	City Commission meets to discuss the Wingate Road Landfill and Incinerator
2002	July	25	Sharon Bourassa and Legal Aid Clinic sends letter to County Commission citing need to address the landfill's potential harmful effects.
2002	July		State Health Dept. begins reviewing a proposal from Legal Aid Service of Broward County
2002	November	5	11th Circuit U.S. Court of Appeals upheld dismal of Broward Gardens Tenant Association suit against EPA, US Dept HUD and City of Fort Lauderdale

APPENDIX B:

WINGATE HEALTH AND SOCIAL SURVEY

ID_____

Wingate Health and Social Survey

YOUR PARTICIPATION IN THIS SURVEY DOES NOT MEAN THAT YOU WILL BE PARTY TO ANY POTENTIAL LAWSUITS.

THE PURPOSE OF THIS SURVEY IS TO COLLECT HEALTH AND SOCIAL DATA.

We are here today to administer a survey to residents of the Wingate community. The survey is being sponsored by Mr. Jan R. Schlichtmann, attorney-at-law, who is assisting the Wingate community in determining the impact of the Wingate Incinerator Site on local residents. Dr. Steve Picou, social impact specialist, will be administering the survey, and along with Dr. Richard Clapp, epidemiologist, will be developing a report of the results. These results will be shared with all participants as well as members of the larger community

The survey contains a number of questions and statements which **require you to respond by circling identified choices or by writing a comment in the space provided.** Please feel free to express your responses in as much detail as you would like. You may write on the back pages of the survey or request additional paper.

Please remember:

1. We want you to **read each question carefully**;
2. There **are no right or wrong answers** to the statements;
3. Provide your **honest response** to all statements;
4. Do not **consult with anyone** regarding responses;
5. It is very important that **you respond to all statements**;
6. If you have **any questions, please ask Dr. Picou or those assisting with the survey.**

Thank you for your time and the careful consideration of your responses.

CONFIDENTIAL

Please read the instructions carefully. If you have any questions, feel free to ask one of the survey administrators.

Name_____ **Do you: Rent or Own**

Survey

I. The following questions focus on background characteristics. Please read each question carefully and circle or write-in the appropriate response.

1. Age_____

2. Gender: 1 male 2 female

3. How much education have you completed at this time?
   1 less than high school
   2 high school graduate
   3 attended vocational/technical school
   4 graduated from vocational/technical school
   5 some college, but did not graduate
   6 college graduate
   7 attended graduate school
   8 masters degree
   9 advanced professional degree, i.e., MD, PhD, DDS, etc.

4. What is your annual household income?
   1 less than $10,000
   2 $10,000-$19,999
   3 $20,000-$29,999
   4 $30,000-$39,999
   5 $40,000-$49,999
   6 $50,000-$59,999
   7 over $60,000

5. What is your marital status?
   1 married
   2 single, never married
   3 single, divorced
   4 widowed

6. What is your occupation?_____

7. How many years have you lived in the Wingate community? _____

Present mailing Address:_____

City:_____

State:_____

Zip code:_____

How long have you lived here?_____

Prior address, if applicable.

Mailing address:_____

City:_____

State:_____

Zip code:_____

How long did you live here?_____

Prior address, if applicable.

Mailing address:_____

City:_____

State:_____

Zip code:_____

How long did you live here?_____

II. For the following questions, please circle or write in the appropriate response.

9. a. Are you now, or have you ever been a party to a lawsuit alleging exposure to

hazardous substances, materials or chemicals within the past 15 years?
0 no
1 yes

b. **IF YES, please state the name of the lawsuit, court and present status of the lawsuit.**

_____
_____

10. a. Were you employed at the Wingate Landfill?
0 no
1 yes

b. **IF YES,** when did you start? _____

c. How many years did you work there?
_____

11. a. Were you employed at the Wingate Incinerator?
0 no
1 yes

b. **IF YES**, when did you start? _____

c. How many years did you work there?
_____

12. a. Were you exposed to ash?
0 no
1 yes

b. **IF YES,** when were you first exposed?_____

c. For how many years?_____

13. a. Did you drink well water?
0 no
1 yes

b. **IF YES**, when?_____

c. For how many years?_____

14. a. Did you grow vegetables?
0 no
1 yes

b. **IF YES**, did you "water" them with:
1 well water
2 city water
3 both

15. a. Do you know of any friends who lived in Wingate and died of cancer?
0 no
1 yes

b. **IF YES**, in what year did they pass on? _____

c. What type of cancer did they have? _____

16. a. Do you know of any close relatives who lived in Wingate and died of cancer?
0 no
1 yes

b. **IF YES**, in what year did they pass on? _____

c. What type of cancer did they have? _____

d. How were they related to you?_____

17. Did any of your children play on or near the landfill?
0 no
1 yes

18. Did any of your pets become ill or die suddenly?
0 no
1 yes

III. In this section, we would like to ask you some questions related to your health. Please read each question carefully; circle your response or answer in the space provided.

