Environmental Justice and the Remediation of Contaminated Land: A National and Arizona Perspective

by

Peter Burns

_____

A Thesis Submitted to the Faculty of the

DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

In the Graduate College

The University of Arizona

2011

STATEMENT BY AUTHOR

This thesis has been submitted in partial fulfillment of requirements for an advanced degree at the University of Arizona.

Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgement of source is made. Requests for permissions for extended quotation form or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Graduate College when in his or her judgment the proposed use of the material is in the interest of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: Peter G. Burns

APPROVAL BY THESIS DIRECTOR

This Thesis has been approved on the dates shown below

Dr. Dennis Cory

8-9-11

Date

Acknowledgements

I would first like to thank my advisors: Dr. Dennis Cory and Dr. Tauhidur Rahman. Their teaching and patience made this effort possible.

I also would like to thank to the entire faculty and staff of Department of Agricultural and Resource Economics (AREC) at the University of Arizona for its support and the opportunities provided to the graduate students.

I am grateful for the tutelage of Dr. Gary Thompson, both in his AREC 559 class and for the opportunity to join him in Italy last summer.

I must also thank my family and friends. Thank you to my parents, Marian and Larry, for always putting our education first, to my sister, Rita, for her support, to my cousin, Melissa, for introducing me to the AREC program and setting the bar so high, and to my girlfriend, Hilary, for putting up with the late nights spent studying and providing comments and insights. Thank you to my classmates, especially Todd and Jorge, who challenged me and grew with me in our two years at Arizona.

Table of Contents

List of Tables 5
List of Figures 8
1. Introduction 10
A. Types of Polluting Activities 11
B. Common Contaminants 13
C. Health Effects 15
D. Economic Impact 18
E. Issues in Arizona 20
F. Environmental Justice 22
G. Literature Review 24
H. Purpose and Organization of Thesis 26
2. Legal and Institutional Background 28
A. CERCLA 34
1. Listing 34
2. Remediation 36
3. Implementation 38
4. Results 41
B. WQARF 41
1. Listing 42
2. Remediation 42
3. Implementation 44
4. Results 47
C. Federalism 48
3. Data Sources and Descriptive Statistics 51
A. Data Sources 51
B. Descriptive Statistics 53
1. Census Tract Population Analysis 54
2. Environmental Justice Sample Analysis 57
3. Geographic Characteristic Mapping 66
4. Remediation Characteristics 72
C. Next Steps 82
4. Econometric Methods 83
A. NPL Siting Estimation 83
B. HRS Scoring Estimation 85
C. NPL Remediation Estimation 85
5. Empirical Results 87
A. NPL Siting Results 87
B. HRS Scoring Results 105
C. NPL Remediation Results 113
6. Conclusions 128
A. Future Work 131
7. Appendix 132
8. References 138

List of Tables

Table 1.1: Top 20 Contaminants Detected at Superfund Sites in 2007 15
Table 3.1: Variable List 52
Table 3.2: Data Overview 57
Table 3.3: “2000 NPL Sample” Mean Census Tract Characteristics 58
Table 3.4: “1982 HRS Sample” Mean Census Tract Characteristics 59
Table 3.5: 2000 NPL Sample Correlation Matrix Significant at the 5% Level (2000 Census) 60
Table 3.6: 2000 NPL Sample Correlation Matrix Significant at the 5% Level (1980 Census) 61
Table 3.7: National Variable t-Tests for 2000 NPL Sample (1980 Census) 64
Table 3.8: National Variable t-Tests for 2000 NPL Sample (2000 Census) 64
Table 3.9: Variable t-Test Summary Analysis by Region for 2000 NPL Sample (1980 Census) 65
Table 3.10: Variable t-Test Summary Analysis by Region for 2000 NPL Sample (2000 Census) 66
Table 3.11: “1982 HRS Sample” Mean Census Tract Characteristics by Geographic Locator (1980 Census) 68
Table 3.12: National Contamination t-Tests for 1982 HRS Sample for Tract Method (1980 Census) 69
Table 3.13: National Contamination t-Tests for 1982 HRS Sample for 2-Mi Rad. Method (1980 Census). 69
Table 3.14: National Contamination t-Tests for 1982 HRS Sample by 3-Mi Rad. Method (1980 Census) . 70
Table 3.15: National NPL t-Tests for the 1982 HRS Sample by Tract Method (1980 Census) 71
Table 3.16: National NPL t-Tests for the 1982 HRS Sample by 2-Mi Rad. Method (1980 Census) 71
Table 3.17: National NPL t-Tests for the 1982 HRS Sample by 3-Mi Rad. Method (1980 Census) 72
Table 3.18: NPL Site Remediation Characteristics 74
Table 3.19: 1980 HRS Sample Correlation Matrix for Census 1980 75
Table 3.20: 1982 HRS Sample Correlation Matrix for Census 2000 75
Table 5.1: Logistic Regression: Dependent Variable – Presence of NPL Site in 1982 HRS Sample, National Analysis by Census Block* 89
Table 5.2: Logistic Regression: Dependent Variable – Presence of NPL Site in 2000 NPL Sample, National Analysis by Census Block* 90
Table 5.3: Logistic Regression: Dependent Variable – Presence of NPL Site in 1982 HRS Sample, National Analysis by Census Block* 91
Table 5.4: Logistic Regression: Dependent Variable – Presence of NPL Site in 2000 NPL Sample, National Analysis by Census Block* 92
Table 5.5: Logistic Regression: Dependent Variable – Presence of NPL Site in 1982 HRS Sample, National Analysis with 2-Mile Radius* 93
Table 5.6: Logistic Regression: Dependent Variable – Presence of NPL Site in 1982 HRS Sample, National Analysis with 3-Mile Radius* 94
Table 5.7: Logistic Regression: Dependent Variable – Presence of NPL Site in 2000 NPL Sample, West Region Analysis by Census Tract* 95
Table 5.8: Logistic Regression: Dependent Variable – Presence of NPL Site in 2000 NPL Sample, South Region Analysis by Census Tract* 96
Table 5.9: Logistic Regression: Dependent Variable – Presence of NPL Site in 2000 NPL Sample, Northeast Region Analysis by Census Tract* 97
Table 5.10: Logistic Regression: Dependent Variable – Presence of NPL Site in 2000 NPL Sample, Midwest Region Analysis by Census Tract* 98
Table 5.11: Logistic Regression: Dependent Variable – Presence of NPL Site in 2000 NPL Sample, EPA Region 9 Analysis by Census Tract* 99
Table 5.12: Logistic Regression: Dependent Variable – Presence of NPL Site in 2000 NPL Sample, Arizona

Analysis by Census Tract* 100
Table 5.13: Logistic Regression: Dependent Variable – Presence of NPL Site in 2000 NPL Sample, Arizona Analysis by Census Tract* 101
Table 5.14: Logistic Regression: Summary Comparison Table by Census Year and Sample, National Analysis by Census Tract 102
Table 5.15: Logistic Regression: Summary Comparison Table by NPL Geographic Locator in 1982 HRS Sample, National Analysis* 103
Table 5.16: Logistic Regression: Summary Comparison Table by Region in 2000 NPL Sample by Census Tract* 104
Table 5.17: Logistic Regression: Summary Comparison Table of Arizona Drill-Down Analysis by Census Year in 2000 NPL Sample 104
Table 5.18: Logistic Regression: Dependent Variable – 1982 HRS >=28.5 = 1, HRS<28.5 = 0 in 1982 HRS Sample, National Analysis by Census Tract* 107
Table5.19: Logistic Regression: Dependent Variable – 1982 HRS >=28.5 = 1, HRS<28.5 = 0 in 1982 HRS Sample, National Analysis by Census Tract* 108
Table 5.20: Logistic Regression: Dependent Variable – 1982 HRS >=28.5 = 1, HRS<28.5 = 0, Summary Comparison Table by Census Year, National Analysis by Census Tract 109
Table 5.21: Logistic Regression: Dependent Variable – 1982 HRS >=28.5 = 1, HRS<28.5 = 0, Summary Comparison Table by NPL Geographic Locator in 1982 HRS Sample, National Analysis* 110
Table 5.22: Logistic Regression: Dependent Variable – 1982 HRS >=28.5 = 1, HRS<28.5 = 0, Summary Comparison Table by Region in 1982 HRS Sample by Census Tract* 111
Table 5.23: Logistic Regression: Summary Comparison Table of Arizona Drill-Down Analysis by Census Year in 1982 HRS Sample 112
Table 5.24: Poisson and Negative Binomial Regression: Dependent Variable - Years from NPL listing to Construction Complete milestone, Summary Comparison Table by Census Year in 1982 HRS Sample, National Analysis by Census Tract 116
Table 5.25: Poisson and Negative Binomial Regression: Dependent Variable - Years from NPL listing to Construction Complete milestone in 1982 HRS Sample, National Analysis by Census Tract* 117
Table 5.26: Poisson and Negative Binomial Regression: Dependent Variable - Years from NPL listing to Construction Complete milestone in 1982 HRS Sample, National Analysis by Census Tract* 118
Table 5.27: Poisson and Negative Binomial Regression: Dependent Variable - Years from NPL listing to Construction Complete milestone, Summary Comparison Table by NPL Geographic Locator in 1982 HRS Sample, National Analysis* 119
Table 5.28: Poisson and Negative Binomial Regression: Dependent Variable - Years from NPL listing to Construction Complete milestone, Summary Comparison Table by Region in 1982 HRS Sample by Census Tract* 120
Table 5.29: Poisson and Negative Binomial Regression: Dependent Variable - Years from NPL listing to Construction Complete milestone, Summary Comparison Table by Region in 1982 HRS Sample by Census Tract* 121
Table 5.30: Poisson and Negative Binomial Regression: Dependent Variable - Years from ROD to Construction Complete milestone, Summary Comparison Table by Census Year in 1982 HRS Sample, National Analysis by Census Tract 122
Table 5.31: Poisson and Negative Binomial Regression: Dependent Variable - Years from ROD Issuance to Construction Complete milestone in 1982 HRS Sample, National Analysis by Census Tract* 123
Table 5.32: Poisson and Negative Binomial Regression: Dependent Variable - Years from ROD Issuance to Construction Complete milestone in 1982 HRS Sample, National Analysis by Census Tract* 124
Table 5.33: Poisson and Negative Binomial Regression: Dependent Variable - Years from ROD to Construction Complete milestone, Summary Comparison Table by NPL Geographic Locator in 1982 HRS

Sample, National Analysis* 125
Table 5.34: Poisson and Negative Binomial Regression: Dependent Variable - Years from ROD to Construction Complete milestone, Summary Comparison Table by Region in 1982 HRS Sample by Census Tract* 126
Table 5.35: Poisson and Negative Binomial Regression: Dependent Variable - Years from ROD to Construction Complete milestone, Summary Comparison Table by Region in 1982 HRS Sample by Census Tract* 127
Table 7.1: Midwest Region Analysis Variable t-Tests for 2000 NPL Sample (1980 Census) 132
Table 7.2: Midwest Region Analysis Variable t-Tests for 2000 NPL Sample (2000 Census) 133
Table 7.3: Northeast Region Analysis Variable t-Tests for 2000 NPL Sample (1980 Census) 133
Table 7.4: Northeast Region Analysis Variable t-Tests for 2000 NPL Sample (2000 Census) 134
Table 7.5: West Region Analysis Variable t-Tests for 2000 NPL Sample (1980 Census) 134
Table 7.6: West Region Analysis Variable t-Tests for 2000 NPL Sample (2000 Census) 135
Table 7.7: South Region Analysis Variable t-Tests for 2000 NPL Sample (1980 Census) 135
Table 7.8: South Region Analysis Variable t-Tests for 2000 NPL Sample (2000 Census) 136
Table 7.9: Arizona Analysis Variable t-Tests for 2000 NPL Sample (1980 Census) 136
Table 7.10: Arizona Analysis Variable t-Tests for 2000 NPL Sample (2000 Census) 137

List of Figures

Figure 1.1: EPA Waste Site Activity Illustration 12
Figure 1.2: EPA Pollution Health Risks Spectrum 16
Figure 1.3: Environmental Justice and Superfund Legislative Timeline 24
Figure 2.1: Superfund Site Status in the U.S. 29
Figure 2.2: Superfund and WQARF Sites in Arizona by Hispanic Population Density 31
Figure 2.3: Superfund and WQARF Sites in Phoenix 32
Figure 2.4: Superfund and WQARF Sites in Tucson 33
Figure 2.5: Federal Superfund Process 34
Figure 2.6: Balance of the Superfund Trust Fund at the Start of Each Fiscal Year, Fiscal Years 1981 through 2009 40
Figure 2.7: WQARF Phases 41
Figure 2.8: WQARF Annual Corporate Tax Revenue Comparison Fiscal Years 2002 through 2010 47
Figure 3.1: 2000 NPL Sample Census Tract Populations in Population Clusters of 50 (2000 Census) 55
Figure 3.2: 2000 NPL Sample Census Tract Populations in Population Clusters of 50 (1980 Census) 56
Figure 3.3: Percent Minority by 1982 Hazardous Ranking Score for 1980 Census 62
Figure 3.4: Average Household Income by 1982 Hazardous Ranking Score for 1980 Census 63
Figure 3.5: Percentage Minority by Actual and Expected Remediation Costs for 2000 All NPL Sample (2000 Census) 76
Figure 3.6: Average Household Income by Actual and Estimated Costs of Remediation for 2000 All NPL Sample (2000 Census) 76
Figure 3.7: Percent Minority by Average Years from NPL to ROD for 1982 HRS Sample (1980 Census) 78
Figure 3.8: Average Household Income by Average Years from NPL to ROD for 1982 HRS Sample (1980 Census) 78
Figure 3.9: Percent Minority by Average Years from NPL to Construction Initiation for 1982 HRS Sample (1980 Census) 79
Figure 3.10: Average Household Income by Average Years from NPL to Construction Initiation for 1982 HRS Sample (1980 Census) 79
Figure 3.11: Percent Minority by Average Years from NPL to Construction Completion for 1982 HRS Sample (1980 Census) 80
Figure 3.12: Average Household Income by Average Years from NPL to Construction Completion for 1982 HRS Sample (1980 Census) 80
Figure 3.13: Percent Minority by Average Years from NPL to Deletion for 1982 HRS Sample (1980 Census) 81
Figure 3.14: Average Household Income by Average Years from NPL to Deletion for 1982 HRS Sample (1980 Census) 81

Abstract

Land contamination has been a major issue in the U.S. for over three decades. The focus on environmental justice, meanwhile, has been more recent, and Environmental Protection Agency (EPA) is still working to integrate it across the Agency. Existing environmental justice studies have been limited in breadth and application. Prior research focused on specific case studies and regional areas over short time frames. Previous studies also investigated only one or two sides of the environmental justice issue. This research aims to be the most complete study done on the topic. This study analyzed EPA's National Priority List (NPL) siting, testing, and remediation efforts in terms of environmental justice at the national and regional level using multiple census years of demographic data. This study finds potential environmental injustice in NPL siting in the West, Midwest, EPA Region 9 and Arizona for low income communities and also percent of Black in Arizona, a strong indication of potential environmental injustice regarding NPL scoring in Hispanic communities in the South, and finally, potentially serious environmental injustice regarding the pace of NPL remediation in the South region in Black and low income communities and in the West and Northeast regions in Hispanic communities. More analysis is required to further explore these potential issues.

1. Introduction

Land contamination has become a major issue in the U.S. during the last forty years, and encompasses a wide variety of situations. While naturally occurring events may pollute land, the vast majority of contamination is caused by humans, either accidentally or intentionally. The U.S. Environmental Protection Agency (EPA) defines contaminated land as real property on which hazardous substances are known to have been released or disposed of. They further define hazardous substance to include any element, compound, mixture, solution or pollutant identified in any existing Federal environmental law.[1] The terms pollutant and contaminant are designated equivalent to hazardous substance and will be used interchangeably in this study.

The U.S. EPA monitors and manages contaminated land through different initiatives including the Toxics Release Inventory (TRI) Program, Brownfields Revitalization, and the National Priorities List, or Superfund program. The TRI is a database that reports toxic chemical releases for certain industries and government facilities in the United States. Brownfields and Superfund sites, meanwhile, represent two degrees of severity on the EPA's land contamination scale. Brownfield sites are real property that has been left idle due to the presence or potential presence of a contaminant impeding reuse, redevelopment or expansion.[2] The National Priorities List (NPL) contains the worst hazardous waste sites throughout the United States, those that pose a greater public health risk than Brownfields. Superfund sites are remediated under EPA regulation while Brownfield site revitalization is a voluntary program managed at the state level.

Federal Superfund sites are properties that have been selected for cleanup under the federal

[1] Federal environmental law includes section 307(a) of the Federal Water Pollution Control Act, section 311(b)(2)(A) of the Federal Water Pollution Control, section 3001 of the Solid Waste Disposal Act, section 112 of the Clean Air Act, and section 7 of the Toxic Substances Control Act.
[2] http://www.epa.gov/brownfields/overview/glossary.htm

Superfund program. These sites were contaminated by hazardous substances and identified by EPA as posing a risk to human health and/or the environment.[3] The Superfund program was established under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The program finances and executes EPA's hazardous waste removal and remedial activities, at both emergency and long-term timeframes. Within Superfund, CERCLA established the National Priorities List (NPL), which monitors the hazardous waste sites in the U.S. eligible for Superfund and entails a priority ranking to guide the EPA in determining which sites warrant further investigation.

A. Types of Polluting Activities

Many human activities result in land contamination. Generally responsible activities include industrialization, urbanization, agribusiness, and domestic waste.[4] Industrial activities create varying degrees of pollution, from the emission of toxic gases to machinery byproducts and leaks. Furthermore, specific industries, like mining, also cause hazardous waste, such as heavy metals, to be released into the environment. The urbanization movement in the U.S. has led to deforestation, sewage and waste problems, runoff from roads, and other types of pollution. The growth of agricultural activities has increased pesticide and chemical fertilizer use and intensified the concentration of animal manures, all of which pollutes land. Increases to the standard of living have escalated domestic waste production, overflowing landfills and creating dumping grounds where household items are improperly discarded.

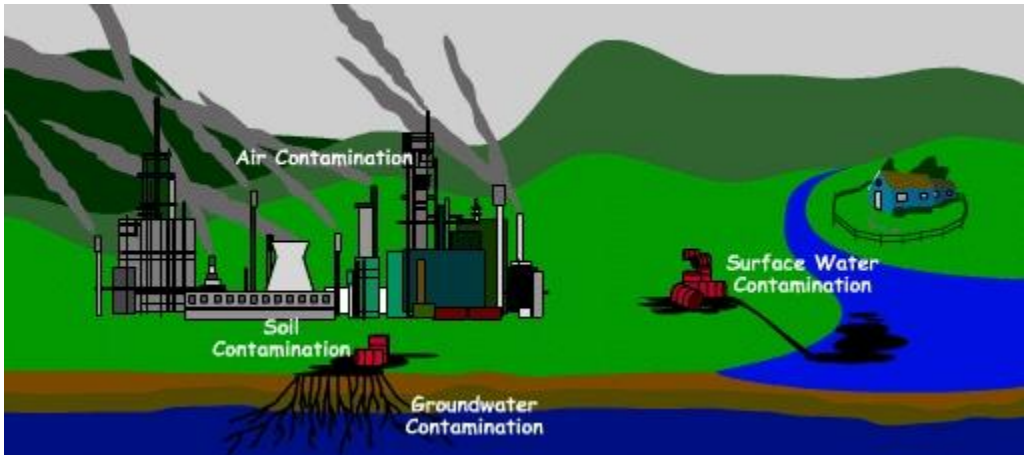
According to EPA, common sources of land contamination at Superfund sites include industrial facilities, waste management sites, mining and sediment sites, and federal facilities such as abandoned mines; nuclear, biological, chemical, and traditional weapons productions plants; and military base industrial sites (e.g., used for aircraft and naval ship maintenance).[5] The EPA, however, maintains that

[3] (EPA, 2009)
[4] (Pillai)
[5] (EPA, 2008)

most land contamination is the result of historical activities, and accidental spills and unanticipated events are the main causes of recent and future contamination.[6] They further specify that hazardous material and waste management and disposal are now highly regulated.[7][8]

The EPA defines and tests for contamination in four areas of the environment: air, soil, groundwater and surface water.[9] The four contamination locations are interrelated. Often, a contaminant found in one environmental location originated in another. These areas are shown in an EPA illustration in Figure 1.1.

Figure 1.1: EPA Waste Site Activity Illustration[10]



Air pollution is generally a problem at the macro level, involving large-scale pollution due to multiple sources, like automobile exhaust in a city. Most air pollution is also caused by real-time, operating activities, such as factory smokestacks. There are situations, however, where toxic gases

[6] (EPA, 2008)
[7] Developing countries, however, are still industrializing production and agriculture, and the size of international portfolio of contaminated land will depend on the rate at which they adopt regulation of hazardous material and waste management. China, for example, is facing serious concerns with soil pollution. In 2006, the State Environmental Protection Administration (SEPA) reported that more than 12 million hectares of arable land, over 10% of the total cultivatable land in China, had been polluted.
[8] (Pan, 2006)
[9] (EPA, 2011)
[10] (EPA, 2011)

continue to be released after a facility is no longer operating, such as concentrated methane at a landfill. Additionally, air pollution at Superfund sites may be due to the prolonged evaporation of hazardous liquids or contaminated soil that becomes airborne due to wind. As the focus of Superfund is land contamination, air pollution plays a small part of the process.

Soil contamination refers to the mixing of a hazardous substance with existing soil, either physically or chemically. Soil contamination may be the result of a spill, buried hazardous materials, or deposits from a smokestack or other source of air pollution that settle out of the air. Soil contamination has a close relationship to groundwater pollution, and it is often difficult to separate exactly where the soil ends and the underground water table begins.

Groundwater pollution is not only related to soil contamination but also surface water contamination. Pollutants generally reach groundwater through one of those two channels. Hazardous substances can soak through soil into the water table or be carried in rain or surface water into groundwater. In some cases, the pollutants are not mixed directly with the groundwater, but remain pooled below the ground. This can be a long-term source of contamination as the groundwater is continually contaminated when it flows through these pools.

Surface water pollution is usually due to contaminated runoff carried by rain into rivers, lakes or oceans. Other forms may include discharge from an outfall pipe or contaminated groundwater reaching the surface through a spring. Surface water contamination is often difficult to contain due to the constant movement of the contamination and concentrations in the sediment on the floor of the body of water.

B. Common Contaminants

Some of the more common pollutants that cause land contamination include heavy metals, pesticides, solvents, and petroleum hydrocarbons. According to a 2009 EPA TRI Report, approximately

3.4 billion pounds of toxic chemicals are released into the U.S. environment annually.[11] This is down from 6.2 billion pounds of toxic chemicals released in 1990. The Pollution Prevention Act of 1990 changed focus from waste management and pollution control to source reduction. EPA estimates that over 5 billion pounds of pesticides are applied annually according to a 2006 and 2007 market estimates, up slightly from 4.5 billion pounds reported in 1994. [12] [13] Although the annual quantity of pesticide application has not increased significantly in recent decades, the toxicity of individual pesticides has increased 10-fold in the last fifty years.[14] The shift to aircraft application has also caused serious drift problems, with 40% to 60% of the pesticide applied drifting away from the target area.[15] In the United States, an estimated 45% of lake water, 39% of rivers, and 51% of estuaries are polluted, primarily by erosion runoff containing nitrates, phosphates, and other agricultural chemicals.[16]

The Agency for Toxic Substances and Disease Registry (ATSDR) has standardized the reporting of Superfund contamination characteristics into three categories for pollutants. The three criteria are frequency of occurrence, toxicity, and potential for human exposure. Frequency of occurrence is the number of documented presences at NPL sites. Substances present at three or more NPL sites were considered, totaling 859 unique hazardous substances.[17] The toxicity score is a based on a tiered structure of the five reportable quantity levels of 1, 10, 100, 1,000, and 5,000 pounds originally established by the Clean Water Act.[18] The potential for human exposure includes the relative concentration by source as well as exposure information. The hazard potential of each candidate substance was ranked according to the following algorithm: [19]

---

[11] (EPA, 2011)
[12] (Grube, 2011)
[13] (Aspelin, 1997)
[14] (Pimentel, 1997)
[15] (Cox, 1995)
[16] (EPA, 2002)
[17] (U.S. Department of Health and Human Services, 2007)
[18] (EPA, 2011)
[19] (U.S. Department of Health and Human Services, 2007)

$$\frac{Total\ Score}{(max\ 1{,}800\ pts.)} = \frac{NPL\ Frequency}{(600\ pts.)} + \frac{Toxicity}{(600\ pts.)} + \frac{Potential\ for\ Human\ Exposure}{(300\ source\ pts.) + (300\ exposure\ pts.)}$$

The resulting priority list of contaminants was published every two years through 2007 by ATSDR, and represents a prioritization based on the algorithm above. The top twenty contaminants by total points are shown in Table 1.1 with their score for each category.

Table 1.1: Top 20 Contaminants Detected at Superfund Sites in 2007[20]

Substance Name	Frequency Points	Toxicity Points	Source Points	Exposure Points	Total Points
Arsenic	540	600	248	285	1,673
Lead	600	400	234	300	1,534
Mercury	407	600	267	231	1,505
Vinyl Chloride	296	600	270	221	1,388
Polychlorinated Biphenyls	272	600	253	240	1,366
Benzene	476	400	242	238	1,356
Cadmium	478	400	196	250	1,324
Polycyclic Aromatic Hydrocarbons	206	600	282	229	1,317
Benzo(A)Pyrene	265	600	228	219	1,312
Benzo(B)Fluoranthene	222	600	234	211	1,267
Chloroform	385	400	216	222	1,223
DDT, P,P'-	180	600	203	210	1,193
Aroclor 1254	158	600	218	207	1,183
Aroclor 1260	149	600	223	206	1,178
Dibenzo(A,H)Anthracene	135	600	222	209	1,166
Trichloroethylene	495	178	200	281	1,155
Dieldrin	148	600	192	210	1,151
Chromium, Hexavalent	63	600	284	203	1,150
Phosphorus, White	44	600	300	201	1,145
Chlordane	111	600	214	207	1,133

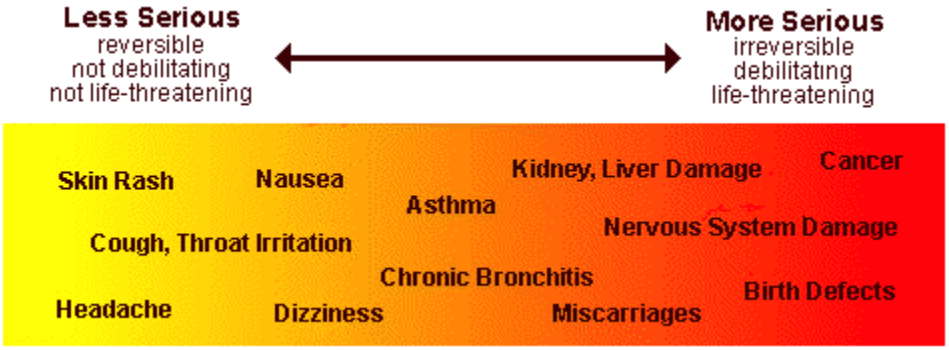
C. Health Effects

Land contamination can play a major role in people's health in associated communities. As

[20] (U.S. Department of Health and Human Services, 2007)

captured in the priority ranking, the dangers of land contamination to human health are multidimensional. The health risks are related to type of contamination exposure including direct skin contact, inhalation of vapors, and indirect ingestion of contaminated food and water sources. The severity of human health risks from contamination ranges from a mild irritant to a life-threatening illness. Common health risks from pollution include allergies, birth defects, cancer, dizziness, emphysema, lead and mercury poisoning, nervous system damage, and radiation poisoning.[21] The EPA illustrates these and other risks as a spectrum in Figure 1.2.

Figure 1.2: EPA Pollution Health Risks Spectrum[22]



A study done at Cornell University in 2007 found that about 40% of deaths worldwide are caused by soil, air, and water pollution, specifically organic and chemical pollutants.[23] The study also states that U.S. citizens carry more than 116 extraneous chemicals in their bodies including lead, mercury, dioxins, and even banned substances like DDT and benzene hexachloride (BHC). In 2004, U.S. facilities released more than 70 million pounds of recognized carcinogens into the air and water.[24] Regarding agricultural pesticides, 15 of the most common 27 pesticides are known carcinogens. Chronic exposure to chromium, lead and other metals, petroleum, and solvents can also be carcinogenic as well, causing congenital disorders and other chronic health conditions.

---

[21] (Drexel University)
[22] (EPA, 1991)
[23] (Lang, 2007)
[24] (Cassady, 2007)

In addition to cancer risks, another major health problem associated with land contaminants is developmental problems. In 2004, U.S. facilities reported more than 96 million pounds of air and water emissions of chemicals linked to developmental problems and nearly 38 million pounds of chemicals linked to reproductive disorders.[25] Lead has been linked specifically to brain damage and reduced learning capabilities in exposed children.[26] Currently, an estimated 250,000 children aged one to five in the USA are exposed to hazardous levels of lead.[27] In addition, approximately 6% of women of childbearing age in the USA have blood levels of mercury above the recommended level, which can cause developmental defects in fetuses.[28]

There are a host of other illnesses linked to contaminants. Benzene has been linked to leukemia. Chronic mercury exposure has also been linked to damage to the gastrointestinal tract, the nervous system, and kidneys as well as respiratory failure.[29] PCBs have been linked to liver toxicity. Solvents and pesticides known as cyclodienes have been linked to kidney and liver damage. Solvents have also been linked to depression of the nervous system. Insecticides and herbicides known as organophosphates and carbamates have been linked to neuromuscular blockages. These and other pollutants are also known to cause many other symptoms and conditions.

There are over 1,300 sites on the National Priorities List (NPL). Approximately 11 million people, including 3 to 4 million children, live within one mile of these sites putting the magnitude of the health risks in perspective for the nation's most contaminated sites.[30] The EPA provides specific guidance for dealing with some common contaminants.[31] These include lead and mercury, ranked two and three in 2007, and asbestos, which had forms ranked 90, 119, and 129. The major health effects associated with

[25] (Cassady, 2007)
[26] (Canfield, 2004)
[27] (Center for Disease Control and Prevention, 2009)
[28] (Center for Disease Control and Prevention, 2005)
[29] (EPA, 2010)
[30] (Green Media Toolshed)
[31] (EPA, 2011)

asbestos exposure include cancer, including lung cancer and mesothelioma, and asbestosis, a long-term, non-cancer, lung-related illness.[32] They also provide guidance on bioavailability, the amount of a contaminant that is absorbed into the body upon exposure. The EPA gives special instructions for dealing with radioactive contamination.

Another social cost of land contamination is the economic effects on the surrounding community. The health effects can be monetized to include treatment costs and missed employment. In a sample of 150 NPL sites, a study in the *Journal of Policy Analysis and Management* found an average of 4.87 cancer cases could be avoided per remediated site over a 30 year period.[33] The median number of cases in the study, however, was 0.017, as the majority of sites had less than 0.1 anticipated cancer cases. The study also estimated the cost per cancer case averted at over $100 million. Figures like these bring a very real economic cost to diseases associated with land contamination sites.

D. Economic Impact

Contaminated land sites have a substantial economic impact on the communities where they reside. From an economic perspective, the costs associated with land contamination sites relate to the decrease in overall social welfare. Costs are multidimensional, a function of direct and indirect damages for both current and future generations. There are also non-use, altruistic, bequest and existence values associated with contaminated land.[34] Consequences of land contaminated sites on the economy include medical costs and missed employment, property value decrease, unemployment increase, tainted resources, decrease in leisure, decaying infrastructure, image problem and litigation expenses.

Several studies have researched the impact of the land contamination on the real estate values

[32] (EPA, 2011)
[33] (Hamilton, 1999)
[34] (Hardisty, 2005)

including Greenstone and Gallagher (2005), which the data and structure of this study are based on.[35] The EPA has collected the available research and published a review.[36] While individual conclusions vary, one of the consistent findings is that homes close to NPL sites suffer a loss of about 7.5% in property value, with the effect as high as 13% in close proximity. Another recurring conclusion is that the initial discovery of the contamination is responsible for the decline in value. The release of the Record of Decision for an NPL site, before the actual cleanup, is when prices start to rebound. One of the noted limitations of nearly all studies is that they evaluate few Superfund sites proving more of a case study, not information on the Superfund program as a whole. Greenstone and Gallagher's research is the only one recognized as evaluating the entire Superfund program. EPA cautions, however, that the use of self-reported, geographically coarse data of census tract average values likely obscures any effect due to Superfund responses. It's interesting to note that Greenstone and Gallagher's research was one of two (out of twelve) that did not find that NPL designation and eventual clean-up had a statistically significant effect on the value of nearby housing.

Land contamination not only decreases real estate value, but also drives out economic development. Developers have historically been hesitant to develop contaminated urban land for fear of future liability. Many current laws dictate that current landowners are liable for past contamination, whether or not the owner was aware or responsible for the contamination.[37] Non-contaminated green space is often developed instead leading to suburban sprawl and possible destruction of wildlife, among others. Therefore, the costs associated with contaminated land include the extra costs associated with locating development in other areas.

