SOUTH CHATTANOOGA AND CHATTANOOGA CREEK FLOODPLAIN: A CASE STUDY

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To the Graduate Council:

I am submitting herewith a thesis written by Maya M. Belka entitled "South Chattanooga and Chattanooga Creek Floodplain: A Case Study." I have examined the final paper copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science with a major in Environmental Science.

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DEDICATION

This thesis is dedicated to my mother, Marsha Alan, my guiding light, role model, kindred spirit and hero.

"I pledge allegiance to the Earth,
and to the flora, fauna,
and human life that it supports,
one planet, indivisible,
with safe air, water, and soil,
economic justice, equal rights
and peace for all."

-Women's Environmental and
Development Organization
of the Women's Foreign
Council Policy

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ABSTRACT

South Chattanooga, Tennessee, has been the object of numerous investigations due to its large minority population and industrial history. Utilizing the case study approach, the area was examined as both an environmental justice community and home to an active Superfund site. Through legal analysis, historical research, environmental sampling, and government agency assessment, patterns emerged. The patterns provided a means for comparison with other communities in similar situations. The comparisons allowed for the formulation of several recommendations.

The community's proximity to the heavily polluted Chattanooga Creek was a key component of the South Chattanooga case study. Chattanooga Creek flows through the heart of South Chattanooga and has been an industrial dumping ground for over 100 years. Decades of pollution and frequent flooding events gave rise to community concern regarding contact with the Creek. As a result, Chattanooga Creek was included on the National Priorities List (NPL) and a Superfund site investigation commenced.

After several site investigations and some Creek remediation, the United States Environmental Protection Agency (EPA) awarded the City of Chattanooga a Superfund Redevelopment Initiative (SRI) pilot grant. Portions of the grant were used to develop a detailed Superfund site reuse plan. The reuse plan proposed a greenway linking individual South Chattanooga communities to Chattanooga Creek and to one another. The greenway and park would offer recreational opportunities and would run through the floodplain along the entire length of the Chattanooga Creek Superfund site.

Due to persistent flooding of Chattanooga Creek and lingering questions about the adequacy of past and proposed removal actions, South Chattanooga citizens were not

convinced that the floodplain was safe enough to accommodate public use without additional remediation. To address this concern, the Biological and Environmental Sciences Department at The University of Tennessee at Chattanooga (UTC), the Center for the Management, Utilization, and Protection of Water Resources at Tennessee Technological University (TTU), and the local environmental justice community organization Stop Toxic Pollution (S.T.O.P.), requested a grant from EPA's Region IV Office of Environmental Justice. EPA funded the *Chattanooga Creek Hazardous Substances Monitoring Program* grant, which allowed for environmental sampling of the Chattanooga Creek floodplain.

The results of the floodplain sampling showed soil polycyclic aromatic hydrocarbon (PAH) levels above several EPA Region IV remediation guidelines. Although guidelines are not legally enforceable, the remediation guidelines are the only guidance provided for this type of site assessment. As a result, South Chattanooga citizens indicated that the greenway, as proposed, should not be constructed without further remediation of floodplain soils. Despite EPA guideline exceedance and community concern, the Agency for Toxic Substances and Disease Registry (ATSDR) issued a Health Consultation that declared no apparent public health hazard existed from contact with soil PAH contamination. Because of the discrepancy between guideline exceedance and the ATSDR conclusion, other Superfund communities were investigated for comparison purposes.

Five Superfund communities from different EPA regions were analyzed. Major discrepancies between EPA Superfund remediation projects were discovered. The primary causes were a lack of guideline consistency, inconsistent interpretation of relevant environmental laws, and undeterminable risk associated with PAH mixtures. Although South Chattanooga's struggle was by no means unique, understanding the complexities associated with Superfund remediation and environmental justice communities were essential in order to provide recommendations for agency discrepancy and the risk assessment process. This thesis will identify the multiple factors that impede remediation of the Chattanooga Creek floodplain and hinder efforts by South Chattanooga residents to achieve environmental justice.

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ABBREVIATIONS

ACW	American Creosote Works
ARAR	Applicable or Relevant and Appropriate Requirements
ATSDR	Agency for Toxic Substances and Disease Registry
BaP	Benzo(a)pyrene
CCHSMP	Chattanooga Creek Hazardous Substances Monitoring Program
CCTD	Chattanooga Creek Tar Deposit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHA	Chattanooga Housing Authority
cPAH	Carcinogenic PAH
CREG	Cancer Risk Evaluation Guide
CWP	Central Wood Preserving
DOE	Department of Energy
ELISA	Enzyme-Linked Immunosorbent Assay
EMEG	Environmental Media Evaluation Guide
EO	Executive Order
EPA	Environmental Protection Agency
GPS	Global Positioning System
HI	Hazard Index
HSWA	Hazardous and Solid Waste Amendments
Koc	Organic carbon Partition Coefficient
Kow	Octonal-water Coefficient
MSA	Metropolitan Statistical Area
NCP	National Oil and Hazardous Substances Contingency Plan
NMPC	Niagara Mohawk Power Corporation
NPL	National Priorities List
PAH	Polycyclic Aromatic Hydrocarbons
PRG	Preliminary Remediation Goals
PRP	Potentially Responsible Parties

RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RG	Remediation Goals
RI/FS	Remedial Investigation and Feasibility Study
RMEG	Reference Dose Media Evaluation Guide
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SF	Slope Factor
SRI	Superfund Redevelopment Initiative
STOP	Stop Toxic Pollution
SVOC	Semi-Volatile Organic Compounds
TAG	Technical Assistant Grant
TDEC	Tennessee Department of Environment and Conservation
TEC	Toxicity Equivalent Soil Concentration
TEF	Toxic Equivalency Factor
TP	Tennessee Products
TPL	Trust for Public Land
TSD	Transfer, Storage, and Disposal
TTEC	Total Toxicity Equivalent Soil Concentrations
TTU	Tennessee Technological University
TVA	Tennessee Valley Authority
UCC	United Church of Christ's Commission for Racial Justice
UCL	Upper Confidence Limit
UTC	University of Tennessee at Chattanooga
VOC	Volatile Organic Compound
VSP	Visual Sampling Plan

I. Introduction

South Chattanooga, Tennessee, has been the object of numerous investigations due to its large minority population and industrial history. Utilizing a case study approach, the area was examined as both an environmental justice community and home to an active Superfund site. Through legal analysis, historical research, environmental sampling, and government agency assessment, patterns emerged. The patterns provided a means for comparison with other communities in similar situations. The comparisons allowed for the formulation of several recommendations. The purpose of this thesis is to identify the multiple factors that impede remediation of the Chattanooga Creek floodplain and hinder efforts by South Chattanooga residents to achieve environmental justice. The community's proximity to the heavily polluted Chattanooga Creek was a key component of the South Chattanooga case study.

Chattanooga Creek, located in Chattanooga, Tennessee, runs for 7.5-miles from the Georgia-Tennessee border to the Tennessee River and has been an industrial dumping ground for over 100 years. Industries such as tanneries, textile mills, and coking facilities used Chattanooga Creek as a means for waste disposal. As a result, Chattanooga Creek became heavily contaminated and South Chattanooga citizens became concerned about related health and safety issues. The prevalence of polycyclic aromatic hydrocarbon (PAH) contamination of the Creek and the surrounding floodplain was one of many concerns articulated by the community.

Major PAH contamination began in 1918, when a coal carbonization facility (Tennessee Products plant or TP) was built in South Chattanooga with the main purpose of coking coal. Coking or coal carbonization is a process that removes gases from coal through intense heating, thereby changing the coal to coke. The TP plant was located west of the creek with a majority of the plant located within or close to the floodplain. The TP plant frequently discharged coal tar into Chattanooga Creek and the surrounding floodplain during its time in operation.

After years of community lobbying, the TP site and a 2.5-mile stretch of Chattanooga Creek were placed on the National Priorities List (NPL) on September 29, 1995, thereby elevating both sites to Superfund status. On November 16, 1996, the U.S. Court of Appeals for the D.C. Circuit, in *Mead Corporation v. Browner*, removed the TP site from the NPL. All that remained was the 2.5-mile stretch of Chattanooga Creek, which flowed through the Alton Park and Piney Woods communities of South Chattanooga.

After several site investigations and some Creek remediation, the United States Environmental Protection Agency (EPA) awarded the City of Chattanooga, Tennessee a Superfund Redevelopment Initiative (SRI) pilot grant. The $100,000 grant was used, in part, to develop a reuse plan for Chattanooga Creek. The resulting reuse plan proposed a greenway that would link Alton Park, Piney Woods, Clifton Hills, and the Southside Gardens neighborhoods of South Chattanooga to Chattanooga Creek and to one another (TPL, 2002). The greenway and park would offer recreational opportunities and would run through the floodplain along the entire length of the Chattanooga Creek Superfund site.

Due to persistent flooding of Chattanooga Creek, the most recent being May 2003, and lingering questions about the adequacy of past and proposed remediation activities, South Chattanooga citizens were not convinced that the Chattanooga Creek floodplain was safe enough to accommodate public use without additional remediation. With the help of The University of Tennessee at Chattanooga (UTC) and Tennessee Technological University (TTU), the citizens requested a study of the health risk(s) presented by the floodplain soil. As a result, the EPA's Region IV Office of Environmental Justice funded the *Chattanooga Creek Hazardous Substances Monitoring Program*. The results of the *Chattanooga Creek Hazardous Substances Monitoring Program* grant found soil PAH levels well above EPA Region IV Preliminary Remediation Goals (PRGs) and Cancer Risk Evaluation Guides (CREGs). As a result, the citizens of South Chattanooga have indicated that the greenway, as proposed, should not be constructed without further remediation of the floodplain soils.

Using the case study approach, this thesis will examine the South Chattanooga community, government agencies, and the Chattanooga Creek Superfund site in order to identify potential areas of improvement in both communication and regulation. Through an understanding of current environmental laws, EPA and the Agency for Toxic Substances and Disease Registry (ATSDR) guidelines, and past Superfund Redevelopment and SRI pilot grant projects, this thesis will elucidate the struggles of the South Chattanooga environmental justice community and compare and contrast this struggle with other Superfund projects.

Five Superfund communities from different EPA regions were analyzed. Major discrepancies between EPA Superfund remediation projects were discovered. The primary causes were a lack of guideline consistency, inconsistent interpretation of relevant environmental laws, and undeterminable risk associated with PAH mixtures. Although South Chattanooga's struggle was by no means unique, understanding the complexities associated with Superfund remediation and environmental justice communities were essential in order to provide recommendations for agency discrepancy and the risk assessment process. This thesis will identify the multiple factors that impede remediation of the Chattanooga Creek floodplain and hinder efforts by South Chattanooga residents to achieve environmental justice.

Chapter I provides an introduction to the South Chattanooga community and Chattanooga Creek floodplain. Chapter II of the thesis reviews the history of South Chattanooga, Chattanooga Creek, and the TP site, along with background information on applicable environmental laws, PAHs, and current EPA and ATSDR guidelines. Chapter III consists of 4 main sections. Section one examines the TP site and agency involvement in remediation and reuse of both the TP site and the Chattanooga Creek Superfund site. Section two examines the floodplain soil sampling results obtained through the *Chattanooga Creek Hazardous Substances Monitoring Program* grant. Section three assesses the impact(s) the grant results and the subsequent ATSDR Health Consultation may have on the surrounding community and the construction of a greenway. Finally, section four analyzes other Superfund Redevelopment projects and other SRI pilot grants as a means for comparison. Recommendations are offered in Chapter IV and the thesis is concluded in Chapter V.

II. Background

Environmental Laws

Hazardous waste in the United States is essentially regulated by two federal laws, the Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments (HSWA), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). In general, RCRA governs the management of hazardous wastes, while CERCLA or "Superfund," regulates the remediation and liability associated with hazardous wastes. The laws established national hazardous waste management programs in the hopes of promoting source reduction, high-technology treatment, and securing long-term disposal of hazardous wastes (Case, 1997).

Congress passed RCRA in 1976 (RCRA 1976) in order to manage the transportation, storage, and disposal of hazardous waste. Under RCRA, EPA is required to establish regulations ensuring the safe management of hazardous substances from "cradle to grave" in order to minimize present and future threat to human health and the environment (RCRA 1976). The act was later amended by HSWA, which strengthened EPA's regulatory authority.

Although RCRA is divided into ten subtitles, A-J, subtitles C, D, and I are the main sections. Subtitle C: *Hazardous Waste Management* establishes the national hazardous waste management program and is perhaps the most significant section of RCRA. Subtitle C requires the identification and listing of hazardous waste, regulation of generators, transporters, and facilities that treat, store or dispose of hazardous waste, and TSD facility permits. Subtitle D: *State or Regional Solid Waste Plans* requires EPA to establish guidelines for state solid waste management plans and to set minimum requirements for state plans. Subtitle I: *Regulation of Underground Storage Tanks* requires owners of underground storage tanks to notify state authorities and requires EPA to issue regulations governing detection, prevention, and correction of leaks from underground storage tanks. Of the three subtitles, subtitle C is the most applicable to the thesis.

As defined by RCRA, hazardous wastes must be "solid waste" (any garbage, refuse, or sludge), a "waste" (i.e. discarded material), and must be defined as hazardous "taking into account toxicity, persistence, and degradability in nature, potential for accumulation in tissue, and other related factors such as flammability, corrosiveness, and other hazardous characteristics" (RCRA 1976). In order to implement RCRA, EPA established two methods of hazardous substance characterization: (1) exhibit one or more of four hazardous characteristics: ignitability, reactivity, corrosivity, and toxicity and (2) be listed as a hazardous waste under EPA's listed wastes regulations (Percival et al., 2003). Entities managing hazardous wastes are required to notify EPA of their hazardous waste activities (RCRA 1976). In essence, RCRA manages the identification, tracking, permitting, restrictions, controls, enforcement, and compliance of hazardous wastes from "cradle to grave" (RCRA 1976).