19. a. Did you ever smoke cigarettes or use tobacco products?
0 no
1 yes

IF YES, for how many years did you smoke or use tobacco products? _____

20. a. Are you now or have you ever been exposed to hazardous substances, hazardous materials, or hazardous chemicals outside of the Wingate community?
0 no
1 yes

b. **IF YES, for how many years?**_____

21. **Specifically, have you ever been exposed to the following agents during your normal course of work:**

Agent	Exposed	If yes, how many years?
Petroleum solvents	no yes	
Paints and paint thinners, varnished, wood finishers	no yes	
Pesticides	no yes	
Wood products or wood processing products	no yes	
Road surface materials	no yes	
Paper production chemicals	no yes	

22. **Have you ever been diagnosed by a doctor with any of the following symptoms? Please circle your answer and IF YES, LIST THE DATE OF DIAGNOSIS AND DOCTOR'S NAME TO THE BEST OF YOUR MEMORY.**

Symptom	Diagnosed	If Yes, Doctor's Name	Date of Diagnosis
Asthma	no yes		
Bronchitis	no yes		
Chloracne	no yes		
Other skin conditions, like eczema	no yes		
Anemia	no yes		
Irregular heartbeat	no yes		
Diabetes (sugar in the urine)	no yes		
Cancer	no yes		

23. **Have you ever had any of the following symptoms? Please circle your answer and IF YES, STATE HOW MANY YEARS THE SYMPTOM HAS OCCURRED.**

Symptom		If yes, how many years?
Headache	no yes	
Coughing	no yes	
Nausea/upset stomach	no yes	
Diarrhea	no yes	
Runny nose	no yes	
Burning throat	no yes	
Blurred vision	no yes	
Sneezing	no yes	

Symptom		If yes, how many years?
Muscle aches and pains	no yes	
Soreness of joints	no yes	
Excess tearing of the eyes	no yes	
Burning eyes	no yes	
Difficulty in concentration	no yes	
Difficulty in sleeping	no yes	
Excessive tiredness	no yes	
Numbness in fingers, toes, legs	no yes	
Respiratory and/or breathing problems, other than coughing	no yes	
Eyesight problems, other than tearing	no yes	
Reproductive problems, (like inability to conceive, lack of interest in sex, or difficulty in having sex)	no yes	
Kidney problems	no yes	
Liver problems	no yes	
Digestive problems, other than diarrhea or nausea (like lack of appetite, food tastes bad, certain foods make you sick)	no yes	
Psychological problems (like anxiety, depression, nightmares, nervousness, excessive worry or fear)	no yes	

24. a. Did you ever eat fish caught from Lake Rockpit?
    0 no
    1 yes

    b. IF YES, what parts?
    1 whole fish
    2 filet
    3 both
    4 other_____

c. How many times per month?_____

d. For how many years? _____

25. a. Did you ever eat fish caught from Lake Stupid?
0 no
1 yes

b. IF YES, what parts?
1 whole fish
2 filet
3 both
4 other_____

c. How many times per month?_____

d. For how many years?_____

26. Do any family members have a history of certain illnesses, like diabetes or cancer?
0 no
1 yes

IF YES, please describe illness and record which relative has/had the illness.

_____

_____

27. How many children do you have?_____

28. Have you ever had trouble having a child?
0 no
1 yes

IF YES, please explain._____

_____

29. Have you had any miscarriages?
    0 no
    1 yes

30. Have you ever had a child who was stillborn (born dead)?
    0 no
    1 yes

IV. These next set of statements are sometimes made by people after experiencing a unusual life event. For each statement, please indicate how often it was true for you in terms of the contamination in your neighborhood as it relates to the Wingate Landfill and Incinerator during the PAST WEEK OR 7 DAYS. It might not have happened at all during the past week, or during the past week it might have occurred only rarely, sometimes or often. Read each statement carefully and circle your response.

During the PAST WEEK OR 7 DAYS. . .

31. I thought about the contamination in my neighborhood when I didn't want to.
    0 not at all
    1 rarely
    2 sometimes
    3 often

32. Pictures about the contamination in my neighborhood popped into my mind.
    0 not at all
    1 rarely
    2 sometimes
    3 often

33. Other things kept making me think about the contamination in my neighborhood.
    0 not at all
    1 rarely
    2 sometimes
    3 often

During the PAST WEEK OR 7 DAYS. . .