The relocation of economic development also directly impacts the community with the contaminated site. There is a decrease in available employment, leading to a decrease in tax revenues to

[35] (Greenstone, 2008)
[36] (EPA, 2009)
[37] (Indiana University)

the community. This has a ripple effect as less money and less demand lead to a failure to maintain roads and infrastructure, decreasing school quality and increasing crime.[38] Specific companies and businesses associated with the source of contamination may experience negative public relations and a decrease in stock value.[39] Responsible parties also are required to pay large sums of litigation expenses. Contamination in areas with physical raw materials may taint those resources and render them unavailable as inputs to production. This may include bodies of water that can no longer be fished for commercial or leisure purposes. Other leisure activities may be compromised and contamination near wildlife areas or parks may cause a decrease in ecological values.[40]

E. Issues in Arizona

Arizona exhibits many unique challenges of land contamination. The arid climate in most of the state places a premium on water. There is a long history of mining operations due to the presence of precious metals including copper, gold, and silver. In addition, asbestos was historically heavily mined in the state until 1982.[41] Arsenic is a naturally occurring contaminant, heavily spread across the state. Mining activities and digging wells have led to the contamination of subsurface water sources from arsenic and other pollutants. Arsenic is a known carcinogen and exposure frequently results in cancers of the skin, lymphoma, stomach, colon, esophageal, kidney, and prostate. Agriculture is a major industry in the state making up thirty-six percent of Arizona's land use.[42] Due to the heavy agriculture operations, the state suffers from pesticide and other types of agriculture-related contamination of land and water sources. Other land contamination issues in Arizona include waste problems along the border with

[38] (Howland, 2007)
[39] (Hardisty P. S., 2006)
[40] (Ministry of Environmental Protection, 2011)
[41] There are at least 103 documented asbestos deposits in Arizona. (U.S. Department of the Interior, 2008)
[42] (National Association of State Departments of Agriculture, 2008)

Mexico and scrap tire piles that breed diseases and present a fire risk.[43]

Arizona is tied for 40th among U.S. states with nine Superfund sites. The most frequent contaminants at these sites are chromium (and chromium compounds), trichloroethylene, and lead, which are ranked #16, #18, and #2 respectively on the national Superfund contaminants list above.[4445] Chromium is a known carcinogen and has an effect on the immune system, kidneys and respiratory system. [46] Trichloroethylene (TCE) is an industrial solvent, a known carcinogen that has been linked to liver and kidney cancer as well as leukemia and non-Hodgkin lymphoma.[47] The University of Arizona is studying these and other contaminants as part of the Superfund Basic Research Program. The national effort works directly with EPA to research potential solutions to the complex health and environmental issues associated with these sites.[48]

At the state level, the Arizona Department of Environmental Quality (ADEQ) has also set up a Superfund program, known as Water Quality Assurance Revolving Fund (WQARF). WQARF was created under the Environmental Quality Act of 1986, to support hazardous substance cleanup efforts in the state.[49] There are 35 sites on the WQARF Registry, representing land contamination that poses less of a threat than NPL sites to humans and the environment.[50] Common contaminants include tetrachloroethene (PCE), 1,2-dichloropropane and 1,2-dichloroethane, as well as chromium, TCE, arsenic, and heavy metals.[51] PCE is a solvent that has been identified as a probable carcinogen and has been linked to non-Hodgkin lymphoma.[52] 1,2-dichloropropane and 1,2-dichloroethane are both solvents

---

[43] (Border 2012 Waste Policy Forum, 2009)
[44] Chromium and chromium compounds were present at seven sites. Trichloroethylene was present at 6 sites. Lead was present at four sites.
[45] (Green Media Toolshed)
[46] (Agency for Toxic Substance and Disease Registry, 2011)
[47] (EPA, 2007)
[48] (National Institute of Environmental Health Sciences, 2011)
[49] (ADEQ, 2011)
[50] (ADEQ, 2011)
[51] (ADEQ, 2009)
[52] (International Programme on Chemical Safety, 1995)

and recognized carcinogens, though the primary uses of 1,2-dichloropropane including soil fumigation and paint stripping have been discontinued.[53]

F. Environmental Justice

Over the last two decades issues of environmental justice have gained a large public following. EPA defines environmental justice as the "fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies".[54] The Civil Rights Act of 1964 laid the groundwork for environmental justice by giving protection to all people in the United States from discrimination in "any program or activity receiving Federal financial assistance." Environmental issues, however, weren't specifically targeted until 1992. EPA created an Office of Environmental Justice and integrated environmental justice across all Agency policies and programs in response to public concerns.[55] EPA then established the National Environmental Justice Advisory Council (NEJAC) in 1993 to seek independent advice and recommendations from all stakeholders involved in the environmental justice process. President Clinton issued Executive Order (EO) 12898 in 1994 aimed at addressing environmental justice issues in minority and low-income populations. The EO tasked each federal agency to "collect, maintain, and analyze information assessing and comparing environmental and human health risks borne by populations identified by race, national origin, or income." The Environmental Protection Agency (EPA) was tasked with heading an Interagency Working Group on Environmental Justice. In 2000, the EPA issued Draft Title VI Guidance for investigating environmental justice claims related to the Civil Rights Act. To celebrate the 20th anniversary of EO 12898, the EPA will release EPA EJ Plan 2014 to further the Agency's priority of "Expanding the Conversation on

[53] (Agency for Toxic Substances and Disease Registry, 1989)
[54] (EPA, 2011)
[55] (EPA, 2010)

Environmentalism and Working for Environmental Justice".[56]

The Title VI Guidance stipulates that the demographic disparity must be statistically significant to 2 or 3 standard deviations. It states that all claims will be handled on a case-by-case basis. Critics of the guidance cite vague standards for demographic disparity. The guidance admits that "it is impossible to determine a single factor that could be applicable in all cases." It does provide examples, however, stating that demographic disparity "at least a factor of 2 times higher for affected population" would generally show violation of Title VI, while a disparity "under 20%" would be "relatively slight." The demographic disparity is analyzed in tandem with the significance of the adverse impact. EPA also developed an Environmental Justice Smart Enforcement Assessment Tool (EJ SEAT) to analyze Superfund and hazardous waste facilities in relation to a variety of assessment variables. The assessment variables include demographics, per capita income, and percent below the poverty line.[57]

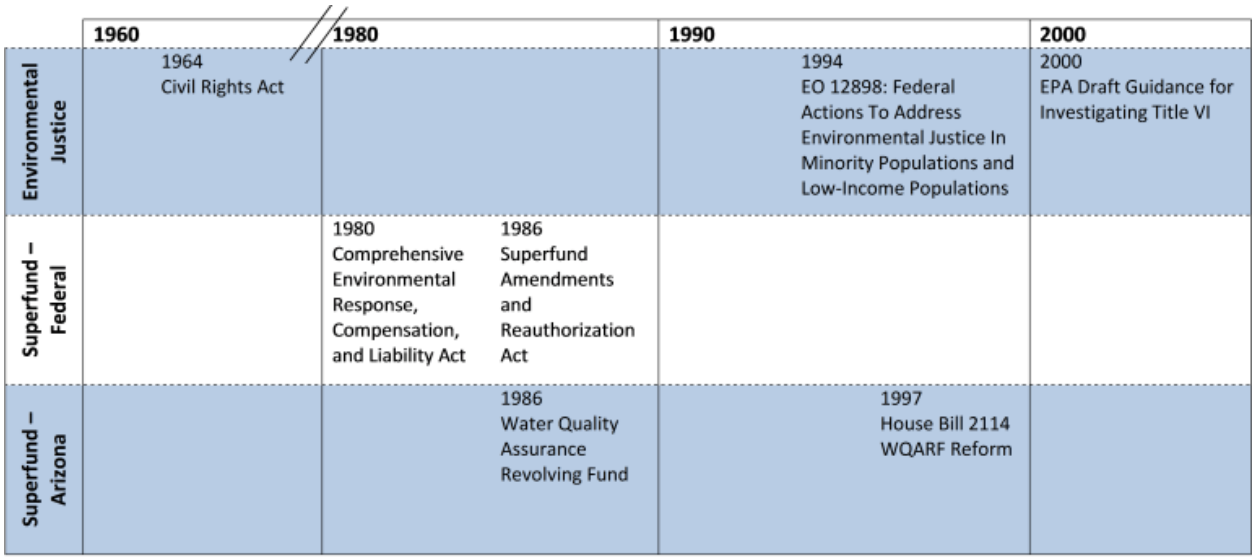
The timeline below in Figure 1.3 demonstrates the relationship between the timing of environmental justice legislation and superfund programs, both Federal and state-level in Arizona. The gap between the legislatures suggests that environmental justice protection (beyond basic civil rights) was not captured in the initial Superfund programs. Also, while the superfund programs were established in the 1980's, the majority of the purpose includes remediating past contamination in communities that have suffered historical environmental justice issues.

In the Southwest, EPA has faced environmental justice concerns in Region 9, which includes Arizona. EPA agrees that minority and low-income communities are often disproportionately exposed to pollution in Region 9. EPA Region 9 supports programs and projects to help address these adverse and disproportionate effects. EPA sites tools on their website and other recent developments that combat historical EJ issues.[58] Current Administrator for EPA Region 9, Jared Blumenfeld, renewed the emphasis

[56] (EPA, 2010)
[57] (Evans, 2006)
[58] (EPA, 2011)

on EPA's environmental efforts regardless of skin color or income.[59] As a border state, Arizona works closely with EPA Region 9 and Region 6 to further environmental justice efforts along the border.[60]

Figure 1.3: Environmental Justice and Superfund Legislative Timeline



G. Literature Review

There are many studies that examine the relationship between land contamination and environmental justice. A report by the Government Accountability Office in the 1980s on the potential presence of environmental justice in EPA Region 4 concluded that blacks make up the majority of the population in 75% of communities with landfills.[61] The *United Church of Christ's (UCC) Commission for Racial Justice's* 1987 report evaluated racial and socio-economic factors against waste at the national level. The report found that race was the most significant factor of those tested in determining the location of commercial hazardous waste facilities.[62] The study also found that communities with the greatest number of commercial hazardous waste facilities had the highest composition of racial and

[59] (EPA, 2010)
[60] (EPA, 2011)
[61] (World Resources Institute, 1999)
[62] (Chavis, 1987)

ethnic residents. A 1992 study titled "Unequal Protection: The Racial Divide in Environmental Law" found that penalties under hazardous waste laws at sites in white communities were 46% lower than minority communities.[63] The study also found that EPA clean up at Superfund sites began 12-42 months later at sites in minority communities than in white communities. The UCC commissioned a follow-up report, "Toxic Wastes and Race at Twenty: 1987-2007", which found similar conclusions to the first report. It concluded that race continues to be a significant and robust predictor of commercial hazardous waste facility locations, and that neighborhoods with commercial waste facilities have nearly twice the minority concentration (56% versus 30%) than those without a facility.[64]

One of the limitations of studying the socioeconomic characteristics of communities with land contamination is capturing the characteristics at the timing of the siting. A study by Wolverton (2009) determined that using contemporary socioeconomic characteristics confirms the findings of most environmental justice literature that minority and low-income populations are disproportionately close to contaminating plant location. A deeper analysis in the study, using socioeconomic characteristics at the time of siting, shows that race is not significant, though income is still negatively related to plant location.[65] The study was limited to hazardous waste sites in Texas, however, using decennial census socioeconomic characteristics for plants sited over 10 year periods.

The EPA Office of Inspector General (OIG) and GAO published multiple reports in the mid-2000s. The GAO found in 2005 that the EPA failed to include environmental justice concerns in the establishment of the Clean Air Rules. [66] In 2007, GAO published a report that concluded that the EPA lacked measurable benchmarks to evaluate its progress in correcting past environmental justice issues.[67] A 2004 study done by the EPA OIG reached a similar conclusion, that the Agency had not developed a

[63] (EPA, 2006)
[64] (Bullard, 2007)
[65] (Wolverton, 2008)
[66] (GAO, 2005)
[67] (GAO, 2007)

clear vision or a comprehensive strategic plan to fully implement EO 12898.[68] A 2006 study again confirmed the lack of direction to program and regional offices to conduct environment justice reviews in accordance with Executive Order 12898.[69]

H. Purpose and Organization of Thesis

None of the existing environmental justice research provides an all encompassing view of environmental justice issues in land contamination. Contaminated sites targeted by Superfund and other programs can suffer from environmental justice during multiple stages, generally labeled here as quantity, quality and remediation issues. The first potential occurrence of environmental justice, quantity, is during the siting of contaminating activities. The potential environmental injustice is that specific communities were exposed to contamination because of racial or low-income characteristics. The next potential occurrence of environmental justice, quality, relates to the level of contamination at the sites on the NPL. This would involve low-income and racial communities being exposed to greater levels of contamination putting them at a higher risk than other communities with sites on the NPL. The third and final potential occurrence is during the remediation process. The potential injustice would be that remediation of contaminated sites in low-income and minority communities would take longer than comparable sites in other communities. Evaluating these three potential occurrences will create a complete environmental justice study.

The paper is further organized into five sections. The next section details the legal and institutional structure of Superfund programs at the Federal level and in Arizona. The general processes are divided into listing and remediation steps. The implementation, funding, and division of labor between the NPL and WQARF are all documented. The data consists of two different NPL site lists with demographic data from two different decennial censuses and is explained further in Part III. The

[68] (EPA Office of Inspector General, 2004)
[69] (EPA Office of the Inspector General, 2006)

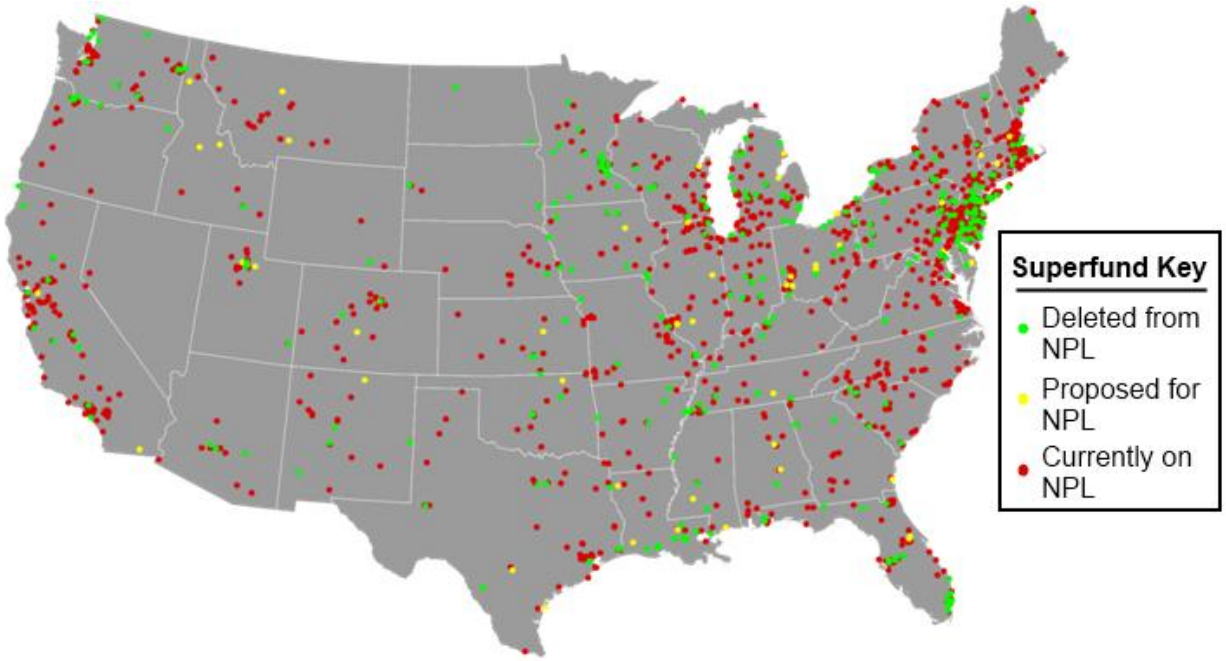
descriptive statistics include a combination of analysis tools including summary tables, variable mean t-tests, correlation matrices and graphs. The econometric models used in this study are laid out in Part IV. Land contamination siting and HRS Scoring are both analyzed using logistic regressions, and NPL remediation is analyzed using Poisson and Negative Binomial regressions. The empirical results are presented in Part V. Finally, conclusions are drawn in Part VI.

2. Legal and Institutional Background

The Federal Superfund program was created under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) enacted by Congress in December 1980 and amended by the Superfund Amendments and Reauthorization Act (SARA) on October 17, 1986. CERCLA created the EPA's National Priorities List (NPL) to monitor and manage long-term remedial response actions to reduce the dangers associated with releases (or threats of releases) of hazardous substances.[70] While the total number of potential Superfund sites is relatively unknown, an estimate by the U.S. General Accounting Office (GAO) five years after the release of the initial NPL put the figure as high as 425,000. As of December 1988, EPA had identified nearly 30,000 potential sites.[71] There are currently 1,288 sites on the NPL, 66 proposed for the list, and 349 sites that have already been deleted. Figure 2.1 shows the distribution of NPL sites across the continental U.S. and their status as of April, 2010.

[70] (EPA, 2011)
[71] (Hird, 1990)

Figure 2.1: Superfund Site Status in the U.S.[72][73]



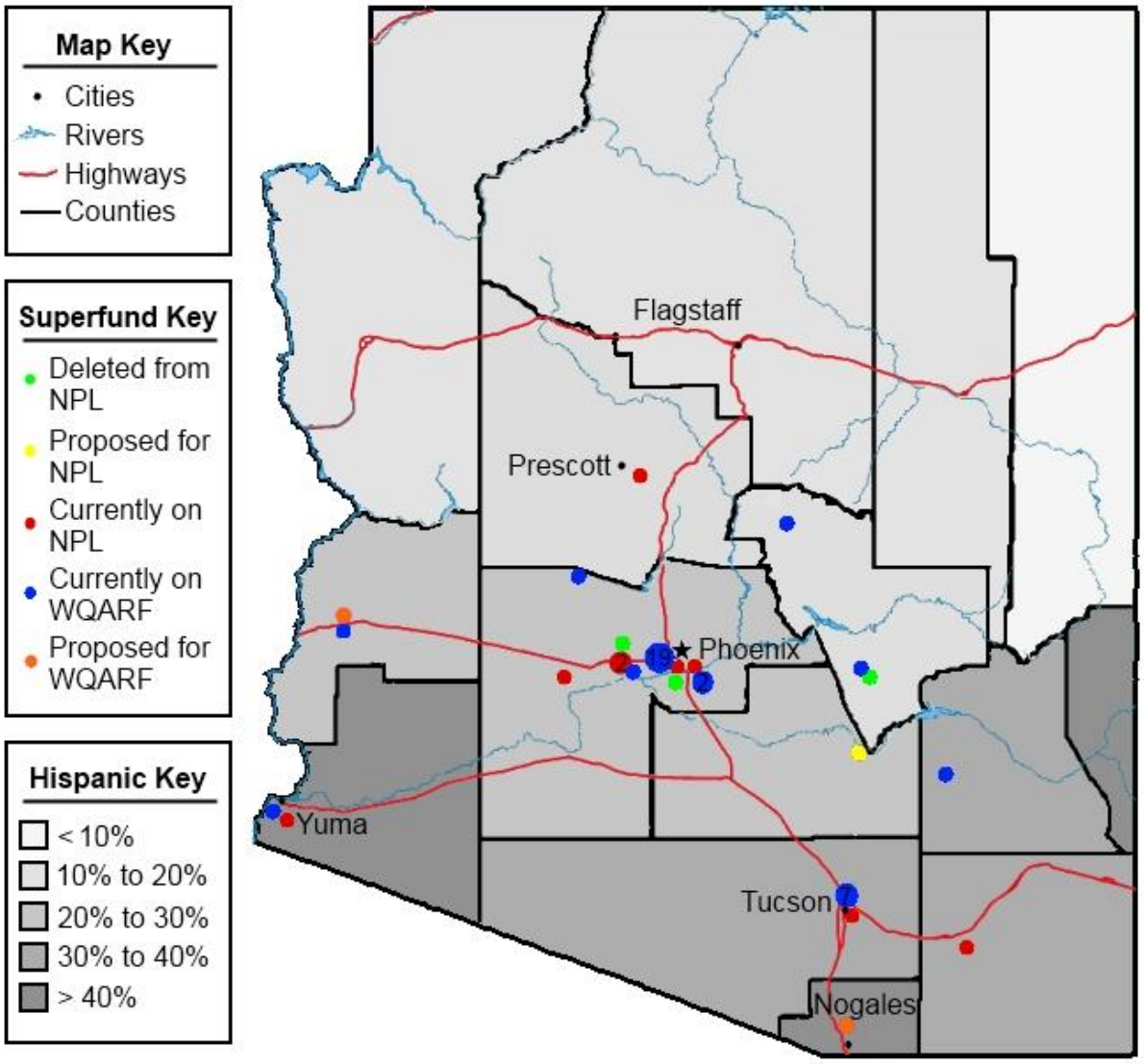
The Federal Superfund program is reserved for the worst instances of land contamination and lacks the resources to clean up all sites, so Arizona and several other states have created their own state superfunds.[74] Arizona's superfund, the Water Quality Assurance Revolving Fund (WQARF), was established in 1986. The Remedial Projects Section of the Waste Programs Division at the Arizona Department of Environmental Quality (ADEQ) uses WQARF to support hazardous substance cleanup efforts throughout Arizona with support from state and federal funds.[75] The program also oversees privately-funded, volunteer cleanup efforts. The parties ultimately found to be responsible in WQARF and Superfund actions are liable for paying costs of remedial actions required or monitored by ADEQ. In addition to the NPL and the WQARF Registry sites, the Superfund Programs Section also provides state review and oversight at 12 Department of Defense (DoD) sites. DoD contaminated sites that are independent of the NPL are beyond the scope of this research.

[72] Map current as of April 26, 2010.
[73] (Wikipedia, 2010)
[74] (Davenport, 1999)
[75] (ADEQ, 2011)

While NPL sites focus on discrete areas of significant contamination, WQARF sites generally have been designated because of groundwater contamination, known as plumes, which may or may not impact property located above it.[76] While there are only nine current Federal Superfund sites in Arizona and two more sites that have been deleted, there are 35 sites currently on the WQARF list and two more proposed sites. The locations of the contaminated sites across the state are typically associated with the placement of industry. In an exercise to look at potential environmental justice in the state, locations and statuses of contaminated sites have been plotted against the percentage of Hispanic residents by population for the fifteen counties in Arizona shown in Figure 2.2.

[76] (Peters, 1996)

Figure 2.2: Superfund and WQARF Sites in Arizona by Hispanic Population Density[77]

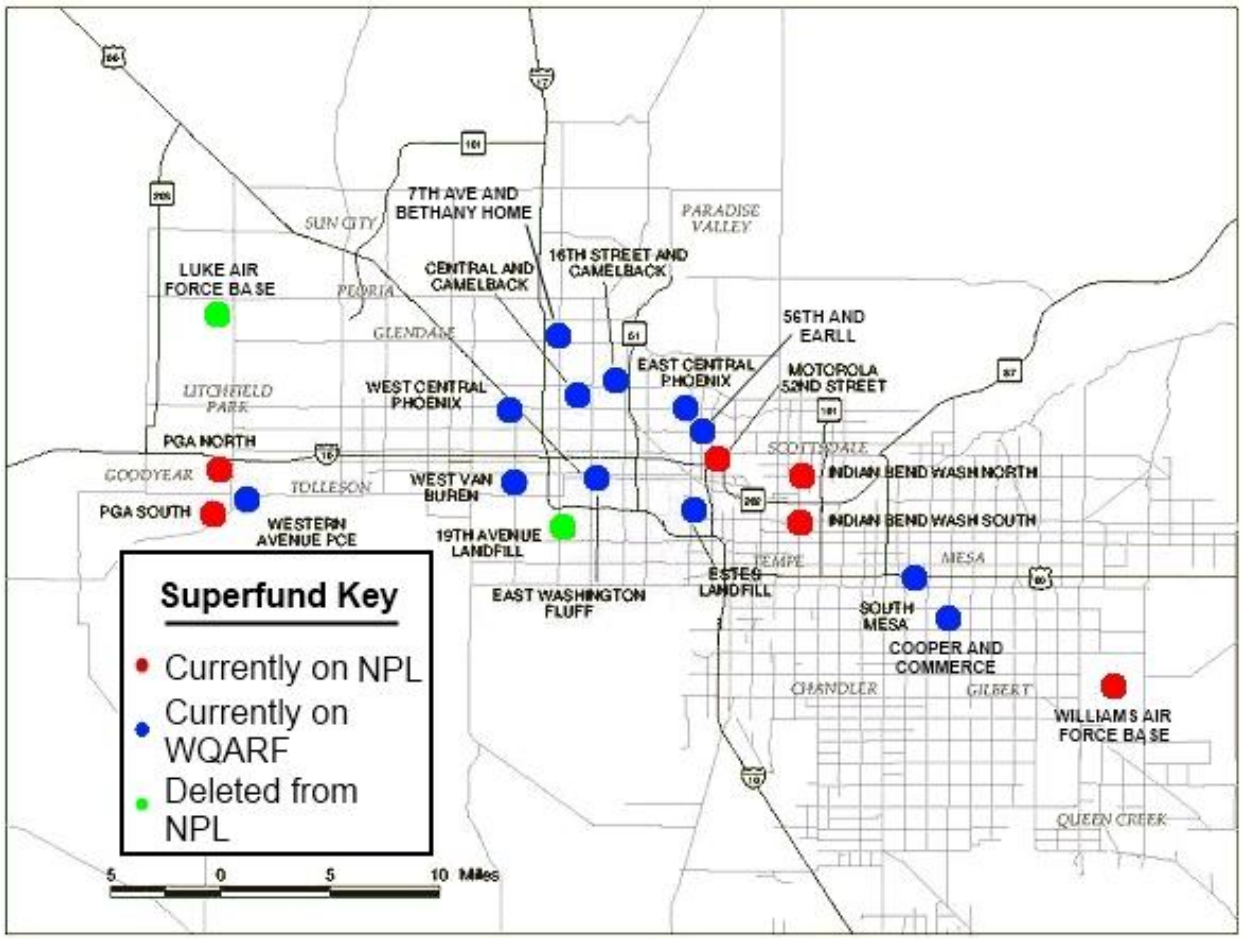


The majority of the contamination sites are located in and around the Phoenix area, which is shown in detail in Figure 2.3. Similarly, Figure 2.4 displays the status and placement of land contamination in Tucson in greater detail. The Hispanic population densities from the 2010 Census demonstrate that higher concentrations of Hispanics are logically located closer to the border with Mexico. Nearly all of the sites are located in counties with at least 20% Hispanic populations, representing 9 of the 15 counties in the state. These counties also contain the largest cities and most of

[77] Hispanic population density is from the 2010 Census.

the industry in the state, which cautions that drawing conclusions on relation to Hispanic density alone is premature. The maps do not indicate the size or the severity of the contamination. In the case of WQARF sites, some of the plumes stretch for miles.[78] Two of NPL sites in the state are divided into north and south portions, indicating the magnitude of their size.

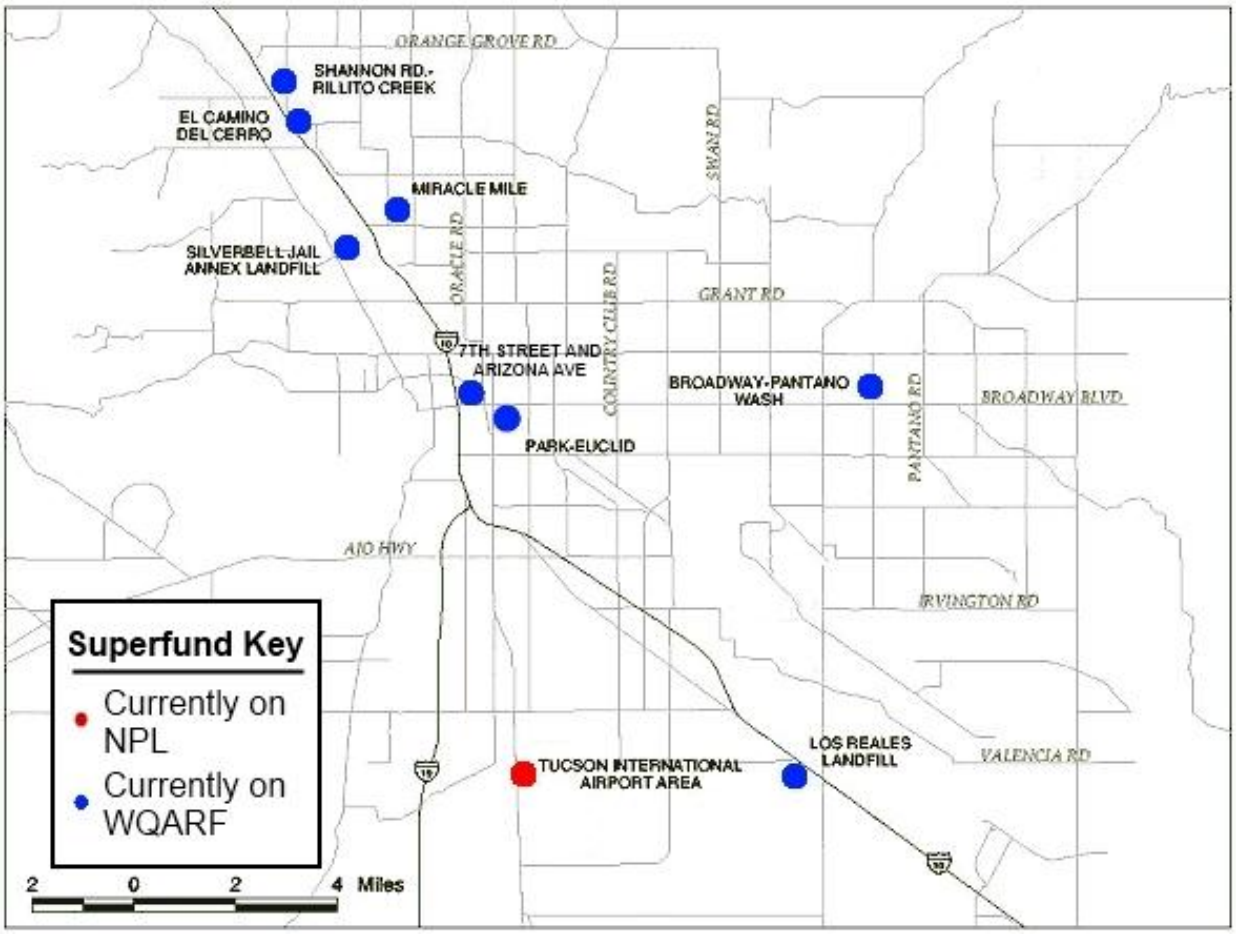
Figure 2.3: Superfund and WQARF Sites in Phoenix[79]



[78] The West Van Buren WQARF site plume is approximately 8 miles long and nearly 2 miles wide at the thickest point according to an ADEQ Fact Sheet with a map of the estimated plume. (ADEQ, 2006)

[79] (Davenport, Performance Audit: Department of Environmental Quality, Aquifer Protection Permit Program, Water Quality Assurance Revolving Fund Program, and Underground Storage Tank Program., 1999)

Figure 2.4: Superfund and WQARF Sites in Tucson[80]



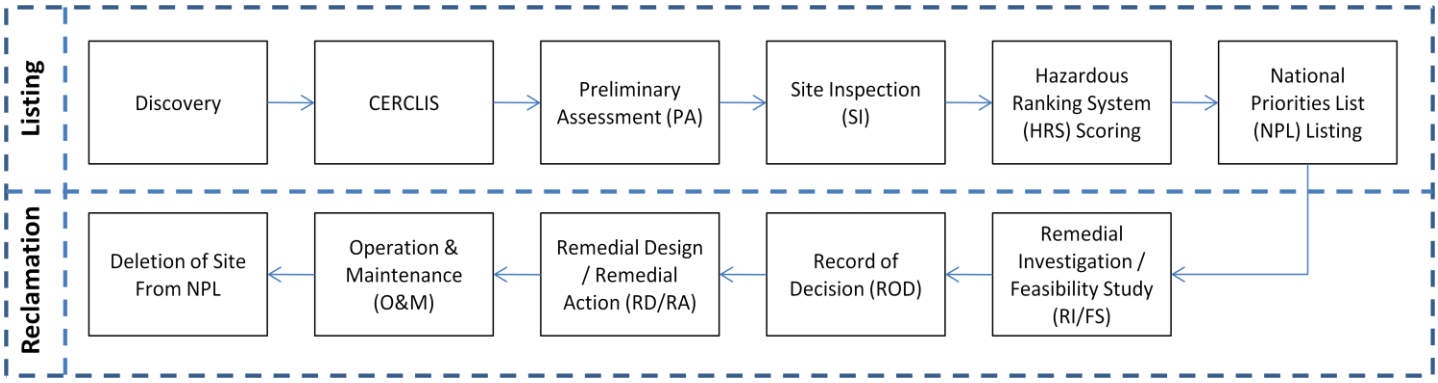
The general procedure for Superfund programs can be broken into two major processes: listing and remediation. Listing begins with the identification of sites through their listing on the NPL or WQARF list. Remediation begins with the remedial investigation and feasibility study through the successful cleanup and potential reuse of the site. Each program has guidelines about the implementation and enforcement of listing and remediation. ADEQ and EPA work together and have different roles in the efforts of each program. The specific procedures of the Federal CERCLA program and Arizona's WQARF program will be documented here.

[80] (Davenport, Performance Audit: Department of Environmental Quality, Aquifer Protection Permit Program, Water Quality Assurance Revolving Fund Program, and Underground Storage Tank Program., 1999)

A. CERCLA

The Federal Superfund process follows a series of documented steps illustrated in Figure 2.5.

Figure 2.5: Federal Superfund Process



1. Listing

The first step is the discovery or the notification to EPA of possible releases of hazardous substances. Sites are discovered by various parties, including citizens, State agencies, and EPA Regional offices. Once discovered, sites are entered into the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS), EPA's computerized inventory of potential hazardous substance release sites. The sites in CERCLIS are updated quarterly with information on the current status of cleanup efforts, cleanup milestones reached, and amounts of liquid and solid media treated at sites on the National Priorities List (NPL) or under consideration for the NPL.[81]

The next step involves performing a Preliminary Assessment/Site Inspection (PA/SI). This includes investigations of site conditions. Information collected during the PA and SI is used to calculate a Hazard Ranking System (HRS) score. If the release of hazardous substances requires immediate or short-term response actions, these are addressed under the Emergency Response program of Superfund.

The PA is an assessment of information about a site and its surrounding area. PA is designed to

[81] (US National Library of Medicine, 2010)

determine whether a site poses little or no threat to human health and the environment; or if it does pose a threat, whether the threat requires further investigation. If the PA results in a recommendation for further investigation, a Site Inspection is performed.[82] The SI identifies sites that enter the NPL Site Listing Process and provides the data needed for HRS scoring and documentation. SI investigators typically collect environmental and waste samples to determine what hazardous substances are present at a site.

The HRS score analyzes chemical pollutants along four migration pathways: soil, groundwater, surface water, and air.[83] The score is calculated using the following formula:[84]

$$\mathrm{HRS} = \sqrt{(S_{GW}^2 + S_{SW}^2 + S_S^2 + S_A^2)/4}$$

where:

HRS = Hazardous Ranking System Score
S_{GW} = Ground Water Migration Pathway Score
S_{SW} = Surface Water Migration Pathway Score
S_S = Soil Exposure Pathway Score
S_A = Air Migration Pathway Score

HRS ranges from 0 to 100, and scores over 100 are censored. Each pathway has a maximum score of 100. Each pathway score is made up of three parts: likelihood of release, waste characteristics, and targets. Furthermore, surface water migration and soil exposure are scored across multiple threats. Surface water migration is composed of three threats: drinking water, human food chain and environmental. Soil exposure is composed of two threats: resident population and nearby population.

The purpose of the HRS scoring is solely to determine whether a site should be included on the NPL, so testing does not represent a formal risk assessment. The magnitude of the score, however, is related to the health and environmental hazards posed. The nature of the equation amplifies the impact of the dominant pathway while discounting the secondary pathways. Consequently, sites with a single

[82] (EPA, 2011)
[83] The original guidance in 1982 listed three pathogens locations: groundwater, surface water, and air. HRS was revised in 1990 to add soil as an additional pathway.
[84] (Center for Hazardous Substances in Urban Environments, 2003)

large pathway score will receive higher overall HRS scores than sites with balanced, lower scores across multiple pathways.[85] According to EPA, this is an important requirement for HRS scoring, because some extremely dangerous sites pose threats through only one pathway.[86]

The National Priorities List (NPL) Site Listing depends primarily on the HRS. In 1982, EPA established a cut-off score at 28.5 for NPL listing consideration. Due to budget constraints, EPA was given authority to put 400 sites on the initial NPL in 1982.[87] The cutoff was chosen originally to separate the 400th and 401st sites in the HRS Score ranking. The cutoff, though a relative measure, remains a screening level indicator of the highest priority hazardous waste release sites. In 1990, each state was granted the ability to assign one site to the NPL without the site meeting the HRS Score cutoff.[8889] In 1995, state governor approval was also added to the criteria for NPL placement since some places oppose Superfund designation due to the stigma that comes with it.

2. Remediation

Once a site has been listed on the NPL, the next step is the Remedial Investigation and Feasibility Study (RI/FS). The RI and FS are conducted concurrently. Information collected in the RI influences the development of remediation alternatives in the FS, which consequently affects the data and scope of the feasibility studies. The goal of the parallel studies is to determine the nature and extent of the contamination and assess the performance and cost of the treatment options. Remediation alternatives are assessed against nine evaluation criteria developed by EPA:

[85] (Hird, 1990)
[86] (EPA, 2011)
[87] (Greenstone, 2008)
[88] As of 2003, 38 states have used their exception.
[89] (Greenstone, 2008)

- Overall protection of human health and the environment
- Short-term effectiveness
- Community acceptance
- Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)
- Implementability
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Cost
- State acceptance

The next step is the issuance of the Record of Decision (ROD). The ROD identifies which remediation alternative will be used at the site.[90] Most of the cleanup occurs during the Remedial Design and Remedial Action (RD/RA) phase. The conclusion of this stage is the Construction Completion milestone. Sites qualify for Construction Completion status when one of the following conditions has been reached:

- All necessary physical construction is complete, whether or not final cleanup levels or other requirements have been achieved
- EPA has determined that the response action should be limited to measures that do not involve construction
- The site qualifies for Deletion from the NPL

The goal of the Post Construction Completion stage is to ensure that the Superfund response actions provide long-term protection to human health and the environment. Post construction tasks include long-term response actions (LTRA), operation and maintenance, institutional controls, five-year reviews, and remedy optimization. The final stage in the process involves deletion from the NPL and potential site reuse. Once all remediation actions are complete and cleanup goals have been achieved the site is deleted from the NPL. EPA then works with local communities in an effort to return the hazardous waste site to safe and productive use.