By 1980, Congress enacted CERCLA, more commonly known as Superfund. CERCLA was the direct result of a national concern regarding the uncontrolled release of hazardous substances from abandoned waste sites (hazardous substances being defined by references to substances listed or designated under other environmental statutes) (Lee, 1997). CERCLA created a tax to fund cleanups and granted broad Federal authority to respond directly to releases or threatened releases of hazardous substances that posed a threat to human health or the environment (CERCLA 1980). The Hazardous Substance Superfund obtained revenue from taxes on petroleum and chemical industries and corporations, and is how CERLCA obtained the synonym Superfund. The Act's main objective is the remediation of inactive hazardous waste sites and the distribution of cost among the responsible parties who generated and handled hazardous waste at the sites (Lee, 1997).

At the heart of CERCLA are the liability provisions and the authorization for removal operations (CERCLA 1980). The liability provisions allow for potentially responsible parties (PRPs) to be held liable for (1) removal costs or remedial action costs incurred by the federal government and (2) any other necessary costs of response incurred by any person. The hope was to dissuade spills or illegal dumping of hazardous substances through PRP liability (Percival et al., 2003). The removal operations authorize two response actions: (1) short-term removals, where action may be taken to address releases or threatened releases requiring prompt response and (2) long-term remedial response actions, that permanently and significantly reduce the dangers associated with releases or threats of releases of hazardous substances that are serious, but not immediately life threatening (CERCLA 1980). Only sites requiring long-term remediation are placed on the NPL and eligible for Superfund financing.

CERCLA requires that EPA develop criteria for determining priorities among the various releases or threatened releases throughout the nation. The criteria are based on risks to public health, welfare, or the environment, taking into account a variety of factors including the extent of population at risk, the hazard potential of the facility's hazardous substances, the potential for contamination of drinking water supplies, and the threat to air quality (CERCLA 1980). Applying the criteria, EPA ranks and scores various sites for possible listing on the NPL.

To implement CERCLA, EPA issued the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) in 1982. The NCP is the primary guidance document for CERCLA response actions. The document set guidelines and procedures for responses to releases or threats of releases of hazardous substances that may present a risk to public health or welfare (NCP 1982). The guidelines identify several key requirements. First, the guidelines identify the responsibilities of various organizations taking part in response to releases. Second, the guidelines describe how coordination among the various organizations is to occur. Third, the guidelines establish methods and criteria for determining the appropriate extent of response. Fourth, the guidelines outline the procedures to be followed in performing cleanups and finally, the guidelines establish the method by which EPA is to prepare an administrative record to support its actions (NCP 1982). Under CERCLA and in accordance with NCP, EPA is authorized to remove and provide remedial actions relating to hazardous substances by way of two distinct actions: "remedial actions" and "removals" (NCP 1982).

Removal actions can be conducted at either NPL or non-NPL sites. The removal actions are usually short-term actions taken to clean up or remove releases or threatened releases of hazardous substances. The NCP categorizes removal actions in three ways: (1) emergency removal actions, (2) time-critical removal actions, and (3) non-time-critical removal actions. The categories are based on the type of situation, the urgency of the threat of release, and the subsequent time frame in which the action must be initiated (NCP 1982).

Unlike removals, remedial actions are considerably more complex, costly, and detailed (Lee, 1997). Remedial actions include the discovery, selection, study, design, and construction of long-term actions aimed at a permanent remedy. The Superfund remedial process includes the following 9 steps:

- *Preliminary assessment* --- EPA performs a preliminary assessment (PA) of a site (often a review of data without an actual site visit) to determine the nature of the associated threats.

- *Site inspection* --- A site inspection (SI) is an on-site investigation conducted to find out whether there is a release or threatened release and to determine the nature of the associated threats.

- *Hazard Ranking System* --- Under the Hazard Ranking System (HRS) pertinent data about a site are evaluated and "scored." The score is based on items such as waste volume, waste toxicity, proximity to population, and distance to underground drinking water. Sites receiving an HRS score of 28.5 or higher are considered for listing on the NPL. As HRS studies are performed, releases and waste sites may be removed or added to the list.

- *National Priorities List* --- The NPL is complied by EPA and lists those sites, including federally owned facilities, that appear to pose the most serious threats to public health or the environment. The EPA determines whether or not to place a site on the NPL by using the HRS.

- *Remedial investigation* --- A remedial investigation (RI), conducted by the lead agency, determines the nature and extent of the problem presented by the release.

- *Feasibility study* --- The lead agency undertakes a feasibility study (FS) to develop and evaluate options for remedial actions. The remedial investigation and feasibility study are collectively referred to as the RI/FS. The various phases of the RI/FS process are described below:

- *Scoping*--- The initial planning phase of the RI/FS, including the preliminary assessment and site investigation.

- *Site characterization*--- Definition of the nature and extent of contamination, identification of applicable or relevant and appropriate requirements (ARARs) and development of the baseline risk assessment (BA).

- *Development and screening of alternatives*--- Identification of potential treatment technologies, screening of these technologies, assembly of the technologies into alternatives, and screening of the alternatives.

- *Detailed analysis of alternatives*--- Further refinement of the alternatives, analysis of the alternatives with respect to nine evaluation criteria (protection of human health and environment, compliance with state and federal requirements, short-term effectiveness, long-term effectiveness, reduction of mobility, toxicity, and volume; implementability, cost, state acceptance, and community acceptance) and comparison of the alternatives against each other.

- *Record of Decision* --- After completing the RI/FS, EPA selects the appropriate cleanup option and publishes it in a public document known as the Record of Decision (ROD).

- *Remedial design* --- The remedial design includes the technical analysis and procedures that follow the selection of a remedy for a site.

- *Remedial action* --- The remedial action involves the actual construction or implementation of a cleanup. If a hazardous substance will remain at the site, a review of the remedial action is required five years after implementation of the remedy. The review evaluates the protectiveness of the remedial action and, for long-term remedial actions, the technology effectiveness and specific performance levels.

One of the most controversial issues at any CERCLA site is the level or degree of cleanup that must be achieved before the site is considered "clean" (Lee, 1997). Questions regarding cleanup standards, cleanup adequacy, and acceptable levels of risk are difficult to answer given that CERCLA provides no explicit language or precise definitions. However, CERCLA does establishes a clear preference for remedies that are permanent and involve treatment of hazardous substances to reduce their volume, toxicity or mobility (CERCLA 1980). CERCLA also sets forth requirements for cleanup and cleanup levels by stating that cleanup levels must be protective of human health and the environment and in accordance with ARARs. Applicable requirements are defined as:

> those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances found at a CERCLA site. Only those State standards that are identified by a State in a timely manner and that are more stringent than Federal requirements may be applicable (CERCLA 1980; NCP 1982).

Relevant and appropriate requirements are defined as:

> those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those State standards that are identified in a timely manner and are more stringent than Federal requirements may be relevant and appropriate (CERCLA 1980; NCP 1982).

Each of the ten EPA Regions is responsible for defining and achieving ARARs. For this reason, uniformity between remediation events is difficult to achieve. Consequently, communities in close proximity to Superfund sites are subjected to varying degrees of exposure, some more, some less. Discrimination occurs when communities of color are subjected to a disproportionately higher degree of exposure than white communities.

When RCRA was first enacted, there was concern as to how to impose the new, more stringent guidelines on older TSD facilities, predominantly located in urban settings. To accommodate these facilities, a grandfathering provision was included in

RCRA. For fear that the older facilities may close due to impeding costs of compliance, they were not required to meet the new RCRA standards. As a result, RCRA allowed older urban facilities to continue operating without being subject to EPA's more rigorous standards and with little or no facility improvements (Shelton, 1997). According to a 1992 study conducted by the National Law Journal, penalties levied by the EPA for RCRA violations were 506% higher in majority white communities than in minority communities (Lavelle and Coyle, 1992). Although the racial discrimination proposed by the 1992 study is disputed, advocates for environmental justice believe that the lack of EPA enforcement provides a disincentive resulting in further RCRA violations (Lavelle and Coyle, 1992). In this way, companies regard the fine as merely a "cost of doing business" rather than a deterrent (Lavelle and Coyle, 1992).

According to the 1992 National Law Journal study, uncontrolled hazardous waste sites in minority communities take 20% longer to be placed on the NPL than abandoned sites in majority white communities (Lavelle and Coyle, 1992). The reasoning behind a site being placed on the NPL is often dependent on community activism and political pressure. Since minority communities frequently have less political influence than others, NPL pleas often go unnoticed (Shelton, 1997). The study also noted that it can take up to 42% longer for NPL site clean-ups in minority communities when compared with NPL sites in majority white communities (Lavelle and Coyle, 1992). Once a NPL site is scheduled for remediation, EPA often chooses the least costly and arguably the least effective methods for clean up such as capping. The Journal found that in minority communities, the EPA was 7% more likely to choose a containment method (Lavelle and

Coyle, 1992) versus remedial action, the most common method used in white communities (Duncan, 1993).

The disproportionate amount of hazardous waste found in minority communities and the failure of government agencies to protect minorities in the face of increasing environmental threats, led to the development of environmental justice, a concept that combines social, political and economic factors. The original environmental movement was begun by grassroots organizations with a desire to preserve the world's wildlife and wilderness. The idea of conserving or preserving land and nature for today and for future generations has come to represent white values that may be inappropriate for poor minority people (Austin and Schill, 1991). Environmental justice bridged the gap between "white" environmental issues and social justice.

The environmental justice movement includes concepts such as environmental racism and fair treatment. Environmental racism is defined as "racial discrimination in environmental policy making, the enforcement of regulations and laws, the deliberate targeting of people of color communities for toxic waste facilities… and the history of excluding people of color from the leadership of the environmental movement" (Willard, 1992). Fair treatment occurs when "no group of people, including a racial, ethnic, or socioeconomic group, bears a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies" (Smith, 2002). The environmental justice movement also acknowledges the "not in my backyard" or NIMBY phenomenon, in which political and economic decisions drive the placement of waste facilities and the disposal of hazardous wastes. The environmental justice movement has heightened global awareness of the struggles by minority communities to avoid the burden of hazardous waste facilities and to cope with the consequences of past contamination (Freeman and Godsil, 1994).

On February 11, 1994, President Clinton issued Executive Order 12898, *Federal Action to Address Environmental Justice in Minority Populations and Low-income Populations* with the intent to incorporate environmental justice into the mission of each federal agency (EO 1994). The Order requires that federal agencies identify and address the effects of their programs, policies and activities on the distribution of environmental impacts on minority and low-income populations (EO 1994). As a result, EPA Region IV developed an *Environmental Justice Strategic Plan* through the Tennessee Department of Environment and Conservation (TDEC). The Strategic Plan envisions that "Tennessee residents will have access to environmental knowledge and be empowered to ensure an equal opportunity to attain a high quality of life...ensure the fair and equitable treatment and empowerment of all Tennessee residents in the implementation of federal and state environmental laws, rules, regulations and policies" (TDEC, 2000). In 2004, the Office of Inspector General issued an evaluation report entitled *EPA Needs to Consistently Implement the Intent of the Executive Order on Environmental Justice.* This report states "EPA has not fully implemented Executive Order 12898 nor consistently integrated environmental justice into its day-to-day operations" (OIG, 2004). Without legislative support, the full intent of EO 12898 may never be recognized.

Arguments over whether environmental inequity is a result of income or racial status are common. To dispel this argument, the United Church of Christ's Commission for Racial Justice (UCC) conducted a study entitled *Toxic Wastes and Race in the United*

States. The Commission concluded that "the racial composition of a community was found to be the single variable best able to explain the existence or nonexistence of commercial hazardous waste facilities in a given community area" (UCC, 1987). In 1990, the University of Michigan held a symposium and published proceedings concluding that although race and income are both significant factors in terms of location of commercial hazardous waste facilities, the effect of race is the "stronger" determinant (Lazarus, 1993). Both the UCC report and the Michigan findings are heavily disputed due to statistical controversy, but other studies indicate that race is independent of class in the distribution of abandoned toxic waste dumps, cleanup of Superfund sites, and lead poisoning in children (Bullard and Johnson, 2000; Lavelle and Coyle, 1992; Pirkle et al., 1994; Stretesky and Hogan, 1998). Regardless of whether communities are discriminated against because of minority status, financial standing, or lack of education and empowerment, minority communities share a larger proportion of environmental risk.

The Environmental Justice movement has had a significant effect on the South Chattanooga Community. The Community has acquired the support of several universities, enabling them to investigate environmental justice issues in the area. A comparison of the South Chattanooga community struggle with other communities in similar situations, illustrates significant differences as well as important similarities. The analysis provides useful information for community members, stakeholders, universities, and government officials, enabling them to learn from past experiences and make conscious decisions to avoid mistakes and repeat successes, thus improving the Superfund cleanup program and the SRI pilot grant projects.

Chattanooga Creek

Chattanooga Creek is part of the middle Tennessee-Chickamauga watershed and lies within three states: Alabama, Georgia, and Tennessee. The watershed receives approximately 53 inches of rain annually, maintains an average temperature of 59.7 degrees Fahrenheit, and has 215 annual frost-free days (EPA, 1999a). Chattanooga Creek originates in Walker County on the eastern slopes of Georgia's Lookout Mountain, 12 miles south of the Tennessee-Georgia state line (TVA, 1959). The Creek then flows northwards for 26 miles emptying into the Tennessee River at mile 460.7 (Milligan et al., 1981), just downstream of downtown Chattanooga, and above Nickajack Lake. The Creek has a 75 square mile watershed, of which 20% falls within Tennessee (Tinker et al., 1995). The depth of the Creek ranges between 3 inches to 4 feet and has an average slope of 1.5 feet per mile (EPA, 1999a).

The Creek has an annual flow of 100 cubic feet per second and maintains an average temperature of 55 degrees Fahrenheit. Chattanooga Creek has a 100-year floodplain that ranges between a few feet to 2,000 feet wide in areas and has experienced numerous flooding events (TVA, 1959) (Figure 1). Much of the Chattanooga Creek watershed lies within the highly developed urban area of South Chattanooga.