34. I had trouble falling asleep or staying asleep because of the contamination in my neighborhood.
    0 not at all

1 rarely
2 sometimes
3 often

35. I had waves of strong feelings about the contamination in my neighborhood.
0 not at all
1 rarely
2 sometimes
3 often

36. I had dreams about the contamination in my neighborhood.
0 not at all
1 rarely
2 sometimes
3 often

37. Any reminder brought back feelings about the contamination in my neighborhood.
0 not at all
1 rarely
2 sometimes
3 often

38. I avoided letting myself get upset when I thought about the contamination in my neighborhood or was reminded of it.
0 not at all
1 rarely
2 sometimes
3 often

39. I tried to remove the contamination in my neighborhood from my memory.
0 not at all
1 rarely
2 sometimes
3 often

During the PAST WEEK OR 7 DAYS. . .

40. I stayed away from the reminders of the contamination in my neighborhood.
0 not at all
1 rarely
2 sometimes

3 often

41. I felt as if the contamination in my neighborhood hadn't happened or wasn't real.
0 not at all
1 rarely
2 sometimes
3 often

42. I was aware that I still had a lot of feelings about the contamination in my neighborhood, but I didn't deal with them.
0 not at all
1 rarely
2 sometimes
3 often

43. I tried not to think about the contamination in my neighborhood.
0 not at all
1 rarely
2 sometimes
3 often

44. My feelings about the contamination in my neighborhood were kind of numb.
0 not at all
1 rarely
2 sometimes
3 often

45. I tried not to talk about the contamination in my neighborhood.
0 not at all
1 rarely
2 sometimes
3 often

46. I felt physically uncomfortable (heart racing, sweating, stomach upset) when I was reminded of the contamination in my neighborhood.
0 not at all
1 rarely
2 sometimes
3 often

V. In this section, we would like to ask you some questions about the government. Please circle your response.

47. Would you say the government is pretty much run by a few big interests looking out for themselves or that it is run for the benefit of all the people?
    1 few big interests
    2 benefit of all
    3 don't know/depends

48. Do you think that people in the government waste a lot of money we pay in taxes, waste some of it, or don't waste very much of it?
    1 a lot
    2 some
    3 not very much

49. Do you think that quite a few of the people running the government are:
    1 a little crooked
    2 not very many are
    3 or do you think hardly any of them are crooked at all?

50. Sometimes politics and government seem so complicated that a person like me can't really understand what's going on.
    1 agree
    2 disagree
    3 neither agree nor disagree

51. People like me don't have any say about what the government does.
    1 agree
    2 disagree
    3 neither agree nor disagree

52. Public officials don't care much what people like me think.
    1 agree
    2 disagree
    3 neither agree nor disagree

VI. Now we would like for you to carefully read the following statements and circle your responses.

53. Taken altogether, how would you say things are these days? Would you say that you are:
    1 not too happy

2 pretty happy
3 very happy

(IF NOT MARRIED, SKIP TO QUESTION 55.)

54. Taken altogether, now would you describe your marriage? Would you say that your marriage is:
1 not too happy
2 pretty happy
3 very happy

55. Would you say your overall health, in general is:
1 poor
2 fair
3 good
4 excellent

(IF YOU DO NOT HAVE ANY CHILDREN, SKIP TO QUESTION 57).

56. Taken altogether, how would you describe the health of your children? Would you say that their health is:
1 poor
2 fair
3 good
4 excellent

VII. Please read the following statements carefully. These statements refer to your experience during the PAST WEEK OR LAST 7 DAYS. On how many days during the PAST WEEK OR LAST 7 DAYS have you had the following experience or feelings. (0=NO DAYS; 7=EVERYDAY).

57. I felt that I could not get rid of the blues.

0 1 2 3 4 5 6 7

58. I had trouble keeping my mind on what I was doing.

0 1 2 3 4 5 6 7

On how many days during the PAST WEEK OR 7 DAYS. . .

59. Everything that I did took a great effort.

0 1 2 3 4 5 6 7

60. I felt sad.

0 1 2 3 4 5 6 7

61. I felt that I could not get going.

0 1 2 3 4 5 6 7

62. I lost my appetite.

0 1 2 3 4 5 6 7

63. I had trouble falling asleep or staying asleep.

0 1 2 3 4 5 6 7

64. I felt lonely.

0 1 2 3 4 5 6 7

65. I was bothered by things that usually do not irritate me.

0 1 2 3 4 5 6 7

66. I felt that my life was a failure.

0 1 2 3 4 5 6 7

VIII. For the following questions, circle the statement that best describes your feelings about the Wingate Incinerator and Landfill.

67. I believe my home and personal property were exposed to health-threatening chemicals because of the Wingate Incinerator and Landfill.