[90] When proposed remedies exceed $25 million, they are reviewed by the National Remedy Review Board.

3. Implementation

The Superfund Enforcement program remediates hazardous waste sites by finding the companies or people responsible for contamination at a site and negotiating with them to do the clean up themselves or to pay for the cost of cleanup. EPA has authority to perform short or long-term cleanups at a site and later recover cleanup costs from potentially responsible parties (PRPs) under Section 107 of CERCLA. EPA can also gather information, obtain access to a site, and seek penalties for non-compliance with orders and agreements. EPA can order, or ask a court to order, PRPs to clean up the site when an imminent danger exists.

EPA prefers that PRPs do the work of investigating, cleaning up, and maintaining the cleanup of Superfund sites. The term “work agreement” is used to cover a variety of agreements that involve the PRP doing the work. When EPA performs investigations or cleanup work, it can recover these costs from PRPs through a cost recovery agreement. There are a few situations when it is more appropriate for PRPs not to be involved in performing work at a site. In such cases, EPA may negotiate a “cash out” agreement with the PRP, where the PRP pays an appropriate amount of estimated site costs in advance of the work being done.

Superfund liability is retroactive, strict, and joint and several. Parties may be held liable for acts that happened before Superfund's enactment in 1980. A PRP cannot use non-negligence or compliance with industry standards as a defense. If a PRP contributed to the hazardous waste found at the site, that party is liable. Any of the PRPs may be held liable for the entire cleanup of the site when the contamination cannot be separated between parties. In determining PRPs, EPA follows a series of steps. EPA looks for evidence to determine liability by matching wastes found at the site with parties that may have contributed wastes to the site. EPA seeks out the nature of a party's involvement. There are four classes of Superfund liable parties:

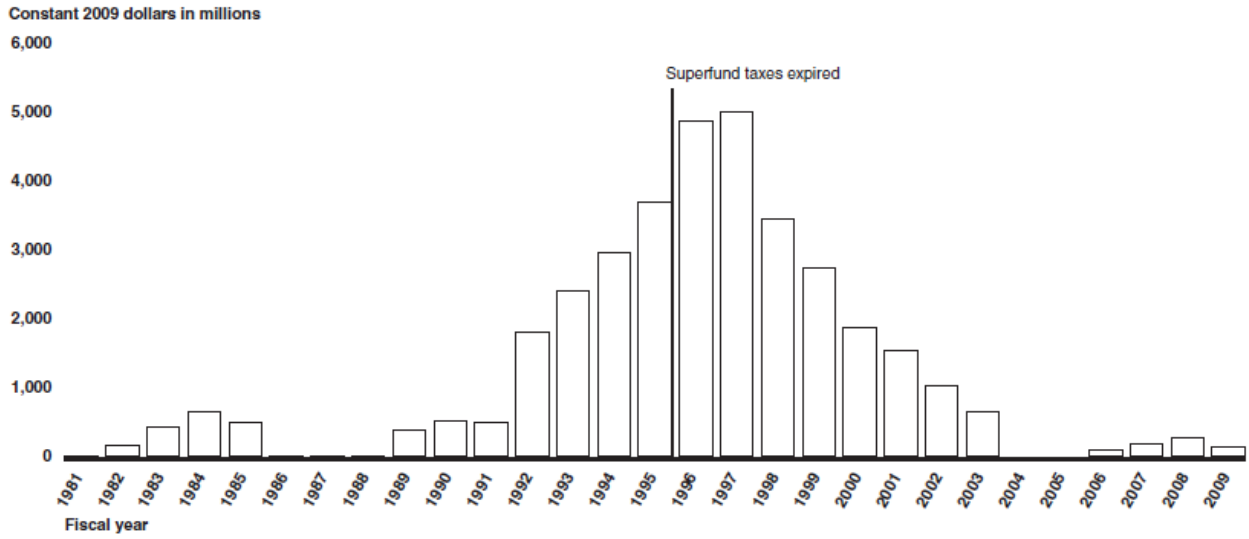
- Current owners and operators of a facility

- Past owners and operators of a facility at the time hazardous wastes were disposed
- Generators and parties that arranged for the disposal or transport of the hazardous substances
- Transporters of hazardous waste that selected the site where the hazardous substances were delivered

EPA also reviews a party's potential defenses and any applicable exemptions or exclusions. Acceptable defenses to Superfund liability are limited to cases in which the release was caused by an act of God, act of war, or acts of a third party with whom a PRP had no contractual relationship. EPA also attempts to determine the amount of waste a party contributed, and the PRP's ability to pay for cleanup.

CERCLA established a trust fund from which EPA receives annual appropriations for Superfund program activities. The Superfund trust fund has received revenue from four major sources: taxes on crude oil and certain chemicals, appropriations from the general fund, fines and cost recoveries from responsible parties, and interest accrued on the balance of the fund. In the program's early years, dedicated taxes provided the majority of revenue to the Superfund trust fund. In 1995, however, the authority for these taxes expired and has not been reinstated. Since 2001, appropriations from general revenues have been the largest source of funding for the trust fund. Superfund program appropriations have averaged about $1.2 billion annually since 1981, although the annual level of these appropriated funds has generally declined in recent years when adjusted for inflation. After the expiration of the tax authority, at the start of fiscal year 1997, the trust fund balance reached its peak of $5.0 billion, and in 1998, the trust fund balance began decreasing. By the start of fiscal year 2009, the balance of the trust fund had decreased in value to $137 million. Figure 2.6 shows a timeline of the Superfund trust fund balance from fiscal year 1981 through 2009.

Figure 2.6: Balance of the Superfund Trust Fund at the Start of Each Fiscal Year, Fiscal Years 1981 through 2009[91]



The decrease in available funding has had dire effects on the operating capacity of the program. According to EPA Superfund Accomplishment Reports, between fiscal years 2004 and 2008, 54 sites, or over one-third of all sites ready for new construction funding, were not funded in the year that they were ready to begin construction. Some sites were not funded for several years after they were construction-ready. Recently, EPA has sought other areas of funding, taking advantage of the American Recovery and Reinvestment Act of 2009 (Recovery Act), EPA's Superfund remedial program received $600 million.[92] The funding will accelerate ongoing cleanup activities or initiate new construction projects at 51 Superfund sites, meeting the goals of the Recovery Act by boosting local economies through job creation.[93] The future financial needs of the program only become greater. In 2010, EPA regional officials estimated that up to 125 sites would be added to the NPL over a 5 year period. The annual estimated increase of 20 to 25 sites is noticeably higher than the average annual increase in sites for fiscal years 2005 to 2009 of about 16.[94] Funding limitation can also impact state cleanup programs,

[91] (GAO, 2010)
[92] (GAO, 2010)
[93] (EPA, 2011)
[94] (GAO, 2010)

which sometimes receive funding from EPA to take the lead in cleaning up seriously contaminated sites that are not listed on the NPL. Several state officials said that less funding from EPA has limited the number of investigations and assessment compared to recent history.

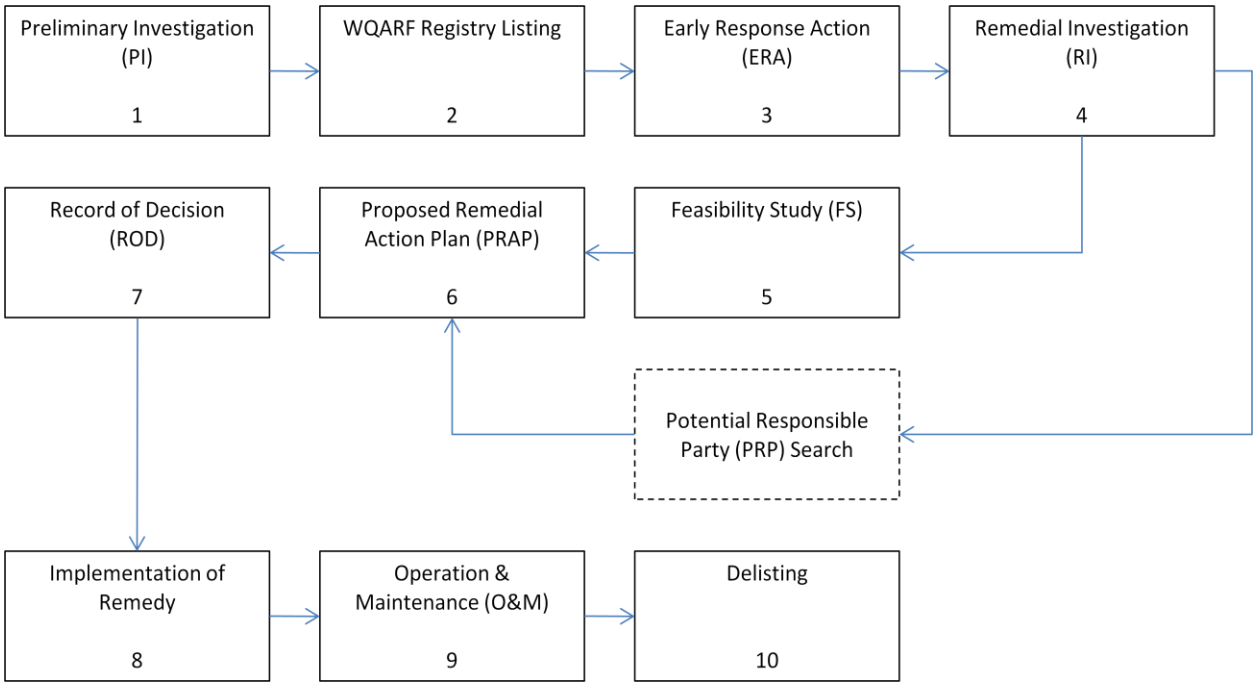
4. Results

Figure 2.1 showed the success of the Federal Superfund program, showing that 349 sites that have been fully remediated and removed from the NPL. This represents remediation of over 20% of the total NPL listing in its 30 year history. Recent budget shortfalls have slowed the progress of the remediation efforts, but Superfund has shown that with adequate funding, sites are fully remediated.

B. WQARF

The Arizona Superfund process, known as Water Quality Assurance Revolving Fund (WQARF) follows a similar approach to the Federal Superfund process. The WQARF process is shown in Figure 2.7.

Figure 2.7: WQARF Phases[95]



[95] (ADEQ, 2010)

1. Listing

The WQARF process begins when ADEQ receives information about a release or potential release of a hazardous substance.[96] This information may come from a citizen complaint, from an investigation conducted by ADEQ or from an investigation conducted by an outside party. ADEQ assesses whether the information is credible, if another regulatory program has jurisdiction, or if the site is already being cleaned up voluntarily. If a potentially hazardous release has occurred and no other regulatory program has jurisdiction, a WQARF Preliminary Investigation (PI) is initiated. The purpose of the PI is to confirm the release or potential release and determine whether further investigation or action is necessary. If ADEQ determines that additional investigation or action is necessary, the site is scored using the eligibility and evaluation model and is eligible for listing on the WQARF registry. Sites on the Registry are given a numeric score based in part upon the type of contaminants present, the location of the contaminants, and the number of people that may be affected by the contaminant. Scores are used to help determine relative risk at the site and do not necessarily mean that there is a direct risk to humans or the environment. The maximum score for a WQARF site is 120.

The WQARF registry provides public access to information on WQARF sites. The registry replaced the former WQARF Priority List and provides a list of sites where groundwater or soil contamination is known to be present. Sites listed on the WQARF registry qualify for WQARF funds for investigation and clean up. The WQARF registry contains a brief description of each site, the site's score, and the current status of the cleanup.

2. Remediation

ADEQ developed the Early Response Action (ERA) process to address contamination where human health or the environment is potentially impacted, where sources of contamination can cause

[96] (ADEQ, 2010)

significant environmental impact, or where early actions can save significant WQARF funds by limiting the spread of contamination. ERAs may be relatively inexpensive short-term actions, such as fencing or providing alternative water supplies, or they may involve an expensive large-scale groundwater treatment system. An initial ERA evaluation of risks at a site occurs immediately after a site is listed in the WQARF registry. If a current or potential risk to human health or the environment exists through direct contact with a hazardous substance, an ERA may be implemented immediately.

Once in the WQARF program, sites undergo a remedial investigation and feasibility study (RI/FS). An RI/FS is a two-phase investigation conducted by ADEQ or interested parties to investigate the scope of contamination and determine the alternatives for remediation. The purpose of a Remedial Investigation (RI) is to collect enough information to determine the appropriate cleanup actions needed at the site. The information collected includes the physical characteristics of the site: the nature, extent and sources of the contamination and the actual and potential impacts of contaminants on the site to public health, welfare and the environment. The RI also identifies present and foreseeable uses of land and waters of the state that have been or may be impacted by the contamination.

Using the information collected in the RI, the Feasibility Study (FS) documents technologies and options that may achieve remedial objectives. Various options are identified and compared to facilitate selection of the most feasible and cost-effective cleanup method for the site. Concurrently, ADEQ is required at most sites to conduct an extensive search to identify potentially responsible parties (PRPs). During and following the RI/FS, legal negotiations may be undertaken in response to a party's request to settle liability early and to gain access to private properties for investigation or cleanup implementation.[97]

After the FS is completed, ADEQ prepares a Proposed Remedial Action Plan (PRAP) to document the proposed cleanup or remedy. The plan describes the means by which the proposed remedy will

[97] (ADEQ, 2010)

meet each of the remedial objectives identified in the RI and how accomplishment of the remedial objectives is to be measured. The plan also provides an estimate of the cost of the cleanup.

A record of decision (ROD) documenting the selected cleanup alternative is finalized, followed by a liability allocation process in which past and future remediation costs are distributed among responsible parties. The ROD includes an estimated cost, time-frames for beginning and completing the cleanup process, and a demonstration that the selected remedy meets the remedial objectives. After the ROD is signed, an allocation process follows in which past and future costs are distributed among responsible parties. After the ROD is finalized, extensive remedial system design development and review must be undertaken. After the remedial system is constructed, operation and maintenance may be conducted as appropriate to the remedy.[98]

The design and implementation stage includes the development of the engineered design of the selected remedy and implementation of the remedy through construction. A period of operation and maintenance (O&M) may follow the design and construction activities. The O&M is conducted pursuant to a schedule applicable to the type of remedy completed. Once the remedy is completed at a site, or ADEQ determines that no further investigation or cleanup is needed, the site is eligible for delisting from the WQARF registry.

3. Implementation

Through the WQARF Program, ADEQ has the authority to identify, assess, and clean up soil and groundwater contamination. The program conducts these efforts state-wide using state funds and also oversees privately funded cleanup efforts. Responsible parties are identified and notified, and then legal and technical evidence is gathered for recovery of ADEQ's costs and enforcement of cleanup requirements. WQARF was created under the Environmental Quality Act of 1986 and underwent

[98] (ADEQ, 2010)

significant revisions as a result of the WQARF Reform Legislation of 1997.

One of the focuses of the WQARF revision was requiring enhanced community involvement at all stages of the cleanup process. The statute established a process to encourage active community involvement, including provisions for notices, community involvement plans, and the formation of a community advisory board for each site. These community involvement efforts may include the formation of community advisory boards to assist in relaying information and concerns between the public, ADEQ, and interested parties. After conditions at the site are known, ADEQ holds public meetings to establish remedial objectives. ADEQ invites land owners, local governments, water providers, and the public to discuss land and water uses impaired or lost due to the contamination, as well as future uses which could be impacted by the contamination.

Arizona is one of a growing number of states to address the liability issues associated with buying, selling or developing real property contaminated by hazardous substances. Because of the potential for liability as an owner of property contaminated with hazardous substances, property owners and other participants in property transactions frequently need to determine if the property in question is contaminated. When contamination is discovered, participants in property transactions may also want to know the extent of the ADEQ's authority to take enforcement actions or to recover cleanup costs.[99]

The WQARF Revision changed liability for the costs of the cleanup of WQARF sites to proportionate from joint and several. Cleanup costs are proportionately allocated among responsible parties using a process defined in statute. Identification of responsible parties and the allocation of cleanup costs are the responsibility of ADEQ. Therefore, ADEQ can no longer identify a single party who contributed to pollution at a site and hold that party responsible. It must now use its best efforts to identify all contributing parties, allocate responsibility proportionately among them, and determine

[99] (ADEQ, 2011)

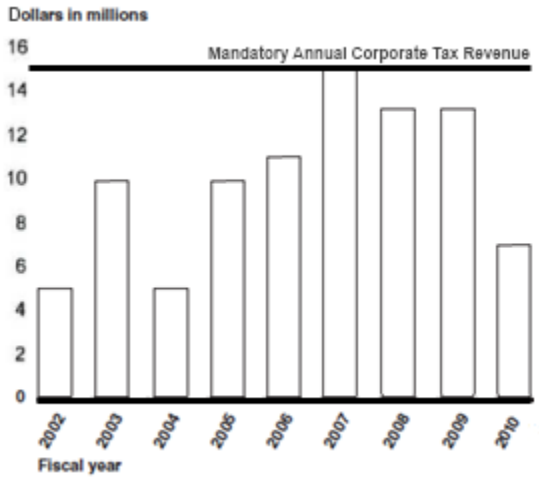
each party's ability to pay. Proportional liability is considered more equitable because one party is not held solely responsible for all cleanup costs unless it is solely responsible for the contamination. In addition, if parties are unable to pay their fair share, the State is now responsible for paying these orphan shares.

Although the restructured investigation and allocation processes have helped resolve inequities, these additional requirements are time-consuming and contribute to further cleanup delays and increased costs. In particular, searches for potentially responsible parties can be very time-consuming and difficult. Lengthy searches for responsible parties may further delay cleanup efforts and increase the costs, as untreated contamination continually leaches into previously uncontaminated soil and groundwater. Environmental experts have stated that investigating a single party may take 18 months or longer and cost thousands of dollars. Although an investigator can research between 5 and 10 parties at once, some sites have several hundred parties to investigate. One site investigation began with as many as 1,000 potentially responsible parties. ADEQ estimates that the investigation at that site could take as long as 10 years, and that a plume of contamination already 12 miles long could spread another half mile during that time. Prompt settlements as an alternative to litigation are encouraged. In an attempt to offset some of the delays in the process, ADEQ is authorized to offer a 25 percent discount to responsible parties who settle after the department provides notice to them of their proportionate share of liability.

The adoption of a proportionate liability system increased the need for adequate and dedicated program funding. ADEQ's ability to administer and implement the WQARF program depends on $18 million per year in dedicated funding. The statute mandates that $15 million of that $18 million is transferred from Corporate Income Tax revenue. Due to budget shortfalls, however, the WQARF Program received $46 million less in Corporate Income Tax revenue for fiscal years 2002 through 2010 and only once, in fiscal year 2007, did they receive the full amount. Figure 2.8 shows the actual annual

corporate tax revenue from the last nine fiscal years. WQARF is also funded by direct transfers of funds from legislative appropriations, costs recovery, and an assortment of contamination related registration fees.

Figure 2.8: WQARF Annual Corporate Tax Revenue Comparison Fiscal Years 2002 through 2010[100]



4. Results

Since WQARF's inception in 1986, 35 sites have been added to the WQARF Registry. As of FY2000, 33 sites had been added to the list, and no sites have been deleted from the list meaning only 2 sites have been added to the registry over the last decade. In the FY2003 Annual Report, 25 of the 33 sites on the Registry listed "Unknown" for Estimated Duration of Cleanup. Furthermore, 30 of the 33 sites had "Unknown at this time" listed for Estimated Expenditures to Complete Final Cleanup. At that time, $9.8 million had been spent collectively on those sites. Program status and cumulative cost figures were not detailed in recent reports. In FY2007, WQARF finished the first site Record of Decision (ROD). In the same period, however, ADEQ issued stop work directives on January to all WQARF contractors for site activities that were not related to the operation and maintenance of soil and groundwater treatment systems due to budget cuts. WQARF cleans between 2 and 3 billion gallons of water annually,

[100] (ADEQ, 2010)

though efforts ramped up to 4.4 billion gallons in FY2009. ADEQ also uses WQARF for Early Response Actions (ERA) to imminent threats. During FY2010, the WQARF program initiated an ERA at one site and continued operation and maintenance (O&M) on numerous ERAs that were initiated in prior years. Overall, the program suffers from budget shortfalls and has not demonstrated the ability to take contaminated sites from identification to remediation in its 25 year history.

C. Federalism

State superfund programs and Federal Superfund support the efforts of each other. As discussed above, states follow the lead of Federal Superfund, evaluating sites for state-level remediation only after sites are passed over for the NPL. States and Federal Superfund share costs at different stages in the remediation process. The goals of the division of labor structure between ADEQ and EPA in Arizona land contamination remediation are achieving efficiency and realizing the benefits of synergies between the programs.

The history of state and Federal program relationships was established by two Executive Orders (EOs). EO 12372, "Intergovernmental Review of Federal Programs," was issued in 1982 with the desire to foster the intergovernmental partnership and strengthen federalism by relying on State and local processes for the coordination and review of proposed Federal financial assistance and direct Federal development. EO 12875, “Enhancing Intergovernmental Partnership,“ issued in 1993, states that Federal agencies must consider any application by a State, local, or tribal government for a waiver of statutory or regulatory requirements in connection with any program administered by that agency.[101] This order relates to the amendment to the Federal Superfund process that made state approval a requirement for listing on the NPL.

The CERCLA legislation establishes the guidelines for state involvement in the Federal Superfund

[101] (The White House, 1993)

process. It says that States should have substantial and meaningful involvement in initiation, development, and selection of remedial actions to be undertaken in that State. The regulations, at a minimum, shall include each of the following:[102]

- State involvement in decisions whether to perform a preliminary assessment and site inspection
- Allocation of responsibility for hazard ranking system scoring
- State concurrence in deleting sites from the National Priorities List
- State participation in the long-term planning process for all remedial sites within the State
- State participation in negotiations with potentially responsible parties regarding the scope of any response action at a facility and be a party to any settlement
- A reasonable opportunity for States to review and comment on the remedial investigation and feasibility study, the planned remedial action, the engineering design, and other technical data

CERCLA dictates that the Administrator may award a grant to a State or Indian tribe that has its own response program, like WQARF, that includes each of the elements or is taking reasonable steps to include each of the elements. In general, a State may use a grant under this subsection to establish or enhance the response program of the State. Additionally a State or Indian tribe may use a grant under this subsection to capitalize a revolving loan fund for brownfield remediation or purchase an insurance mechanism to provide financing for response actions under a State response program. CERCLA does give the Federal Superfund program the power to intervene in State efforts when a threatened release may present an imminent and substantial endangerment to public health or welfare or the environment, and additional response actions are likely to be necessary to address, prevent, limit, or mitigate the release or threatened release.

CERCLA requires that each State maintains an inventory, which describes the location of hazardous waste sites within each State. The inventory must also include information on the amount, nature, and toxicity of the hazardous waste at each such site and the extent of any health hazard, if

[102] (Cornell University Law School)

available. Also required is information about the PRPs including the name and address of the owner of each such site, an identification of the types or techniques of waste treatment or disposal which have been used at each site, and information concerning the current status of the site. Reporting is required of historical waste sites that predate permitting and other requirements.

3. Data Sources and Descriptive Statistics

A. Data Sources

The data was obtained from a study done by Michael Greenstone and Justin Gallagher on the effect of Superfund sites on the housing market[103]. The data file contains housing prices and characteristics, demographic characteristics, and Superfund site listing and remediation information (through 2000) by census tract for the 1980 and 2000 censuses. The data for 1980 was normalized to census 2000 boundaries[104] using GeoLytics's Neighborhood Change Database. Several key demographic variables[105], however, were missing from the data file for the 2000 census. These variables were attained from the 2000 census data using the U.S. Census American Factfinder site. The complete list of variables used in this study can be seen in Table 3.1.

The updated data file contains two samples, the "2000 NPL Sample" and the "1982 HRS Sample". The 2000 NPL Sample contains 1980 and 2000 census information for the census tracts containing the 1,398 sites placed on the NPL by January 1, 2000 and the census tracts without an NPL site by that date. The 1982 HRS Sample also contains 1980 and 2000 census information, but for the 676 hazardous waste sites evaluated in 1982, with 407 placed on the first NPL and another 36 added later. The location of each Superfund site was matched to a census tract using latitude and longitude. For census tracts with more than one contaminated site, there is an observation for each site with the same census tract information and unique information for the contaminated site. This applies to 100 census tracts in the 2000 NPL Sample and 44 census tracts in the 1982 HRS Sample.

---

[103] (Greenstone, 2008)

[104] Census tracts are drawn to include approximately 4,000 people and are intended to represent homogenous neighborhoods. Geographic boundaries change from census to census, which means different years are not directly comparable. Also, the 1980 census only defined tracts for urban areas.

[105] Missing variables for the 2000 NPL Sample include % Hispanic, % > 25 without a high school diploma, poverty rate and unemployment rate for the 2000 census.

Table 3.1: Variable List[106]

Variable	Definition
NPL Ever	Dummy variable =1 if census tract has had an NPL site by January 1, 2000
HRS 82	Hazardous Ranking Score for sites tested in 1982
HRS Final	Final HRS for NPL site
Avg. HH Income	Average household income in census tract
% Black	% of census tract population Black
% Hispanic	% of census tract population Hispanic
% Minority	% of census tract population either Black or Hispanic
Med. Rent	Median monthly rental cost of renter occupied housing units in census tract
Med. Housing Price[107]	Median value of owner occupied housing units in census tract
% Without HS Dipl.	% of census tract population over 25 that failed to complete high school
% BA or Better	% of census tract population over 25 that have a BA or better (i.e., at least 16 years of education)
Unemployment Rt.	Unemployment rate in the census tract
Poverty Rate	% of households with income below poverty line
% Under 18	% of census tract population under age 18
% Over 65	% of census tract population 65 or older
Northeast[108]	Dummy variable =1 if census tract is in one of the following states: CT, MA, ME, NH, NJ, NY, PA, RI, or VT
Midwest	Dummy variable =1 if census tract is in one of the following states: IA, IL, IN, KS, MI, MN, MO, ND, NE, OH, SD, or WI
South	Dummy variable =1 if census tract is in one of the following states: AL, AR, DC, DE, FL, GA, KY, LA, MD, MS, NC, OK, SC, TN, TX, VA, or WV
West	Dummy variable =1 if census tract is in one of the following states: AK, AZ, CA, CO, HI, ID, MT, NM, NV, OR, UT, WA, or WY
EPA Region 9	Dummy variable=1 if census tract is in AZ, CA, HI or NM
Size	Size of NPL site in acres
Years NPL to ROD	Years on NPL until ROD issued
Years NPL to 1st ACT	Years on NPL until construction initiated
Years NPL to CC	Years on NPL until construction complete
Years NPL to DEL	Years on NPL until deleted from list
Years ROD to CC	Years from ROD until construction complete
Estimated Cost	Estimated costs for remediation (obtained from ROD) in $ millions
Actual Cost	Actual EPA total costs for remediation (construction complete only) in $ millions

The 2000 NPL Sample contains a high level overview of the Superfund program. The 1982 HRS

[106] Census tract population and demographic variables are populated for both 1980 and 2000 censuses.
[107] The median is unavailable in 1980, so mean is used instead.
[108] Geographic regions are defined by the Census Bureau.
http://www.census.gov/geo/www/us_regdiv.pdf

Sample, however, includes more detailed information about listing and remediation efforts of the initial testing in 1982. The 1982 HRS Sample breaks down the 1982 Hazardous Ranking Score with the individual scores for groundwater, surface water, and air pathway contamination. Some sites, especially those who did not make the initial cut-off, were retested later and the updated score is provided as well. The sample also includes information on the hazardous waste sites tested 1982 that did not make the NPL. The EPA provided the length of time to reach each remediation milestone (release of the ROD, initiation of clean-up, completion of remediation, and deletion from the NPL). These time intervals, along with the expected costs of clean-up before remediation and the actual costs for the sites that reached the construction complete stage, are used in the second stage analysis in this study. The NPL hazardous waste site sizes (measured in acres) were taken from the RODs. In some cases there were discrepancies between size of the NPL site in the Fact Sheet and Site Narrative, and the sources were averaged in those cases.

B. Descriptive Statistics

This section employs a number of tools to present summary statistics of the dataset. These tools include summary tables with variable means, medians and maximums, variable means t-tests between two segments, correlation matrices and graphs where visual illustration is helpful. The initial analysis will evaluate restricting census tract population. The second section will analyze basic environmental justice variable characteristics in both national and regional segments of both samples. The next analysis will evaluate different methods of mapping demographic characteristics to the physical area around a contaminated site. The final section will analyze the remediation efforts on NPL sites relative to environmental justice characteristics. Each section will present a combination of the aforementioned tools.

1. Census Tract Population Analysis

In order to perform the environmental justice analysis, the first step is to limit the data set to observations with legitimate census tract populations. Observations with a census tract population of zero or less than an acceptable threshold impair demographic variables that are calculated as percentage of population. When the 1980 census data was standardized to 2000 census tract boundaries, the 1980 census information remained incomplete due to limited reporting in non-urban areas. In an effort to maintain a maximum amount of observations, the samples were restricted to census tracts with a population of 50 or more.

The frequencies of census tract populations for the 2000 NPL Sample for both the 1980 and 2000 censuses are shown in Figures 3.1 and 3.2. The bar graphs are grouped into population intervals of 50 people. For the 2000 census, the distribution peaks between 3,250 and 3,750 people. This is consistent with the U.S. Census ideal tract population goal of 4,000. There are 362 observations with a census tract population of zero and 122 observations with a population between 1 and 49. The graph is censored at 11,000 with 547 observations above that and a maximum population of 36,146. For the 1980 census, the distribution peaks between 3,000 and 3,200. The highest frequency is expectedly less than year 2000, as the U.S. population grew from 226.5M to 281.4M over that time. A smaller population and limited non-urban reporting led to 13,605 observations with a census tract population of zero in 1980. There were also 73 observations with a population between 1 and 49. The 1980 census graph is censored at 8,000 with 573 observations above that and a maximum population of 40,845.

The results for the 1982 HRS Sample were similar and both samples are shown numerically in Table 3.2. The population restrictions result in reducing the 1980 census sample size for both samples by nearly 21%. The 2000 census sample size for both samples remains much more comprehensive, losing less than 1%.

Figure 3.1: 2000 NPL Sample Census Tract Populations in Population Clusters of 50 (2000 Census)

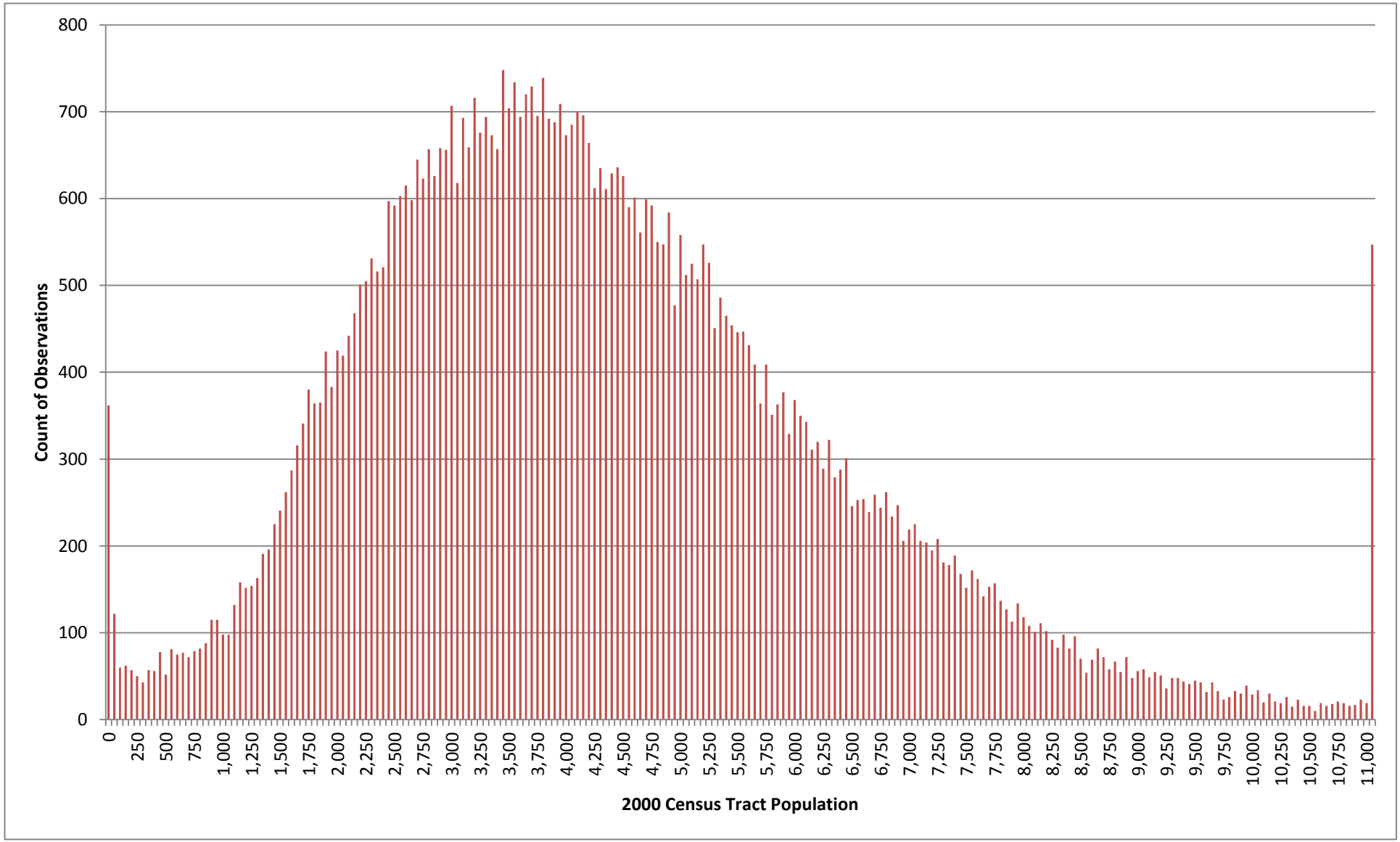


Figure 3.2: 2000 NPL Sample Census Tract Populations in Population Clusters of 50 (1980 Census)

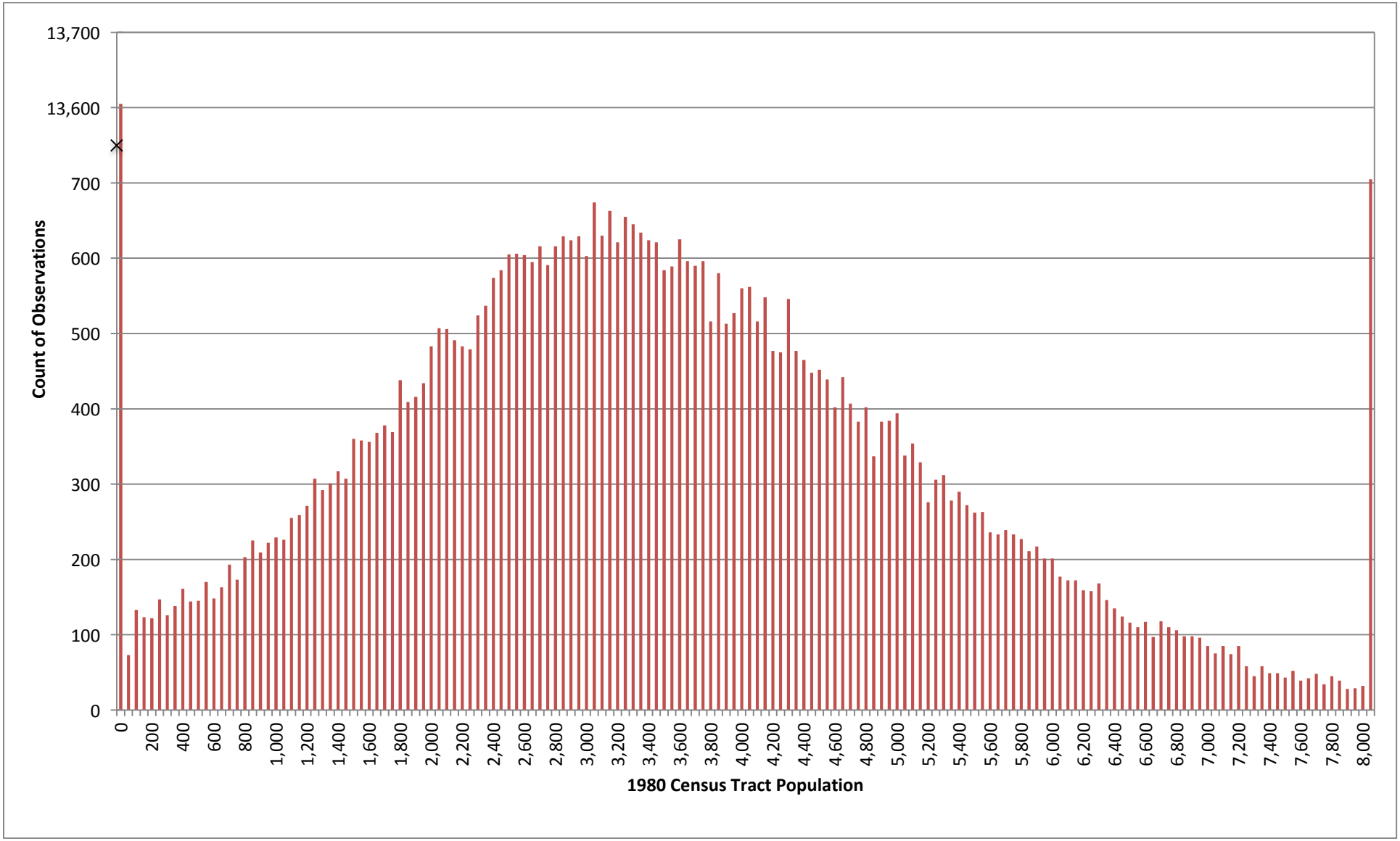


Table 3.2: Data Overview

	With Contaminated Site			Without Contaminated Site		
	Census Tract Pop. ≥ 50	**Census Tract Pop. < 50**	**% of Sample**	**Census Tract Pop. ≥ 50**	**Census Tract Pop. < 50**	**% of Sample**
2000 NPL Sample						
1980 Census	1,093	305	78.2%	50,795	13,370	79.2%
2000 Census	1,387	11	99.2%	63,692	473	99.3%
Total			1,398			64,165
1982 HRS Sample						
1980 Census	513	163	75.9%	51,309	13,502	79.2%
1982 HRS Score ≥ 28.5	322	79	80.3%	------	------	--
1982 HRS Score < 28.5	191	84	69.5%	------	------	--
2000 Census	670	6	99.1%	64,336	475	99.3%
1982 HRS Score ≥ 28.5	398	3	99.3%	------	------	--
1982 HRS Score < 28.5	272	3	98.9%	------	------	--
Total			676			64,811

2. Environmental Justice Sample Analysis

There are multiple levels of analysis to understanding the relationship between NPL sites and demographics and all of the available analysis tools are used in this section. The first level provides summary statistics for the demographics of each sample by each census year. The next part shows the correlation between the demographic variables. The correlation matrices help identify when environmental justice issues may be related to other correlated demographic variables like education or age. Then, graphs are used to illustrate the relationships between the Hazardous Ranking Score and environmental justice variables in the 1982 HRS Sample. Finally, t-tests are used to test the differences in variable means between census tracts with and without contaminated sites. The t-tests are performed at the national and regional level and also for the state of Arizona. All of these tools will have input into the regression analysis in the next chapter.