Flooding

Much of the Chattanooga Creek watershed north of the Georgia state line is highly developed. The floodplain of Chattanooga Creek is located in an urban industrial residential area of South Chattanooga in Hamilton County, Tennessee. The Chattanooga Creek watershed includes a 2.5 mile stretch of creek near the Piney Woods and Alton

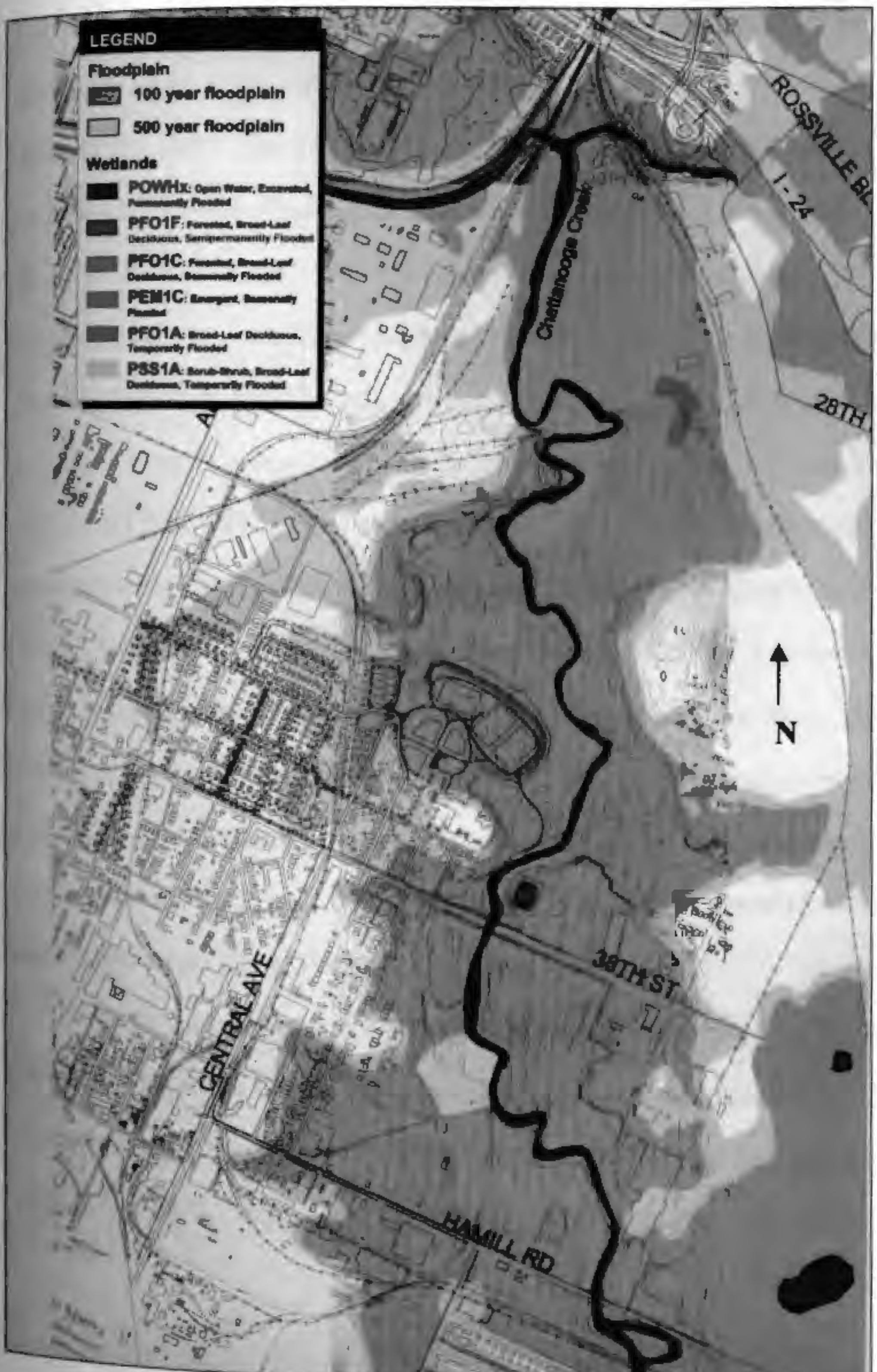

Figure 1. Depiction of the Chattanooga Creek Floodplain (TPL 2002).

The floodplain is affected by both headwater floods resulting from heavy rainfall in the watershed of the creek and by backwater overflow from floods on the Tennessee River (TVA, 1959). Since a 1950 stream gage installation, Chattanooga Creek has experienced headwater floods exceeding bankfull stage of 7.5 feet on an average of four times a year (TVA, 1959). The most serious flooding resulting from backwaters occurs during high floods on the Tennessee River. This backwater begins to overflow the low banks in the vicinity of 38th Street at river stages of about 20 feet. By a river stage of 30 feet, the backwater in the Creek inundates about 900 acres along the stream within the city limits (TVA, 1959). Since 1951, two significant backwater flooding events have occurred on the Tennessee River, both resulting in backwater flooding of Chattanooga Creek. In February 1973, the Tennessee River crested at 36.9 feet, a modern record, while on May 5, 2003, the River reached 36 feet, 6 feet above flood stage. The May 2003 event resulted in backwater flooding of Chattanooga Creek that covered over two miles of South Chattanooga (Figure 2). Before 1959, the largest known headwater flood on Chattanooga Creek occurred on March 29, 1951 at a flood stage of 12.9 feet (5.4 feet above flood stage) (TVA, 1959).

Of the land subjected to flooding within the city of Chattanooga, over three-fourths lies within the Chattanooga Creek floodplain. Industrial, commercial and residential construction in the Chattanooga Creek valley has been on a steady rise since 1959 (TVA, 1959). In 1959, much of the city's existing industry was located in this area

and the Tennessee Valley Authority (TVA) noted that "its [Chattanooga Creek floodplain] protection is therefore of great importance" (TVA, 1959).

Relocation

During the late 1950s and early 1960s, the city of Chattanooga began an Urban Renewal Project. The project incorporated the construction of Interstate 24 which would require the removal of 500-600 families within the district (Anonymous, 1956). Another source reported a total of 2,700 families (67% African-American) in the freeway right of way on the West Side of Chattanooga in need of relocation (Gibson, 1957). In response, the City purchased inexpensive land in the heavily industrialized South Chattanooga area and built several public housing projects. By 1962, the Chattanooga Housing Authority (CHA) had acquired "1,040 parcels of land, moved 1,438 families and 119 business establishments, demolished 1,190 structures and moved seven million cubic yards of dirt" (Chester, 1962). By 1963, Interstate 24 construction was complete.

Between 1954 and 1956, the CHA built McCallie homes. In 1961, Maurice Poss Homes was under construction and Emma Wheeler was opened for the elderly. Many of these housing projects, as well as schools, recreation centers, and daycare facilities were located near Chattanooga Creek, well within the 100-year floodplain. No remedial investigation of the area was performed prior to construction to determine possible safety and exposure hazards, despite the high potential for exposure.

The Urban Renewal Project required the clearing of 340-acres of "slums and blight" for redevelopment (Anonymous, 1959). The project also focused on relocating predominantly "low income Negro families" (Peck, 1959). As a result, industrialized

South Chattanooga became home to an overwhelming abundance of low-income minorities.

Tennessee Products Plant

Chattanooga Creek has been an industrial dumping ground for over 100 years. Beginning in the late 1800's, a large number of industries discharged untreated waste into the creek (ATSDR, 1999a). The contributors included: industries manufacturing organic chemicals, metallurgical and foundry operations, wood preserving plants, tanning and leather mills, textile plants, pharmaceutical companies, and brick-making plants. One of the main industries linked to extensive creek contamination was the coal carbonization industry.

In 1918, a coal carbonization facility was built at 4800 Central Avenue with the main purpose of coking coal. Coking or coal carbonization is a process by which gases are removed from coal by intense heating, changing the coal to coke. The destructive distillation of coal produces 80% coke, 12% coke-oven gases, 3% coal tar (containing 50-85% pitch, naphthalenes, creosotes, anthracenes, other PAHs, cyanide, and mercury (EPA, 1999a)), and 1% light oils (such as benzene, toluene, and xylene). One ton of coal produces 1200-1500 pounds of coke and 70-120 pounds of coal tar (EPA, 2002a). Coal tar consists of an estimated 10,000 compounds including single ring aromatics (light oils), PAHs, acidic compounds (phenols), basic compounds (nitrogen), and sulfur heterocyclics (Enzminger and Ahlert, 1987). Coal tar is one of the leading contaminants at gasworks sites (Brown et al., 1999; Various, 1991). The coke plant is located less than one mile west of the creek (EPA, 1999a) and a majority of the site acreage is situated within or adjacent to the floodplain (Figure 3) (EPA, 2002a).

The plant had many owners between 1918 and 1987, including the United States Department of Defense during World War II and the Mead Corporation (1964-1974). The coking facility doubled its production of coke, and subsequently its discharge of coal tar, during the U.S. Department of Defense ownership. Tennessee Products (TP) owned the site the longest from 1926-1964, which is why the coke plant is referred to as the TP site. There was unknown waste management for 69 years, with both offsite and onsite disposal.

Runoff and waste disposal from the TP site has been documented entering Chattanooga Creek as early as 1935 (EPA, 2002a). Contaminated runoff entered Chattanooga Creek through three different routes. First, facility runoff was routed towards an on-site API separator, used to separate oil from water, which emptied into the sewer system. The sewer system discharged into Chattanooga Creek, just upstream of the Hamill Street Bridge. EPA documents suggest that the sewer existed from at least 1944 and was later abandoned at an unspecified time decades later (EPA, 1999b; EPA, 2002a). A recent geophysical survey indicated that the sewer line still exists (EPA, 1999b). Second, if and when the API separator overflowed, runoff flowed into a ditch, located along the eastern boundary of the property, which flowed into the Northeast Tributary. Finally, runoff from the northwestern section of the facility reached the Northwest Tributary through on-site underground culverts (EPA, 1999b). The tributaries flowed from the TP site and discharged into Chattanooga Creek, 1,800 feet downstream of the intersection with the Hamill Road Bridge. The contaminated surface water

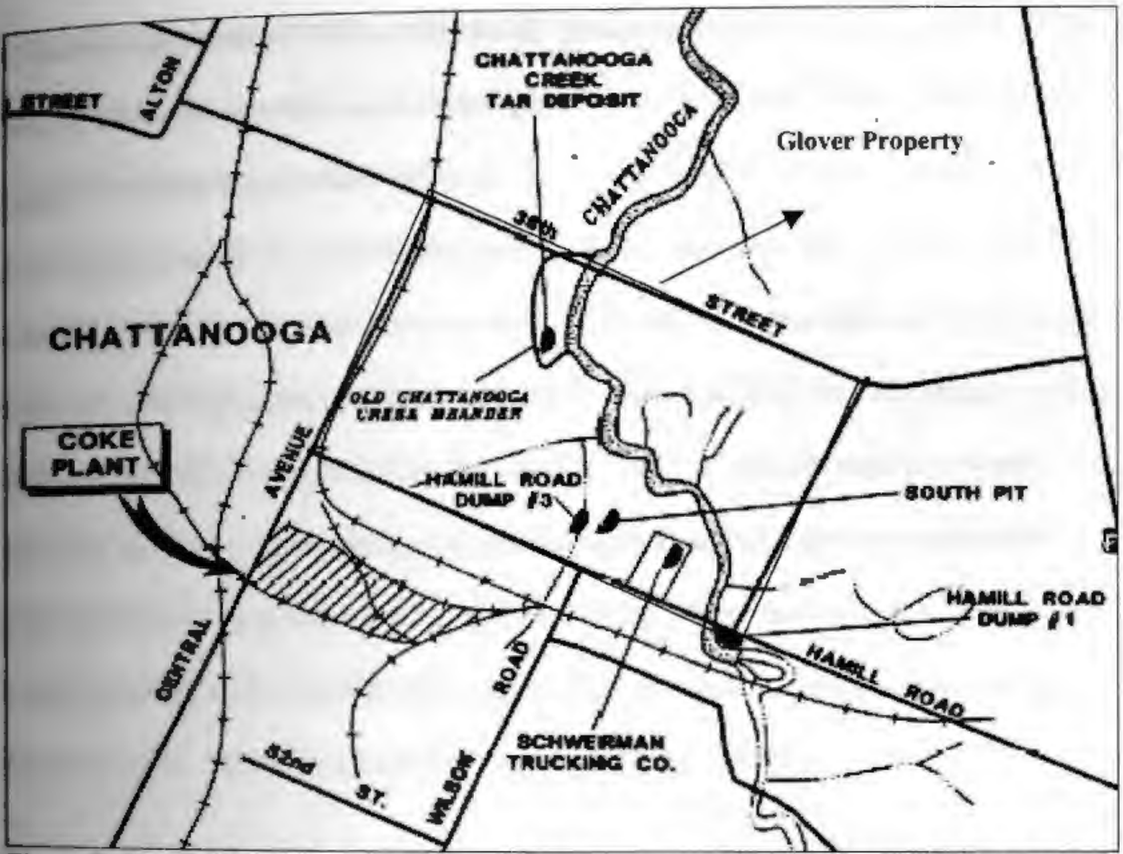

Figure 3. Map of South Chattanooga areas of concern. Areas of concern include the Coke Plant, Chattanooga Creek, Glover Property (site of EPA Phase I removal action), and numerous coal tar waste mounds, most notably the Chattanooga Creek Coal Tar Deposit (EPA, 1999b).

contained high levels of PAHs, phenols, oil, grease, ammonia, and metals (EPA, 2002a). The TP plant also injected wastes from light oil washer columns into abandoned water supply wells between the late 1960's and early 1970's (EPA, 1999a). Between 1935 and 1994, approximately 23 aerial photographs of the TP site were taken. Photo analysis identified suspected disposal areas, staining, tanks, debris, impoundments, coal storage areas, open storage areas, containers, drums, mounded material, and discharges to surface drainage pathways throughout the TP site (EPA, 2002a). The photographs clearly confirm coal storage, processing, and loading areas along with dark staining on the ground located throughout the TP site (EPA, 2002a). From this evidence, EPA concluded that the pollution of the Creek and the surrounding floodplain was mainly attributed to the industrial waste from the TP site (EPA, 1999b).