1 strongly disagree
2 disagree
3 neither agree nor disagree
4 agree

5 strongly agree

68. I believe I was exposed to health-threatening chemicals from the Wingate Incinerator and Landfill.
    1 strongly disagree
    2 disagree
    3 neither agree nor disagree
    4 agree
    5 strongly agree

69. Overall, how would you describe your neighborhood:
    1 **maximally contaminated:** living there poses immediate threats to one's health.
    2 **contaminated**: toxins and dangerous chemicals are present, a possible threat to one's health.
    3 **marginally contaminated:** traces of toxins and dangerous chemicals are present with no known threats to one's health.
    4 **not contaminated:** no persistent traces of toxins and dangerous chemicals are present.
    5 **pristine:** completely free of any chemical pollutants of any form.

70. How often do you worry about the quality of the air you are breathing?
    1 never
    2 sometimes
    3 often
    4 very often

71. How often do you find yourself worrying about contaminants that may be in soil and dirt in your yard?
    1 never
    2 sometimes
    3 often
    4 very often

72. How often do you worry about the quality of the water in your wells?
    1 never
    2 sometimes
    3 often
    4 very often
    5 not applicable, on city water

IX. Please answer the next set of questions carefully. Circle one of the following responses: 1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree or 5=strongly agree.

Because I have lived in the Wingate community:

73. I have an increased chance of getting cancer.
    1 strongly disagree
    2 disagree
    3 neither agree nor disagree
    4 agree
    5 strongly agree

(IF YOU DO NOT HAVE ANY CHILDREN, SKIP TO QUESTION 75).

74. My children have an increased chance of getting cancer.
    1 strongly disagree
    2 disagree
    3 neither agree nor disagree
    4 agree
    5 strongly agree

75. I have been exposed to dangerous levels of health threatening chemicals.
    1 strongly disagree
    2 disagree
    3 neither agree nor disagree
    4 agree
    5 strongly agree

(IF YOU DO NOT HAVE ANY CHILDREN, SKIP TO QUESTION 77)

76. I worry a lot about my future health status of my children.
    1 strongly disagree
    2 disagree
    3 neither agree nor disagree
    4 agree
    5 strongly agree

77. I worry a lot about my future health.
    1 strongly disagree
    2 disagree

3 neither agree nor disagree
4 agree
5 strongly agree

78. My friends from outside my neighborhood area think that my family has been exposed to dangerous chemicals.
1 strongly disagree
2 disagree
3 neither agree nor disagree
4 agree
5 strongly agree

X. How often have you talked about the contamination in Wingate to the following: (Circle your responses.)

79. Members of your household.
1 very often
2 often
3 sometimes
4 one time
5 never

80. Relatives.
1 very often
2 often
3 sometimes
4 one time
5 never

81. Co-workers
1 very often
2 often
3 sometimes
4 one time
5 never

82. Friends
1 very often
2 often
3 sometimes
4 one time

5 never

XI. Please answer the next set of questions using the following responses. 1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree, or 5=strongly agree.

(IF YOU DO NOT HAVE ANY CHILDREN, SKIP TO QUESTION 84.)

83. My children have expressed fear about being exposed to chemicals from living in Wingate.
1 strongly disagree
2 disagree
3 neither agree nor disagree
4 agree
5 strongly agree

84. I have had problems growing plants and vegetables in my yard.
1 strongly disagree
2 disagree
3 neither agree nor disagree
4 agree
5 strongly agree

85. Because of the contamination in my neighborhood, the value of my property has declined.
1 strongly disagree
2 disagree
3 neither agree nor disagree
4 agree
5 strongly agree

86. Because of the contamination in my neighborhood, relatives visit my home less often.
1 strongly disagree
2 disagree
3 neither agree nor disagree
4 agree
5 strongly agree

87. Because of the contamination in my neighborhood, friends visit my home less often.
1 strongly disagree
2 disagree
3 neither agree nor disagree

4 agree
5 strongly agree

88. **If you were completely free to move to any neighborhood, what would you do?**

1 remain in the neighborhood in which I currently reside

2 move out of the neighborhood in which I currently reside

Why?_____

_____

_____

_____

_____

89. Are you satisfied with what has been done to the Wingate Landfill & Lake?
1 Yes
0 No

IF NO, what do you think should be done? _____

_____
_____
_____
_____
_____
_____
_____
_____

90. What would you like the parties responsible for the contamination to do?

_____
_____
_____

Thank you for taking the time to complete the survey.

APPENDIX C:

GIS AND GEOCODING

A geographic information system (GIS) is an "approach to scientific analysis and use of spatial data" which allows the integration of various types of information (Clarke 2001). The integration of the information allows the researcher to examine a large amount of spatial data in a visually accessible manner. GIS software, such as GeoMedia and ArcView GIS, provide a relatively user-friendly platform in which spatial data, in the form of maps, aerial images, coordinate points for example, can be entered and integrated for analysis.