Tables 3.3 and 3.4 present summary statistics for each sample. The samples are divided by

census tracts with and without contaminated sites. The 1982 HRS Sample is further refined by the Hazardous Ranking Score with a line at 28.5, the preliminary cut-off made by the EPA. Demographic characteristics are given for both 1980 and 2000 censuses. The tables show that there is a high concentration of contaminated sites in the northeastern United States relative to the count of census tracts. The southern and western regions, by comparison, consistently have a low number of contaminated sites compared to the count of census tracts in the region. The environmental justice variables show a mixture of trends. The average household income is generally lower in contaminated sites across samples. Minorities, on the other hand, tend to have a lower propensity to live near contaminated sites. Within the 1982 HRS Sample, contaminated sites below the 28.5 cut-off have the highest percentage without a HS diploma and unemployment and lowest percent with a BA across all three categories in both censuses.

Table 3.3: "2000 NPL Sample" Mean Census Tract Characteristics

	1980 census		2000 census	
	NPL Site	**No NPL Site**	**NPL Site**	**No NPL Site**
# Census Tracts	1,093	50,795	1,387	63,692
Geographic Region				
% Northeast	35.2%	22.5%	31.1%	19.9%
% Midwest	22.4%	23.3%	25.4%	25.2%
% South	24.0%	31.4%	25.2%	33.7%
% West	18.4%	22.8%	18.3%	21.2%
Characteristics				
Average Household Income	19,491.02	20,676.36	54,530.79	55,200.39
% Black	0.092	0.120	0.104	0.144
% Hispanic	0.052	0.074	0.086	0.116
% Minority	0.144	0.194	0.190	0.260
Median Rent	228.84	213.23	616.84	629.22
Median Housing Price	58,137.12	68,906.33	125,469.36	135,470.74
% > 25 Without HS Diploma	0.331	0.317	0.195	0.208
% > 25 With BA or Better	0.141	0.175	0.206	0.232
Unemployment Rate	0.071	0.067	0.052	0.059
Poverty Rate	0.105	0.117	0.114	0.135
% Under 18	0.091	0.085	0.069	0.066
% Over 65	0.091	0.108	0.119	0.130

Table 3.4: "1982 HRS Sample" Mean Census Tract Characteristics

	1980 census			2000 census		
	HRS ≥ 28.5	**HRS < 28.5**	**No Site**	**HRS ≥ 28.5**	**HRS < 28.5**	**No Site**
# Census Tracts	322	191	51,309	398	272	64,336
Geographic Region						
% Northeast	45.3%	31.4%	22.5%	39.4%	25.7%	20.1%
% Midwest	23.9%	33.5%	23.3%	27.9%	35.7%	25.2%
% South	20.2%	24.1%	31.4%	21.1%	24.6%	33.5%
% West	10.6%	11.0%	22.8%	11.6%	14.0%	21.2%
Characteristics						
Avg. HH Income	20,213.06	18,810.50	20,662.28	56,287.40	49,671.86	55,181.86
% Black	0.072	0.116	0.120	0.085	0.122	0.143
% Hispanic	0.043	0.042	0.074	0.069	0.071	0.115
% Minority	0.115	0.158	0.194	0.154	0.193	0.259
Med. Rent	225.06	213.86	213.41	621.74	540.96	628.91
Med. Housing Price	52,136.80	44,886.39	68,892.62	123,854.27	108,491.54	135,244.42
% Without HS Dipl.	0.341	0.406	0.317	0.189	0.227	0.208
% BA or Better	0.139	0.101	0.174	0.212	0.166	0.232
Unemployment Rt.	0.071	0.086	0.067	0.058	0.066	0.059
Poverty Rate	0.101	0.117	0.117	0.107	0.131	0.135
% Under 18	0.086	0.086	0.085	0.066	0.067	0.066
% Over 65	0.097	0.104	0.108	0.124	0.127	0.130

Tables 3.5 and 3.6 display pair-wise correlation matrices between the demographic characteristics of the 2000 NPL Sample for census years 1980 and 2000, respectively. The matrices for the 1982 HRS Sample exhibited similar results. Minority was highly positively correlated with not having a high school diploma by age 25 (0.64) and poverty rate (0.6) in 2000. The two correlations have moved in opposite directions since 1980, however, as not having a high school diploma by age 25 increased (from 0.54) and poverty rate decreased (from 0.72). Minority was mildly negatively correlated with average household income (-0.33) and attaining a bachelor's degree or better by age 25 (-0.35) in 2000. This was a large departure for household income (from -0.06) from 1980. Minority populations were also mildly positively correlated with percentage of kids (0.37 in 2000 and 0.41 in 1980). Average household income was highly correlated with education level, positively correlated with bachelor's degree or better by age 25 (0.74) and negatively correlated with not having a high school diploma by age 25 (-0.57) in 2000. In general, the correlations between the variables match the expected signs.

Table 3.5: 2000 NPL Sample Correlation Matrix Significant at the 5% Level (2000 Census)

	Avg. HH Income	% Black	% Hispanic	% Minority	Med. Rent	Med. Housing Price	% Without HS Dipl.	% BA or Better	Unemployment Rt.	Poverty Rate	% Under 18	% Over 65
Avg. HH Income	1											
% Black	-0.27	1										
% Hispanic	-0.15	-0.06	1									
% Minority	-0.31	0.76	0.6	1								
Med. Rent	0.69	-0.17	0.02	-0.12	1							
Med. Housing Price	0.74	-0.2	-0.02	-0.17	0.65	1						
% Without HS Dipl.	-0.57	0.35	0.57	0.64	-0.44	-0.39	1					
% BA or Better	0.74	-0.25	-0.22	-0.35	0.59	0.64	-0.7	1				
Unemployment Rt.	-0.04	0.07	0.05	0.09	-0.01	-0.02	0.08	-0.05	1			
Poverty Rate	-0.56	0.49	0.31	0.6	-0.43	-0.33	0.7	-0.42	0.39	1		
% Under 18	-0.1	0.19	0.33	0.37	-0.02	-0.12	0.35	-0.28	0.11	0.25	1	
% Over 65	*	-0.11	-0.22	-0.23	-0.06	*	-0.08	-0.01	*	-0.13	-0.4	1

Table 3.6: 2000 NPL Sample Correlation Matrix Significant at the 5% Level (1980 Census)

	Avg. HH Income	% Black	% Hispanic	% Minority	Med. Rent	Med. Housing Price	% Without HS Dipl.	% BA or Better	Unemployment Rt.	Poverty Rate	% Under 18	% Over 65
Avg. HH Income	1											
% Black	-0.08	1										
% Hispanic	*	0.01	1									
% Minority	-0.06	0.85	0.53	1								
Med. Rent	0.54	0.12	0.07	0.14	1							
Med. Housing Price	0.02	-0.03	*	-0.02	0.05	1						
% Without HS Dipl.	-0.58	0.41	0.35	0.54	-0.19	-0.06	1					
% BA or Better	0.59	-0.26	-0.2	-0.33	0.22	0.06	-0.77	1				
Unemployment Rt.	0.08	0.5	0.25	0.55	0.31	-0.02	0.54	-0.46	1			
Poverty Rate	-0.1	0.61	0.38	0.72	0.18	-0.03	0.65	-0.37	0.69	1		
% Under 18	0.36	0.27	0.34	0.41	0.39	*	0.23	-0.34	0.57	0.47	1	
% Over 65	0.23	0.1	0.06	0.11	0.4	0.01	0.23	-0.11	0.34	0.31	0.18	1

Figures 3.3 and 3.4 further explore the environmental justice variables in the 1982 HRS Sample. The Hazardous Ranking Score scale is 0-80, and the cutoff for the initial NPL was 28.5. Therefore, the scores have been grouped into intervals of 4, starting at 0.5. Figure 3 displays the average minority percentage by count of contaminated sites within each HRS interval for the 1980 census. The graph shows that the average census tract minority percentage generally decreases as HRS increases. Figure 3.4 displays the average monthly income by count of contaminated sites within each HRS interval for the 1980 census. The line graph is generally flat with a slight upward slope, showing that there is little difference between average census tract household incomes relative to 1982 HRS. Both of these trends support the results in Table 3.6.

Figure 3.3: Percent Minority by 1982 Hazardous Ranking Score for 1980 Census

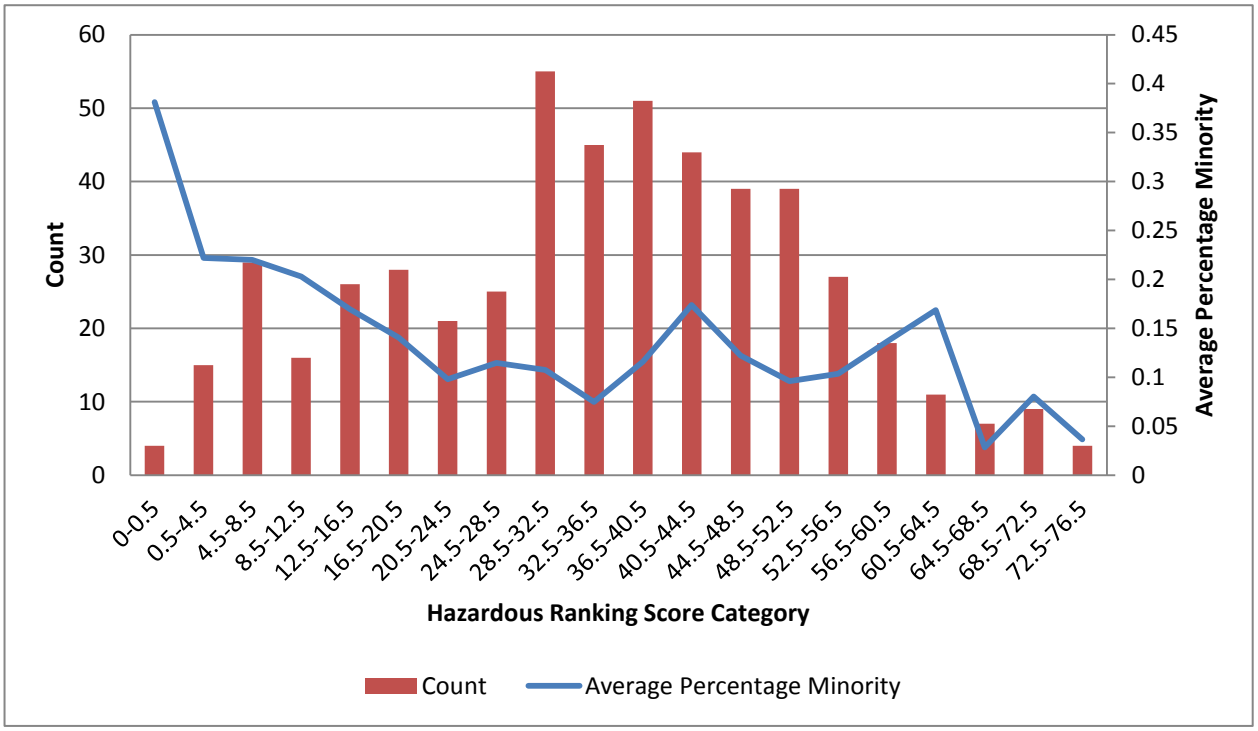
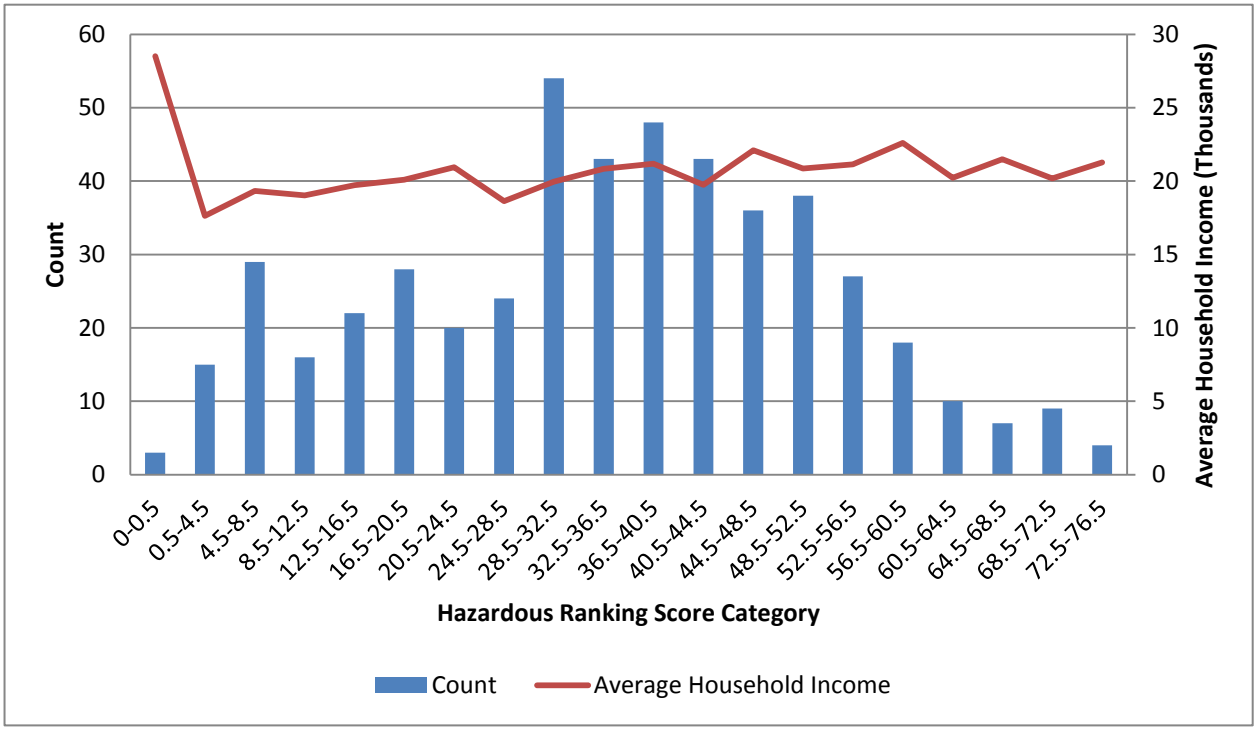


Figure 3.4: Average Household Income by 1982 Hazardous Ranking Score for 1980 Census



The next type of analysis consists of testing the general hypothesis that the means of demographic characteristics of census tracts with contaminated sites and demographic characteristics of census tracts without contamination are equal.

$$Hypothesis\ \ H_0: \mu_{contaminated} = \mu_{uncontaminated}$$

The analysis was conducted on both the 2000 NPL Sample using 1980 and 2000 census data. The analysis is conducted at the national level, at the regional level and specific to Arizona. Tables 3.7 and 3.8 show the results of the tests at the national level for each census year. The results illustrate that average household income is significant and lower in NPL tracts for 1980 but not significant in 2000. Minority values, including percent black, percent Hispanic and percent minority, are significant and lower in NPL tracts for both the 1980 and 2000 census suggesting that there are not environmental justice issues at the national level. The t-tests for each region and the state of Arizona are shown in the Appendix, but Tables 3.9 and 3.10 summarize the signs of significant variables for each segment for both census years.

Table 3.7: National Variable t-Tests for 2000 NPL Sample (1980 Census)[109]

Variable	NPL mean	Non NPL mean	Difference	t Stat.
Avg. HH Income	19,550.64	20,674.54	-1,123.90	-4.877***
% Black	0.093	0.120	-0.027	-4.693***
% Hispanic	0.052	0.074	-0.022	-6.419***
% Minority	0.144	0.194	-0.050	-7.325***
Med. Rent	228.30	213.01	15.30	4.662***
Med. Housing Price	58,097.65	68,919.40	-10,821.75	-3.385***
% Without HS Dipl.	0.331	0.317	0.014	2.922***
% BA or Better	0.142	0.175	-0.032	-10.58***
Unemployment Rt.	0.071	0.067	0.005	3.427***
Poverty Rate	0.105	0.117	-0.012	-4.226***
% Under 18	0.091	0.085	0.006	6.711***
% Over 65	0.092	0.108	-0.016	-9.425***

Table 3.8: National Variable t-Tests for 2000 NPL Sample (2000 Census)

Variable	NPL mean	Non NPL mean	Difference	t Stat.
Avg. HH Income	54,541.91	55,187.22	-645.31	-1.093
% Black	0.104	0.144	-0.040	-8.116***
% Hispanic	0.086	0.116	-0.030	-7.413***
% Minority	0.190	0.260	-0.070	-10.86***
Med. Rent	615.80	628.55	-12.75	-1.862*
Med. Housing Price	124,973.80	135,321.91	-10,348.11	-4.468***
% Without HS Dipl.	0.195	0.208	-0.013	-3.846***
% BA or Better	0.205	0.232	-0.028	-7.479***
Unemployment Rt.	0.052	0.059	-0.007	-0.934
Poverty Rate	0.113	0.135	-0.022	-8.267***
% Under 18	0.069	0.066	0.003	4.312***
% Over 65	0.119	0.130	-0.012	-7.144***

[109] *** significant at 1% level, ** significant at 5% level, * significant at 10% level

The summary tables display the sign of each variable significant at the 10% level for each segment. The results show that average household income was significant and lower in 5 of the 6 segments tested in 1980 and 3 out of 6 segments in 2000. Minority populations are generally a lower percent in NPL tracts except in one region. The results of the Southern region show the percent black was higher in NPL tracts for both the 1980 and 2000 census. It's interesting to note that the Southern region also had a significant and lower average household income in NPL tracts for both census years. This suggests that there may be both types of environmental justice issues in the South. Another interesting trend is the age makeup of tracts with and without contaminated sites. When significant, the percentage of kids is higher in NPL tracts and the percent old is lower in NPL tracts. The results are consistent across both census years. As for education, the percent without a high school diploma is mixed across segments for both census years, but the percent with a bachelor's degree is consistently lower when significant across segments in both census years. The other variables display mixed results.

Table 3.9: Variable t-Test Summary Analysis by Region for 2000 NPL Sample (1980 Census)

	Sample					
Variable	**Nat.**	**AZ**	**MW**	**NE**	**W**	**S**
Avg. HH Income	**-**	**-**	**-**	**+**	**-**	**-**
% Black	**-**		**-**	**-**		**+**
% Hispanic	**-**		**-**	**-**		**-**
% Minority	**-**		**-**	**-**		**+**
Med. Rent	**+**		**-**		**+**	**+**
Med. Housing Price	**-**	**-**	**-**	**+**		
% Without HS Dipl.	**+**			**-**	**+**	**+**
% BA or Better	**-**	**-**	**-**		**-**	**-**
Unemployment Rt.	**+**			**-**	**+**	**+**
Poverty Rate	**-**		**-**	**-**	**+**	**+**
% Under 18	**+**		**+**	**+**	**+**	**+**
% Over 65	**-**	**-**	**-**	**-**	**-**	**-**

Table 3.10: Variable t-Test Summary Analysis by Region for 2000 NPL Sample (2000 Census)

	Sample					
Variable	**Nat.**	**AZ**	**MW**	**NE**	**W**	**S**
Avg. HH Income		**-**		**+**	**-**	**-**
% Black	**-**		**-**	**-**		**+**
% Hispanic	**-**		**-**	**-**		**-**
% Minority	**-**		**-**	**-**		
Med. Rent	**-**	**-**			**-**	**-**
Med. Housing Price	**-**			**-**	**-**	**-**
% Without HS Dipl.	**-**		**-**	**-**		**+**
% BA or Better	**-**	**-**	**-**		**-**	**-**
Unemployment Rt.			**-**		**+**	**+**
Poverty Rate	**-**		**-**	**-**	**+**	
% Under 18	**+**				**+**	**+**
% Over 65	**-**		**-**	**-**	**-**	**-**

3. Geographic Characteristic Mapping

The third analysis explores a different method of mapping the demographic characteristics around the physical location of a contaminated site. While analyzing census tract level information for the entire country provides an in-depth study[110] there are limitations. Averaging the land size of the continental United States across the number of census tracts gives an average tract size of 45 square miles. As census tracts are drawn based on population, we know that tracts are concentrated and thereby much smaller in cities. This calls into question both the relative size of the census tract with a contamination site and the location of the contamination site within census tract. Contamination sites in small area census tracts or on edge of a census tract may influence characteristics of neighboring census tracts as well than the census tract in which they are contained.

In an effect to control for some of the limitations of the census tract analysis, the data for contaminated sites was rearranged into geographic areas bound by a radius from the contamination.

[110] A study only partially possible on the original 1980 census since the entire country was not covered by census tracts until 2000.

The data was arranged into 2- and 3-mile radius areas from the specific latitude and longitude of the site.[111] For the 2 mile radius, the maximum number of neighboring tracts is 80, with a median of 5.[112] This suggests that the effect on demographics of areas around a contaminated site in smaller, denser areas may extend beyond the single census tract containing the site. While the radius method better incorporates the neighboring tracts there are still limitations. Unable to obtain demographic characteristics at the household level, the radius method simply weights the data for the different census tracts within range of the contaminated site. The new variables are constructed by summing the weighted data for neighboring tracts with the weight being the product of each tract's 1980 population and the portion of the total area within the radius of the site that each tract makes up.

Table 3.11 explores the different methods of mapping the demographic characteristics around the physical location of a contaminated site. The 1982 HRS Sample contains variables for contaminated sites using the 2- and 3-mile radii method in addition to census tract data for the 1980 census. The summary statistics are grouped by each geographic mapping method for contaminated that were above and below the 1982 HRS threshold of 28.5. Average household income was lowest using the census tract method and highest in the 3-mile radius method. This finding suggests that the results from the t-Tests for the 2000 NPL Sample where average household income was consistently lower in NPL tracts may need to be revisited. The percent black is also lowest using the census tract method and highest in the 3-mile radius method. This finding also suggests that the results from the t-Tests in the analysis should be re-examined for potential environmental justice issues in minority populations. The education variables also suggest inconsistencies between methods as percent without a high school diploma is highest using the census tract method and percent with a bachelor's degree is lowest using the census tract method.

[111] As the original authors of the data were interested in housing prices, the 2- and 3-mile radius data was only constructed for census tracts with non-missing housing prices. After restricting the 1980 data to census tract with populations of 50 or more there are another 24 tracts with missing housing data where information is not given at the 2- and 3-mile radius level. This applies to 16 with an HRS above 28.5 and 8 with an HRS below 28.5.

[112] (Greenstone, 2008)

These findings are further explored using t-Tests on the 1982 HRS Sample for the 1980 census.

Table 3.11: "1982 HRS Sample" Mean Census Tract Characteristics by Geographic Locator (1980 Census)

	Census Tract		2 Mile Radius		3 Mile Radius	
	HRS ≥ 28.5	**HRS < 28.5**	**HRS ≥ 28.5**	**HRS < 28.5**	**HRS ≥ 28.5**	**HRS < 28.5**
# Census Tracts	322	191	306	183	306	183
Average Household Income	20,213.06	18,810.50	20,741.76	19,534.03	20,914.42	19,606.15
% Black	7.17%	11.59%	7.45%	11.55%	7.70%	12.09%
% Hispanic	4.33%	4.25%	4.27%	4.52%	4.18%	4.27%
% Minority	11.51%	15.84%	11.72%	16.06%	11.88%	16.36%
Mean Rent	225.06	213.86	225.09	221.40	227.11	223.86
Mean Housing Price	52,136.80	44,886.39	52,136.80	44,966.37	52,136.80	44,966.37
% > 25 Without HS Diploma	34.12%	40.60%	33.41%	38.24%	32.98%	37.27%
% > 25 With BA or Better	13.86%	10.14%	14.32%	12.02%	14.90%	12.67%
Unemployment Rate	7.12%	8.61%	7.11%	8.22%	7.05%	8.14%
Poverty Rate	10.08%	11.66%	10.04%	12.04%	10.06%	12.05%
% Under 18	8.64%	8.65%	8.51%	8.82%	8.50%	8.78%
% Over 65	9.67%	10.41%	10.46%	10.84%	10.67%	10.93%

Tables 3.12 through 3.14 present t-Tests for the 1982 HRS Sample using the census tract, 2-mile radius and 3-mile radius methods. The tables compare contaminated sites that were tested in 1982 against census tracts without contaminated sites tested in 1982. As demonstrated in Table 3.11, average household income is higher near contaminated sites using the 2- and 3-mile radius methods. This shows in the t-Tests as the income mean differences using those methods are not significant, while it is significant and less using the census tract method. Minority variable means are generally higher using the 2- and 3-mile radius methods but still less than non-contaminated tracts. The difference in educational variables is less pronounced using the 2- and 3-mile radius methods. The differences in percent without a high school diploma and percent with a bachelor's degree are both still highly significant.

Table 3.12: National Contamination t-Tests for 1982 HRS Sample for Tract Method (1980 Census)[113]

Variable	Con. mean	Non Con. mean	Difference	t Stat.
Avg. HH Income	19,690.86	20,662.28	-971.42	-3.318***
% Black	0.088	0.120	-0.031	-3.580***
% Hispanic	0.043	0.074	-0.031	-6.717***
% Minority	0.131	0.194	-0.063	-6.255***
Med. Rent	220.89	213.41	7.49	1.625
Med. Housing Price	49,432.75	68,892.62	-19,459.87	-9.217***
% Without HS Dipl.	0.365	0.317	0.049	7.568***
% BA or Better	0.125	0.174	-0.050	-12.23***
Unemployment Rt.	0.077	0.067	0.010	5.052***
Poverty Rate	0.107	0.117	-0.010	-2.648***
% Under 18	0.086	0.085	0.001	1.305
% Over 65	0.099	0.108	-0.009	-3.792***

Table 3.13: National Contamination t-Tests for 1982 HRS Sample for 2-Mi Rad. Method (1980 Census)

Variable	Con. mean	Non Con. mean	Difference	t Stat.
Avg. HH Income	20,289.79	20,662.24	-372.45	-1.631
% Black	0.090	0.120	-0.030	-4.348***
% Hispanic	0.044	0.074	-0.030	-6.669***
% Minority	0.133	0.194	-0.060	-7.043***
Med. Rent	223.71	213.41	10.30	3.468***
Med. Housing Price	49,499.74	68,891.00	-19,391.26	-9.171***
% Without HS Dipl.	0.352	0.317	0.035	6.388***
% BA or Better	0.135	0.174	-0.040	-11.17***
Unemployment Rt.	0.075	0.067	0.009	5.725***
Poverty Rate	0.108	0.117	-0.009	-2.741***
% Under 18	0.086	0.085	0.001	1.610
% Over 65	0.106	0.108	-0.002	-1.014

[113] *** significant at 1% level, ** significant at 5% level, * significant at 10% level

Table 3.14: National Contamination t-Tests for 1982 HRS Sample by 3-Mi Rad. Method (1980 Census)

Variable	Con. mean	Non Con. mean	Difference	t Stat.
Avg. HH Income	20,424.82	20,662.24	-237.42	-1.089
% Black	0.093	0.120	-0.026	-3.966***
% Hispanic	0.042	0.074	-0.032	-7.653***
% Minority	0.136	0.194	-0.058	-7.086***
Med. Rent	225.89	213.41	12.47	4.670***
Med. Housing Price	49,499.74	68,891.00	-19,391.26	-9.171***
% Without HS Dipl.	0.346	0.317	0.029	5.580***
% BA or Better	0.141	0.174	-0.034	-9.523***
Unemployment Rt.	0.075	0.067	0.008	5.731***
Poverty Rate	0.108	0.117	-0.009	-2.850***
% Under 18	0.086	0.085	0.001	1.455
% Over 65	0.108	0.108	-0.001	-0.246

The t-Tests were repeated in Tables 3.15 through 3.17 limited to contaminated site with a HRS of 28.5 or higher for inclusion on the first NPL. The results shifted even further away from environmental justice issues, as average household income was no longer significant using any of the methods. The average income was actually higher near NPL sites than non-NPL census tracts using the 2- and 3-mile radius methods. Differences in minority variables were still highly significant and lower near NPL sites. The significance of the percent without a high school diploma also dropped to the 5% level for the 2- and 3-mile radius methods. The initial conclusions from the geographic mapping exercise suggest that the manner of quantifying the effect of a contaminated site on neighboring household demographics may impact the results of an environmental justice analysis. These findings will be further explored in the regression analysis.

Table 3.15: National NPL t-Tests for the 1982 HRS Sample by Tract Method (1980 Census)[114]

Variable	NPL mean	Non NPL mean	Difference	t Stat.
Avg. HH Income	20,130.08	20,656.23	-526.15	-1.473
% Black	0.072	0.120	-0.048	-5.226***
% Hispanic	0.043	0.074	-0.031	-5.351***
% Minority	0.115	0.194	-0.078	-7.146***
Med. Rent	224.51	213.41	11.11	1.995**
Med. Housing Price	51,625.06	68,814.60	-17,189.54	-7.784***
% Without HS Dipl.	0.341	0.317	0.024	3.347***
% BA or Better	0.136	0.174	-0.038	-7.340***
Unemployment Rt.	0.072	0.067	0.005	2.295**
Poverty Rate	0.101	0.117	-0.016	-3.952***
% Under 18	0.086	0.085	0.001	0.889
% Over 65	0.097	0.108	-0.012	-4.806***

Table 3.16: National NPL t-Tests for the 1982 HRS Sample by 2-Mi Rad. Method (1980 Census)

Variable	NPL mean	Non NPL mean	Difference	t Stat.
Avg. HH Income	20,769.03	20,658.02	111.01	0.394
% Black	0.075	0.120	-0.044	-5.859***
% Hispanic	0.042	0.074	-0.032	-5.765***
% Minority	0.118	0.194	-0.076	-7.767***
Med. Rent	225.26	213.43	11.83	3.112***
Med. Housing Price	51,625.06	68,815.26	-17,190.20	-7.785***
% Without HS Dipl.	0.332	0.317	0.015	2.510**
% BA or Better	0.143	0.174	-0.031	-7.047***
Unemployment Rt.	0.071	0.067	0.005	2.677***
Poverty Rate	0.100	0.117	-0.017	-4.939***
% Under 18	0.085	0.085	0.000	-0.055
% Over 65	0.104	0.108	-0.004	-1.623

[114] *** significant at 1% level, ** significant at 5% level, * significant at 10% level

Table 3.17: National NPL t-Tests for the 1982 HRS Sample by 3-Mi Rad. Method (1980 Census)

Variable	NPL mean	Non NPL mean	Difference	t Stat.
Avg. HH Income	20,883.99	20,658.56	225.43	0.826
% Black	0.078	0.120	-0.042	-5.781***
% Hispanic	0.042	0.074	-0.032	-6.282***
% Minority	0.119	0.194	-0.074	-7.932***
Med. Rent	227.08	213.44	13.64	3.941***
Med. Housing Price	51,625.06	68,815.26	-17,190.20	-7.785***
% Without HS Dipl.	0.329	0.317	0.012	2.064**
% BA or Better	0.149	0.174	-0.026	-5.779***
Unemployment Rt.	0.071	0.067	0.004	2.665***
Poverty Rate	0.100	0.117	-0.017	-4.980***
% Under 18	0.085	0.085	0.000	-0.081
% Over 65	0.107	0.108	-0.001	-0.607

4. Remediation Characteristics

The final level of descriptive analysis investigates the speed of and funds allotted to the remediation of NPL sites relative to their demographic characteristics. This analysis is performed only on the portion of each sample that was included on the NPL. The samples are further reduced specific to each analysis to sites that have reached certain stages of remediation or that have non-missing estimated and actual remediation costs. The potential environmental justice issues are whether NPL sites in low income or higher minority tracts face a slower remediation process or are granted less funds for remediation.

Table 3.18 presents the remediation statistics of NPL sites for both samples restricted by 1980 and 2000 census population counts. The first section of the table reports the timing of the placement on the NPL in intervals of five years. Expectedly, the sites in the 2000 NPL Sample were spread out over a longer time period than the 1982 HRS Sample. The second section gives details of the size of the sites.