Polycyclic Aromatic Hydrocarbons (PAHs)

There are over 100 different polycyclic aromatic hydrocarbons (Mehlman et al., 2002; NRC, 1983a). PAHs are formed during the incomplete combustion of coal, oil, gas, and other organic substances. Since incomplete burning is a major source of PAHs in soils, soil PAH concentrations have risen over the last 100-150 years, especially in urban areas (Boström et al., 2002; Menzie et al., 1992). Generally, PAHs have low water solubility causing emitted PAHs to adhere to solid particles and settle at the bottom of a water body or adhere tightly to soil particles (Villholth, 1999). The strong adsorption of PAHs to soil particles, colloids, or soluble organic material can also contribute to transport during flooding events (Gocht et al., 2001; McKay et al., 2003; Petty et al., 1998; Witt and Siegel, 2000; Witter et al., 2003).

The physiochemical properties of PAHs such as molecular weight, water solubility, vapor pressure, Henry's law constant, octanol-water partition coefficient (K_{ow}), and organic carbon partition coefficient (K_{oc}), commonly dictate the transportation and partitioning of PAHs in the environment. Some characteristics of PAHs such as the Henry's law constant and the K_{oc} and K_{ow} values can be roughly correlated to molecular weight. PAHs having molecular weights in the range of 228-278 g/mol, such as benzo[a]pyrene, chrysene and indeno[1,2,3-c,d]pyrene, all demonstrate similar transportation and partitioning characteristics. As PAH molecular weight increases, solubility, volatility, and biodegradability decrease (Brown et al., 1999). Environmental factors such as temperature, pH, oxygen concentration, soil type, and moisture also influence the rate of soil PAH degradation in soil (Mehlman et al., 2002).

Humans are exposed to PAHs primarily through respiratory and gastrointestinal routes (NRC, 1983b), although dermal exposure at hazardous waste sites is likely to be the primary route of exposure (LaGoy and Quirk, 1994). PAHs are generally lipophilic resulting in the potential for human bioaccumulation. PAHs enter the body and may be stored in any fat containing tissue, especially the kidney and liver.

PAHs are divided into two groups: carcinogenic and noncarcinogenic. A carcinogenic chemicals is defined as any "agent whose administration to previously untreated animals leads to a statistically significant increased incidence of neoplasms of one ore more histogenetic types as compared with the incidence in appropriate untreated animals" (Pitot, 1986). The EPA considers a chemical to elicit carcinogenic effects when essentially any exposure to such a chemical will produce a "finite probability of generating a carcinogenic response" (EPA, 2002a). Chemicals exhibiting noncarcinogenic effects must overcome protective mechanisms (i.e., exposure or dose thresholds) before an adverse effect is displayed (EPA, 2002a).

EPA classifies chemicals into five categories based on their carcinogenicity: A, B (B1 and B2), C, D, and E. Group A chemicals are scientifically determined to be human carcinogens. Chemicals placed into group B are probable human carcinogens, B1 chemicals have limited data available for human response and B2 chemicals have sufficient data for animal response but inadequate or no evidence of human response. Group C chemicals are possible human carcinogens. Chemicals placed in group D are not classifiable and group E chemicals show evidence of noncarcinogenicity in humans (EPA, 2002a).

PAHs composed of four or more benzene rings (Figure 4) are carcinogenic to animals (Mehlman et al., 2002). Human studies have shown that persons exposed to PAHs via inhalation or dermal contact to PAH mixtures (i.e. coal tar) can develop cancer (ATSDR, 1995a). The most common types of cancer attributed to PAH exposure are epithelial, endothelial, smooth muscle cell, and pulmonary. Among the most toxic and best studied carcinogenic PAH is benzo[a]pyrene (BaP), a Group B2 chemical.

Hazardous wastes sites have been documented to be concentrated sources of PAHs on a local level (ATSDR, 1995a; Enzminger and Ahlert, 1987; LaGoy and Quirk, 1994). Of the 1,408 bazardous wastes sites proposed for NPL inclusion, at least 600 of them have documented PAH contamination (HazDat, 1994). Additional studies have also indicated significantly elevated concentrations of PAHs at contaminated sites (ATSDR, 1995a; Brown et al., 1999) including coking plants (Brown et al., 1999).

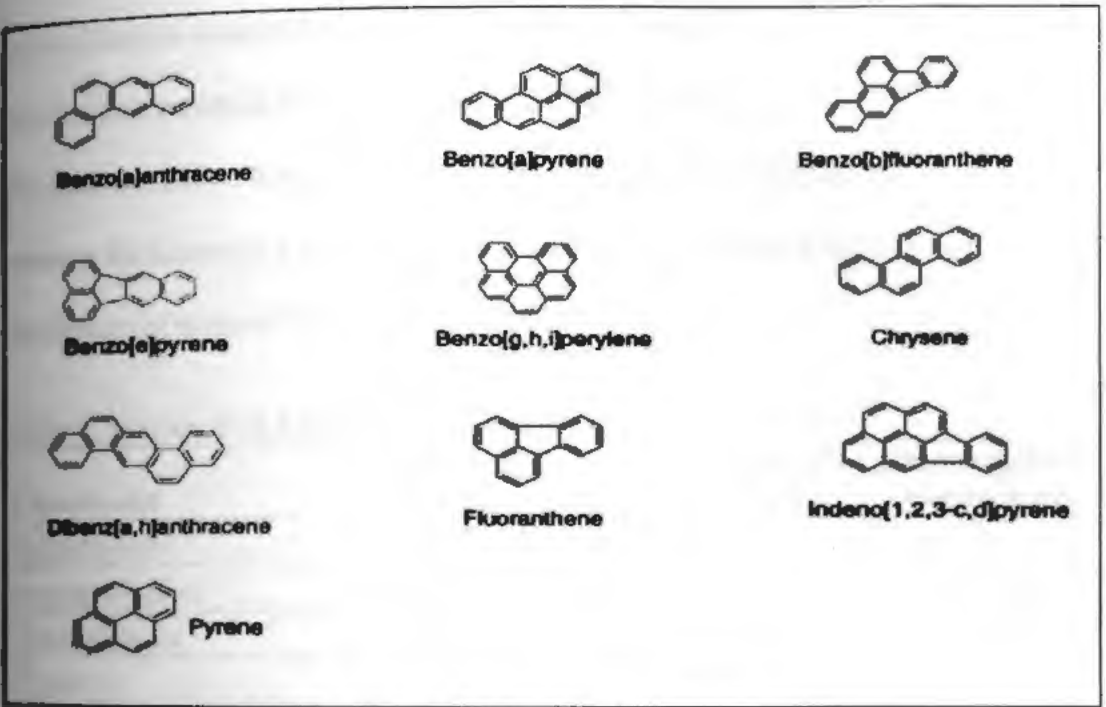

Figure 4. Common PAHs composed of four or more rings.

The EPA has identified 16 PAH compounds as pollutants that are hazardous organic chemicals present in an environmental setting. Selected PAHs are indicators of environmental contamination and are designated by EPA as priority pollutants (listed in Table 1). In order to identify the array of health effects that may be caused by exposure to PAHs, several factors must be considered. The factors include dose received, duration and frequency of exposure, route and site of exposure (ingestion, inhalation, injection, dermal, and absorption), and chemical interaction (additive, synergistic, potentiation, and antagonistic).

Methods to Evaluate PAH Toxicity and Health Risk

Due to concerns that PAHs may cause health effects, government agencies establish guidelines, standards and other regulations to quantify PAH exposure. One method used to assess the health risk attributed to PAH contamination is to calculate the carcinogenic potential of each carcinogenic PAH (cPAH) present at NPL sites (Nisbet and LaGoy, 1992). The toxicity equivalency factor (TEF) methodology was developed to estimate the hazard of a mixture of structurally related chemicals with a common mechanism of action (Chun-The et al., 2003).

Table 1. Sixteen EPA PAH Priority Pollutants (Enzminger 1987).

Constituent	Molecular Weight	Log Kow	Solubility (ppb)	Carcinogenicity Class (IRIS)
Naphthalene	128	3.00-4.00	31,700	C
Acenaphthalene	152	4.07	0	Not Rated
Acenaphthene	154	3.92-5.07	3,930	D
Fluorene	166	4.18	1,980	D
Phenanthrene	178	4.45	1,290	D
Anthracene	178	4.46-4.76	73	D
Fluoranthene	202	4.9	260	D
Pyrene	202	4.9	135	D
Benzo(a)anthracene	228	5.61-5.70	14	B2
Chrysene	228	5.91	2	B2
Benzo(a)pyrene	252	6.50	4	B2
Benzo(b)fluoranthene	252	6.12	1.2	B2
Benzo(k)fluoranthene	252	6.84	0.76	B2
Benzo(g,h,i)perylene	276	7.1	0.26	D
Indeno(1,2,3-cd)pyrene	276	6.58	62	B2
Dibenz(a,h)anthracene	278	5.80-6.50	0.50	B2

Using the assigned TEF values, concentrations of cPAHs can be converted to an equivalent concentration of BaP in order to assess risk associated with PAH mixtures (EPA, 1993a). The TEF values are an estimate of the relative toxicity of a chemical compared to a reference chemical. BaP was chosen as the reference chemical for PAHs because of its well-characterized toxic effects. Known TEF values are shown in Table 2.

Table 2. Toxic Equivalency Factors for PAHs (EPA 2000).

PAHs	TEF
Benzo(a)pyrene	1.0
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Chrysene	0.001
Dibenz(a,h)anthracene	1.0
Indeno(1,2,3-cd)pyrene	0.1

The concentration of each cPAH found in a sample is multiplied by its corresponding TEF value and the sum of the products is said to be the BaP equivalent or toxicity equivalent concentration (TEC) (ATSDR, 1995a). The BaP equivalent is compared to the applicable cleanup level for the reference chemical (BaP). The BaP equivalencies are summed to obtain the total amount of risk attributed to all cPAHs present on-site (TTEC) (EPA, 1993a). The EPA cautions that only "estimated orders of potential potency" can be calculated because a lack of knowledge regarding PAH toxicity and minimal information about PAH interactions limits PAH TEF development (Reeves et al., 2001).

Preliminary Remediation Goals (PRGs) are used as EPA guidelines for evaluating and remediating contaminated sites. PRGs are risk-based concentrations intended to assist in initial screening-level evaluations of environmental measurements. PRGs are remediation goals that protect human health and the environment and comply with ARARs (EPA, 1991). PRGs are not legally enforceable standards. PRGs are used solely for site "screening" and as initial cleanup goals for potential site reuse if applicable. If cleanup does not meet the PRGs then, according to the EPA, the information will be highlighted in any presentation of the results of the detailed analysis (EPA, 1991). EPA PRG values vary between regions and should be modified as more information becomes available during the RI/FS (NCP 1982). EPA Region IV recommends the PRGs presented in Tables 3 and 4 for use in Tennessee (EPA, 2004d). The PRGs were developed by EPA Region IX.

Table 3. EPA Region IX PRG Values for Residential Soil (EPA 2004d).

Contaminant	Soil-inhale (mg/kg)	Soil-dermal (mg/kg)	Soil-ingest (mg/kg)	Combined (mg/kg)
Benzo[a]pyrene	1.2E+03	2.1E-01	8.8E-01	6.2E-01
Dibenz[a,h]anthracene	1.2E+03	2.1E-01	8.8E-01	6.2E-01
Benz[a]anthracene	1.2E+04	2.1E+00	8.8E-02	6.2E-02
Benz[b]fluoranthene	1.2E+04	2.1E+00	8.8E-02	6.2E-02
Indeno[1,2,3-cd]pyrene	1.2E+04	2.1E+00	8.8E-01	6.2E-01

Table 4. EPA Region IX PRG Values for Industrial Soil (EPA 2004d).

Contaminant	Soil-inhale (mg/kg)	Soil-dermal (mg/kg)	Soil-ingest (mg/kg)	Combined (mg/kg)
Benzo[a]pyrene	2.6E+03	4.6E-01	3.9E-01	2.1E-01
Dibenz[a,h]anthracene	2.6E+03	4.6E-01	3.9E-01	2.1E-01
Benz[a]anthracene	2.6E+04	4.6E+00	3.9E+00	2.1E+00
Benz[b]fluoranthene	2.6E+04	4.6E+00	3.9E+00	2.1E+00
Indeno[1,2,3-cd]pyrene	2.6E+04	4.6E+00	3.9E+00	2.1E+00

The EPA also uses Reference Doses (RfDs) and a Hazard Index (HI) to assess risk. The RfDs are estimates of human lifetime daily exposure levels that are used to indicate the potential for adverse health effects from exposure to contaminant(s) of concern that exhibit noncarcinogenic effects (EPA, 1993a). RfDs (expressed in mg/kg-day) represent a level that an individual may be exposed to that is not expected to cause any harmful effect (EPA, 2002a). The estimated intake of contaminant(s) of concern from environmental media are compared to the RfD (EPA, 1993a). The ratio of the calculated intake versus the acceptable intake is the HI. A HI of 1.0 or more shows an intake greater than the acceptable level and indicates the need for remedial action (EPA, 1993a).