The data need to be geocoded, meaning spatial information, geographic coordinates (i.e. latitude and longitude), is converted into a computer-readable form. The spatial information, referred to as attributes, may already exist or may be digitized by the user. In cases where the spatial information already exists, we refer to these maps and data as being geo-referenced, such as USGS GeoTIFF files (maps with coordinates included). Digitizing is a geocoding process that is done manually, in which the user identifies control points and/or uses the cursor to trace map features for the computer to identify. Control points are used for registering, or assigning, geographic coordinates to an image, including paper maps or aerial images. However, the user must be aware of the potential easy-to-detect errors associated with manual digitizing including slivers, spikes, inversions, lines that are not ended and unsnapped nodes. Slivers and inversions "are when the map appears squashed [or flipped], like the titles at the beginning of a wide-screen movie shown on TV" (Clarke 2001:134). These systematic errors can occur when the incorrect control points are entered for the map geometry (Clarke 2001). Spikes are "random hardware or software errors in which a zero or extremely large data value erroneously replaces the real value in one of the coordinates" (Clarke 2001:134). Errors in typology, connection of lines, including

not ended lines and unsnapped nodes, are the result of operator error (Clarke 2001). The user must also be aware of other geocoding errors for addresses, including out-of-date street directories and general imprecision of geographic coordinates where the point is placed some distance from the actual point (Radcliffe 2002). The user must also be aware of general cartographic differences in the map projections and geodetic datums of the information. Map projections are the representations of the earth's three-dimensional surface on a flat, two-dimensional plan. One of the most common map projections is the Mercator projection frequently used for maps in schools from kindergarten to 12th grade. However, there are over two-dozen different map projections and the user must be aware of the map projection to prevent geocoding errors in edge-matching or overlaying. The geodetic datum is precise location of the ellipsoid relative to the Earth's surface and the network of control points (geodetic control), or how the lines of latitude and longitude are drawn on the Earth. This error is more serious than projections error because a single point on the Earth will have a different latitude and longitude depending upon the datum used. A coordinate pair (latitude and longitude) in one datum will not appear in the same location on another datum. There are fewer geodetic datums than there are map projections, but there is no general consensus on the appropriate geodetic datum. For example, the USGS has frequently used the North American Datum of 1927 (NAD27), but has recently begun to shift to using the more recent North American Datum of 1983 (NAD83) which has "moved" features as much as 300 meters on the ground (Clarke 2001:51). This makes it especially important that the user be aware of these potential errors when working with GIS.

Even when the correct spatial information has been collected and entered, the integration of social data and information with spatial information raises concerns about confidentiality and the protection of respondents. As researchers have presented, "there are legal precedents that limit privacy rights with respect to high-resolution aerial photography, [but] the courts have not yet directly addressed questions of privacy and Fourth Amendment rights in the context of space-based remote observation," or in this case survey data (Ulhir 1990; Rindfuss and Stern 1998:11). Social scientists responsibility to respondents is to use the information responsibly to protect the individual. While aggregate social data at the county level may protect the individual, protection of data at the individual or household level has not been discussed in detail within the existing literature (Rindfuss and Stern 1998). The concern is that geographically sensitive individual or household social information poses a threat to confidentiality. Rindfuss and Stern have suggested legal contracts to prevent "any disastrous breaches of confidentiality (1998). The geocoding method itself may also be used to protect the identity of individuals and households, but any alterations to the geographic coordinates of the data may affect the accuracy of the results. Several geocoding methods have been presented in the literature, concentrated primarily within criminal justice research and crime mapping (Harries 1989; Ratcliffe 2002). Researchers have used various geocoding methods to protect the identity of the respondent including, but limited to "jittering," centre-line and rotation/shift method. To review these various methods, "jittering" and rotation/shift method involves shifting the geographic (latitude/longitude) coordinates by several seconds (equivalent to several meters) in any direction. The line-centre method of geocoding is based upon points along a line segment. Whereby the addresses of

survey respondents correspond to a point on a line, where the line represents the center of the street (Radcliffe 2002). This geocoding method has been previous used in crime mapping to protect the identities of crime victims and sexual offenders from public harassment (Radcliffe 2002). For this study, the method is preferred over the jittering and rotation/shift method, because the specific location of respondents is especially important in the analysis. While centre-line geocoding protects the exact location of the respondent, it does not significantly affect the geographic relationship to the site.