The discrepancy between mean and median demonstrates that there are a handful of large sites. This suggests that, in general, the effects of the contaminated area may be contained within a small physical area. The third and fourth sections deal with the milestones in the remediation process. The third section provides the count of NPL sites that have reached each milestone in the process. The fourth section presents the median years passed from listing to each milestone. The numbers show that it takes approximately 5 years for an ROD to be issued, 7 years until cleanup is initiated and a total of 12 years until construction is complete and the site is deleted from the NPL. The fifth and sixth sections convey the estimated and actual costs of remediation. The estimated costs were obtained from the RODs (standardized to 2000 $s). Within the sample of sites with completed construction, the actual costs are 54-56% higher than the estimated costs.

Tables 3.19 and 3.20 explore the correlation between remediation efforts and environmental justice variables. The majority of the variable correlations are not significant at the 10% level. Percent Hispanic is slightly negatively correlated with the ROD and construction complete milestones in the 1980 census data. This suggests that larger Hispanic communities wait a lower amount of time to reach those two milestones in the remediation process. The same was true for the minority variable in the 2000 census for construction complete. The average household income variable, however, was negatively and significantly correlated with years until deletion from the NPL in both the 1980 and 2000 census data. This means that lower income communities must wait longer for NPL sites to reach the deletion stage of the remediation process. Deletion from the list implies that the site can be used for other purposes. This result may suggest that while clean up construction may move at the same pace as higher income communities, the sites are slower to be reintegrated into the community with a new functional use.

Table 3.18: NPL Site Remediation Characteristics

	2000 NPL Sample		1982 HRS Sample	
	1980 Census	**2000 Census**	**1980 Census**	**2000 Census**
Timing of Placement on NPL				
Total	1,023	1,387	351	440
# 1981-1985	429	524	330	406
# 1986-1989	383	485	15	23
# 1990-1994	200	269	4	7
# 1995-1999	81	108	2	4
Size of Site (in acres)				
Number of sites with size data	1,022	1,280	333	412
Mean (Median)	2,979.5 (33)	3,466.5 (33.5)	379.2 (25)	2,667.1 (26)
95th Percentile	6,491	7,112	1,027	1,700
2000 Status Among NPL Sites				
NPL	1,093	1,387	351	440
ROD Issued	941	1,202	336	422
Clean-Up Initiated	846	1,082	320	403
Construction Complete	515	668	212	272
Deleted from NPL	194	194	194	194
Median Years from NPL Listing Until:				
ROD Issued	------	------	4.79	4.82
Clean-Up Initiated	------	------	6.90	6.80
Construction Complete	------	------	11.90	11.78
Deleted from NPL	------	------	11.78	11.81
Expected Costs of Remediation (in year 2000 Million $)				
# Sites with Nonmissing Costs	998	1,275	347	435
Mean (Median)	27.8 (8.2)	22.5 (7.6)	25.2 (11.1)	24.8 (10.4)
95th Percentile	84.9	81.7	94.4	94.4
Actual and Expected Costs Conditional on Construction Complete (in year 2000 Million $)				
# Sites with Both Costs Nonmissing	319	409	150	186
Mean (Median) Expected Costs	17.0 (7.8)	16.0 (7.5)	22.4 (10.5)	20.9 (9.6)
Mean (Median) Actual Costs	26.6 (14.4)	24.8 (13.3)	34.9 (20.3)	32.4 (16.8)

Table 3.19: 1980 HRS Sample Correlation Matrix for Census 1980[115]

	Estimated Cost	Actual Cost	Years NPL to ROD	Years NPL to 1st ACT	Years NPL to CC	Years NPL to DEL
Avg. HH Income	*	*	*	*	*	-0.28
% Black	*	*	*	*	*	*
% Hispanic	*	*	-0.09	*	-0.10	*
% Minority	*	*	*	*	*	*

Table 3.20: 1982 HRS Sample Correlation Matrix for Census 2000

	Estimated Cost	Actual Cost	Years NPL to ROD	Years NPL to 1st ACT	Years NPL to CC	Years NPL to DEL
Avg. HH Income	*	*	*	*	*	-0.19
% Black	*	*	*	*	*	*
% Hispanic	*	*	*	*	*	*
% Minority	*	*	*	*	-0.10	*

Figures 3.5 and 3.6 further explore the remediation costs of NPL sites with a focus on environmental justice variables. The total count of sites in the 2000 NPL Sample that reached construction complete status by 2000 with non-missing estimated and actual remediation costs was 409 sites. The sites were sorted by actual remediation costs and then grouped into twenty intervals of about twenty sites each. Figure 3.5 shows the average minority percentage and average estimated remediation costs by average actual remediation costs. Generally, estimated costs were greater than actual costs when average actual costs were less than $11 million. The trend reversed when actual costs were above $11 million, as actual costs were often multiple times larger than estimated costs. The graph shows that average percentage minority fluctuates between 10% and 25% with no distinct relationship with remediation costs. Figure 4 shows the average household income and average estimated remediation costs by average actual remediation costs. The graph shows that average household income vacillates between 50 and 60 thousand dollars and does not appear to remediation costs.

[115] * not significant at 10% or better

Figure 3.5: Percentage Minority by Actual and Expected Remediation Costs for 2000 All NPL Sample (2000 Census)

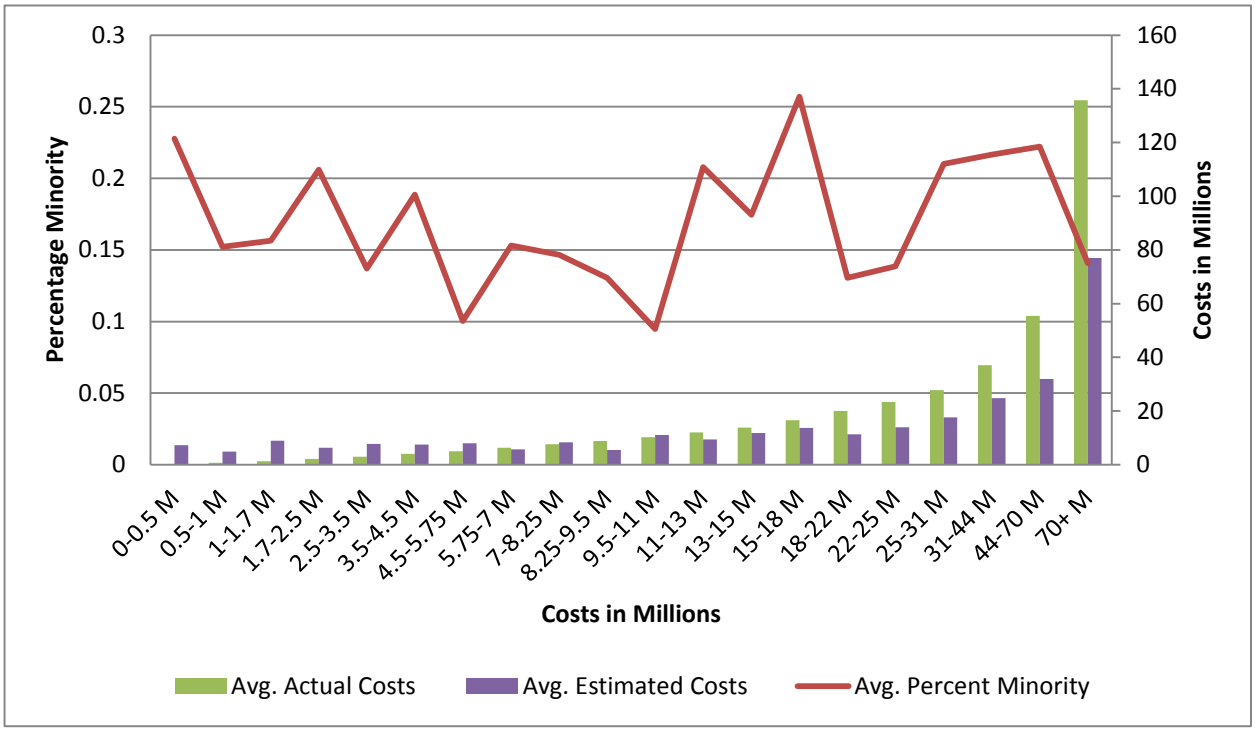
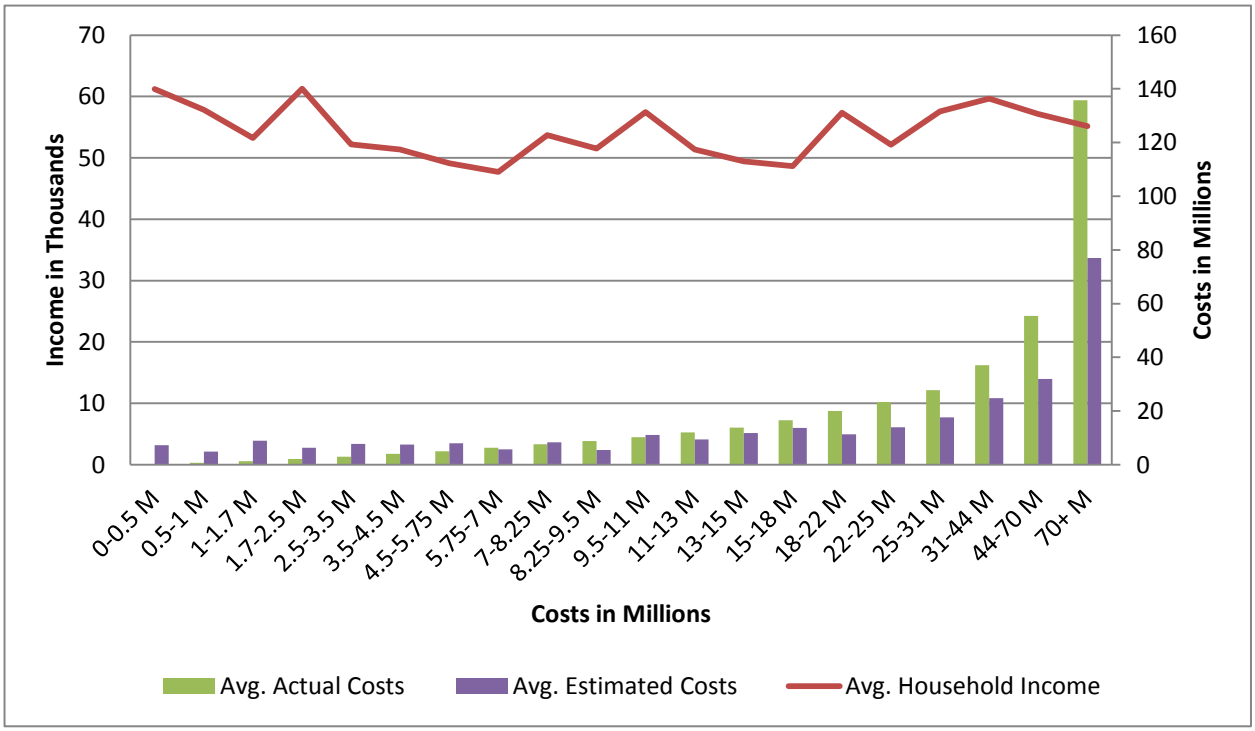


Figure 3.6: Average Household Income by Actual and Estimated Costs of Remediation for 2000 All NPL Sample (2000 Census)



Figures 3.7 through 3.14 explore the relationships between the length of time to reach each remediation milestone and the environmental justice variables. The years to each milestone were grouped into ten intervals based on the data. The bar charts represent the count of sites that fell into each interval and the line graphs show the average minority and household income statistics for those sites. The analysis was performed on the 1982 HRS Sample and the focus is on the 1980 census.

There are some concerns about the accuracy of the lengths of time to each milestone. Beginning with the ROD, there are 15 sites with a negative value for years until the ROD is issued, with a minimum of -4.92. This means that the ROD was issued almost 5 years before site was listed on the NPL. Since this analysis is looking at the 1982 HRS Sample this is not unexpected. Hazardous waste sites were in existence long before CERCLA, and there were efforts to identify and clean them up before the NPL. This finding, however, creates an uneven field for comparison. With some sites issued RODs before the NPL, they would likely have an advantage at every milestone during the remediation process. Another 14 sites have negative values for construction initiation, meaning that cleanup began before they were placed on the NPL. Even more concerning is that these are not the same set of sites with negative ROD values. Simply targeting negative values for deletion would not level the field as there is no indicator of when the remediation process may have started relative to placement on the NPL. Small positive values may indicate that remediation was in progress before the NPL and the milestone was reached soon after placement. The analysis will be performed understanding these limitations.

The trends in the graphs generally suggest a random relationship between length of time to each milestone and environmental justice variables. Figure 8 shows a slight downward slope to the average household income line as length of time to the issue of an ROD increases. Figure 14 shows a downward slope to the average household income line as length of time to deletion increases. This is consistent with the results in the correlation matrix above.

Figure 3.7: Percent Minority by Average Years from NPL to ROD for 1982 HRS Sample (1980 Census)

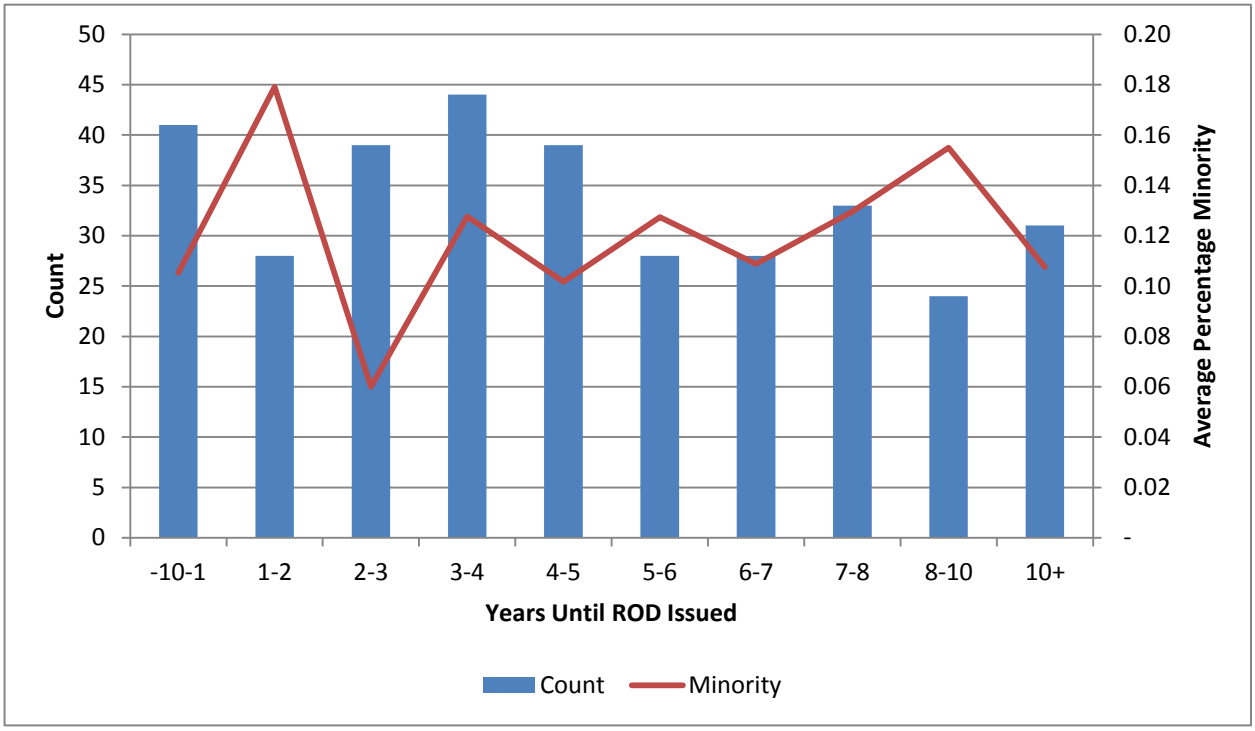


Figure 3.8: Average Household Income by Average Years from NPL to ROD for 1982 HRS Sample (1980 Census)

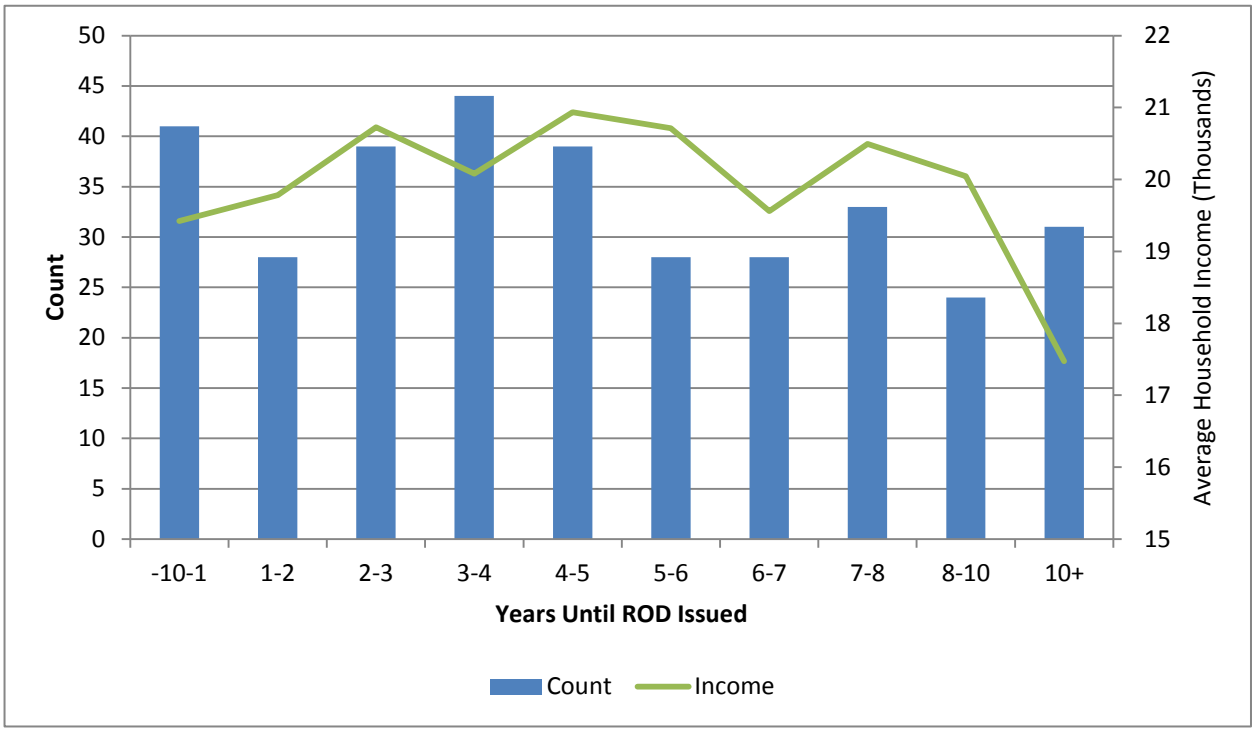


Figure 3.9: Percent Minority by Average Years from NPL to Construction Initiation for 1982 HRS Sample (1980 Census)

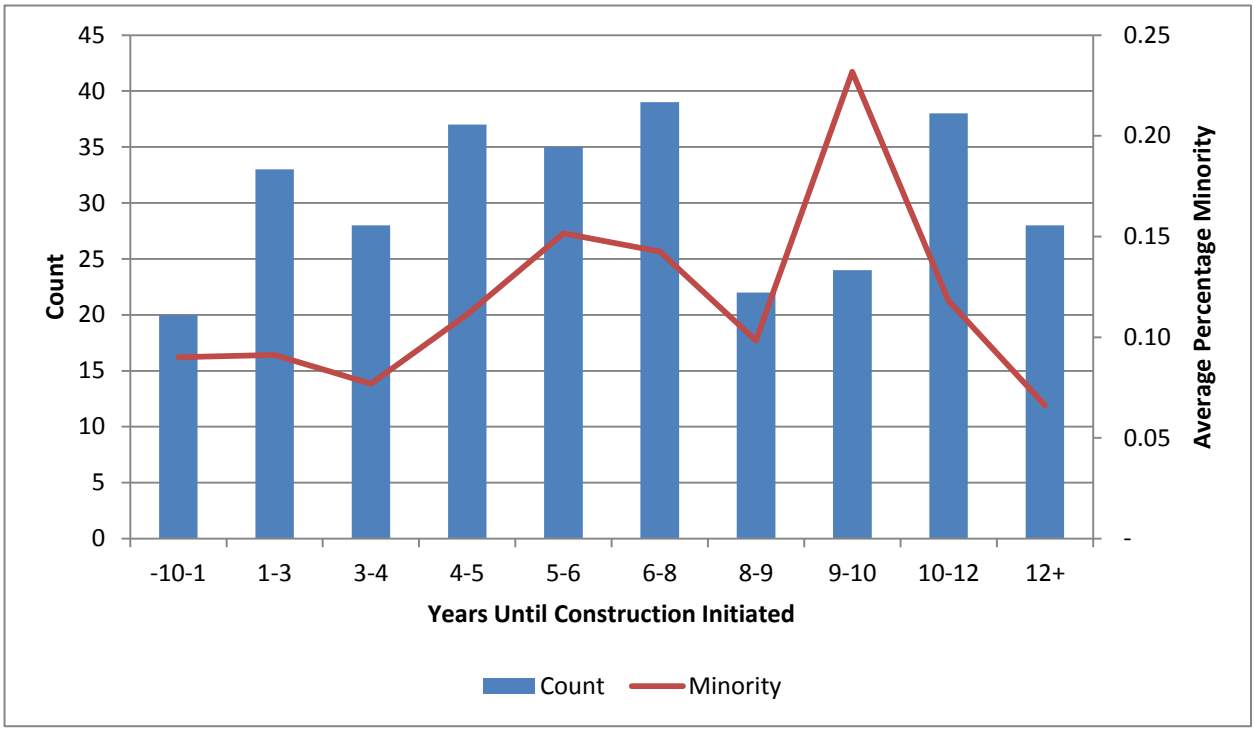


Figure 3.10: Average Household Income by Average Years from NPL to Construction Initiation for 1982 HRS Sample (1980 Census)

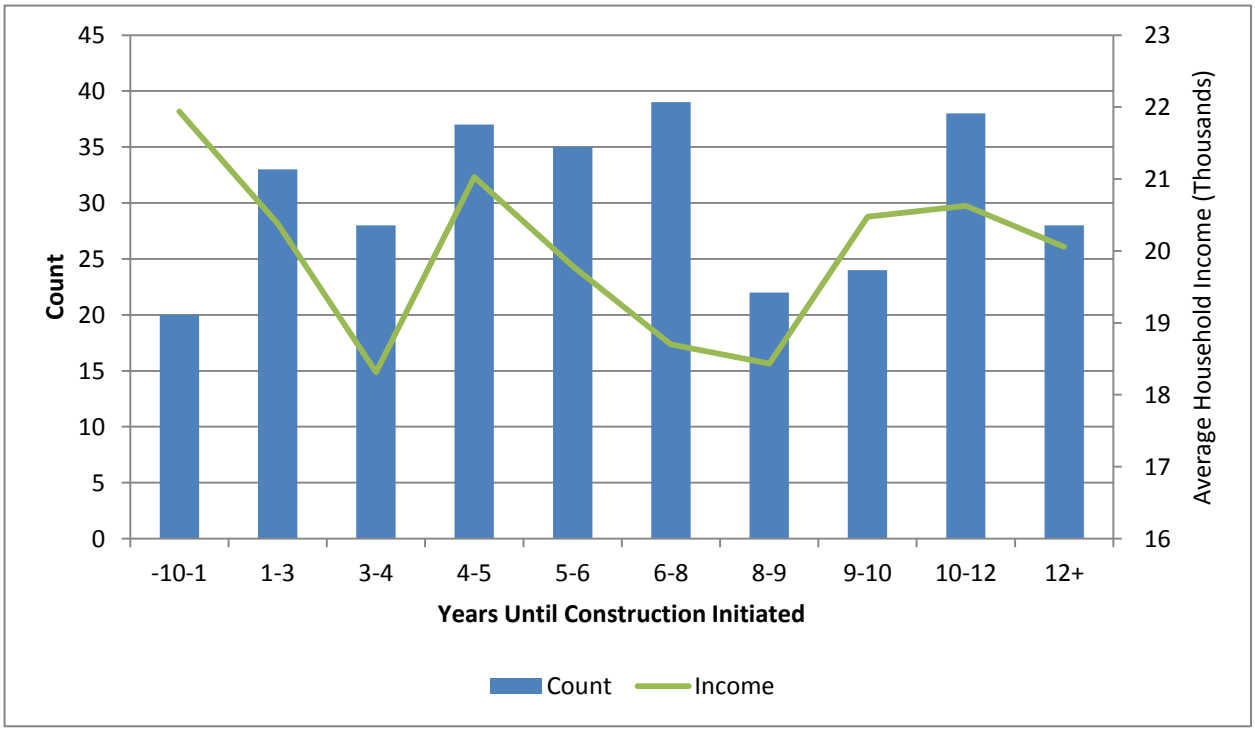


Figure 3.11: Percent Minority by Average Years from NPL to Construction Completion for 1982 HRS Sample (1980 Census)

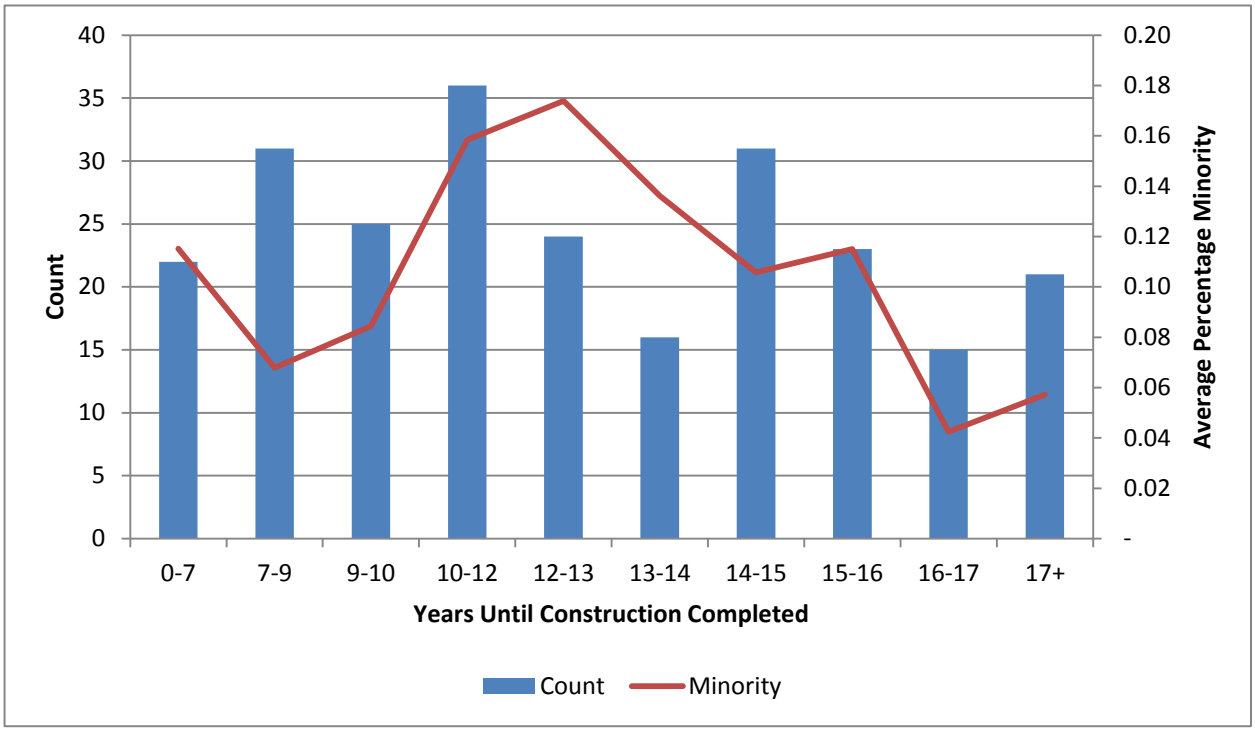


Figure 3.12: Average Household Income by Average Years from NPL to Construction Completion for 1982 HRS Sample (1980 Census)

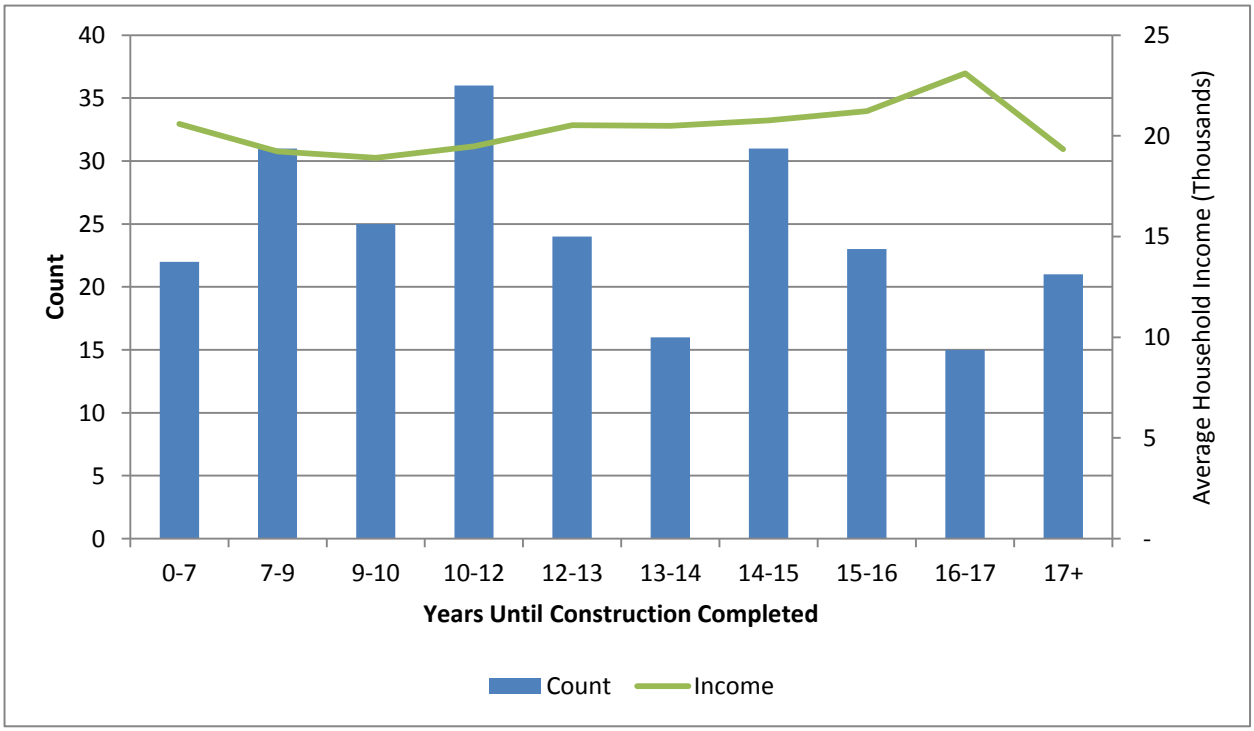


Figure 3.13: Percent Minority by Average Years from NPL to Deletion for 1982 HRS Sample (1980 Census)

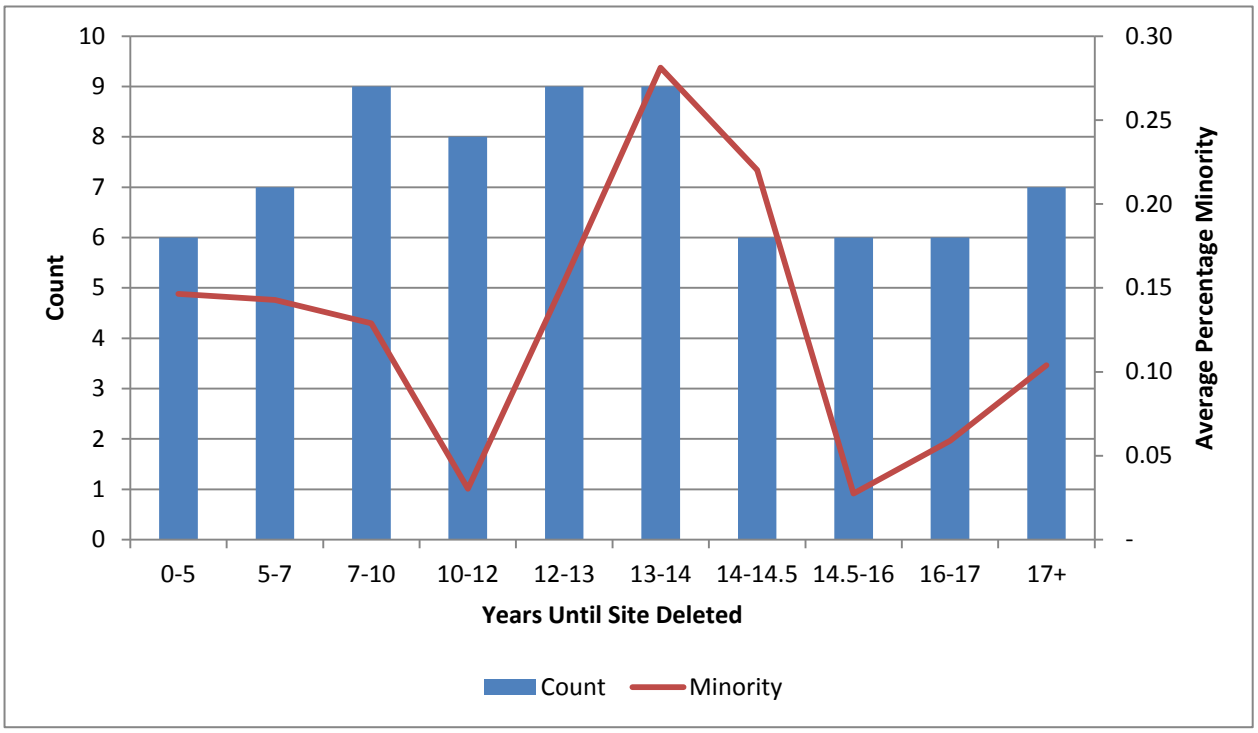
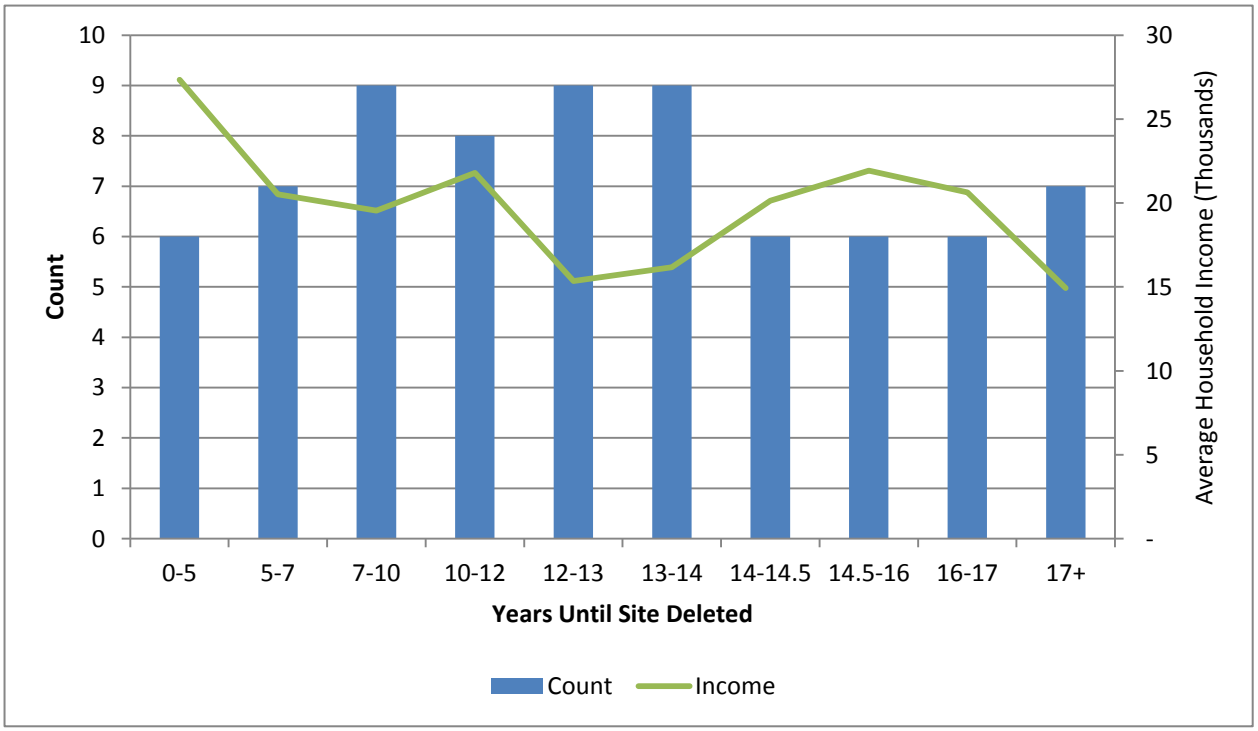


Figure 3.14: Average Household Income by Average Years from NPL to Deletion for 1982 HRS Sample (1980 Census)



C. Next Steps

The analysis revealed important findings about the construction of the data and the relationships between demographic variables in different sample subsets. While there is some suggestion of environmental justice issues in different stages of the listing and remediation process, inconsistency across data subsets and mapping methods calls for further analysis to be performed. The next section of this paper explains the econometrics modeling procedures used. Then, the outcomes of the regression analysis are presented in the empirical results.