Federal agencies use a variety of comparison values for public health assessment when looking at risks associated with soil contamination. The Environmental Media Evaluation Guide (EMEG), Cancer Risk Evaluation Guide (CREG) and the Reference Dose Media Evaluation Guide (RMEG) are three of the guides used by ATSDR. The EMEGs are estimated comparison concentrations that are based on health effects information collected by ATSDR for its Toxicological Profiles for specific chemicals (ATSDR, 1995b). The CREGs are estimated concentrations for specific chemicals that are associated with cancer rates in excess of one in a million persons and are calculated using EPA's cancer slope factors (SFs) (ATSDR, 1995b). Finally, the RMEG comparison concentration values are based on EPA's estimate of the daily dose below which exposure to a contaminant is unlikely to cause adverse noncarcinogenic health effects (ATSDR, 1995b).

EPA's Carcinogenic Risk Assessment Verification Endeavor developed the SFs as a means of estimating excess lifetime cancer risks associated with exposure to potentially carcinogenic chemicals (EPA, 1992a). SFs, expressed as mg/kg-day, are multiplied by the estimated intake of a potential carcinogen to generate an "upper-bound" estimate of the excess lifetime cancer risk related to exposure to the compound at that intake level (EPA, 1992a). The "upper-bound" estimate represents a conservative estimate of the risks calculated from the SF (EPA, 1992a). The acceptable risk range is from 10^{-4} to 10^{-6}, indicating that an individual has a risk of no greater than one in ten thousand to one in a million chance of developing cancer as a result of site-related exposure to a carcinogen over a 70-year period (EPA, 1992a).

The interaction between PAHs found in coal tar is, perhaps, too complex for simple ranking systems such as TEFs and PRGs. Because mixture specific toxicity data is often not available, especially with regards to carcinogenicity (Reeves et al., 2001), accurate risk is difficult to determine. The process is also complicated by several findings that weak or noncarcinogenic PAHs present in such mixtures can act as either cocarcinogens or inhibitors of carcinogenic activity (Mahadevan et al., 2004).

III. Case Study: South Chattanooga and the Chattanooga Creek Floodplain

Case studies provide information about today that can be applied to hypothetical situations of tomorrow. The case study provides the most flexibility of all research designs (Hakim, 1987). However, finding a solid definition of a case study is difficult. Robert Yin claims that a case study is an "empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used" (Yin, 1984). Joe Feagin, Orem *et al.* provide a different definition; a case study is "an in-depth, multifaceted investigation, using qualitative research methods, of a single social phenomenon. The study is conducted in great detail and often relies on the use of several data sources" (Feagin et al., 1991). Randy Stoecker considers case studies to be "studies of any individual persons, organizations, communities, or societies" (Stoecker, 1991). Whichever definition is applied, the case study is a useful tool for understanding the complexity of human behavior in a wide range of situations, over a varied period of time, using a variety of data collection techniques.

According to Colin Jones and Christina Lyons, the case study "has the potential to reveal multiple dimensions of any one given 'case', or indeed, groups of cases…[c]ase study approaches frequently involve asking multiple research questions, or questions with a number of previously unexplored dimensions" (Jones and Lyons, 2004). Properly structured, a case study can provide invaluable information regarding social structure and social action in natural settings, provide information from a number of sources over a period of time, deliver the scope of time and history to the study of social life, and encourage and facilitate theoretical innovation and generalization (Feagin et al., 1991).

Therefore, case studies provide a framework within which, the boundaries of information gathering is determined (Stoecker, 1991). The case study method is the equivalent of a camera; wherein the significance of the study is determined by its focus (Stoecker, 1991).

A case study is not limited by qualitative or quantitative data, but can incorporate both, thereby testing hypotheses regardless of the method of gathering information. The findings can then be used to provide generalizations, which can be used in future settings. A completed case study is therefore, an experiment performed in a real-life, present-day setting.

The case study method can simulate the way people know and understand everyday life. In doing so, case studies provide comprehensive results and "how-to" information that can be emulated in the future (Wilson, 1979). For the purpose of this thesis, the community case study method is employed. The community case study is research of a local community that seeks to describe and analyze the relationships between politics, work, leisure, and community activities (Hakim, 1987). Noted relationships may be analyzed for any underlying patterns. The relationships and patterns can be compared with other communities.

South Chattanooga is comprised of a number of communities including Alton Park, St. Elmo, and Clifton Hills. Alton Park and Piney Woods are the main focus of this thesis. The communities of Alton Park and Piney Woods (Census Tract 19) comprise 2.7 square miles and, in 2000, were home to 4,171 residents. In 1985, land use in the area was 18.7% residential, 15.4% industrial, 3.7% commercial, 0.2% agricultural, and 62.0% undeveloped (EPA, 1999a). In 2000, 95% of the residents were African American and 40% of the total population was under the age of 20. The Chattanooga Metropolitan

Statistical Area (MSA) had a median household income of $50,000 in 2000 while Census Tract 19 had a median household income of less than $13,000 (TPL, 2002). The statistics support the South Chattanooga environmental justice designation, identifying the Alton Park/Piney Woods community as a predominantly low-income, high minority section of Chattanooga.

Howard School of Academics and Technology (Howard School), located on Market Street, lies near mile 2.3 of Chattanooga Creek and is approximately 2 miles north of the TP site. Built between 1951 and 1952, Howard School has experienced numerous flooding events. In January 1954, the Gymnasium basement was slightly flooded when backwater reached 29.8 feet and in February 1957, floodwater was 28 inches deep on the basement floor. There has been documentation of students at Howard School developing rashes and skin problems after contact with floodwaters (Kennedy, 2003). Alton Park Middle School is located about 0.75 miles northeast of TP and is adjacent to Chattanooga Creek. Chattanooga Christian School is located approximately 1.5 miles northwest of TP, Calvin Donelson Elementary School is located approximately one mile north of TP, and the Alton Park Recreation Center is located about 0.2 miles north of TP and has children's playground facilities (EPA, 1999a) (Figure 5). Currently, 42 hazardous waste sites have been located around Chattanooga Creek, 13 are state Superfund sites (Tinker et al., 1995), and many are still uncharacterized. The fact that the communities and schools lie within the Creek's floodplain and that much of the 62% undeveloped space is zoned as "industrial" (EPA, 1999a), raises questions regarding community health and safety.

Figure 5. Map of South Chattanooga areas of interest. Courtesy of EPA Enviromapper.

In response to multiple concerns, federal and state government agencies began looking into the environmental problems of Chattanooga Creek and the TP site. In 1973 and 1977, EPA conducted two studies on Chattanooga Creek. Major sources of contamination were identified and Chattanooga Creek surface water and wastewater discharges were characterized (EPA, 1999a). Throughout the 1970's, the Tennessee Division of Water Quality Control (TDWQC) issued numerous National Pollutant Discharge Elimination System (NPDES) permits to surrounding industries, but Georgia's Environmental Protection Division found that water quality throughout the Chattanooga Creek watershed had deteriorated since a 1969 water quality study (Georgia, 1976). The Tennessee Valley Authority (TVA) listed Chattanooga Creek as a "critically polluted stream" in 1978 (Ashford et al., 1999). In 1981, TVA released findings from a 1980 project that studied the occurrence and distribution of toxic pollutants in Chattanooga Creek. TVA concluded that Chattanooga Creek sediments and, to a lesser degree the water, were heavily contaminated with toxic PAH priority pollutants. The sediment contamination was predominately PAHs and metals, while the water contained mostly aromatic and aliphatic hydrocarbons (Milligan et al., 1981). Unfortunately, none of these studies sampled the 100-year floodplain surrounding the creek.

By 1990, EPA began a series of studies in Chattanooga Creek to assess the nature of improvements since 1983. A water quality and sediment study was completed in 1990. Results of the study indicated that PAHs were still present. After concluding that no significant improvements had occurred, EPA began a comprehensive cleanup effort of Chattanooga Creek in 1991. In 1992, EPA prepared a Sediment Profile Study Report. The report illustrated that the section of the Creek from Hamill Road Bridge downstream was heavily contaminated with coal tar derivatives. As part of the remediation, 14,500 cubic yards of material from the creek bed needed to be removed (EPA, 1999a).

In 1993, a long-time resident of South Chattanooga, along with the grassroots organization Stop Toxic Pollution (S.T.O.P) and other South Chattanooga community members, petitioned ATSDR for a Public Health Advisory for Chattanooga Creek. Subsequently, ATSDR issued the advisory and carried out a Health Assessment that concluded, "the presence of the coal tar in and around the creek poses a health and safety hazard" (TDHE, 1999). ATSDR recommended that nearby residents be separated from the coal tar deposits; that site characterization studies needed to continue; that the site might need to be included on the NPL and that appropriate EPA statutory or regulatory authority might be used to take necessary actions (ATSDR, 1993). ATSDR also initiated a series of public education programs, including a project with local school children (Ashford et al., 1999).

By 1994, the TP site and Chattanooga Creek were formally proposed for inclusion on the NPL and were officially listed on September 29, 1995 (EPA, 2002a). On November 16, 1996, the U.S. Court of Appeals for the D.C. Circuit, in *Mead Corporation v. Browner*, 100 F.3d 152, removed the TP site from the NPL due to aggregation issues (EPA, 2002a). The Court reasoned the TP site would not qualify as a high-risk site and therefore, EPA should not combine high-risk (Chattanooga Creek) and low-risk (TP) sites and designating the entirety high-risk. As a result, all that remained on the NPL was the 2.5-mile stretch of Chattanooga Creek.

Cleanup of Chattanooga Creek area started as early as 1985. Approximately 1,000 tons of waste and contaminated soil from Hamill Road Dump 3 was excavated and removed by EPA during the summer of 1985. Under the oversight of TDEC, the Southern Railway cleared and capped the Hamill Road Dump 1 in the fall of 1986. In October of 1993, EPA's Emergency Response and Removal Branch fenced off a coal tar deposit area south of the Alton Park Middle School in order to minimize and prevent access. The Mead Corporation, a former TP plant operator between 1968 and 1974, demolished site structures and repaired and replaced existing fences and gates from July-December 1994. Finally, between June 1997 and December 1998, the United States Army Corps of Engineers (through an Interagency Agreement with EPA Region IV to provide technical assistance for the RI/FS) performed a Removal Action on a 2.5-mile section of Chattanooga Creek from 800 feet downstream of Hamill Road Bridge to 1,350 feet downstream of E. 38th Street Bridge (Figure 6). The Corps also remediated several coal tar pits and coal tar waste mounds (also noted on Figure 6) (EPA, 1999a). Currently, a Phase II Removal Action is planned and will focus on contaminated sediment between the 38th Street Bridge and Dobbs Branch (EPA, 2002a), downstream of the Phase I area. Despite the past and current removal efforts, there is still ongoing concern regarding the quality of Chattanooga Creek and the surrounding floodplain.

In July of 2000, the EPA awarded the City of Chattanooga, Tennessee, a SRI pilot Grant to design a reuse plan for Chattanooga Creek and make it an accessible and usable recreational site. The goals of the SRI grant are to draw people back to the South Chattanooga neighborhoods such as Alton Park and Piney Woods, ultimately increasing property values and reversing the decline of the neighborhoods. A reuse plan for both the 2.5-mile stretch of Chattanooga Creek and the 24-acre TP site was developed by involving landowners, local government, neighborhood groups and other community

Figure 6. Locations of the TP site and other areas of remedial activity (EPA, 1999b).

stakeholders (TPL, 2002). The Chattanooga-Hamilton County Air Pollution Control Bureau contracted the Trust for Public Land (TPL) to implement the grant and identify recreational and commercial use options for the Superfund site. The $100,000 award would be then be used to enact the proposed reuse option(s) (EPA, 2000a).

Several other plans were in action and were considered during the SRI planning period. The Chattanooga Creek Greenway Master Plan, the Alton Park Master Plan, Recreate 2008!, the HOPE VI Master Plan, and the Chattanooga Urban Area Bicycle Facilities Master Plan[1] suggested that the best use for Chattanooga Creek would be to provide greenway space. The plans, as well as insight from the local communities, supported the idea that the land adjacent to the 2.5-mile Chattanooga Creek Superfund site should be developed into a park and greenway from behind Howard High School to Hamill Road (TPL, 2002). The park would incorporate features such as: a trail suitable for walking, running, and bike riding; parking; benches, picnic tables and covered pavilions; bridges at strategic places to take the trail across the creek; an outdoor amphitheater or music venue (with electric hook-up); a playground; bike racks; and ramps for launcbing canoes (TPL, 2002). The plan would create a greenway that would link Alton Park, Piney Woods, Clifton Hills, and the Southside Gardens neighborhoods to the Creek and to one another. The greenway and park would offer recreational [illegible]ities supporting a fitness-oriented community by making the trails accessible to residents of all ages. The greenway would run the entire length of the current Superfund

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2. [illegible] Creek Greenway Master Plan- Instigated the Greenway idea by mapping out proposed trails and bridges.

3. [illegible] Plan- A revitalized neighborhood plan that incorporated the completed Safewalk connecting St. Elmo to the McCallie Homes. It also suggested the idea of [illegible] development to include Chattanooga Creek.

4. [illegible] A City of Chattanooga comprehensive parks and facilities plan. The plan incorporates many improvements for South Chattanooga such as increased and [illegible] in the area and listing potential regional park sites in the area including Chattanooga Creek.

5. [illegible] VI- Lists physically linked greenways from neighborhoods to Chattanooga Creek and incorporates open spaces and parks to entice new residential development.

6. [illegible] Urban Area Bicycle Facilities Master Plan- Proposes new bike and pedestrian routes through neighborhoods to provide alternative transportation and promote [illegible] and recreational activities.

and provide an alternative transportation corridor as well as enhance the redevelopment of residential property (TPL, 2002). By building a greenway, the SRI grant criteria would be met and South Chattanooga revitalization would be encouraged.

In response to the TPL proposal, community members raised concern regarding the safety of the remediated 2.5-mile stretch of Chattanooga Creek. Despite EPA efforts to remove serious risks to human health in the Creek, the proposal of incorporating a pedestrian greenway and associated picnicking and playground areas raised the issue of whether the 100-year floodplain surrounding the creek was safe enough for this type of reuse. The community members requested an EPA grant to fund a project to detect and assess PAH contamination in the floodplain. More specifically, the question regarding whether the surrounding areas adjacent to the cleaned portion of Chattanooga Creek were safe enough to support recreational use, as proposed by the TPL, would need to be addressed through soil sample collection and scientific analysis. The results of the study would provide information to facilitate informed agency decisions regarding the safety of placing a high-use recreational area in the Chattanooga Creek floodplain as well as provide answers to community members.