For this thesis, the most precise location of the respondent is preferred as the analysis tests exposure to contamination, which is geographically sensitive. To this point and my knowledge, there is no environmental justice research that used geocoded survey and environmental data, which raises the issue of confidentiality and accuracy. To protect the identity of survey respondents, respondents, as part of the informed consent process, were asked to sign a legal retainer statement, which protects the respondent's information from public use, thus ensuring the legal protection of the social information. As the addresses of the respondents are used in this analysis, the geocoding method provided additional protection and confidentiality. As mentioned before, addresses were geocoded using the line-centre method.

APPENDIX D:

FREQUENCY TABLES OF VARIABLES

This appendix provides the frequency tables of variables used in the analysis. They are segregated according to the latent variable identified in the social epidemiological model.

Sociodemographics and Lifestyle

Table D-1: Frequency of Age Responses

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-24	2	0.90	0.91	0.91
	25-34	28	12.56	12.78	13.70
	35-44	44	19.73	20.09	33.79
	45-54	58	26.01	26.48	60.27
	55-64	40	17.94	18.26	78.54
	65-74	40	17.94	18.26	96.80
	75 and over	7	3.14	3.20	100
	Total	219	98.20	100.0	
Missing	Missing	4	1.79		
Total		223	100.0		

Table D-2: Frequency of Gender Responses

	Frequency	Percent	Valid Percent	Cumulative Percent
Male	66	29.6	29.6	29.6
Female	157	70.4	70.4	100.0
Total	223	100.0	100.0	

Table D-3: Frequency of Marital Status Responses

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not Married	123	55.2	55.4	55.4
	Married	99	44.4	44.6	100.0
	Total	222	99.6	100.0	
Missing	Missing	1	.4		
Total		223	100.0		

Table D-4: Frequency of Educational Attainment Responses

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than high school	60	26.9	27.8	27.8
	High school graduate	55	24.7	25.5	53.2
	Attended vocational/technical school	13	5.8	6.0	59.3
	Graduated from vocational/technical school	13	5.8	6.0	65.3
	Some college, but did not graduate	43	19.3	19.9	85.2
	College graduate	15	6.7	6.9	92.1
	Attended graduate school	7	3.1	3.2	95.4
	Master's Degree	7	3.1	3.2	98.6
	Advanced professional degree, i.e. MD, PhD, DDS, etc.	3	1.3	1.4	100.0
	Total	216	96.9	100.0	
Missing	Missing	7	3.1		
Total		223	100.0		

Table D-5: Frequency of Annual Household Income Responses

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than $10,000	70	31.4	33.2	33.2
	$10,000 - $19,999	35	15.7	16.6	49.8
	$20,000 - $29,999	34	15.2	16.1	65.9
	$30,000 - $39,999	25	11.2	11.8	77.7
	$40,000 - $49,999	18	8.1	8.5	86.3
	$50,000 - $59,999	10	4.5	4.7	91.0
	Over $60,000	19	8.5	9.0	100.0
	Total	211	94.6	100.0	
Missing	Missing	12	5.4		
Total		223	100.0		

Table D-6: Frequency of Home Ownership Responses

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rent	68	30.5	36.0	36.0
	Own	121	54.3	64.0	100.0
	Total	189	84.8	100.0	
Missing	Missing	34	15.2		
Total		223	100.0		

Table D-7: Frequency of Smoking Responses

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	147	65.9	65.9	65.9
	Yes	76	34.1	34.1	100.0
	Total	223	100.0	100.0	

Exposure

Table D-8: Frequency of Years of Residence within the Wingate Community

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0-5	11	4.93	5.14	5.14
	5-10	23	10.31	10.74	15.89
	11-20	48	21.52	22.43	38.32
	21-30	38	17.04	17.76	56.07
	31-40	56	25.11	26.17	82.24
	41-50	34	15.25	15.89	98.13
	51 and over	4	1.79	1.87	100
	Total	214	95.96	100.0	
Missing	Missing	9	4.04		
Total		223	100.0		

Table D-9: Frequency of Belief in Self Exposed to Chemical Contaminants

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	29	13.0	13.2	13.2
	Disagree	5	2.2	2.3	15.5
	Neither Agree nor Disagree	13	5.8	5.9	21.5
	Agree	53	23.8	24.2	45.7
	Strongly Agree	119	53.4	54.3	100.0
	Total	219	98.2	100.0	
Missing	Missing	2	.9		
	Total	4	1.8		
Total		223	100.0		

Table D-10: Frequency of Belief in Property Exposed to Chemical Contaminants

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	25	11.2	11.5	11.5
	Disagree	1	.4	.5	12.0
	Neither Agree nor Disagree	14	6.3	6.5	18.4
	Agree	56	25.1	25.8	44.2
	Strongly Agree	121	54.3	55.8	100.0
	Total	217	97.3	100.0	
Missing	Missing	6	2.7		
Total		223	100.0		