4. Econometric Methods

The econometric modeling further investigates the descriptive statistics from the data section. There were three levels of analysis in this study: NPL Siting, HRS Scoring, and NPL Remediation. Both the 2000 NPL Sample and the 1982 HRS Sample are analyzed across the 1980 and 2000 censuses, where possible. In all samples, the observations are restricted to census tracts with a population greater than 50 in the applicable census year. Comparison analysis is performed at the national, regional, and state level (for Arizona). Different demographic matching techniques are used, matching demographics to contaminated sites by census tract as well as 2- and 3- mile radii from the site, as described in the data section.

The regressions use different combinations of the demographic variables described in the data section with a focus on minority and income characteristics. The regional analysis consists of limiting the samples to census tracts in Northeast, Midwest, West and South regions as defined by the Census Bureau. The West region is further broken into EPA Region 9, which includes only California, Arizona, and Nevada from the continental U.S. Finally, regressions are run for Arizona, in the cases where the sample size was large enough, and a geographic drill-down comparison is created. Regarding the demographic matching techniques, census tract level demographic data is available for both census years in both samples. However, 2- and 3- mile radii demographic information is only available for the 1980 census variables in the 1982 HRS Sample.

A. NPL Siting Estimation

Both samples are analyzed across the 1980 and 2000 censuses here. The dependent variable in these regressions is an indicator for NPL status. For the 2000 NPL Sample, the indicator is whether there was an NPL site in the census tract by January 1, 2000.

$$y_{Site\ NPL} = \begin{cases} 1 & if\ NPL\ site \\ 0 & if\ no\ NPL\ site \end{cases}$$

For the 1982 HRS Sample, the indicator is whether the census tract had a contaminated site with an HRS Score ≥ 28.5, and therefore placed on the NPL during the initial testing in 1982.

$$y_{Site\ HRS} = \begin{cases} 1 & if\ NPL\ site \\ 0 & if\ no\ NPL\ site \end{cases}$$

In this HRS Sample analysis, census tracts with contaminated sites that scored below 28.5 and census tracts without contaminated sites are treated the same. The differences between sites above and below the cutoff are explored in the second level of analysis.

The analysis uses the following logistic regressions:

$$y_{Site\ NPL\ 1980} = \alpha + X_{c1980}'\beta_1 + \varepsilon_{c1980}$$

$$y_{Site\ NPL\ 2000} = \alpha + X_{c2000}'\beta_2 + \varepsilon_{c2000}$$

$$y_{Site\ HRS\ 1980} = \alpha + X_{c1980}'\beta_3 + \varepsilon_{c1980}$$

$$y_{Site\ HRS\ 2000} = \alpha + X_{c2000}'\beta_4 + \varepsilon_{c2000}$$

where X_{c1980} and X_{c2000} are the demographic variables from 1980 and 2000 censuses, respectively, and ε_{c2000} and ε_{c1980} are the unobservable determinants of NPL status for each census year regression.

A few features of the X vector are noteworthy. First, we use the 1980 census values of the variables to represent the characteristics of the areas before contaminated sites were assigned to the NPL. The 2000 census values of the variables represent the characteristics of the areas after contaminated sites were assigned to the NPL. While this allows for a compare the before and after effects of NPL listing, it does not allow for a comparison areas before and after contamination, which in many cases occurred decades before the passing of CERCLA in 1982. Secondly, the approach described in this section relies on a comparison of NPL sites to the rest of the country. A more focused approach would compare NPL sites to neighboring areas to determine if NPL sites are placed near low income or minority communities at the local level. The regional and Arizona comparison partially align to that

approach by restricting the comparison between areas with and without NPL sites within smaller geographic areas.

B. HRS Scoring Estimation

Only the 1982 HRS Sample is analyzed here, as it contains information on all sites tested in 1982, both those that did and did not make the initial NPL. For this analysis, the sample is restricted to sites that were tested and given HRS scores. The dependent variable in these regressions is an indicator for HRS Score above the 1982 cutoff.

$$y_{HRS} = \begin{cases} 1 \ \ if \ HRS \geq 28.5 \\ 0 \ \ if \ HRS < 28.5 \end{cases}$$

The analysis also uses a logistic regression.

$$y_{HRS\ 1980} = \ \alpha + \ X_{c1980}{}'\beta_5 + \ \varepsilon_{c1980}$$

$$y_{HRS\ 2000} = \ \alpha + \ X_{c2000}{}'\beta_6 + \ \varepsilon_{c2000}$$

While the HRS is not a absolute measure of risk, it is used here as a relative measure comparing the potential harm of hazardous waste sites against one another.

C. NPL Remediation Estimation

Only the NPL samples are analyzed here across the 1980 and 2000 censuses. The samples were restricted not only to census tracts with an NPL site, but those that reached construction complete remediation milestone. The dependent variable in these regressions is the years from NPL listing to the construction complete status.

$$y_{YRSNPL\_CC} = Number\ of\ Years\ from\ NPL\ Listing\ to\ Construction\ Complete\ Status$$

The dependent variables were generally found to follow a Poisson distribution with longer tails to the right, but both Poisson and Negative Binomial regressions were used for analysis.

$$y_{NPL\_CC\ 1980} = \ \alpha + \ X_{c1980}{}'\beta_7 + \ \varepsilon_{c1980}$$

$$y_{NPL\_CC\ 2000} = \alpha + X_{c2000}'\beta_8 + \varepsilon_{c2000}$$

Some of the remediation milestone variables suggest that remediation had begun before placement on the NPL.[116] This creates a bias in the data. In an attempt to control for this bias, a new dependent variable was created. The new variable baselines the length of time to the construction complete milestone from the issuance of the ROD, which was a step in the remediation process even before CERCLA and the NPL came to be.

$$y_{YRSROD\_CC} = Number\ of\ Years\ from\ ROD\ to\ Construction\ Complete\ Status$$

The new variable is also regressed using Poisson and Negative Binomial regressions.

$$y_{ROD\_CC\ 1980} = \alpha + X_{c1980}'\beta_9 + \varepsilon_{c1980}$$

$$y_{ROD\_CC\ 2000} = \alpha + X_{c2000}'\beta_{10} + \varepsilon_{c2000}$$

[116] Years between NPL Listing and the issuance of an ROD were negative for multiple sites.

5. Empirical Results

The regression analysis builds on the descriptive statistics from Chapter 3. The results are presented in order of the three layers of analysis: NPL Siting, HRS Scoring, and NPL Remediation. The results use the 1982 HRS Sample and 2000 NPL Sample and the 1980 and 2000 censuses, where applicable. The analysis is repeated across the different geographic mapping methods to ensure consistent analysis. Different geographic samples are created and analyzed to determine if potential environmental justice issues are region specific. The results are presented in the following three sections.

A. NPL Siting Results

Tables 5.1 and 5.2 present the results for the NPL regression against the demographics from the 1980 census for each sample at the national level using the census tract method. These results show the status of communities before NPL listing. In Table 5.1, for the 1982 HRS Sample the percentage of Hispanic, Black and Minority are all significant and negative while income is not significant. In Table 5.2, for the 2000 NPL Sample the percentage of Hispanic, Black and Minority are all also significant and negative, but income, however, is significant and negative. This indicates environmental justice in low income communities for the 2000 NPL Sample at the national level.

Tables 5.3 and 5.4 repeat the analysis using demographics from the 2000 census. These results demonstrate the affect of NPL listing. Percent of Hispanic, Black, and Minority are consistently significant and negative across all variable combinations and samples once more. Income, however, is now consistently positive when significant. This means that post-NPL listing attracts higher income communities at the national level. The results suggest that there is no environmental justice in minority communities at the national level using the census tract method and that there is environmental justice in low income communities prior to NPL listing, but that changes after listing as higher income

communities are more likely to have NPL sites in the 2000 census. From an education standpoint, college graduates are significant and negative in across all regressions and samples, indicating that college graduates are less likely to live near an NPL site than those without college degrees. Interestingly, not having a high school diploma alternates between positive and negative signs when significant. Generally, not having a diploma has a positive effect on NPL siting in the 1980 census and a negative effect on NPL siting in the 2000 census. This is consistent with the change in income between the two census years. Table 5.14 displays the comparison for each sample and each census year at the national level using the census tract approach for the best regression.

Tables 5.5 and 5.6 use the 2- and 3- mile radii method for mapping demographics to NPL sites for the 1982 HRS Sample and the 1980 census. The signs for the minority variables are consistent with the census tract method; however, the magnitude of the variables is less. The income variable, however, is generally insignificant and positive and significant at 10% for one regression in both the 2- and 3- mile methods. This indicates that demographic matching method may have an impact on the outcomes of the study. The summary results are presented in Table 5.15, comparing the three methods for the best regression.

Tables 5.7 through 5.10 display the regional analysis for the West, South, Northeast, and Midwest regions defined by the Census Bureau. Table 5.11 displays the results of the EPA Region 9 regression, which is a portion of the West region that includes Arizona. Tables 5.12 and 5.13 display the results of regressions in Arizona. The national and census regions comparison is made in Table 5.16. The drill-down from the national level to the state level in Arizona including the West region and EPA Region 9 is shown in Table 5.17.

Table 5.1: Logistic Regression: Dependent Variable – Presence of NPL Site in 1982 HRS Sample, National Analysis by Census Block*[117]

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	-3.41***	-3.96***	-3.93***	-3.83***	-3.27***	-3.78***	-3.68***	-4.25***	-4.09***
% Black	-1.5***		-1.83***			-1.81***		-1.39***	-1.3***
% Hispanic		-2.05***	-2.61***			-2.6***		-1.96***	-1.88***
% Minority				-2.02***			-2.0***		
Avg. HH Income					-0.01	-0.007	-0.007	0.0091	
Med. Rent	0.043	0.029	0.06	0.059	0.026	0.064	0.063		
Med. Housing Price	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2		
% Without HS Dipl.	0.5	1.79**	1.65**	1.41*	0.93	1.67**	1.43*	-0.33	-0.25
% BA or Better	-3.22***	-2.43**	-2.51**	-2.65***	-2.6**	-2.33**	-2.47**	-4.37***	-4.03***
Unemployment Rt.	3.46*	1.28	2.58	2.9	2.24	2.62	2.94		
Poverty Rate	-1.78*	-3.38***	-0.63	-0.57	-4.23***	-0.89	-0.82		-0.59
% Under 18	-4.65*	-1.98	-3.07	-3.46	-3.57	-3.18	-3.56		
% Over 65	-8.12***	-7.82***	-9.21***	-9.12***	-7.63***	-9.4***	-9.31***		
West	-0.59***	-0.27	-0.3	-0.37*	-0.54**	-0.31	-0.38*	-0.47**	-0.47**
Northeast	0.91***	0.93***	0.94***	0.93***	0.9***	0.94***	0.93***	0.76***	0.76***
South	-0.28	-0.4**	-0.31	-0.29	-0.38**	-0.32*	-0.3	-0.29*	-0.3*
N	48,568 (351)	48,568	48,568	48,568	48,568	48,568	48,568	51,820 (351)	51,820
Log Likelihood Value	3,751.65	3,759.12	3,733.57	3,734.74	3,768.72	3,733.32	3,734.48	4,023.03	4,023.57
Log Likelihood Ratio	220.51***	213.03***	238.58***	237.42***	203.43***	238.83***	237.67***	182.90***	182.36***
Psuedo-R^2	0.0045	.0044	.0049	.0049	.0042	.0049	.0049	0.0035	0.0035

***Explanatory variables based on 1980 Census values**

[117] *** significant at 1% level, ** significant at 5% level, * significant at 10% level

Table 5.2: Logistic Regression: Dependent Variable – Presence of NPL Site in 2000 NPL Sample, National Analysis by Census Block*

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	-3.40***	-3.94***	-3.91***	-3.72***	-2.67***	-3.18***	-2.99***	-2.53***	-2.79***
% Black	-0.83***		-1.20***			-1.14***		-0.76***	-0.62***
% Hispanic		-2.12***	-2.53***			-2.47***		-1.49***	-1.42***
% Minority				-1.53***			-1.46***		
Avg. HH Income					-0.04***	-0.03***	-0.03***	-0.01**	
Med. Rent	0.20***	0.10***	0.20***	0.20***	0.20***	0.20***	0.20***		
Med. Housing Price	-0.01	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02		
% Without HS Dipl.	0.64	2.03***	1.95***	1.42***	1.03**	2.05***	1.53***	-1.36***	-0.99**
% BA or Better	-3.12***	-2.23***	-2.29***	-2.61***	-1.78***	-1.28**	-1.61***	-4.11***	-4.28***
Unemployment Rt.	1.47	-0.39	0.50	1.18	0.71	0.54	1.21		
Poverty Rate	-1.66***	-2.57***	-0.67	-0.44	-4.03***	-1.82***	-1.60**		-0.58
% Under 18	1.11	3.33**	2.57*	1.82	1.12	1.99	1.24		
% Over 65	-6.24***	-6.49***	-7.44***	-7.25***	-6.84***	-8.35***	-8.16***		
West	-0.17	0.16	0.14	0.00	-0.13	0.13	-0.01	0.009	0.032
Northeast	0.73***	0.76***	0.76***	0.75***	0.71***	0.74***	0.73***	0.6***	0.59***
South	-0.03	-0.13	-0.06	-0.02	-0.12	-0.11	-0.07	-0.061	-0.052
N	48,628	48,628	48,628	48,628	48,628	48,628	48,628	51,886	48,628
Log Likelihood Value	9,352.25	9,329.92	9,292.46	9,305.40	9,347.06	9,273.32	9,286.28	10,328.81	10,413.59
Log Likelihood Ratio	372.25***	394.58***	432.05***	419.11***	377.45***	451.18***	438.22***	272.23***	187.45***
Psuedo-R^2	0.0076	0.0081	0.0088	0.0086	0.0077	0.0092	0.0090	0.0052	0.0052

***Explanatory variables based on 1980 Census values**

Table 5.3: Logistic Regression: Dependent Variable – Presence of NPL Site in 1982 HRS Sample, National Analysis by Census Block*

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	-3.02***	-3.38***	-3.61***	-3.52***	-3.25***	-3.83***	-3.75***	-4.27***	-4.04***
% Black	-1.33***		-1.60***			-1.59***		-1.34***	-1.16***
% Hispanic		-1.99***	-2.44***			-2.35***		-1.56***	-1.56***
% Minority				-1.85***			-1.81***		
Avg. HH Income					0.01**	0.01*	0.01**	0.008***	
Med. Rent	-0.02	-0.02	0.01	0.01	-0.05*	-0.01	-0.01		
Med. Housing Price	-0.09	-0.09	-0.10	-0.10	-0.20*	-0.19*	-0.19*		
% Without HS Dipl.	-1.47**	0.50	0.86	0.37	-1.46**	0.71	0.25	-0.88	-0.078
% BA or Better	-2.57***	-1.94***	-1.99***	-2.13***	-2.99***	-2.47***	-2.62***	-3.49***	-2.42***
Unemployment Rt.	1.16	0.08	1.55	1.67	-0.01	1.35	1.45		
Poverty Rate	-2.39**	-3.73***	-2.48***	-2.26**	-2.69***	-1.85*	-1.62*		-1.68**
% Under 18	-0.06	1.37	2.24	1.90	-0.61	1.89	1.55		
% Over 65	-4.49***	-4.66***	-5.31***	-5.19***	-3.82***	-5.08***	-4.97***		
West	-0.54***	-0.18	-0.31*	-0.38**	-0.34*	-0.25	-0.33*	-0.35*	-0.31*
Northeast	0.83***	0.85***	0.84***	0.84***	0.86***	0.86***	0.86***	0.77***	0.76***
South	-0.35**	-0.45***	-0.37**	-0.35**	-0.42***	-0.37**	-0.35**	-0.34**	-0.36**
N	64,594 (438)	64,594	64,594	64,594	64,594	64,594	64,594	64,643 (438)	64,643
Log Likelihood Value	5,030.95	5,032.94	5,005.72	5,007.84	5,043.97	5,002.29	5,004.09	5,045.93	5,048.66
Log Likelihood Ratio	216.52***	214.53***	241.75***	239.63***	203.50***	245.18***	243.38***	202.21***	198.81***
Psuedo-R^2	0.0033	0.0033	0.0037	0.0037	0.0031	0.0038	0.0038	0.0031	0.0031

***Explanatory variables based on 2000 Census values**

Table 5.4: Logistic Regression: Dependent Variable – Presence of NPL Site in 2000 NPL Sample, National Analysis by Census Block*

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	-2.16***	-2.49***	-2.62***	-2.51***	-2.23***	-2.66***	-2.56***	-3.01***	-2.83***
% Black	-0.75***		-1.00***			-1.00***		-0.76***	-0.6***
% Hispanic		-1.49***	-1.81***			-1.80***		-0.86***	-0.88***
% Minority				-1.23***			-1.22***		
Avg. HH Income					0.003	0.001	0.002	0.0062***	
Med. Rent	-0.04**	-0.04**	-0.02	-0.02	-0.06***	-0.02	-0.03		
Med. Housing Price	0.030	0.020	0.020	0.020	-0.001	0.002	0.003		
% Without HS Dipl.	-2.07***	-0.32	-0.15	-0.77*	-1.96***	-0.18	-0.80*	-1.8***	-1.03**
% BA or Better	-2.91***	-2.37***	-2.43***	-2.60***	-2.96***	-2.51***	-2.71***	-3.53***	-2.73***
Unemployment Rt.	0.54	0.00	0.83	1.02	-0.02	0.80	0.99		
Poverty Rate	-2.14***	-3.21***	-2.29***	-2.01***	-2.65***	-2.18***	-1.87***		-1.55***
% Under 18	4.72***	5.92***	6.38***	5.99***	4.50***	6.32***	5.92***		
% Over 65	-4.28***	-4.53***	-4.98***	-4.83***	-3.97***	-4.94***	-4.79***		
West	-0.07	0.18*	0.10	0.02	0.03	0.11	0.03	0.071	0.11
Northeast	0.73***	0.74***	0.74***	0.73***	0.73***	0.74***	0.73***	0.63***	0.63***
South	-0.06	-0.13	-0.07	-0.05	-0.11	-0.07	-0.05	-0.071	-0.088
N	64,667	64,667	64,667	64,667	64,667	64,667	64,667	64,667	64,667
Log Likelihood Value	12,902.54	12,889.90	12,853.14	12,860.91	12,922.23	12,852.83	12,860.39	13,013.14	13,004.26
Log Likelihood Ratio	423.02***	435.66***	472.42***	464.65***	403.33***	472.73***	465.17***	322.19***	321.30***
Psuedo-R^2	0.0065	0.0067	0.0073	0.0072	0.0062	0.0073	0.0072	0.0050	0.0050

***Explanatory variables based on 2000 Census values**

Table 5.5: Logistic Regression: Dependent Variable – Presence of NPL Site in 1982 HRS Sample, National Analysis with 2-Mile Radius*

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	-3.69***	-4.07***	-4.08***	-4.01***	-3.49***	-3.90***	-3.83***	-4.47***	-4.11***
% Black	-1.23***		-1.47***			-1.44***		-1.1***	-1.1***
% Hispanic		-1.56**	-2.02***			-2.00***		-1.86***	-1.84***
% Minority				-1.59***			-1.56***		
Avg. HH Income					-0.020	-0.010	-0.010	0.02*	
Med. Rent	0.03	0.01	0.04	0.04	0.01	0.04	0.04		
Med. Housing Price	-0.540	-0.470	-0.460	-0.470	-0.380	-0.380	-0.390		
% Without HS Dipl.	-0.68	0.22	0.13	-0.03	-0.36	0.16	-0.01	-0.61	-0.74
% BA or Better	-2.68***	-2.19**	-2.22**	-2.31**	-2.20**	-2.02*	-2.11**	-4.33***	-3.73***
Unemployment Rt.	3.91**	2.19	3.25*	3.48*	2.96	3.32*	3.55*		
Poverty Rate	-1.56	-2.91***	-0.72	-0.68	-3.70***	-1.05	-1.01		-0.31
% Under 18	-1.73	0.20	-0.55	-0.83	-0.96	-0.65	-0.93		
% Over 65	-3.76***	-3.41***	-4.36***	-4.32***	-3.48***	-4.58***	-4.54***		
West	-0.56**	-0.32	-0.35	-0.40*	-0.54**	-0.38	-0.43*	-0.48**	-0.5**
Northeast	0.89***	0.91***	0.91***	0.90***	0.88***	0.90***	0.90***	0.87***	0.87***
South	-0.24	-0.32*	-0.25	-0.24	-0.32*	-0.26	-0.25	-0.3*	-0.33*
N	48,567 (332)	48,567	48,567	48,567	48,567	48,567	48,567	51,799 (332)	51,799
Log Likelihood Value	3,792.92	3,799.47	3,782.90	3,783.46	3,804.08	3,782.45	3,783.03	3,836.76	3840.36
Log Likelihood Ratio	179.22***	172.67***	189.24***	188.68***	168.06***	189.69***	189.11***	178.30***	174.70***
Psuedo-R^2	0.0037	0.0035	0.0039	0.0039	0.0035	0.0039	0.0039	0.0034	0.0034

***Explanatory variables based on 1980 Census values**

Table 5.6: Logistic Regression: Dependent Variable – Presence of NPL Site in 1982 HRS Sample, National Analysis with 3-Mile Radius*

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	-4.07***	-4.44***	-4.47***	-4.38***	-3.98***	-4.40***	-4.32***	-4.61***	-4.3***
% Black	-1.12***		-1.35***			-1.34***		-1.01***	-1.03***
% Hispanic		-1.64**	-2.06***			-2.05***		-1.96***	-1.96***
% Minority				-1.50***			-1.49***		
Avg. HH Income					-0.010	-0.004	-0.004	0.02*	
Med. Rent	0.05	0.03	0.06	0.06	0.03	0.06	0.06		
Med. Housing Price	-0.800**	-0.720*	-0.710*	-0.730*	-0.670*	-0.660	-0.680*		
% Without HS Dipl.	-0.65	0.25	0.17	-0.04	-0.37	0.18	-0.03	-0.38	-0.53
% BA or Better	-1.56	-1.09	-1.13	-1.24	-1.25	-1.06	-1.17	-3.44***	-2.94***
Unemployment Rt.	3.70**	2.02	3.04*	3.35*	2.78	3.08*	3.38*		
Poverty Rate	-1.63	-2.79***	-0.81	-0.77	-3.40***	-0.94	-0.89		-0.15
% Under 18	0.35	2.14	1.54	1.20	1.06	1.51	1.17		
% Over 65	-2.43**	-2.17*	-2.97**	-2.93**	-2.08*	-3.05**	-3.00**		
West	-0.52**	-0.28	-0.31	-0.37	-0.49**	-0.32	-0.38*	-0.48**	-0.5**
Northeast	0.87***	0.89***	0.89***	0.88***	0.87***	0.88***	0.88***	0.85***	0.85***
South	-0.26	-0.33*	-0.26	-0.25	-0.32*	-0.26	-0.25	-0.33*	-0.35**
N	48,567 (332)	48,567	48,567	48,567	48,567	48,567	48,567	51,799 (332)	51,799
Log Likelihood Value	3,806.64	3,810.66	3,796.45	3,797.38	3,816.47	3,796.38	3,797.32	3,848.88	3,851.65
Log Likelihood Ratio	165.50***	161.48***	175.70***	174.77***	155.67***	175.76***	174.82***	166.18***	163.41***
Psuedo-R^2	0.0034	0.0033	0.0036	0.0036	0.0032	0.0036	0.0036	0.0032	0.0031

***Explanatory variables based on 1980 Census values**

Table 5.7: Logistic Regression: Dependent Variable – Presence of NPL Site in 2000 NPL Sample, West Region Analysis by Census Tract*

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	-4.71***	-5.32***	-5.26***	-5.17***	-3.37***	-3.82***	-3.71***	-2.37***	-3.1***
% Black	-1.40**		-1.76***			-1.69***		-0.5	-0.59
% Hispanic		-1.86***	-2.34***			-2.43***		-0.58	-0.71
% Minority				-2.03***			-2.04***		
Avg. HH Income					-0.070***	-0.060***	-0.060***	-0.04***	
Med. Rent	0.40***	0.40***	0.40***	0.40***	0.40***	0.40***	0.40***		
Med. Housing Price	-0.030	-0.020	-0.020	-0.020	-0.060	-0.050	-0.050		
% Without HS Dipl.	-0.08	3.12**	3.31**	2.81***	0.68	3.70***	3.09***	-0.72	-0.63
% BA or Better	-3.31***	-1.65	-1.89	-2.14*	-1.11	-0.16	-0.49	-3.77***	-4.71***
Unemployment Rt.	8.51***	6.79***	7.09***	7.34***	7.59***	6.49***	6.81***		
Poverty Rate	0.68	-1.38	0.20	0.49	-2.88**	-1.88	-1.54		1.24
% Under 18	1.12	2.45	1.81	1.65	0.63	0.88	0.69		
% Over 65	-4.81**	-5.84***	-6.82***	-6.63***	-6.34***	-8.88***	-8.62***		
N	11,145 (170)	11,145	11,145	11,145	11,145	11,145	11,145	11,779 (201)	11,779
Log Likelihood Value	1,671.18	1,669.48	1,659.17	1,659.63	1,658.49	1,640.63	1,641.36	1,988.52	1,999.64
Log Likelihood Ratio	88.42***	90.12***	100.43***	99.96***	101.10***	118.97***	118.24***	46.48***	35.36***
Psuedo-R^2	0.0079	0.0081	0.0090	0.0089	0.0090	0.0106	0.0106	0.0039	0.0030

***Explanatory variables based on 1980 Census values**

Table 5.8: Logistic Regression: Dependent Variable – Presence of NPL Site in 2000 NPL Sample, South Region Analysis by Census Tract*

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	-3.33***	-3.63***	-3.64***	-3.38***	-2.70***	-2.78***	-3.06***	-2.19***	-2.38***
% Black	0.16		-0.20				-0.19	0.21	0.31
% Hispanic		-1.85***	-1.96***				-1.92***	-0.98*	-0.93*
% Minority				-0.48		-0.46			
Avg. HH Income					-0.030*	-0.030*	-0.030*	-0.009	
Med. Rent	0.30***	0.30***	0.30***	0.30***	0.30***	0.30***	0.30***		
Med. Housing Price	0.003	0.003	0.003	0.003	0.001	0.001	0.001		
% Without HS Dipl.	-0.04	0.44	0.46	0.06	-0.01	0.10	0.48	-1.81***	-1.59**
% BA or Better	-7.85***	-7.34***	-7.30***	-7.69***	-7.04***	-6.90***	-6.57***	-7.76***	-7.93***
Unemployment Rt.	0.31	-1.04	-0.93	0.53	0.34	0.37	-1.05		
Poverty Rate	-0.74	-0.21	0.17	0.44	-1.15	-0.26	-0.48		-0.35
% Under 18	0.92	3.00	2.90	0.82	0.39	0.56	2.59		
% Over 65	-4.10***	-4.31***	-4.50***	-4.67***	-4.86***	-5.26***	-5.07***		
N	15,155 (234)	15,155	15,155	15,155	15,155	15,155	15,155	16,212 (262)	16,212
Log Likelihood Value	2,274.83	2,263.51	2,263.10	2,272.64	2,272.02	2,269.69	2,260.47	2,586.99	2,587.53
Log Likelihood Ratio	141.46***	152.77***	153.19***	143.64***	144.26***	146.60***	155.81***	94.34***	93.80***
Psuedo-R^2	0.0093	0.0100	0.0101	0.0094	0.0095	0.0096	0.0102	0.0058	0.0058

***Explanatory variables based on 1980 Census values**

Table 5.9: Logistic Regression: Dependent Variable – Presence of NPL Site in 2000 NPL Sample, Northeast Region Analysis by Census Tract*

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	-2.14***	-2.68***	-2.51***	-2.35***	-1.35**	-1.59***	-1.78***	-2.11***	-2***
% Black	-1.76***		-1.75***				-1.67***	-1.71***	-1.19***
% Hispanic		-4.72***	-4.48***				-4.28***	-4.28***	-3.58***
% Minority				-2.29***		-2.19***			
Avg. HH Income					-0.040***	-0.040**	-0.040**	0.01	
Med. Rent	-0.04	-0.02	0.00	-0.01	-0.02	0.02	0.02		
Med. Housing Price	0.100	0.070	0.110	0.110	0.060	0.110	0.100		
% Without HS Dipl.	1.49*	2.73***	2.47***	2.05**	1.94**	2.21***	2.61***	-1.99***	-1.21
% BA or Better	-1.17	-0.29	-0.53	-0.81	0.74	0.57	0.79	-3.61***	-2.9***
Unemployment Rt.	1.70	0.04	0.96	1.47	0.89	1.44	0.97		
Poverty Rate	-5.84***	-6.39***	-3.93***	-4.16***	-9.61***	-5.76***	-5.50***		-3.38***
% Under 18	2.95	4.73*	3.13	2.78	3.09	2.01	2.39		
% Over 65	-10.25***	-10.08***	-11.34***	-11.19***	-10.59***	-12.22***	-12.30***		
N	11,112 (378)	11,112	11,112	11,112	11,112	11,112	11,112	11,793 (385)	11,793
Log Likelihood Value	3,135.10	3,132.32	3,115.86	3,120.61	3,142.21	3,114.16	3,109.86	3,280.56	3,272.91
Log Likelihood Ratio	163.84***	166.62***	183.08***	178.33***	156.73***	184.79***	189.08***	111.69***	119.34***
Psuedo-R^2	0.0146	0.0149	0.0163	0.0159	0.0140	0.0165	0.0169	0.0094	0.0101

***Explanatory variables based on 1980 Census values**

Table 5.10: Logistic Regression: Dependent Variable – Presence of NPL Site in 2000 NPL Sample, Midwest Region Analysis by Census Tract*

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	-2.08***	-2.53***	-2.67***	-2.70***	-1.21	-1.77**	-1.94**	-2.11***	-2.46***
% Black	-2.16***		-2.46***				-2.36***	-1.63***	-1.88***
% Hispanic		-4.32**	-5.32***				-5.19**	-4.12**	-4.3**
% Minority				0.00		-2.60***			
Avg. HH Income					-0.040**	-0.030**	-0.030**	-0.02**	
Med. Rent	-0.09	-0.10	-0.08	-0.08	-0.10	-0.08	-0.07		
Med. Housing Price	-0.300	-0.260	-0.280	-0.280	-0.220	-0.230	-0.230		
% Without HS Dipl.	-1.44	0.49	0.23	-0.35	-0.77	-0.29	0.27	-1.69**	-1.97**
% BA or Better	-4.26***	-3.33**	-3.12**	-3.47***	-3.39***	-2.86**	-2.51*	-4.23***	-4.87***
Unemployment Rt.	0.40	-2.98	-0.43	0.08	-1.56	0.49	-0.01		
Poverty Rate	1.11	-1.99	1.43	1.65	-3.05**	0.38	0.19		1.48
% Under 18	0.93	3.13	2.48	2.04	0.62	1.07	1.53		
% Over 65	-5.03***	-4.99***	-6.10***	-5.85***	-5.49***	-6.76***	-6.99***		
N	11,216 (215)	11,216	11,216	11,216	11,216	11,216	11,216	12,102 (245)	12,102
Log Likelihood Value	2,060.27	2,072.33	2,047.86	2,050.35	2,073.92	2,046.53	2,044.12	2,330.63	2,334.51
Log Likelihood Ratio	66.00***	53.94***	78.41***	75.92***	52.34***	79.74***	82.15***	65.31***	61.43***
Psuedo-R^2	0.0059	0.0048	0.0070	0.0067	0.0047	0.0071	0.0073	0.0054	0.0051

***Explanatory variables based on 1980 Census values**

Table 5.11: Logistic Regression: Dependent Variable – Presence of NPL Site in 2000 NPL Sample, EPA Region 9 Analysis by Census Tract*

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	-5.84***	-6.24***	-6.21***	-6.19***	-4.34***	-4.55***	-4.62***	-3.36***	-4.36***
% Black	-0.99		-1.36*				-1.19	-0.14	-0.002
% Hispanic		-0.81	-1.48				-1.55	0.72	0.48
% Minority				-1.40*		-1.32*			
Avg. HH Income					-0.08***	-0.08***	-0.08***	-0.04***	
Med. Rent	0.40***	0.40***	0.40***	0.40***	0.40***	0.40***	0.40***		
Med. Housing Price	0.003	0.003	0.003	0.003	-0.020	-0.010	-0.010		
% Without HS Dipl.	2.15*	3.86**	4.18**	4.06***	2.96***	4.27***	4.65**	-0.62	0.3
% BA or Better	0.04	0.98	0.79	0.73	2.90*	3.09**	3.28**	-0.34	-1.13
Unemployment Rt.	8.80***	7.67***	7.65***	7.73***	7.87***	7.19***	6.96**		
Poverty Rate	-0.77	-2.41	-0.88	-0.82	-4.97**	-3.78*	-3.96*		0.043
% Under 18	-0.85	0.56	0.56	0.47	-0.32	0.56	0.85		
% Over 65	-6.23**	-6.45**	-7.19**	-7.16**	-7.96***	-9.01***	-9.13***		
N	7,671 (87)	7,671	7,671	7,671	7,671	7,671	7,671	8,074 (102)	8,074
Log Likelihood Value	903.25	904.33	901.23	901.24	885.47	882.25	882.15	1077.79	1,087.88
Log Likelihood Ratio	49.16***	48.07***	51.18***	51.17***	66.94***	70.15***	70.25***	16.69***	6.59
Psuedo-R^2	0.0064	0.0062	0.0066	0.0066	0.0087	0.0091	0.0091	0.0021	0.0008

***Explanatory variables based on 1980 Census values**

Table 5.12: Logistic Regression: Dependent Variable – Presence of NPL Site in 2000 NPL Sample, Arizona Analysis by Census Tract*