Chattanooga Creek Hazardous Substance Monitoring Program

Since neither EPA nor the state of Tennessee monitored the Chattanooga Creek floodplain for priority pollutants since the completion of the Phase I cleanup, except for several surface soil samples taken by TDEC from the floodplain of the cleaned section of the Creek (Tucker et al., 2002), public safety was of major concern. Another concern was EPA use of "visual confirmation" to verify the success of the Chattanooga Creek

Phase I removal action (EPA, 1999a). As a result, the community felt that a greenway and park might not be the safest alternative for the Glover Property (the floodplain property between Hamill and 38th, which was the location of the Phase I removal action.)

To help answer the questions posed by the community regarding Chattanooga Creek floodplain safety, the Biological and Environmental Sciences Department at the University of Tennessee at Chattanooga (UTC), in conjunction with the Center for the Management, Utilization, and Protection of Water Resources at Tennessee Technological University (TTU) and the local environmental justice community organization Stop Toxic Pollution (STOP), submitted a grant to the U.S. EPA Region IV Environmental Justice Office. The *Chattanooga Creek Hazardous Substance Monitoring Program* (CCHSMP) project was granted in September of 2002 (Tucker et al., 2002). The project's goals were to identify and quantify hazardous PAHs in the floodplain soils of Chattanooga Creek. The information would then be disseminated to the communities through public meetings. The objective being to provide community members, government, and other persons the information necessary to make knowledgeable, informed decisions about whether levels of hazardous substances in Chattanooga Creek water and floodplain soils could safely support recreational use.

Materials and Methods

Training

Sampling could not progress on a designated State Superfund site without personnel being certified via the Hazardous Waste Operations and Emergency Response (HAZWOPER) training process. The 40- hour class, taught at Chattanooga State

Community College, was completed by Maya Belka and the HAZWOPER certification was obtained in March 2003. Through the 8-hour HAZWOPER re-certification class, also taught at Chattanooga State, a re-certification was obtained in April 2004.

Soil Sample Design

Using the TPL proposed greenway path (TPL, 2002) (Figure 7) for probable greenway location, the computer program, Visual Sampling Plan (VSP) version 2.0®, developed a random sampling plan for the proposed greenway. VSP allowed for the sampling area to be divided into triangular grids based on the set budget of $80/sample for initial screening. Calculating the probability (95.7%) of finding a hot spot (hotspot defined as something unusual, an anomaly, an aberration, elevated cluster and/or a critical resource area (Patil and Taillie, 2004)) of a predetermined size (elliptical, 30 feet) in the given area (5 meter buffer along each side), VSP identified a minimum of 59 and a maximum of 61 surface soil samples that would be taken along the proposed path. A total of 127,494.41 square feet was to be sampled on the Glover property (Figure 8).

The VSP program also generated state plane coordinates that were converted into a geographic coordinate system to determine sampling locations. To convert the locations, the state plane coordinates were first exported from VSP to ArcMap®. Once in ArcMap®, the coordinates were exported into Excel by using the "export data to excel function." In Excel, the data was converted into a .txt format. Then, using the U.S. Army Corps of Engineer's CORPSCON®, the state plane .txt file was converted to geographic coordinates. The new comma delimited .txt file was then imported into the

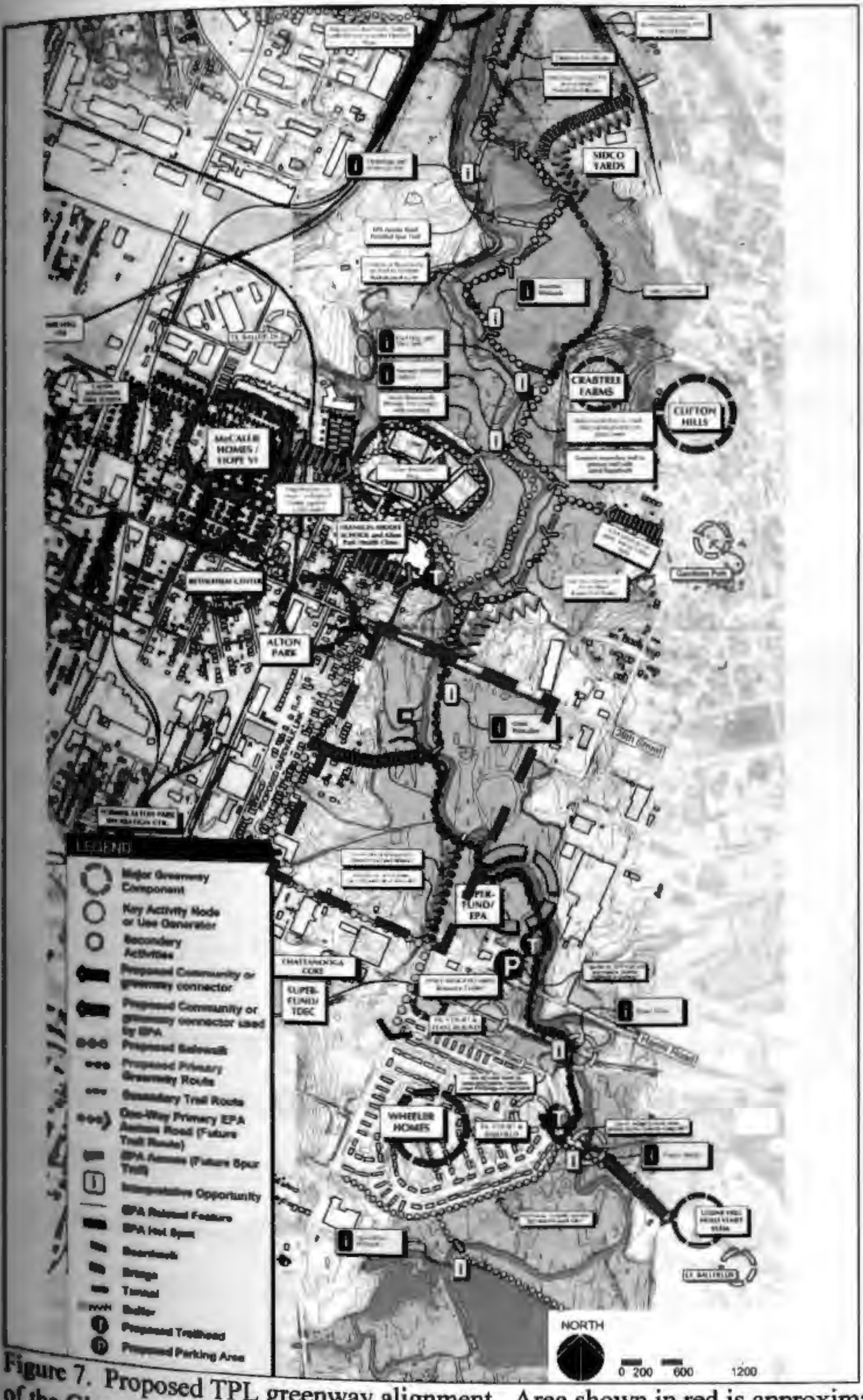

Figure 7. Proposed TPL greenway alignment. Area shown in red is approximate location of the Glover property (TPL 2002).

National Geographic "TOPO®" software as waypoints. The generated waypoints were uploaded into a Garmin III *plus*® global positioning system (GPS).

Locating and Identifying Soil Sampling Locations

Sites 14-44, situated on the West Bank of Chattanooga Creek, were located and identified on July 17-18, 2003, using the handheld GPS unit. Sample locations were marked with pin flags, flagging tape, and flagging tape wrapped surveying nails to allow for re-sampling, should a hot spot be located. Attending parties, weather and locations were recorded in a laboratory logbook. On July 21, 2003, West Bank sites 1-13 were identified using the handheld GSP unit. Due to dense canopy cover, the GPS was not working effectively and as a result, samples 1-9 were roughly located by GPS and then estimated by an approximate 30-foot radius using a topographic map and measuring tape. East Bank sites 59-45 were located on July 24, 2003, using the handheld GPS unit and a compass for accuracy.

Surface Soil Sampling

The sampling of the Chattanooga Creek floodplain began on July 21, 2003, and continued through September 10, 2003. To incorporate a greater area, the samples were collected at 4 corners of a 1 foot by 1 foot square with the center location, sample 5, as the predetermined VSP/GPS location (Figure 9).

Figure 8. Glover property and Chattanooga Floodplain soil sampling locations (1-59). Red locations indicate potential hot spots.

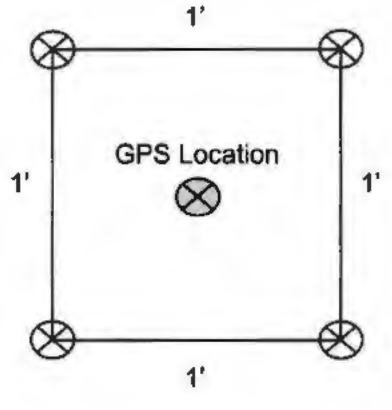

Figure 9. Composite surface soil sampling design.

Using a stainless steel spoon, samples were collected from 0 inch -3 inch depth and placed into a disposable tin pan (Figure 10). By combining the five samples, one composite sample was generated. Five-hundred grams of the composite sample were collected in labeled 16 ounce, wide-mouth, glass amber jars with Teflon-lined screw caps and stored on ice, in a cooler for no more than 12 hours. The steps were repeated at all 59 sites.

Chain of custody (COC) forms, provided by TTU, were completed and accompanied the samples. Sampling protocol followed SW 846, Chapter 4, Revision 3, December 1996 and SW 846, Revision 3, December 1996. Decontamination for sample containers was performed by TTU by washing with soap and water, rinsing with tap water, acid-rinsing, rinsing with deionized water, and leaving the containers to drain dry. The clean bottles were rinsed with methylene chloride and set to dry in a chemical fume hood for a number of hours. The clean bottles were capped and stored away from organic vapors. Sampling material, such as spoons and tin pans, decontaminations were performed according to TDEC standards (EPA, 2001a), using liquinox soap, water, isopropyl alcohol and distilled water. If decontamination was necessary in the field, liquid waste was left to evaporate; solid waste was removed. The coolers were transported to TTU for analysis after each sampling date. TTU, an EPA certified laboratory, performed all sample analysis. Upon receipt of samples, each sample was assigned a laboratory log number and stored in a 4° C walk-in refrigerator. No preservatives were added to the samples.

Surface Soil Sample Analysis

Samples were analyzed at the Center for the Management, Utilization, and Protection of Water Resources at TTU according to SW 848, Chapter 2, Section 2.3.1.2, Revision 3, December 1996. Initial PAH screenings were conducted according to EPA method SW 846, Method 4035, Revision 0, December 1996. The Sample Extraction Kit (Strategic Diagnostics, 2000a) and the PAH specific Enzyme-Linked Immunosorbent Assay (ELISA) guide, as described in RaPID Assay PAH In Soil Application (Strategic Diagnostics Inc, 2000), were used to screen the soil samples and obtain total PAH concentration.

If total PAH concentrations above 100 mg/kg were detected by ELISA screening, the samples were prepared for extraction using EPA SW 846 Method 3545, Revision 0, 1996: Pressurized Fluid Extraction (PFE) (EPA, 1996). The project personnel chose 100 mg/kg as the threshold value for GC/MS analysis due to environmental relevance and budget constraints. GC/MS method SW 846, Method

Figure 10. Sampling the Chattanooga Creek Floodplain. Photo of Daniel Basham (TTU) and Maya Belka (UTC) taken by A. Young (TDEC) 2003.

8270C, December 1996 was used to perform the PAH analysis. Samples showing exceedingly high PAH levels were designated as Hot Spots.

Hotspot Soil Re-sampling (Surface and Subsurface)

Sites 3, 10 and 12 were determined to be hotspots based on the discovery of uncharacteristically high concentrations of PAHs found at these locations when compared to the remaining 56 sites. Re-sampling occurred on September 10, 2003. In order to avoid re-sampling a previously sampled site and to incorporate the possibility of a correlation between sites 10 and 12, a location approximately 8-10 feet away from the original sample 12 site was chosen. The new sampling location was upslope from site 12 and between sampling location 10 and 12. Three re-samples were taken, each with separate stainless steel spoons. The samples were placed directly into individual 16 ounce, glass amber jars and therefore were not composite samples. The first re-sample occurred at 0-3 inch depth. The second re-sample occurred at 3-6 inch depth and the final re-sample occurred at 6-9 inch depth. All samples were taken consecutively, placed on ice in a cooler and, along with the COC form, taken to TTU. Soil analysis was performed according to methods previously stated.

Results

The results for the initial surface soil sample analysis using the ELISA PAH screening test are reported in Figures 11 and 12. Samples 1-44 were collected from the floodplain along the west side of the Chattanooga Creek, and Samples 45-59 were collected from the floodplain along the east side of the Chattanooga Creek.