Table D-11: Frequency of the Desire to Move Responses

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Remain in the neighborhood in which I currently reside	57	25.6	29.1	29.1
	Move out of the neighborhood in which I currently reside	139	62.3	70.9	100.0
	Total	196	87.9	100.0	
Missing	N/A	16	7.2		
	Missing	11	4.9		
	Total	27	12.1		
Total		223	100.0		

Table D-12: Frequency of Well Water Consumption Responses

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	114	51.1	54.3	54.3
	Yes	96	43.0	45.7	100.0
	Total	210	94.2	100.0	
Missing	Missing	13	5.8		
Total		223	100.0		

Table D-13: Frequency of Consumption of Home-Grown Vegetable Responses

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	125	56.1	56.8	56.8
	Yes	95	42.6	43.2	100.0
	Total	220	98.7	100.0	
Missing	Missing	3	1.3		
Total		223	100.0		

Table D-14: Frequency of Fish Consumption from Rock Pit Lake

		Frequency	Percent	Valid Percent	Cumulative Percent
	No	106	47.5	48.2	48.2
Valid	Yes	114	51.1	51.8	100.0
	Total	220	98.7	100.0	
Missing	Missing	3	1.3		
Total		223	100.0		

Table D-14: Frequency of Fish Consumption from Lake Stupid

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	154	69.1	72.3	72.3
	Yes	59	26.5	27.7	100.0
	Total	213	95.5	100.0	
Missing	Missing	10	4.5		
Total		223	100.0		

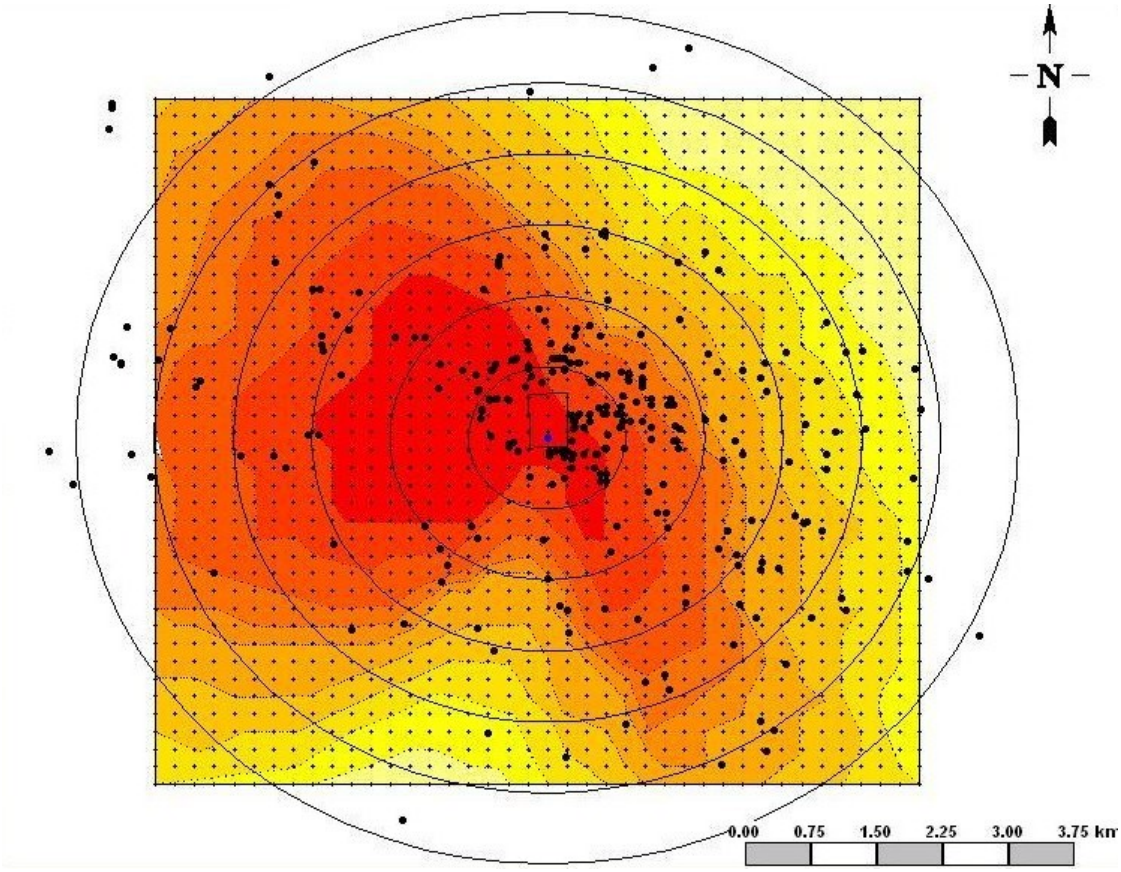

Figure D-1: Chloropleth Model of Ash Deposition & 1/2 mile Radial Proximity Buffers with Geocoded Survey Data (black dots)