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	1.94	-1.12	-0.14	1.00	0.85	0.24	-0.66	-1.29	-3.21*
% Black	5.17*		3.31				3.25	4.25**	4.06**
% Hispanic		-8.34*	-7.53				-7.69	-1.03	-1.35
% Minority				-1.54		-1.56			
Avg. HH Income					0.080	0.080	0.070	-0.12***	
Med. Rent	-0.50	-0.20	-0.30	-0.30	-0.40	-0.30	-0.40		
Med. Housing Price	-6.000	-7.000	-7.000	-6.000	-7.000	-7.000	-8.000		
% Without HS Dipl.	6.25	17.20*	14.97*	7.81	4.91	7.38	14.67	-2.57	-1.07
% BA or Better	4.10	12.35	10.31	4.32	2.36	4.07	9.84	-4.49	-6.95
Unemployment Rt.	-3.05	4.47	1.99	0.87	1.80	2.04	2.80		
Poverty Rate	-11.32	-16.97	-16.81	-8.74	-6.41	-7.45	-16.05		-0.15
% Under 18	-33.00*	-23.68	-23.95	-31.25*	-34.58*	-32.76*	-25.06		
% Over 65	-13.49	-17.47*	-17.75*	-13.29	-11.45	-12.15	-16.82		
N	840 (5)	840	840	840	840	840	840	890 (9)	890
Log Likelihood Value	51.13	49.63	48.60	53.37	53.36	53.14	48.40	88.69	94.95
Log Likelihood Ratio	10.08	11.58	12.61	7.84	7.85	8.07	12.82	11.92**	5.65
Psuedo-R^2	0.0119	0.0137	0.0149	0.0093	0.0093	0.0096	0.0151	0.0133	0.0063

***Explanatory variables based on 1980 Census values**

Table 5.13: Logistic Regression: Dependent Variable – Presence of NPL Site in 2000 NPL Sample, Arizona Analysis by Census Tract*

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	-2.50	-2.48	-2.50	-2.38	-0.22	-0.05	-0.60	-1.25	-2.03
% Black	5.95		5.93				5.28	6.01	6.23*
% Hispanic		0.55	0.24				-0.30	0.61	0.26
% Minority				1.92		2.00			
Avg. HH Income					-0.07	-0.07	-0.06	-0.02	
Med. Rent	-0.10	-0.10	-0.10	-0.10	-0.09	-0.10	-0.10		
Med. Housing Price	0.51	0.43	0.52	0.34	2.00	1.00	1.00		
% Without HS Dipl.	-3.21	-3.88	-3.55	-5.18	-2.08	-4.44	-1.55	-6.04	-4.35
% BA or Better	-8.56*	-8.58*	-8.57*	-8.68*	-6.73	-7.25	-6.75	-8.83*	-9.77**
Unemployment Rt.	8.28	8.13	8.53	7.83	8.85	8.57	8.98		
Poverty Rate	-5.75	-5.05	-5.66	-4.56	-9.36	-8.52	-9.62		-1.24
% Under 18	7.92	9.60	7.65	9.97	8.12	8.08	6.73		
% Over 65	-1.02	-1.21	-0.94	-0.78	-3.54	-2.73	-2.91		
N	1,088 (11)	1,088	1,088	1,088	1,088	1,088	1,088	1,088	1,088
Log Likelihood Value	111.87	113.57	111.86	112.49	110.75	109.58	109.60	114.35	114.63
Log Likelihood Ratio	11.09	9.39	11.10	10.48	12.21	13.38	13.36	8.61	8.33
Psuedo-R^2	0.0101	0.0086	0.0101	0.0096	0.0112	0.0122	0.0122	0.0079	0.0076

***Explanatory variables based on 2000 Census values**

Table 5.14: Logistic Regression: Summary Comparison Table by Census Year and Sample, National Analysis by Census Tract

	1982 HRS Sample		2000 NPL Sample	
Variable	**1980 Census**	**2000 Census**	**1980 Census**	**2000 Census**
Intercept	-4.25***	-4.27***	-2.53***	-3.01***
% Black	-1.39***	-1.34***	-0.76***	-0.76***
% Hispanic	-1.96***	-1.56***	-1.49***	-0.86***
Avg. HH Income	0.0091	0.008***	-0.01**	0.0062***
% Without HS Dipl.	-0.33	-0.88	-1.36***	-1.8***
% BA or Better	-4.37***	-3.49***	-4.11***	-3.53***
West	-0.47**	-0.35*	0.009	0.071
Northeast	0.76***	0.77***	0.6***	0.63***
South	-0.29*	-0.34**	-0.061	-0.071
N	51,820 (351)	64,643 (438)	51,886	64,667
Log Likelihood Value	4,023.03	5,045.93	10,328.81	13,013.14
Log Likelihood Ratio	182.90***	202.21***	272.23***	322.19***
Psuedo-R^2	0.0035	0.0031	0.0052	0.0050

Table 5.15: Logistic Regression: Summary Comparison Table by NPL Geographic Locator in 1982 HRS Sample, National Analysis*

Variable	Census Tract	2-Mile	3-Mile
Intercept	-4.25***	-4.47***	-4.61***
% Black	-1.39***	-1.1***	-1.01***
% Hispanic	-1.96***	-1.86***	-1.96***
Avg. HH Income	0.0091	0.02*	0.02*
% Without HS Dipl.	-0.33	-0.61	-0.38
% BA or Better	-4.37***	-4.33***	-3.44***
West	-0.47**	-0.48**	-0.48**
Northeast	0.76***	0.87***	0.85***
South	-0.29*	-0.3*	-0.33*
N	51,820 (351)	51,799 (332)	51,799 (332)
Log Likelihood Value	4,023.03	3,836.76	3,848.88
Log Likelihood Ratio	182.90***	178.30***	166.18***
Psuedo-R^2	0.0035	0.0034	0.0032

***Explanatory variables based on 1980 Census values**

Table 5.16: Logistic Regression: Summary Comparison Table by Region in 2000 NPL Sample by Census Tract*

Variable	National	West	South	Northeast	Midwest
Intercept	-2.59***	-2.37***	-2.19***	-2.11***	-2.11***
% Black	-0.88***	-0.5	0.21	-1.71***	-1.63***
% Hispanic	-1.71***	-0.58	-0.98*	-4.28***	-4.12**
Avg. HH Income	-0.0067	-0.04***	-0.009	0.01	-0.02**
% Without HS Dipl.	-0.92***	-0.72	-1.81***	-1.99***	-1.69**
% BA or Better	-3.92***	-3.77***	-7.76***	-3.61***	-4.23***
N	48,628	11,779 (201)	16,212 (262)	11,793 (385)	12,102 (245)
Log Likelihood Value	10,414.52	1,988.52	2,586.99	3,280.56	2,330.63
Log Likelihood Ratio	186.52***	46.48***	94.34***	111.69***	65.31***
Psuedo-R^2	0.0036	0.0039	0.0058	0.0094	0.0054

***Explanatory variables based on 1980 Census values**

Table 5.17: Logistic Regression: Summary Comparison Table of Arizona Drill-Down Analysis by Census Year in 2000 NPL Sample

	1980 Census				2000 Census			
Variable	**National**	**West**	**EPA Region 9**	**Arizona**	**National**	**West**	**EPA Region 9**	**Arizona**
Intercept	-2.59***	-2.37***	-3.36***	-1.29	-2.94***	-2.74***	-4.55***	-1.25
% Black	-0.88***	-0.5	-0.14	4.25**	-0.83***	-0.19	-0.25	6.01
% Hispanic	-1.71***	-0.58	0.72	-1.03	-0.91***	-0.5	-0.3	0.61
Avg. HH Income	-0.0067	-0.04***	-0.04***	-0.12***	0.0068***	-0.01***	-0.0076	-0.02
% Without HS Dipl.	-0.92***	-0.72	-0.62	-2.57	-1.68***	-0.93	1.32	-6.04
% BA or Better	-3.92***	-3.77***	-0.34	-4.49	-3.35***	-1.12	1.66*	-8.83*
N	48,628	11,779 (201)	8,074 (102)	890 (9)	64,667	13,704 (250)	8,560 (106)	1,088 (11)
Log Likelihood Value	10,414.52	1,988.52	1077.79	88.69	13,122.00	2,469.24	1,137.35	114.35
Log Likelihood Ratio	186.52***	46.48***	16.69***	11.92**	213.33***	28.16***	4.31	8.61
Psuedo-R^2	0.0036	0.0039	0.0021	0.0133	0.0033	0.0021	0.0005	0.0079

B. HRS Scoring Results

Tables 5.18 and 5.19 present the results for the HRS regression against the demographics from the 1980 and 2000 censuses for the 1982 HRS Sample. These results compare sites that scored above and below the threshold for NPL listing. In Table 5.18, the results for the 1980 census variables are presented indicating pre-HRS testing status. The minority percentage variables are generally not significant except percentage of Black, which is significant at 10% and negative in two of the five associated regressions. Income is insignificant in all regressions, but poverty, which is related to average income, is significant and positive in three regressions. In terms of education, college graduate rate was insignificant, but percentage without a high school diploma was significant and negative in seven of nine regressions. Geographically, the northeast region indicator was significant and positive. This means that the northeast region has both the largest quantity of NPL sites, as evidenced by the previous section, and the highest concentration of HRS score above the NPL threshold. In Table 5.19, results for the 2000 census variables are presented indicating post-HRS testing (and in some cases post cleanup) status. Only percentage Hispanic was significant among the minority variables, and it's positive in all associated regressions. The percentage without a high school diploma was again significant and negative in five of nine regressions. The northeast region indicator was again significant and positive, but with less magnitude. Table 5.20 shows the comparison between the two census years for the best regression.

Table 5.21 shows the summary comparison between demographic mapping methods to the contaminated sites. The comparison displays the best regression analyzing the 1980 census demographics across the census tract and 2- and 3-mile radii mapping methods. Of the minority variables, only Hispanic was significant and only in the 2-mile radius method, which was positive. Income was insignificant across all methods. Percentage without a high school diploma was significant and negative across all methods. The northeast region was again significant and positive across all regions. The south region indicator was significant and positive only in the 2- and 3-mile radii regressions. This is

likely due to the differences between the samples than the demographic mapping method.

Table 5.22 shows the summary comparison between the national and regional analysis for the best regression using the 1980 census values. None of the variables were significant in the west region. In the south region, percent Hispanic was significant and positive with a magnitude over 30. Percentage without a high school diploma was significant and negative. College graduate rate was also significant and negative. That means that both ends of the education spectrum are associated with lower HRS scores in the South. In the northeast region, percent Hispanic was the only variable that significant, which was negative and significant at 10%. In the Midwest, college graduate rate was the only variable that was significant, which was positive and significant at 10%.

Table 5.23 shows the drill-down summary comparison for the nation, west region, and EPA Region 9. There are not enough observations in the Arizona sample to do an analysis. No variables in the west region or EPA Region 9 were significant for the 1980 census values. For the 2000 census values, income and percent of college graduates were significant at 10%. Income was negative, and percent of college graduates was positive. Overall, the regional and the Arizona drill-down summaries did not provide many significant variables to compare.

Table 5.18: Logistic Regression: Dependent Variable – 1982 HRS >=28.5 = 1, HRS<28.5 = 0 in 1982 HRS Sample, National Analysis by Census Tract*[118]

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	0.06	0.44	0.26	0.01	0.94	0.89	0.64	1.54**	1.4**
% Black	-1.25*		-1.19*			-1.12		-0.12	-1.01
% Hispanic		1.22	1.01			1.08		1.69	1.71
% Minority				-0.67			-0.60		
Avg. HH Income					-0.030	-0.030	-0.030	-0.01	
Med. Rent	0.03	0.03	0.03	0.04	0.03	0.03	0.03		
Med. Housing Price	0.300	0.180	0.270	0.280	0.400	0.400	0.430		
% Without HS Dipl.	-2.70*	-3.41**	-3.25**	-2.35	-2.71*	-3.26**	-2.37	-3.25**	-4.5***
% BA or Better	1.51	0.86	1.14	1.64	2.00	1.68	2.19	1.08	0.29
Unemployment Rt.	-2.83	-3.13	-2.64	-3.26	-3.17	-2.47	-3.09		
Poverty Rate	3.90*	2.17	3.94*	2.91	1.15	3.15	2.12		4.48**
% Under 18	7.08	6.89	6.90	7.21	6.48	6.33	6.67		
% Over 65	-0.22	0.62	0.06	-0.15	-0.62	-0.66	-0.87		
West	0.25	0.17	0.10	0.40	0.28	0.03	0.33	-0.013	-0.17
Northeast	0.71***	0.71***	0.71***	0.71***	0.68***	0.68***	0.68***	0.55**	0.61**
South	0.43	0.43	0.45	0.39	0.36	0.43	0.36	0.38	0.39
N	488 (322)	488	488	488	488	488	488	513 (322)	513
Log Likelihood Value	601.89	604.26	601.11	604.19	604.61	600.56	603.63	642.75	637.00
Log Likelihood Ratio	42.77***	40.40***	43.55***	40.47***	40.05***	44.10***	41.03***	34.59***	40.35***
Psuedo-R^2	0.0839	0.0794	0.0854	0.0796	0.0788	0.0864	0.0806	0.0652	0.0756

***Explanatory variables based on 1980 Census values**

[118] *** significant at 1% level, ** significant at 5% level, * significant at 10% level

Table5.19: Logistic Regression: Dependent Variable – 1982 HRS >=28.5 = 1, HRS<28.5 = 0 in 1982 HRS Sample, National Analysis by Census Tract*

Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Intercept	0.06	0.47	0.38	0.09	-0.04	0.16	-0.09	0.59	0.57
% Black	-0.78		-0.66			-0.68		-0.28	-0.47
% Hispanic		1.71*	1.57*			1.58*		1.66*	1.78**
% Minority				-0.14			-0.15		
Avg. HH Income					0.006	0.007	0.006	-0.0008	
Med. Rent	0.10**	0.10**	0.10**	0.10**	0.10**	0.10**	0.10**		
Med. Housing Price	-0.340	-0.350	-0.350	-0.340	-0.410	-0.450	-0.410		
% Without HS Dipl.	-2.10	-3.64**	-3.55**	-1.94	-2.07	-3.58**	-1.94	-2.94**	-3.65**
% BA or Better	1.01	0.79	0.78	1.05	0.78	0.44	0.79	0.79	0.66
Unemployment Rt.	1.49	0.84	1.36	1.00	0.81	1.28	0.93		
Poverty Rate	0.92	0.60	1.22	0.26	0.47	1.65	0.58		1.3
% Under 18	-1.48	-2.61	-2.35	-1.63	-1.90	-2.53	-1.78		
% Over 65	-0.69	-0.08	-0.37	-0.47	-0.26	-0.20	-0.34		
West	-0.02	-0.13	-0.19	0.08	0.12	-0.14	0.12	-0.2	-0.25
Northeast	0.50**	0.52**	0.51**	0.51**	0.52**	0.52**	0.52**	0.54**	0.57***
South	0.25	0.28	0.31	0.21	0.21	0.31	0.21	0.29	0.32
N	664 (396)	664	664	664	664	664	664	664 (396)	664
Log Likelihood Value	857.61	856.12	854.59	859.68	859.53	854.20	859.44	861.31	860.47
Log Likelihood Ratio	38.06***	39.55***	41.08***	35.99***	36.14***	41.47***	36.23***	34.36***	35.20***
Psuedo-R^2	0.0557	0.0578	0.0600	0.0528	0.0530	0.0605	0.0531	0.0504	0.0516

***Explanatory variables based on 2000 Census values**

Table 5.20: Logistic Regression: Dependent Variable – 1982 HRS >=28.5 = 1, HRS<28.5 = 0, Summary Comparison Table by Census Year, National Analysis by Census Tract

Variable	1982 HRS Sample	
	1980 Census	2000 Census
Intercept	1.54**	0.59
% Black	-0.12	-0.28
% Hispanic	1.69	1.66*
Avg. HH Income	-0.01	-0.0008
% Without HS Dipl.	-3.25**	-2.94**
% BA or Better	1.08	0.79
West	-0.013	-0.2
Northeast	0.55**	0.54**
South	0.38	0.29
N	513 (322)	664 (396)
Log Likelihood Value	642.75	861.31
Log Likelihood Ratio	34.59***	34.36***
Psuedo-R^2	0.0652	0.0504

Table 5.21: Logistic Regression: Dependent Variable – 1982 HRS >=28.5 = 1, HRS<28.5 = 0, Summary Comparison Table by NPL Geographic Locator in 1982 HRS Sample, National Analysis*

Variable	Census Tract	2-Mile	3-Mile
Intercept	1.54**	2.88***	2.29*
% Black	-0.12	-0.29	-0.54
% Hispanic	1.69	2.06*	2.02
Avg. HH Income	-0.01	-0.03	-0.01
% Without HS Dipl.	-3.25**	-5.66***	-5.02***
% BA or Better	1.08	-2.06	-1.79
West	-0.013	0.006	0.043
Northeast	0.55**	0.81***	0.8***
South	0.38	0.68**	0.69**
N	513 (322)	489 (306)	489 (306)
Log Likelihood Value	642.75	612.99	615.03
Log Likelihood Ratio	34.59***	33.63***	31.59***
Psuedo-R^2	0.0652	0.0665	0.0626

***Explanatory variables based on 1980 Census values**

Table 5.22: Logistic Regression: Dependent Variable – 1982 HRS >=28.5 = 1, HRS<28.5 = 0, Summary Comparison Table by Region in 1982 HRS Sample by Census Tract*

Variable	National	West	South	Northeast	Midwest
Intercept	1.34*	-0.035	3.73**	0.17	2.28
% Black	-0.29	-1.09	0.06	3.16	0.097
% Hispanic	1.16	-1.7	31.46**	-6.22*	-6.26
Avg. HH Income	-0.01	-0.02	0.02	0.02	-0.06
% Without HS Dipl.	-2.43**	3.65	-7.03***	-0.38	-4.04
% BA or Better	2.49	-0.24	-11.15**	3.08	8.35*
N	488	55 (34)	111 (65)	206 (146)	141 (77)
Log Likelihood Value	648.75	70.59	128.55	234.47	167.83
Log Likelihood Ratio	28.60***	2.55	22.06***	14.09**	26.44***
Psuedo-R^2	0.0542	0.0454	0.1802	0.0661	0.1710

***Explanatory variables based on 1980 Census values**

Table 5.23: Logistic Regression: Summary Comparison Table of Arizona Drill-Down Analysis by Census Year in 1982 HRS Sample

	1980 Census			2000 Census		
Variable	**National**	**West**	**EPA Region 9**	**National**	**West**	**EPA Region 9**
Intercept	1.34*	-0.035	0.47	0.37	0.96	2.72
% Black	-0.29	-1.09	-1.54	-0.31	-1.22	-1.65
% Hispanic	1.16	-1.7	-4.74	0.98	-0.14	0.071
Avg. HH Income	-0.01	-0.02	-0.011	0.0037	-0.04*	-0.07
% Without HS Dipl.	-2.43**	3.65	6.08	-2	2.56	-0.52
% BA or Better	2.49	-0.24	6.34	1.09	4.98*	6.77
N	488	55 (34)	24(14)	664	84 (46)	31 (16)
Log Likelihood Value	648.75	70.59	28.31	870.91	108.41	38.16
Log Likelihood Ratio	28.60***	2.55	4.29	24.77***	7.28	4.78
Psuedo-R^2	0.0542	0.0454	0.1636	0.0366	0.0830	0.1430

Note: Arizona does not have enough observations to evaluate in the 1980 or 2000 Census.

C. NPL Remediation Results

The NPL Remediation results present analysis of two dependent variables and use two different regressions, Poisson and Negative Binomial in the 1982 HRS Sample. There are two dependent variables: Years from NPL listing to Construction Complete and Years from ROD to Construction Complete, which are explained in the data section. The initial regressions mirrored the set of explanatory variables from the previous sections. Table 5.24 presents the results of those variables for the Years from NPL listing to Construction Complete regressions at the national level for the 1980 and 2000 censuses. The only variable significant is the South region indicator, which is negative in each regression. None of the minority or income variables were significant. It was noted, however, that the level of hazardous waste and toxicity at each site would likely play a factor in the remediation timeframe. In the previous two sections, the analysis was not concerned with the question of why the situation had occurred, only documenting the existence. In this case, the regression must control for the level of toxicity or the results may be biased by the analysis already performed in the second section of this chapter. Therefore, HRS and Actual Costs were incrementally added to the set of explanatory variables. Tables 5.25 and 5.26 show that HRS Score and Actual Costs are significant and positive in nearly all situations. Actual Costs is a more direct indication of the length of remediation efforts and was chosen as the control for further regressions. Using the expanded set of explanatory variables, the results were consistent across the demographic mapping methods in Table 5.27. Aside from Actual Costs, only the South region dummy variable registered at 10% and negative for the Negative Binomial regressions for the 2-mile method.

Table 5.28 presents the summary comparison between the national and regional analysis for Years from NPL listing to Construction using the 1980 census values without Actual Costs. The South region has the only significant variable values. The Poisson and Negative Binomial results are nearly identical for the South region. Percent Black is significant and positive. Income is significant and

negative. Percentage without a high school diploma and percent of college graduates are both significant and negative. These results imply that there are environmental justice concerns regarding remediation in low income and black communities in the South. When Actual Costs are included in Table 5.29, however, none of the minority or income variables are significant in any of the regions, including the South. It must be noted, though, that Actual Costs are missing for approximately one third of the observations. Therefore, it is possible that Actual Costs are not missing at random and the observations missing costs in the South region are the ones with environmental justice concerns.

The same analysis is repeated for the dependent variable: Years from ROD to Construction Complete to analyze whether remediation beginning before the establishment of the NPL affects the results. Table 5.30 presents the results for the Years from ROD to Construction Complete regressions at the national level for the 1980 and 2000 censuses with Actual Costs. South is no longer significant. The only significant variables are in the Poisson regression for the 2000 census. Hispanic is significant at 10% and positive. Percentage without a high school diploma and percent of college graduates are both significant and negative. Northeast region indicator is significant and positive. Actual Costs and HRS Score are again used in Tables 5.31 and 5.32 and are the only significant variables. Table 5.33 again compares geographic mapping methods, showing consistency except for the West region showing at 10% in only census tract method. Table 5.34 presents the summary comparison between the national and regional analysis for Years from ROD to Construction using the 1980 census values without Actual Costs. Percent Hispanic is significant and positive in the West region for the Poisson regression. Percent Black is significant and negative in the Northeast region for the Poisson regression. In the South region, percent Black is significant and positive for the Poisson regression. Percentage without a high school diploma and percent of college graduates are both significant and negative for both regressions in the South region. Table 5.35 adds in Actual Costs and this time tells a different story. Percent Hispanic is positive and very significant in the West and Northeast across both regression types. The inconsistencies

across different methods suggest that the analysis should be followed up in more detail. These findings imply that there may be instances of environmental injustice in remediation timelines in different regions.

Table 5.24: Poisson and Negative Binomial Regression: Dependent Variable - Years from NPL listing to Construction Complete milestone, Summary Comparison Table by Census Year in 1982 HRS Sample, National Analysis by Census Tract[119]

	1982 HRS Sample			
	1980 Census		2000 Census	
Variable	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**
Intercept	2.49***	2.5***	2.55***	2.55***
% Black	0.12	0.12	0.015	0.016
% Hispanic	-0.27	-0.28	0.097	0.098
Avg. HH Income	-0.0009	-0.001	-0.001	-0.001
% Without HS Dipl.	0.034	0.027	-0.14	-0.14
% BA or Better	0.2	0.19	0.15	0.15
West	-0.033	-0.033	-0.079	-0.079
Northeast	0.004	0.004	0.019	0.019
South	-0.14**	-0.14**	-0.13***	-0.13**
N	244	244	307	307
Log Likelihood Value	4,294.81	4,295.99	5,355.47	5,356.50
Deviance/DF	1.3061	1.1444	1.2483	1.1168
Pearson X^2/DF	1.1849	1.0243	1.1547	1.0236

[119] *** significant at 1% level, ** significant at 5% level, * significant at 10% level

Table 5.25: Poisson and Negative Binomial Regression: Dependent Variable - Years from NPL listing to Construction Complete milestone in 1982 HRS Sample, National Analysis by Census Tract*

	Poisson				Negative Binomial			
Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(1)**	**(2)**	**(3)**	**(4)**
Intercept	2.49***	2.31***	2.45***	2.45***	2.5***	2.31***	2.44***	2.44***
% Black	0.12	0.11	0.12	0.12	0.12	0.12	0.11	0.11
% Hispanic	-0.27	-0.35	-0.11	-0.11	-0.28	-0.35	-0.11	-0.11
Avg. HH Income	-0.0009	-0.002	0.0008	0.0008	-0.001	-0.002	0.001	0.001
% Without HS Dipl.	0.034	0.094	0.063	0.062	0.027	0.088	0.065	0.066
% BA or Better	0.2	0.27	0.076	0.076	0.19	0.27	0.077	0.079
HRS Score		0.004**		-0.0001		0.004**		0.0001
Actual Costs			0.002***	0.002***			0.001***	0.001***
West	-0.033	-0.008	0.042	0.042	-0.033	-0.008	0.042	0.042
Northeast	0.004	-0.0003	0.003	0.003	0.004	0.0002	0.004	0.003
South	-0.14**	-0.13**	-0.092	-0.092	-0.14**	-0.13**	-0.092	-0.092
N	244	240	164	164	244	240	164	164
Log Likelihood Value	4,294.81	4,204.81	3,177.50	3,177.50	4,295.99	4,205.76	3,180.92	3,180.92
Deviance/DF	1.3061	1.2969	0.8349	0.8404	1.1444	1.1507	1.1269	1.1344
Pearson X^2/DF	1.1849	1.1856	0.8052	0.8104	1.0243	1.0403	1.0964	1.1037

***Explanatory variables based on 1980 Census values**

Table 5.26: Poisson and Negative Binomial Regression: Dependent Variable - Years from NPL listing to Construction Complete milestone in 1982 HRS Sample, National Analysis by Census Tract*

	Poisson				Negative Binomial			
Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(1)**	**(2)**	**(3)**	**(4)**
Intercept	2.55***	2.4***	2.41***	2.41***	2.55***	2.4***	2.41***	2.41***
% Black	0.015	0.03	0.047	0.047	0.016	0.031	0.044	0.044
% Hispanic	0.097	0.012	-0.14	-0.13	0.098	0.013	-0.14	-0.14
Avg. HH Income	-0.001	-0.002	0.0004	0.0004	-0.001	-0.002	0.0004	0.0004
% Without HS Dipl.	-0.14	-0.009	0.25	0.25	-0.14	-0.01	0.26	0.26
% BA or Better	0.15	0.27	0.12	0.12	0.15	0.27	0.13	0.13
HRS Score		0.003**		-0.0001		0.003*		0.0001
Actual Costs			0.001***	0.001***			0.001***	0.001***
West	-0.079	-0.065	0.028	0.028	-0.079	-0.065	0.028	0.028
Northeast	0.019	0.01	0.01	0.01	0.019	0.01	0.011	0.011
South	-0.13***	-0.13**	-0.1	-0.1	-0.13**	-0.13**	-0.1*	-0.1*
N	307	300	202	202	307	300	202	202
Log Likelihood Value	5,355.47	5,251.42	3,860.14	3,860.15	5,356.50	5,251.90	3,863.85	3,863.85
Deviance/DF	1.2483	1.2061	0.8419	0.8464	1.1168	1.1164	1.1146	1.1204
Pearson X^2/DF	1.1547	1.1249	0.8111	0.8153	1.0236	1.0355	1.0832	1.0889

***Explanatory variables based on 2000 Census values**

Table 5.27: Poisson and Negative Binomial Regression: Dependent Variable - Years from NPL listing to Construction Complete milestone, Summary Comparison Table by NPL Geographic Locator in 1982 HRS Sample, National Analysis*

	Census Tract		2-Mile		3-Mile	
Variable	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**
Intercept	2.45***	2.44***	2.14***	2.14***	2.19***	2.18***
% Black	0.12	0.11	0.026	0.026	0.051	0.051
% Hispanic	-0.11	-0.11	-0.42	-0.42	-0.49	-0.5
Avg. HH Income	0.0008	0.001	0.008	0.008	0.008	0.008
% Without HS Dipl.	0.063	0.065	0.5	0.49	0.4	0.4
% BA or Better	0.076	0.077	0.32	0.31	0.2	0.2
Actual Cost	0.002***	0.001***	0.002***	0.002***	0.002***	0.002***
West	0.042	0.042	0.089	0.088	0.091	0.091
Northeast	0.003	0.004	-0.017	-0.016	-0.013	-0.013
South	-0.092	-0.092	-0.11	-0.11*	-0.1	-0.1
N	164	164	153	153	153	153
Log Likelihood Value	3,177.50	3,180.92	2,965.98	2,969.34	2,965.80	2,969.11
Deviance/DF	0.8349	1.1269	0.8353	1.1369	0.8378	1.1378
Pearson X^2/DF	0.8052	1.0964	0.8059	1.1067	0.8087	1.1080

***Explanatory variables based on 1980 Census values**

Table 5.28: Poisson and Negative Binomial Regression: Dependent Variable - Years from NPL listing to Construction Complete milestone, Summary Comparison Table by Region in 1982 HRS Sample by Census Tract*

	National		West		South		Northeast		Midwest	
Variable	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**
Intercept	2.5***	2.5***	2.02***	2.02***	3.41***	3.41***	2.18***	2.18***	2.2***	2.19***
% Black	0.086	0.087	0.31	0.31	0.54***	0.54***	-0.69	-0.71	-0.091	-0.09
% Hispanic	-0.35*	-0.35	0.28	0.28	-0.18	-0.18	0.53	0.53	-0.47	-0.48
Avg. HH Income	0.0004	0.0003	0.025	0.025	-0.014**	-0.014**	0.004	0.004	0.007	0.007
% Without HS	-0.087	-0.091	-0.045	-0.056	-1.53***	-1.53***	0.45	0.45	0.49	0.49
% BA or Better	0.076	0.074	-0.74	-0.76	-2.18**	-2.18**	0.76	0.75	0.23	0.23
N	244	244	23	23	56	56	95	95	70	70
Log Likelihood	4,290.96	4,292.68	383.21	383.65	838.25	838.25	1,784.50	1,785.49	1303.61	1,304.84
Deviance/DF	1.3220	1.1273	1.8768	1.4490	1.2268	1.2125	1.4512	1.1980	0.8598	1.1329
Pearson X^2/DF	1.1984	1.0052	1.7843	1.3572	1.1947	1.1806	1.2954	1.0449	0.8331	1.1059

***Explanatory variables based on 1980 Census values**

Table 5.29: Poisson and Negative Binomial Regression: Dependent Variable - Years from NPL listing to Construction Complete milestone, Summary Comparison Table by Region in 1982 HRS Sample by Census Tract*

	National		West		South		Northeast		Midwest	
Variable	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**
Intercept	2.44***	2.44***	3.52**	3.47***	2.63***	2.62***	2.46***	2.45***	2.28***	2.29***
% Black	0.036	0.033	3	2.21	0.13	0.12	-0.64	-0.63	0.033	0.013
% Hispanic	-0.056	-0.059	0.16	0.16	0.013	0.004	1.03	1.01	-1.71	-1.61
Avg. HH Income	0.002	0.003	-0.013	-0.012	-0.008	-0.008	0.007	0.007	0.005	0.005
% Without HS	0.001	0.003	-1.77	-1.68	-0.06	-0.05	-0.38	-0.36	0.23	0.2
% BA or Better	-0.035	-0.034	-1.95	-1.93	-0.61	-0.57	-0.11	-0.091	0.095	0.11
Actual Cost	0.002***	0.001***	0.003	0.003	0.001	0.0009	0.002***	0.002***	0.003*	0.003***
N	164	164	12	12	35	35	63	63	54	54
Log Likelihood	3,176.15	3179.07	244.82	245.77	611.56	612.92	1,283.16	1,283.76	1,043.63	1,047.57
Deviance/DF	0.8363	1.1023	1.1895	2.2305	0.8409	1.2836	1.0226	1.2481	0.6486	1.1806
Pearson X^2/DF	0.8053	1.0707	1.2404	2.2262	0.8484	1.2806	0.9508	1.1777	0.6576	1.1722

***Explanatory variables based on 1980 Census values**

Table 5.30: Poisson and Negative Binomial Regression: Dependent Variable - Years from ROD to Construction Complete milestone, Summary Comparison Table by Census Year in 1982 HRS Sample, National Analysis by Census Tract

	1982 HRS Sample			
	1980 Census		2000 Census	
Variable	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**
Intercept	2.3***	2.32***	2.12***	2.11***
% Black	0.023	0.045	0.029	0.035
% Hispanic	0.15	0.14	0.41*	0.4
Avg. HH Income	-0.0007	-0.0008	0.002	0.003
% Without HS Dipl.	-0.53	-0.56	-0.77**	-0.77
% BA or Better	-0.72	-0.77	-0.72**	-0.76
West	0.018	0.019	0.047	0.054
Northeast	0.07	0.074	0.11**	0.11
South	-0.07	-0.072	-0.065	-0.069
N	240	240	299	299
Log Likelihood Value	1,896.00	1,935.36	2294.94	2,337.38
Deviance/DF	2.4530	1.2861	2.3031	1.2553
Pearson X^2/DF	1.9790	0.8662	1.8875	0.8783

Table 5.31: Poisson and Negative Binomial Regression: Dependent Variable - Years from ROD Issuance to Construction Complete milestone in 1982 HRS Sample, National Analysis by Census Tract*[120]

	Poisson				Negative Binomial			
Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(1)**	**(2)**	**(3)**	**(4)**
Intercept	2.3***	1.68***	2.23***	1.9***	2.32***	1.68***	2.22***	1.89***
% Black	0.023	-0.024	-0.13	-0.11	0.045	-0.011	-0.11	-0.089
% Hispanic	0.15	-0.059	0.29	0.18	0.14	-0.069	0.29	0.19
Avg. HH Income	-0.0007	-0.004	-0.002	-0.004	-0.0008	-0.004	-0.002	-0.005
% Without HS Dipl.	-0.53	-0.18	-0.52	-0.37	-0.56	-0.2	-0.51	-0.36
% BA or Better	-0.72	-0.19	-0.45	-0.2	-0.77	-0.23	-0.46	-0.21
HRS Score		0.012***		0.007***		0.012***		0.007**
Actual Costs			0.004***	0.004***			0.004***	0.004***
West	0.018	0.028	0.08	0.093	0.019	0.029	0.076	0.091
Northeast	0.07	0.024	0.033	0.015	0.074	0.027	0.032	0.014
South	-0.07	-0.11	-0.078	-0.11	-0.072	-0.11	-0.079	-0.11
N	240	240	164	164	240	240	164	164
Log Likelihood Value	1,896.00	1,912.22	1,469.35	1473.16	1,935.36	1,942.63	1,473.37	1,476.09
Deviance/DF	2.4530	2.3226	1.6507	1.6118	1.2861	1.3095	1.2601	1.2781
Pearson X^2/DF	1.9790	1.9268	1.4367	1.4288	0.8662	0.9403	1.0507	1.0970

***Explanatory variables based on 1980 Census values**

[120] *** significant at 1% level, ** significant at 5% level, * significant at 10% level

Table 5.32: Poisson and Negative Binomial Regression: Dependent Variable - Years from ROD Issuance to Construction Complete milestone in 1982 HRS Sample, National Analysis by Census Tract*

	Poisson				Negative Binomial			
Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(1)**	**(2)**	**(3)**	**(4)**
Intercept	2.12***	1.61***	1.97***	1.66***	2.11***	1.6***	1.95***	1.65***
% Black	0.029	-0.036	0.075	0.054	0.035	-0.038	0.085	0.064
% Hispanic	0.41*	0.18	0.18	0.075	0.4	0.18	0.18	0.081
Avg. HH Income	0.002	0.001	0.003	0.003	0.003	0.001	0.003	0.003
% Without HS Dipl.	-0.77**	-0.4	-0.72	-0.55	-0.77	-0.36	-0.7	-0.52
% BA or Better	-0.72**	-0.44	-0.6	-0.48	-0.76	-0.44	-0.61	-0.49
HRS Score		0.011***		0.007***		0.011***		0.007**
Actual Costs			0.004***	0.003***			0.004***	0.004***
West	0.047	0.067	0.24**	0.26**	0.054	0.064	0.24*	0.26**
Northeast	0.11**	0.076	0.081	0.07	0.11	0.076	0.08	0.069
South	-0.065	-0.087	-0.051	-0.062	-0.069	-0.088	-0.054	-0.064
N	299	299	201	201	299	299	201	201
Log Likelihood Value	2294.94	2,310.74	1,707.82	1,711.72	2,337.38	2,344.77	1,712.52	1,715.29
Deviance/DF	2.3031	2.2017	1.5931	1.5605	1.2553	1.2732	1.2206	1.2357
Pearson X^2/DF	1.8875	1.8514	1.4130	1.4053	0.8783	0.9420	1.0433	1.0811