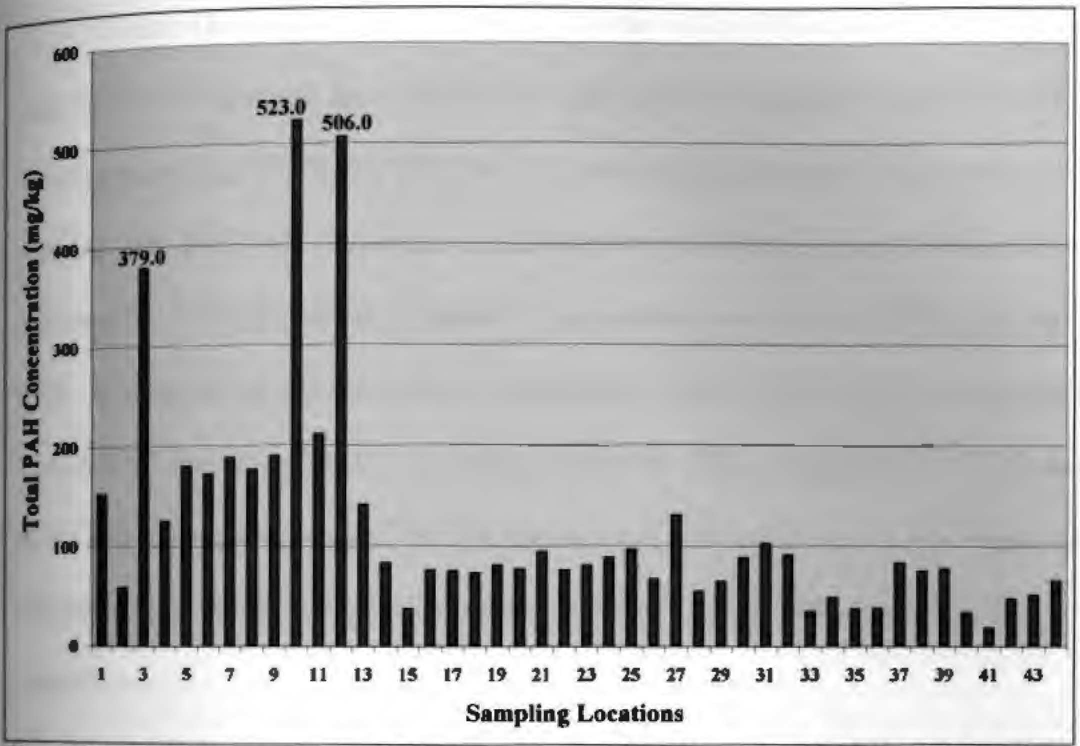

Figure 11. ELISA screening results for soil samples taken from the Floodplain along the west side of Chattanooga Creek.

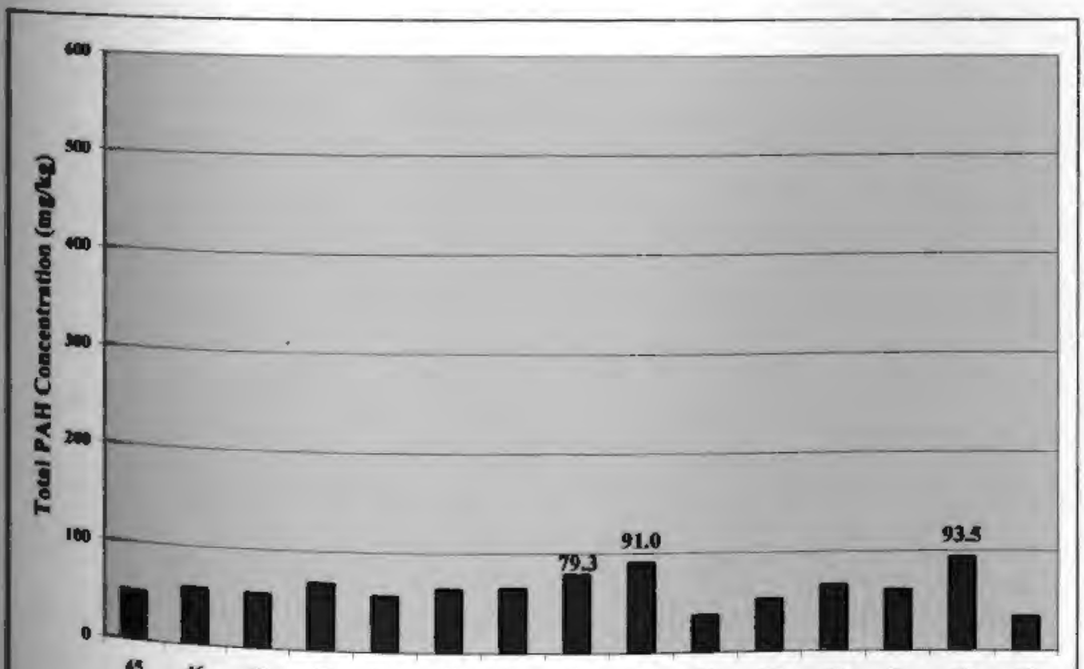

Figure 12. ELISA screening results for soil samples taken from the Floodplain along the east side of Chattanooga Creek.

Figure 13 illustrates data for sites where the ELISA PAH screening test found total PAH concentrations greater than 100 mg/kg. GC/MS analysis was performed on the samples exceeding 100 mg/kg total PAH. Figure 14 illustrates all PAHs present in samples with total PAH concentrations greater than 100 mg/kg. Figure 15 illustrates only carcinogenic PAHs present in the samples that contained more than 100 mg/kg total PAH. The results for the hotspot soil re-sampling (surface and subsurface) analysis using ELISA PAH screening test are reported in Figure 16. The results for the GC/MS analysis of the soil re-sampling (surface and subsurface) are reported in Figure 17. Figure 18 illustrates only carcinogenic PAHs present in the soil re-sampling (surface and subsurface).

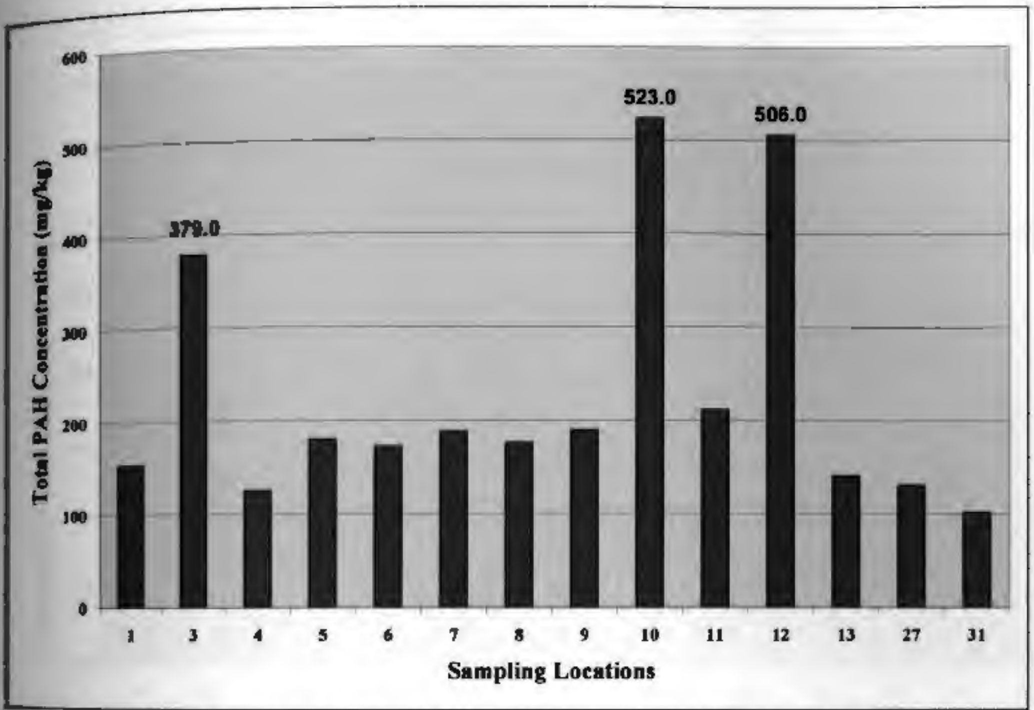

Figure 13. ELISA screening results for soil samples indicating a total PAH concentration of greater than 100 mg/kg.

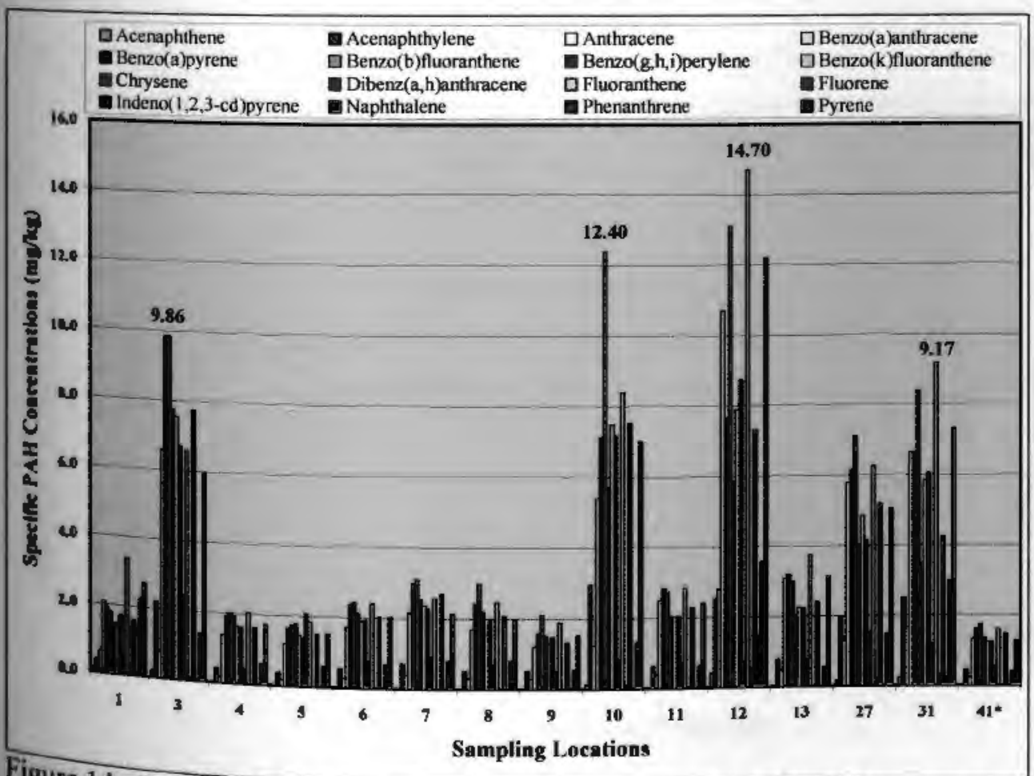

Figure 14. Specific PAH concentrations for soil samples with total PAH concentrations above 100 mg/kg. *Sample 41(lowest total PAH concentration) included for comparison.

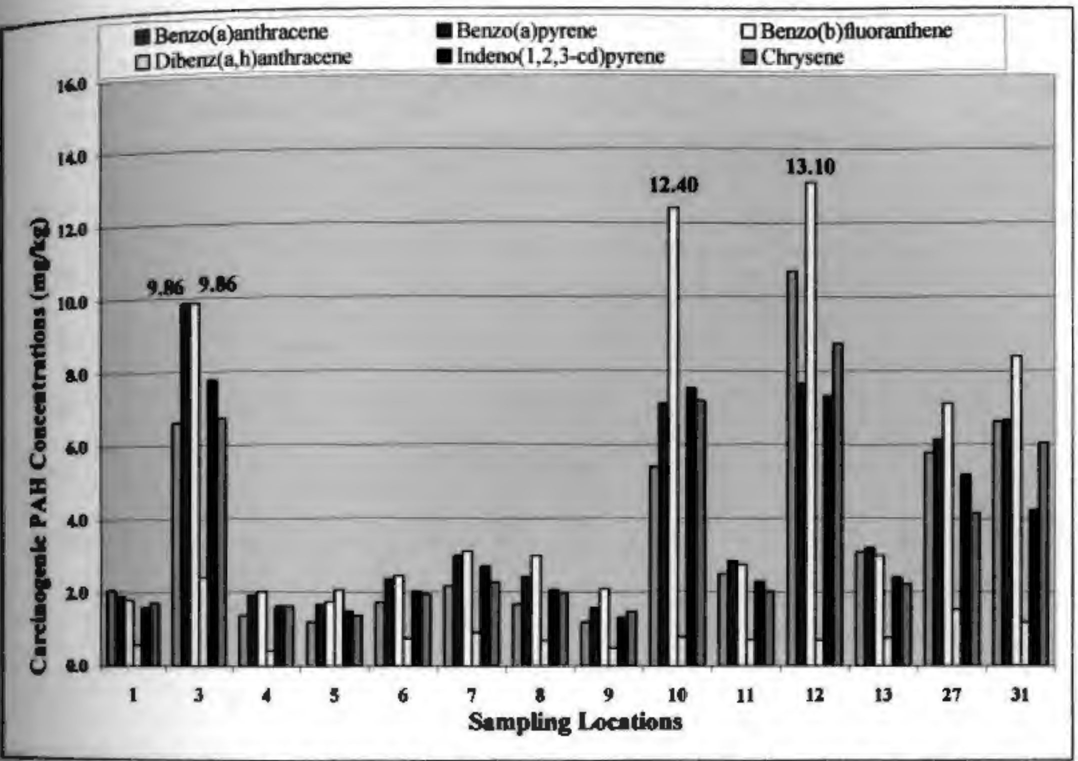

Figure 15. Probable carcinogenic PAH concentrations for soil samples with total PAH concentrations above 100 mg/kg.