APPENDIX E:

IRB HUMAN SUBJECTS PERMISSION LETTER

University of Central Florida

Office of Research

December 12, 2003

Christine Bevc
Department of Sociology and Anthropology
College of Arts and Sciences
University of Central Florida
4000 Central Florida Boulevard
Orlando, Florida 32816

Dear Ms. Bevc:

With reference to your protocol entitled, "Exposure Matters? Examining the Physical and Mental Health Impacts of Environmental Contamination," I am enclosing for your records the exempt, executed document of the UCFIRB Form you had submitted to our office.

Should there be any addendums or administrative changes to the already approved protocol, they must also be submitted to the Board. Changes should not be initiated until written IRB approval is received. Adverse events should be reported to the IRB as they occur.

Should you have any questions, please do not hesitate to call me at 823-2901.

Please accept our best wishes for the success of your endeavors.

Cordially,

Chris Grayson
Institutional Review Board (IRB)

Copies: Brent Marshall
IRB File

12443 Research Parkway • Suite 207 • Orlando, FL 32826-3252 • 407-823-3778 • Fax 407-823-3299

ENDNOTES

1. Health assessments and public participation were not required before CERCLA was amended in 1986.
2. However, this number is thought to be underestimated, with the actual amount closer to forty billion pounds (Foster 1994: 126).
3. Although the assignment of pseudonyms to research participants is regularly practiced, because of their historical significance and the nature of the case study, it would make it difficult to not identify individuals, people and places without using their real names. However, the names of individuals, people and places used are collected from publicly available sources, i.e. newspapers, historical maps, and public records.
4. Incidence refers to the "number of *new cases* of a disease in specific populations over a *specific period of time*." (Timmerick 1998:5).
5. Mortality is the "epidemiological and vital statistics term for death" (Timmerick 1998:107).
6. The modifiable areal unit problem is concerned with "the fact that varying the scale of data aggregation, and/or aggregating data using different aggregation boundaries at a single scale, may affect the results of spatial statistical analysis" (Mennis 2002:283).
7. Immediately Dangerous to Life and Health concentrations were developed in the mid-1970s, but was first discussed in the 1940s (NIOSH 1987). These concentrations are currently defined by the National Institute for Occupational Safety and Health as a situation "that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or

immediate or delayed permanent adverse health effects or prevent escape from such an environment" (NIOSH 1987).

8. The variable of race was excluded because the racial composition of the survey sample was entirely African-American.
9. The length of residency within the community is a very subjective variable. Although the response is self-reported, whether or not an individual lived within the Wingate community is a subjective response dependent upon the resident's perceptions of the community's boundary. For purposes of analysis, this is considered to be perceived variable rather than a sociodemographic characteristic or a self-reported exposure pathways, which are defined by known epidemiological variables.
10. Although the Florida Department of Health and Rehabilitative Services in cooperation with the Agency for Toxic Substances and Disease Registry evaluated the health threat related to fish consumption, their study only examined fish samples collected from Rock Pit Lake. In addition, the resulting dose estimates, or the total amount of a chemical that can be received over a period of time, for these samples are based upon the assumption that fish consumption was limited to the fillet of the fish, not the entire fish as found in this study (1995). At the time of their study, information concerning "fish eating habits" was not available (FDHRS/ATSDR 1995:5).
11. Spherical distance refers to the distance between two spherical coordinates of latitude and longitude. In this case, the coordinates are those for the site and the respondent's geocoded address of residence. This method of measurement takes into consideration the curvature of

the earth, which is different from determining the distance between two points in a planar coordinate systems, which assumes the coordinates are placed on a Cartesian (x-y axis) plane.

12. Because of the spatial limitations of the deposition model's area of coverage, those respondent locations not within the area covered by the model were considered to be null, or equal to zero, when averaged into estimated level of deposition.
13. One caveat is the dependence on the reporting of the respondent's location and the length of time at each location. This may lead to values that are higher or lower than actual exposure to ash deposition.
14. This variable had 34 missing responses (15.2% out of the total 223 respondents). This number missing responses could be attributed to the design of the survey instrument. This question was placed at the very top of the first page of the actual instrument, separate from the rest of the sociodemographic questions. See Appendix B for a copy of the survey instrument
15. One obvious caveat of this measure is the potentially limited availability of the information, or residential history, needed to calculate the value.

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