***Explanatory variables based on 2000 Census values**

Table 5.33: Poisson and Negative Binomial Regression: Dependent Variable - Years from ROD to Construction Complete milestone, Summary Comparison Table by NPL Geographic Locator in 1982 HRS Sample, National Analysis*

	Census Tract		2-Mile		3-Mile	
Variable	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**
Intercept	1.97***	1.95***	1.77***	1.76***	1.87***	1.87***
% Black	0.075	0.085	-0.2	-0.19	-0.1	-0.086
% Hispanic	0.18	0.18	-0.19	-0.2	-0.39	-0.4
Avg. HH Income	0.003	0.003	0.009	0.009	0.01	0.009
% Without HS Dipl.	-0.72	-0.7	-0.044	-0.014	-0.33	-0.32
% BA or Better	-0.6	-0.61	0.11	0.15	-0.017	0.018
Actual Cost	0.004***	0.004***	0.003***	0.004***	0.003***	0.004***
West	0.24**	0.24*	0.18	0.19	0.2	0.2
Northeast	0.081	0.08	0.015	0.01	0.023	0.02
South	-0.051	-0.054	-0.072	-0.072	-0.06	-0.058
N	201	201	153	153	153	153
Log Likelihood Value	1,707.82	1,712.52	1,356.84	1,360.33	1,358.06	1,361.24
Deviance/DF	1.5931	1.2206	1.6587	1.2790	1.6416	1.2803
Pearson X^2/DF	1.4130	1.0433	1.4389	1.0628	1.4206	1.0627

***Explanatory variables based on 1980 Census values**

Table 5.34: Poisson and Negative Binomial Regression: Dependent Variable - Years from ROD to Construction Complete milestone, Summary Comparison Table by Region in 1982 HRS Sample by Census Tract*

	National		West		South		Northeast		Midwest	
Variable	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**
Intercept	2.31***	2.31***	2.13***	2.11**	3.33***	3.51***	1.69***	1.7***	2.29***	2.28***
% Black	-0.024	-0.015	-0.28	-0.34	0.48*	0.54	-1*	-1	0.21	0.21
% Hispanic	0.089	0.074	1.17*	1.11	0.23	0.19	2.55	2.4	-1.89	-1.9
Avg. HH Income	0.0004	0.0004	0.025	0.024	-0.011	-0.013	0.0008	0.002	0.003	0.003
% Without HS	-0.57*	-0.57	-1.44	-1.32	-2.25***	-2.53***	0.78	0.74	-0.54	-0.53
% BA or Better	-0.72	-0.72	-1.57	-1.5	-3.34***	-3.65**	0.79	0.69	-1.11	-1.12
N	240	240	22	22	56	56	94	94	68	68
Log Likelihood	1,893.67	1,934.26	188.18	193.74	368.43	371.99	819.13	842.10	535.35	538.14
Deviance/DF	2.4415	1.2681	3.8405	1.7709	2.0181	1.3218	2.9225	1.3633	1.8858	1.3323
Pearson X^2/DF	1.9848	0.8615	3.1145	1.1340	1.8055	1.1174	2.2903	0.8329	1.5534	1.0127

***Explanatory variables based on 1980 Census values**

Table 5.35: Poisson and Negative Binomial Regression: Dependent Variable - Years from ROD to Construction Complete milestone, Summary Comparison Table by Region in 1982 HRS Sample by Census Tract*

	National		West		South		Northeast		Midwest	
Variable	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**	**Poisson**	**Neg. Bin.**
Intercept	2.22***	2.21***	2.68	2.76***	2.32***	2.33***	1.96***	1.88***	2.42***	2.43***
% Black	-0.23	-0.21	2.26	1.48	-0.0005	0.006	-4.62***	-4.84***	0.23	0.23
% Hispanic	0.37	0.37	1.93**	2.11***	-0.046	-0.043	5.7***	5.5**	-3.29	-3.29
Avg. HH Income	-0.0003	-0.0006	0.043	0.043	-0.01	-0.01	0.0002	-0.0002	-0.003	-0.003
% Without HS	-0.55	-0.54	-3.68	-3.99**	-0.5	-0.52	-0.27	-0.12	-1.04*	-1.04*
% BA or Better	-0.52	-0.53	-4.14*	-4.2	-0.65	-0.68	0.2	0.36	-1.12	-1.12
Actual Cost	0.004***	0.004***	-0.0003	-0.0006	0.003***	0.003***	0.005***	0.006***	0.007***	0.007***
N	164	164	12	12	35	35	63	63	54	54
Log Likelihood	1468.20	1,472.57	136.29	138.09	262.08	262.16	636.01	638.66	451.13	451.14
Deviance/DF	1.6339	1.2333	1.1855	3.7450	1.3549	1.2346	2.0723	1.5005	1.3188	1.3522
Pearson X^2/DF	1.4276	1.0316	1.2373	3.2981	1.3840	1.2640	1.6561	1.1032	1.1812	1.2144

***Explanatory variables based on 1980 Census values**

6. Conclusions

The descriptive statistics lay the foundation for determining if there were environmental justice issues in land contamination regarding the NPL in the 1980's and 1990's. Three levels of analysis attempt to tackle multiple sides of the question. The first level of analysis is NPL siting, which involves determining if NPL sites are disproportionately located in minority or low income communities. The initial analysis shows that minority concentrations were actually lower in census tracts with NPL sites, but average household income was lower in tracts with NPL sites. The regression analysis delves deeper into the issue. The national level analysis again found that the percentage of minority has a negative impact on explaining NPL sites for both census years. The significance of annual income was more inconsistent, but when significant income had a positive impact on explaining NPL sites in 1980 and a negative impact on explaining NPL sites. This means that NPL sites were originally identified in areas with average to above average income and in the decades following NPL listing, the demographics changed to below average income levels. The different methods of demographic mapping confirmed these results for the 1980 census in the 1982 HRS Sample. The regional analysis generally followed the national level, except regarding income in the West and Midwest, where it had a negative impact on explaining NPL sites for the 1980 census in the 2000 NPL Sample. When the West region was further broken down to EPA Region 9, the results were consistent with income having a negative impact on explaining NPL sites for the 1980 census in the 2000 NPL Sample. Drilling even further into Arizona also found a negative impact for income on NPL sites and a positive impact for percent of Black on NPL sites. The issues with income and percent of Black do not show up in the analysis on the 2000 census. The analysis indicates potential Environmental Justice in the West, Midwest, EPA Region 9 and Arizona for low income communities and also percent of Black in Arizona.

The second level of analysis revolves around HRS scoring for inclusion on the NPL. The

environmental justice issues involve a question of magnitude of the land contamination. Higher HRS scores in minority or low income communities would indicate that the contamination in these areas is disproportionally worse than other areas.This is a direct compliment to the first level of analysis, which analyzed quantity of contamination, while this analyzes quality of contamination. The initial analysis shows that minority concentrations were generally higher in census tracts below the HRS score cutoff. Likewise, average household income was lower in tracts below the cutoff. The regression analysis furthers the investigation. Of the minority variables, percent of Black is infrequently significant, but had a negative impact on explaining HRS Score meeting the threshold in the 1980 census. In the 2000 census, percent of Hispanic had a positive impact on explaining HRS Score meeting the threshold. Income was not a significant indicator of HRS Score meeting the threshold. These results were confirmed by the different methods of demographic mapping analysis. The only notable difference was that percent of Hispanic has a positive impact on explaining HRS Score meeting the threshold for the 2-mile radius method for the 1980 census. The regional analysis generally agreed with the national level results. The notable differences were that percent of Hispanic had a very large positive impact on explaining HRS Score meeting the threshold in the South region, and that percent of Hispanic had a negative impact on explaining HRS Score meeting the threshold in the Northeast region. EPA Region 9 did not show any significant results, and unfortunately the limited sample size precluded an analysis of Arizona. These results indicate that there may be weak instances of environmental injustice at the national level for minority populations. There is also a strong indication of potential environmental injustice regarding Hispanic communities in the South.

The third level of analysis revolves around the pace of remediation at NPL sites. The environmental justice issues involve determining if the length of time to reach the Construction Complete milestone is longer in minority or low income communities than other communities. The inherent flaw in this analysis is that the sample is limited to sites that have been successfully

remediated. If remediation was significantly slower in minority or low income communities, many of these sites would not be fully remediated within the time period of the sample. Another issue revolves around the calculation of length of time. Using NPL listing as a start date makes sense until realizing that remediation activities were often occurring before the establishment of the NPL. Therefore, the analysis is repeated for a second dependent variable that calculates elapsed time from the issuance of the ROD, which is the first step in the remediation process and often predates NPL listing. The initial graphs showed that percent of minority and income were random across different lengths of remediation. The regression analysis explores the issue further. Actual Costs were added to the set of explanatory variables to control for the magnitude of contamination evaluated in the previous section. The national analysis did not have much in terms of significant results in the 1980 census except that percent of Hispanic had a negative impact on NPL remediation length using the Poisson regression for the NPL listing to Construction Complete dependent variable. In the 2000 census, percent of Hispanic had a positive impact on NPL remediation length using the Poisson regression for the ROD to Construction Complete dependent variable. For the regional analysis, percent of Black had a positive impact on NPL remediation length, and income had a negative impact on NPL remediation length for the 1980 census using both the Poisson and Negative Binomial regressions for the NPL listing to Construction Complete dependent variable. The results are less definite for the ROD to Construction Complete variable with only percent of Black having a positive impact and only using the Poisson regression without Actual Costs. With the ROD based dependent variable and using Actual Costs, percent of Hispanic had a significant positive impact in the West and Northeast regions. The results varied depending on the inclusion of Actual Costs. This indicates that there could be serious environmental injustice issues in the South region regarding the pace of remediation in Black and low income communities and the West and Northeast regions regarding Hispanic communities, but that more research is needed.

The timing of environmental justice legislature provides insight into its absence from original

land contamination legislature. While the EPA is continuing to integrate environmental justice into all of their programs, they need to fully understand how things worked historically in order to properly address any shortfalls and move forward. The process flows for both ADEQ and EPA show the potential instances for environmental justice. The relationship between ADEQ and EPA and the division of labor further convolutes the processes and clouds responsibility for environmental justice issues. As a standalone program, ADEQ's WQARF has not demonstrated the ability to take a contaminated site from identification to remediation. The lack of any successful sites prevents any possible data analysis on the program.

A. Future Work

This research fully acknowledges its limitations and the need for further analysis. The initial next step would be to focus on each of the three levels of analysis completely. A larger effort would include expanding the database into the recent decade and backfilling data for the 1990 census. Another deeper level would be expanding on the geographic mapping to include 1-mile or even half-mile radius demographic matching data. Demographics could also be mapped more precisely to each contaminated site. Using dates of NPL listing and remediation to each NPL site would allow an analysis over time and ensure that NPL sites from similar generations are analyzed against each other. This analysis could also trace the trends of environmental justice over time, mapping the progress of EPA's environmental justice efforts.

7. Appendix

Table 7.1: Midwest Region Analysis Variable t-Tests for 2000 NPL Sample (1980 Census)[121]

Variable	NPL mean	Non NPL mean	Difference	t Stat.
Avg. HH Income	19,309.010	20,816.200	-1,507.190	-2.781***
% Black	0.054	0.121	-0.067	-6.345***
% Hispanic	0.016	0.028	-0.012	-6.449***
% Minority	0.070	0.148	-0.078	-7.000***
Med. Rent	208.767	218.191	-9.424	-1.747*
Med. Housing Price	50,306.250	68,750.590	-18,444.340	-3.980***
% Without HS Dipl.	0.309	0.310	-0.001	-0.137
% BA or Better	0.134	0.163	-0.030	-5.348***
Unemployment Rt.	0.078	0.079	-0.001	-0.380
Poverty Rate	0.089	0.106	-0.017	-3.297***
% Under 18	0.094	0.088	0.006	4.621***
% Over 65	0.090	0.104	-0.014	-4.818***

[121] *** significant at 1% level, ** significant at 5% level, * significant at 10% level

Table 7.2: Midwest Region Analysis Variable t-Tests for 2000 NPL Sample (2000 Census)

Variable	NPL mean	Non NPL mean	Difference	t Stat.
Avg. HH Income	53,029.160	53,031.550	-2.390	-0.002
% Black	0.059	0.132	-0.073	-8.730***
% Hispanic	0.039	0.048	-0.009	-2.397**
% Minority	0.098	0.180	-0.082	-8.637***
Med. Rent	533.162	546.318	-13.156	-1.507
Med. Housing Price	103,934.380	108,396.700	-4,462.320	-1.641
% Without HS Dipl.	0.169	0.180	-0.011	-2.267**
% BA or Better	0.187	0.216	-0.029	-4.735***
Unemployment Rt.	0.050	0.056	-0.006	-2.201**
Poverty Rate	0.097	0.119	-0.023	-5.423***
% Under 18	0.068	0.067	0.002	1.611
% Over 65	0.125	0.133	-0.008	-2.755***

Table 7.3: Northeast Region Analysis Variable t-Tests for 2000 NPL Sample (1980 Census)

Variable	NPL mean	Non NPL mean	Difference	t Stat.
Avg. HH Income	22,120.450	21,068.870	1,051.580	3.335***
% Black	0.044	0.115	-0.071	-11.60***
% Hispanic	0.022	0.062	-0.040	-15.89***
% Minority	0.067	0.178	-0.111	-15.51***
Med. Rent	247.215	250.121	-2.906	-0.564
Med. Housing Price	55,383.930	53,588.700	1,795.230	1.728*
% Without HS Dipl.	0.311	0.342	-0.031	-4.437***
% BA or Better	0.165	0.169	-0.004	-0.763
Unemployment Rt.	0.062	0.070	-0.009	-4.705***
Poverty Rate	0.076	0.117	-0.042	-10.27***
% Under 18	0.079	0.075	0.004	3.359***
% Over 65	0.104	0.126	-0.021	-6.444***

Table 7.4: Northeast Region Analysis Variable t-Tests for 2000 NPL Sample (2000 Census)

Variable	NPL mean	Non NPL mean	Difference	t Stat.
Avg. HH Income	64,150.780	60,013.780	4,137.000	3.536***
% Black	0.057	0.139	-0.082	-14.82***
% Hispanic	0.047	0.100	-0.053	-13.60***
% Minority	0.105	0.239	-0.134	-16.73***
Med. Rent	715.338	693.599	21.739	1.608
Med. Housing Price	148,581.250	158,167.620	-9,586.370	-2.353**
% Without HS Dipl.	0.158	0.198	-0.039	-8.872***
% BA or Better	0.256	0.259	-0.003	-0.431
Unemployment Rt.	0.024	0.061	-0.037	-1.583
Poverty Rate	0.073	0.126	-0.053	-16.50***
% Under 18	0.063	0.062	0.001	1.083
% Over 65	0.132	0.141	-0.009	-3.131***

Table 7.5: West Region Analysis Variable t-Tests for 2000 NPL Sample (1980 Census)

Variable	NPL mean	Non NPL mean	Difference	t Stat.
Avg. HH Income	18,410.310	21,676.200	-3,265.890	-5.449***
% Black	0.059	0.054	0.005	0.567
% Hispanic	0.160	0.149	0.011	0.815
% Minority	0.219	0.203	0.015	0.989
Med. Rent	241.054	208.692	32.363	3.569***
Med. Housing Price	78,524.630	93,694.580	-15,169.950	-1.487
% Without HS Dipl.	0.294	0.257	0.037	3.180***
% BA or Better	0.149	0.191	-0.042	-5.687***
Unemployment Rt.	0.085	0.067	0.018	4.746***
Poverty Rate	0.123	0.109	0.014	2.315**
% Under 18	0.107	0.090	0.016	4.965***
% Over 65	0.075	0.098	-0.022	-6.036***

Table 7.6: West Region Analysis Variable t-Tests for 2000 NPL Sample (2000 Census)

Variable	NPL mean	Non NPL mean	Difference	t Stat.
Avg. HH Income	52,649.110	60,312.850	-7,663.740	-5.295***
% Black	0.055	0.053	0.002	0.288
% Hispanic	0.218	0.230	-0.011	-0.827
% Minority	0.273	0.283	-0.010	-0.641
Med. Rent	688.109	769.106	-80.997	-4.161***
Med. Housing Price	168,881.330	199,629.860	-30,748.530	-3.789***
% Without HS Dipl.	0.206	0.202	0.003	0.345
% BA or Better	0.216	0.255	-0.039	-4.007***
Unemployment Rt.	0.081	0.062	0.019	4.267***
Poverty Rate	0.145	0.132	0.013	1.714*
% Under 18	0.079	0.069	0.010	4.517***
% Over 65	0.093	0.114	-0.022	-5.179***

Table 7.7: South Region Analysis Variable t-Tests for 2000 NPL Sample (1980 Census)

Variable	NPL mean	Non NPL mean	Difference	t Stat.
Avg. HH Income	16,890.020	19,560.130	-2,670.110	-6.335***
% Black	0.224	0.170	0.054	3.240***
% Hispanic	0.046	0.063	-0.017	-2.327**
% Minority	0.270	0.233	0.038	2.134**
Med. Rent	209.023	185.730	23.293	3.254***
Med. Housing Price	54,811.610	61,841.030	-7,029.420	-0.760
% Without HS Dipl.	0.408	0.349	0.060	5.776***
% BA or Better	0.113	0.175	-0.062	-10.83***
Unemployment Rt.	0.068	0.054	0.014	5.089***
Poverty Rate	0.150	0.131	0.018	2.638***
% Under 18	0.094	0.085	0.009	5.274***
% Over 65	0.089	0.108	-0.019	-5.329***

Table 7.8: South Region Analysis Variable t-Tests for 2000 NPL Sample (2000 Census)

Variable	NPL mean	Non NPL mean	Difference	t Stat.
Avg. HH Income	45,643.930	50,710.510	-5,066.580	-6.138***
% Black	0.242	0.214	0.028	2.052**
% Hispanic	0.085	0.105	-0.020	-2.469**
% Minority	0.327	0.319	0.007	0.482
Med. Rent	523.486	562.885	-39.399	-4.078***
Med. Housing Price	84,982.950	101,357.170	-16,374.220	-7.172***
% Without HS Dipl.	0.261	0.239	0.022	3.203***
% BA or Better	0.151	0.214	-0.063	-10.95***
Unemployment Rt.	0.067	0.058	0.009	3.078***
Poverty Rate	0.157	0.154	0.003	0.499
% Under 18	0.069	0.066	0.003	2.508**
% Over 65	0.114	0.132	-0.018	-5.540***

Table 7.9: Arizona Analysis Variable t-Tests for 2000 NPL Sample (1980 Census)

Variable	NPL mean	Non NPL mean	Difference	t Stat.
Avg. HH Income	12,707.740	20,595.380	-7,887.640	-2.812***
% Black	0.095	0.025	0.070	1.236
% Hispanic	0.166	0.151	0.015	0.382
% Minority	0.261	0.176	0.085	1.021
Med. Rent	147.222	162.820	-15.598	-0.405
Med. Housing Price	43,893.850	64,366.820	-20,472.970	-2.718***
% Without HS Dipl.	0.326	0.269	0.057	0.851
% BA or Better	0.120	0.173	-0.053	-2.336**
Unemployment Rt.	0.070	0.060	0.010	0.590
Poverty Rate	0.139	0.113	0.026	1.109
% Under 18	0.110	0.093	0.017	1.607
% Over 65	0.060	0.113	-0.053	-3.351***

Table 7.10: Arizona Analysis Variable t-Tests for 2000 NPL Sample (2000 Census)

Variable	NPL mean	Non NPL mean	Difference	t Stat.
Avg. HH Income	43,291.840	53,909.920	-10,618.080	-2.750***
% Black	0.062	0.035	0.027	1.136
% Hispanic	0.304	0.251	0.053	0.829
% Minority	0.365	0.286	0.079	1.025
Med. Rent	594.091	698.021	-103.930	-2.391**
Med. Housing Price	103,263.640	122,636.550	-19,372.910	-1.171
% Without HS Dipl.	0.240	0.203	0.037	0.679
% BA or Better	0.143	0.230	-0.087	-3.924***
Unemployment Rt.	0.079	0.063	0.016	0.692
Poverty Rate	0.155	0.145	0.010	0.241
% Under 18	0.087	0.072	0.014	1.154
% Over 65	0.101	0.131	-0.030	-1.121

8. References

ADEQ. (2009). *2009 Water Quality Assurance Revolving Fund Registry.* Retrieved June 20, 2011, from http://www.azdeq.gov/environ/waste/sps/download/reg2009.pdf

ADEQ. (2011). *Superfund/WQARF: About the Program.* Retrieved June 20, 2011, from http://www.azdeq.gov/environ/waste/sps/program.html

ADEQ. (2011). *Superfund/WQARF: Liability and Real Estate Issues.* Retrieved June 20, 2011, from http://www.azdeq.gov/environ/waste/sps/liability.html

ADEQ. (2010). *Water Quality Assurance Revolving Fund: Annual Report Fiscal Year 2010.*

ADEQ. (2006, February). *West Van Buren Water Quality Assurance Revolving Fund Site.* Retrieved June 20, 2011, from http://www.azdeq.gov/environ/waste/sps/download/phoenix/wvbfact.pdf

ADEQ. (2011). *WQARF Registry .* Retrieved June 20, 2011, from http://www.azdeq.gov/environ/waste/sps/download/registry.pdf

Agency for Toxic Substance and Disease Registry. (2011, March 3). *Chromium.* Retrieved June 20, 2011, from http://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=17

Agency for Toxic Substances and Disease Registry. (1989). *1,2-Dichloropropane.* Retrieved June 20, 2011, from http://www.eco-usa.net/toxics/chemicals/1,2-dichloropropane.shtml

Aspelin, A. L. (1997, August). *EPA.* Retrieved June 20, 2011, from Pesticides Industry Sales and Usage 1994 and 1995 Market Estimates: http://www.epa.gov/opp00001/pestsales/95pestsales/market_estimates1995.pdf

Border 2012 Waste Policy Forum. (2009). *Goal 3: Reduce Land Contamination.* Retrieved June 20, 2011, from http://www.epa.gov/Border2012/fora/waste-forum/docs/09presentations/Wpf2009AzSonWetfRev10Mar09.pdf

Bullard, R. D. (2007, March). *Toxic Wastes and Race at Twenty: 1987-2007.* Retrieved June 20, 2011, from http://www.ejnet.org/ej/twart.pdf

Canfield, R. M.-S. (2004). Impaired neuropsychological functioning in lead-exposed children. *Developmental Neuropsychology* , 513.

Cassady, A. a. (2007, March). *Toxic Pollution and Health.* Retrieved June 20, 2011, from U.S. PIRG Education Fund : http://cdn.publicinterestnetwork.org/assets/KTfes5EXnCLOgG9eWTKU6g/ToxicPollutionandHealth2007.pdf

Center for Disease Control and Prevention. (2005, November 5). *Blood Mercury Levels in Young Children*

and Childbearing-Aged Women --- United States, 1999--2002. Retrieved June 20, 2011, from http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5343a5.htm

Center for Disease Control and Prevention. (2009, June 1). *Lead.* Retrieved June 2011, 20, from Center for Disease Control and Prevention: http://www.cdc.gov/nceh/lead/

Center for Hazardous Substances in Urban Environments. (2003, January 16). *Central Chemical Site.* Retrieved June 20, 2011, from http://www.jhu.edu/hsrc/cchrs.pdf

Chavis, J. B. (1987). *Toxic Waste and Race in the United States.* Retrieved June 20, 2011, from http://www.ucc.org/about-us/archives/pdfs/toxwrace87.pdf

Cornell University Law School. (n.d.). *Cleanup standards.* Retrieved June 20, 2011, from http://www.law.cornell.edu/uscode/42/9621.html

Cox, C. (1995). Indiscriminately from the Skies. *Journal of Pesticide Reform* , 1-6.

Davenport, D. K. (1999). Performance Audit: Department of Environmental Quality, Aquifer Protection Permit Program, Water Quality Assurance Revolving Fund Program, and Underground Storage Tank Program. *State of Arizona Office of the Auditor General* , 33.

Drexel University. (n.d.). Retrieved June 20, 2011, from Effects of Pollution on Human Health: http://www.pages.drexel.edu/~cy34/health.htm

EPA. (1991, March). *Air Pollution and Health Risk.* Retrieved June 20, 2011, from EPA: http://www.epa.gov/oar/oaqps/air_risc/3_90_022.html

EPA. (2011, March 15). *Asbestos: Basic Information.* Retrieved June 20, 2011, from http://www.epa.gov/asbestos/pubs/help.html

EPA. (2011, May). *Border Progress Report.* Retrieved June 20, 2011, from http://www.epa.gov/usmexicoborder/docs/reports/R6-R9BorderProgressReportMay2011final.pdf

EPA. (2009, November 13). *Brownfields and Land Revitalization*. Retrieved June 20, 2011, from EPA: summary tables with variable means, medians and maximums, variable means t-tests between two segments, correlation matrices and graphs where visual illustration

EPA. (2011, March 25). *CERCLA Overview.* Retrieved June 20, 2011, from http://www.epa.gov/superfund/policy/cercla.htm

EPA. (2009, January). *Challenges in Applying Property Value Studies to Assess the Benefits of the Superfund Program.* Retrieved June 20, 2011, from http://www.epa.gov/superfund/programs/recycle/pdf/PropertyStudy.pdf

EPA. (2011, February 28). *Contaminants.* Retrieved June 20, 2011, from http://www.epa.gov/superfund/health/contaminants/index.htm

EPA. (2011, June 16). *Environmental Justice.* Retrieved June 20, 2011, from http://www.epa.gov/environmentaljustice/

EPA. (2010, January). *Environmental Justice Fact Sheet.* Retrieved June 20, 2011, from http://www.epa.gov/environmentaljustice/resources/publications/factsheets/fact-sheet-nejac-2009.pdf

EPA. (2006). *Environmental Justice: The Intersection of Land Use Planning and Deliberative Public Involvement.* Retrieved June 20, 2011, from http://www.epa.gov/ciconference/previous/2006/download/presentations/encouraging1.pdf

EPA. (2011, June 3). *EPA Region 9 Environmental Justice.* Retrieved June 20, 2011, from http://www.epa.gov/region9/ej/

EPA. (2008). *EPA's 2008 Report on the Environment.* Washington, DC: National Center for Environmental Assessment.

EPA. (2011, March 25). *Introduction to the Hazard Ranking System (HRS).* Retrieved June 20, 2011, from http://www.epa.gov/superfund/programs/npl_hrs/hrsint.htm

EPA. (2010, October 1). *Mercury Health Effect.* Retrieved June 20, 2011, from http://www.epa.gov/mercury/effects.htm

EPA. (2010, January 27). *Obama Appointee Jared Blumenfeld Upholds, Renews EPA's Commitment to Underserved Communities in the Pacific Southwest.* Retrieved June 20, 2011, from http://yosemite.epa.gov/opa/admpress.nsf/2dd7f669225439b78525735900400c31/83aed0d6a9f9e633852576ba006ace7d!OpenDocument

EPA Office of Inspector General. (2004, March 1). *EPA Needs to Consistently Implement the Intent of the Executive Order on Environmental Justice .* Retrieved June 20, 2011, from http://www.epa.gov/oig/reports/2004/20040301-2004-P-00007.pdf

EPA Office of the Inspector General. (2006, September 18). *EPA Needs to Conduct Environmental Justice Reviews of Its Programs, Policies, and Activities.* Retrieved June 20, 2011, from http://www.epa.gov/oig/reports/2006/20060918-2006-P-00034.pdf

EPA. (2010, July 27). *Plan EJ 2014.* Retrieved June 20, 2011, from http://www.epa.gov/compliance/ej/resources/policy/plan-ej-2014.pdf

EPA. (2011, February 28). *Preliminary Assessment/Site Inspection.* Retrieved June 20, 2011, from http://www.epa.gov/superfund/cleanup/pasi.htm

EPA. (2011, March 25). *Reportable Quantities.* Retrieved June 2011, 20, from EPA: http://www.epa.gov/superfund/policy/release/rq/

EPA. (2011, April 6). *Superfund Program Implements the Recovery Act.* Retrieved June 20, 2011, from http://www.epa.gov/superfund/eparecovery/index.html

EPA. (2011, March 23). *Toxics Release Inventory (TRI) Program*. Retrieved June 20, 2011, from http://www.epa.gov/tri/tridata/tri09/nationalanalysis/index.htm

EPA. (2007, November 6). *Trichloroethylene.* Retrieved June 20, 2011, from http://www.epa.gov/ttn/atw/hlthef/tri-ethy.html

EPA. (2011, February 28). *Waste Site Activity*. Retrieved June 20, 2011, from EPA: http://www.epa.gov/superfund/students/wastsite/index.htm

EPA. (2002, August). *Water Quality Conditions in the United States.* Retrieved June 20, 2011, from EPA: http://www.epa.gov/owow/305b/2000report/factsheet.pdf

Evans, C. R. (2006, April 6). *Environmental Justice Mapping Tools.* Retrieved June 20, 2011, from http://www.epa.gov/superfund/policy/ic/pdfs/evans_map.pdf

GAO. (2005, July). *Environmental Justice: EPA Should Devote More Attention to Environmental Justice When Developing Clean Air Rules.* Retrieved June 20, 2011, from http://www.gao.gov/new.items/d05289.pdf

GAO. (2007, July). *Environmental Justice: Measurable Benchmarks Needed to Gause EPA Progress in Correcting Past Problems.* Retrieved June 20, 2011, from http://www.gao.gov/new.items/d071140t.pdf

GAO. (2010, May). *EPA's Estimated Costs to Remediate Existing Sites Exceed Current Funding Levels, and More Sites Are Expected to Be Added to the National Priorities List.* Retrieved June 20, 2011, from http://www.gao.gov/new.items/d10380.pdf

Green Media Toolshed. (n.d.). *Contaminants Detected at Superfund Sites in Arizona.* Retrieved June 20, 2011, from http://scorecard.goodguide.com/env-releases/land/state-chems.tcl?fips_state_code=04

Green Media Toolshed. (n.d.). *Pollution Locator: Superfund.* Retrieved June 20, 2011, from Scorecard: http://scorecard.goodguide.com/env-releases/land/index.tcl

Greenstone, M. a. (2008, January). *Does Hazardous Waste Matter? Evidence from the Housing Market and the Superfund Program.* Retrieved June 20, 2011, from http://www.brookings.edu/~/media/Files/rc/papers/2008/01_housing_market_greenstone/01_housing_market_greenstone.pdf

Grube, A. D. (2011, February). *EPA.* Retrieved June 20, 2011, from Pesticides Industry Sales and Usage 2006 and 2007 Market Estimates: http://www.epa.gov/opp00001/pestsales/07pestsales/market_estimates2007.pdf

Hamilton, J. T. (1999). How Costly Is "Clean"? An Analysis of the Benefits and Costs of Superfund Site Remediations. *Journal of Policy Analysis and Management* , 2-27.

Hardisty, P. E. (2005). The Economics of Remediating NAPLs in Fractured Aquifers. *Proceedings of NGWA Cost of Cleanup Conference* .

Hardisty, P. S. (2006). *Assessing the Costs and Benefits of MGP Site Remediation.* Retrieved June 20, 2011, from http://epppublications.com/Documents/14-02-26.pdf

Hird, J. A. (1990). Superfund Expenditures and Cleanup Priorities: Distributive Politics or the Public

Interest? *Journal of Policy Analysis and Management* , 455-483.

Howland, M. (2007, January). *Employment Effects of Brownfield Redevelopment: What Do We Know From the Literature?* Retrieved June 20, 2011, from http://yosemite.epa.gov/ee/epa/eed.nsf/54e92d0d1f202a6885256e46007b104c/6d1dc078786fce948525725d007a0d6b/$FILE/2007-01.pdf

Indiana University. (n.d.). *Economic Impact.* Retrieved June 20, 2011, from http://classwebs.spea.indiana.edu/kenricha/brownfields/resolution.htm

International Programme on Chemical Safety. (1995). *Tetrachloroethylene.* Retrieved June 20, 2011, from http://www.inchem.org/documents/iarc/vol63/tetrachloroethylene.html

Lang, S. (2007, August 2). Water, air and soil pollution causes 40 percent of deaths worldwide, Cornell research survey finds. *Cornell Chronicle* .

Ministry of Environmental Protection. (2011, Janurary 18). *Ministerial Committee Approves Land Contamination Bill: Those Responsible for Land Contamination will Be Responsible for Remediation and Cleanup.* Retrieved June 20, 2011, from http://sviva.gov.il/bin/en.jsp?enPage=e_BlankPage&enDisplay=view&enDispWhat=Object&enDispWho=News^l5470&enZone=e_news

National Association of State Departments of Agriculture. (2008). *Arizona Department of Agriculture.* Retrieved June 20, 2011, from http://www.nasda.org/cms/7195/8617/8745.aspx

National Institute of Environmental Health Sciences. (2011, June 10). *Superfund Research Program.* Retrieved June 20, 2011, from http://www.niehs.nih.gov/research/supported/srp/

Pan, L. (2006, July 18). *China faces "serious" soil pollution: SEPA*. Retrieved June 20, 2011, from http://english.gov.cn/2006-07/18/content_339294.htm

Peters, K. L. (1996, August). *Untangling the Web of WQARF.* Retrieved June 20, 2011, from http://www.myazbar.org/AZAttorney/Archives/Aug-Sept96/aug96_peters.PDF

Pillai, P. (n.d.). *Causes and Effects of Land Pollution*. Retrieved June 20, 2011, from http://www.buzzle.com/articles/causes-and-effects-of-land-pollution.html

Pimentel, D. (1997). *Techniques for Reducing Pesticides: Environmental and Economic Benefits.* Chichester, UK: John Wiley & Sons.

The White House. (1993, October 26). *Executive Order 12875: Enhancing Intergovernmental Partnership.* Retrieved June 20, 2011, from http://govinfo.library.unt.edu/npr/library/direct/orders/257e.html

U.S. Department of Health and Human Services. (2007, December). *Agency for Toxic Substances and Disease Registry.* Retrieved June 20, 2011, from 2007 CERCLA Priority List: http://www.atsdr.cdc.gov/cercla/supportdocs/text.pdf

U.S. Department of the Interior. (2008). *Reported Historic Asbestos Mines, Historic Asbestos Prospects, and Natural Asbestos Occurrences in the Southwestern United States.* Retrieved June 20, 2011, from

http://pubs.usgs.gov/of/2008/1095/pdf/Plate.pdf

US National Library of Medicine. (2010, July 26). *What is CERCLIS?* Retrieved June 20, 2011, from http://toxmap.nlm.nih.gov/toxmap/faq/2009/08/what-is-cerclis.html

Wikipedia. (2010, April). *Superfund Sites.* Retrieved June 20, 2011, from http://upload.wikimedia.org/wikipedia/commons/9/91/Superfund_sites.svg

Wolverton, A. (2008, August). *Effects of Socio-Economic and Input-Related Factors on Polluting Plants' Location Decisions.* Retrieved June 20, 2011, from http://yosemite.epa.gov/ee/epa/eed.nsf/WPNumber/2008-08/$File/2008-08.PDF

World Resources Institute. (1999). *Resolving environmental racism: Toward environmental justice.* Retrieved June 20, 2011, from http://www.wri.org/publication/content/8445