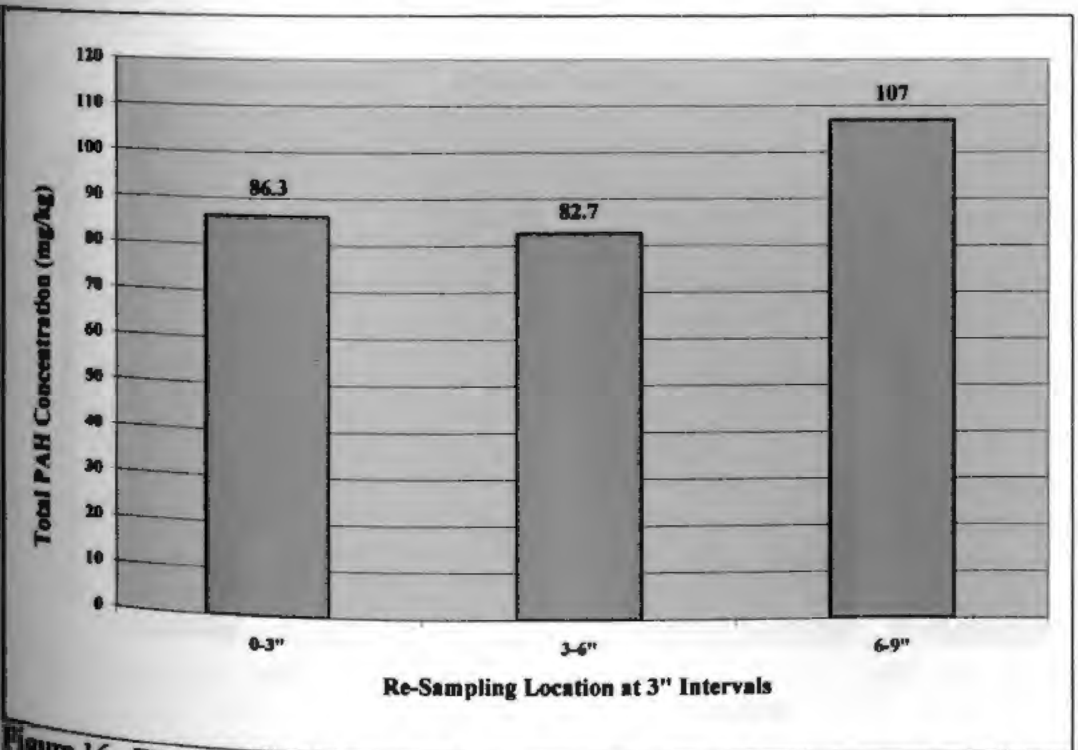

Figure 16. ELISA screening results for soil samples taken from re-sampling location at 0-3", 3-6", and 6-9" depth.

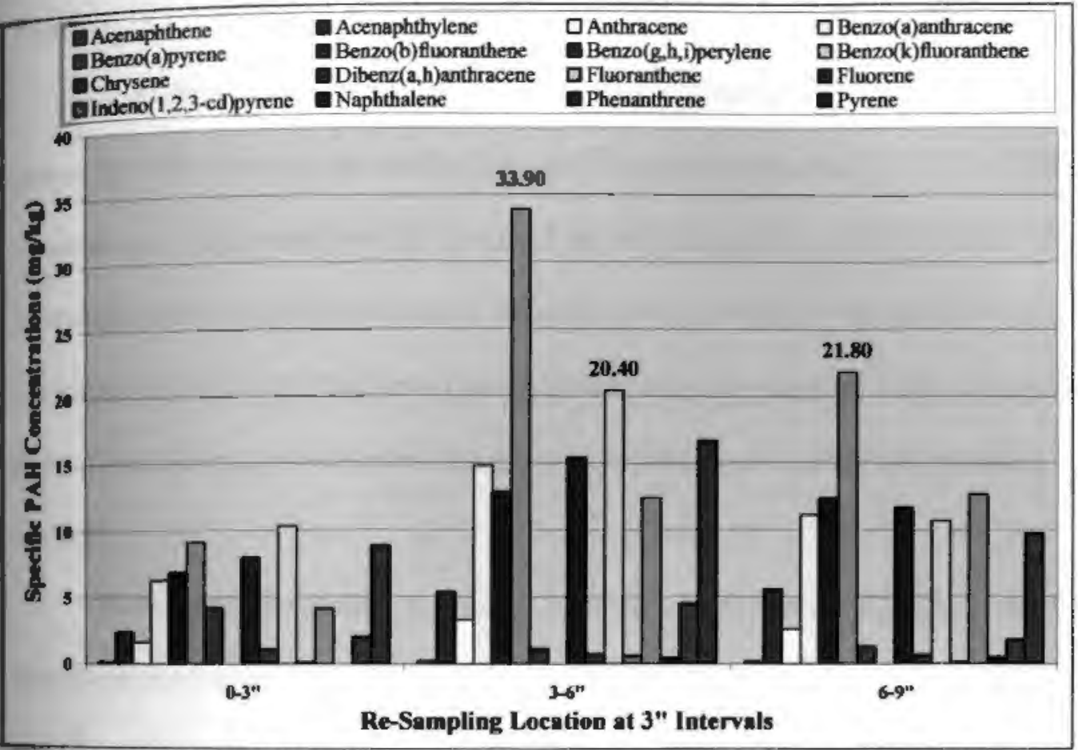

Figure 17. Specific PAH concentrations for re-sampling location at 0-3", 3-6", and 6-9" depth.

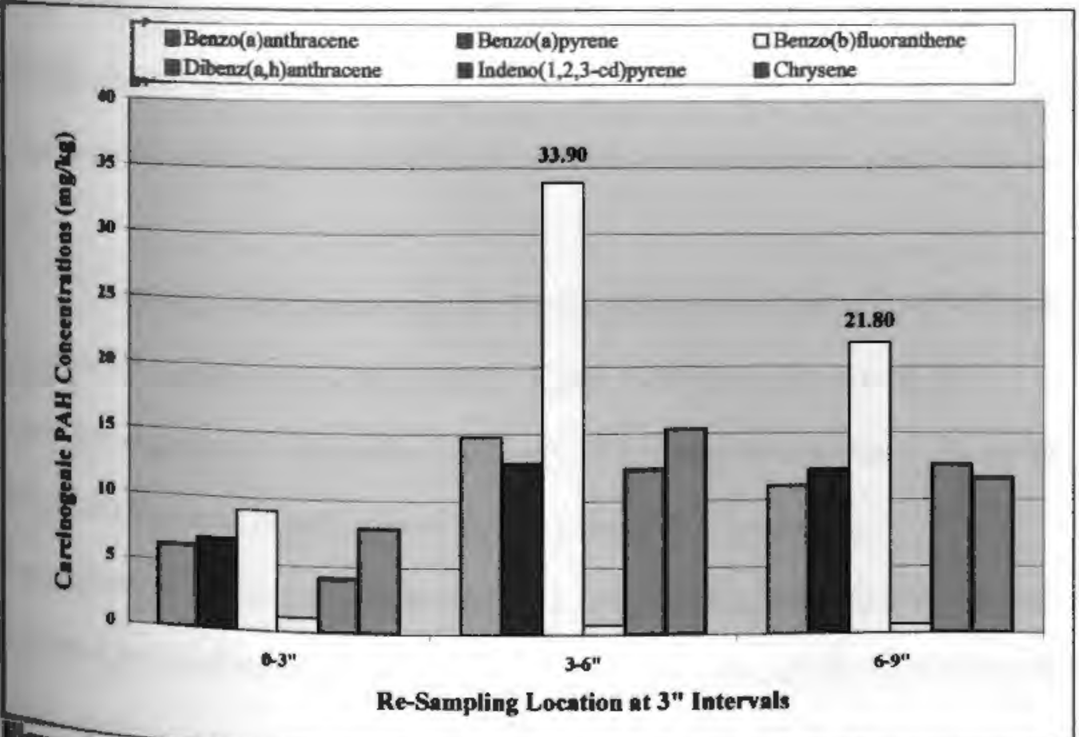

Figure 18. Probable carcinogenic PAH concentrations for re-sampling location at 0-3", 3-6", and 6-9" depth.

Analysis

The Glover property soil sampling sites were located within the TPL proposed greenway path. As the exact width of any future greenway has not yet been established, a 10 meter wide zone was sampled. Much of the proposed pathway follows existing gravel haul roads used during EPA's Phase I removal of coal tar from Chattanooga Creek. The sampling locations were randomly chosen by the computer program VSP v2.0, based on above stated criteria and a limited budget, with the intent of locating any potential hotspots.

Each composite sample was screened using a PAH specific ELISA. Total PAH concentrations for the west and east side of Chattanooga Creek are shown in Figures 11 and 12, respectively. Sampling locations 3, 10, and 12 show high levels of total PAH concentration. These locations are considered to be potential hotspots.

No potential hotspots were located on the east side of the Chattanooga Creek. ELISA results from the east side of Chattanooga Creek (Figure 12) show lower PAH concentrations when compared with the west side of Chattanooga Creek as seen in Figure 11.

Any soil sample containing total PAH concentrations greater than 100 mg/kg (Figure 13) was analyzed using GC/MS. Figure 14 illustrates specific PAH concentrations for all soil samples with total PAH concentrations above 100 mg/kg. Sampling locations 12 and 31 show similar patterns in fluoranthene, benzo(b)fluoranthene, and pyrene levels, whereas sampling locations 3 and 10 both show elevated levels of benzo(b)fluoranthene. Site 41, having the lowest ELISA total PAH concentration, was analyzed using GC/MS and included for comparison purposes. All four sampling locations (3, 10, 12, and 31) illustrate higher levels of specific PAHs when compared to the 10 other locations, with site 27 as an exception.

The EPA requires the use of Preliminary Remediation Goals (PRGs) as initial screening levels and cleanup guidelines for regional use. For the soil samples analyzed for carcinogenic compounds, many of the results are higher than EPA industrial soil PRGs (Figures 19 and 20) and residential soil PRGs (Figures 21 and 22). Therefore, before a greenway is placed through the Glover property, more analytical research is needed.

The EPA has also developed toxic equivalency factors (TEFs) in order to rank the relative carcinogenic potential of other PAHs relative to BaP. As shown in Table 5, the applicable TEF was multiplied by each soil concentration to obtain a BaP Equivalent. By summing the values, a TTEC value is obtained for each potential hotspot location. The TTEC was compared with the cleanup level for BaP (0.1mg/kg). The TTEC for each potential hotspot location exceeds the cleanup level for BaP. Therefore, the cleanup level for BaP was not reached.

Table 5. BaP Equivalents and TTEC Values for Hotspot Locations 3, 10, and 12.

PAH Parameter (mg/kg)	Site 3 BaP Equivalent (mg/kg)	Site 10 BaP Equivalent (mg/kg)	Site 12 BaP Equivalent (mg/kg)
Benzo(a)pyrene	9.86	7.12	7.65
Benzo(a)anthracene	0.661	0.540	1.070
Benzo(b)fluoranthene	0.990	0.120	0.130
Dibenz(a,h)anthracene	2.410	0.790	0.714
Indeno(1,2,3-cd)pyrene	0.780	0.753	0.730
TTEC	**14.70**	**9.32**	**10.29**

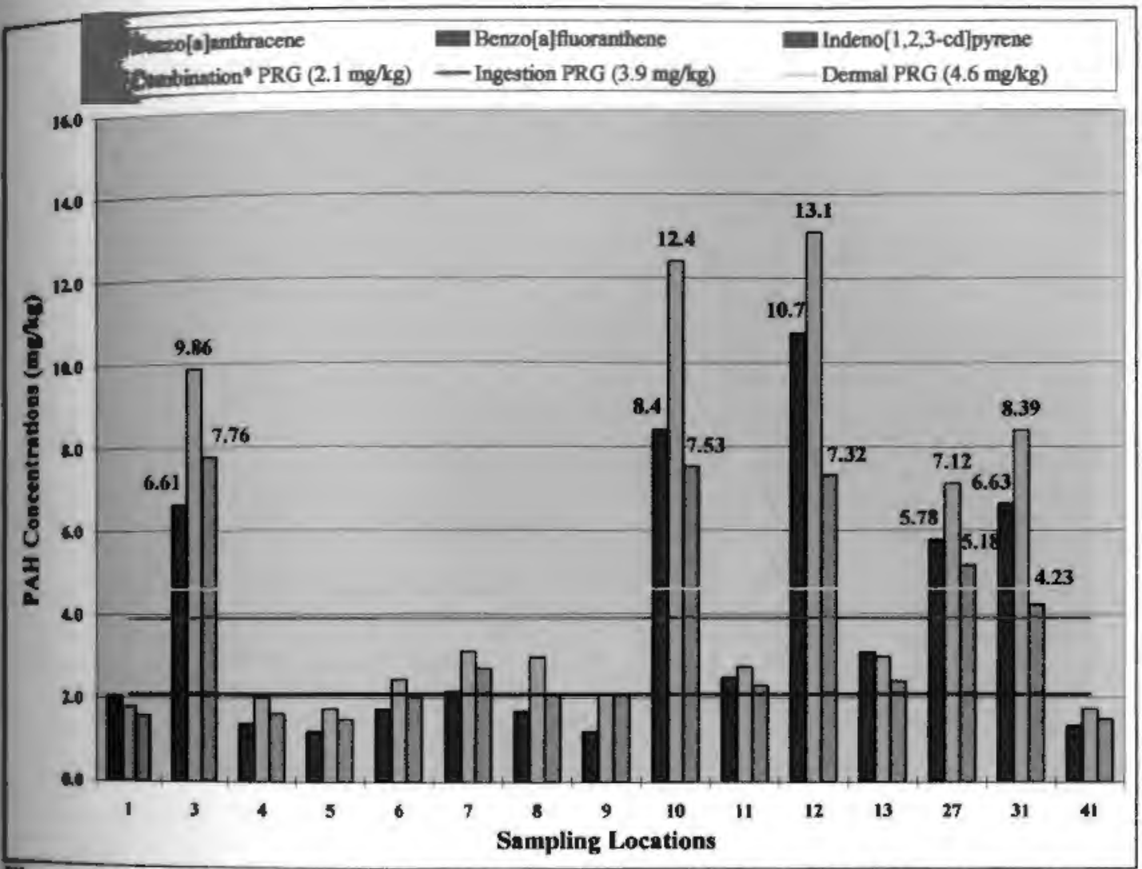

Figure 19. Benzo[a]anthracene, benzo[a]fluoranthene, and indeno[1,2,3-cd]pyrene levels found in the Chattanooga Creek floodplain (mg/kg) compared to EPA Region IX industrial soil PRGs for dermal (4.6 mg/kg), ingestion (3.9 mg/kg) and combination (2.1 mg/kg). *Combination PRG includes inhalation, dermal and ingestion exposure routes.

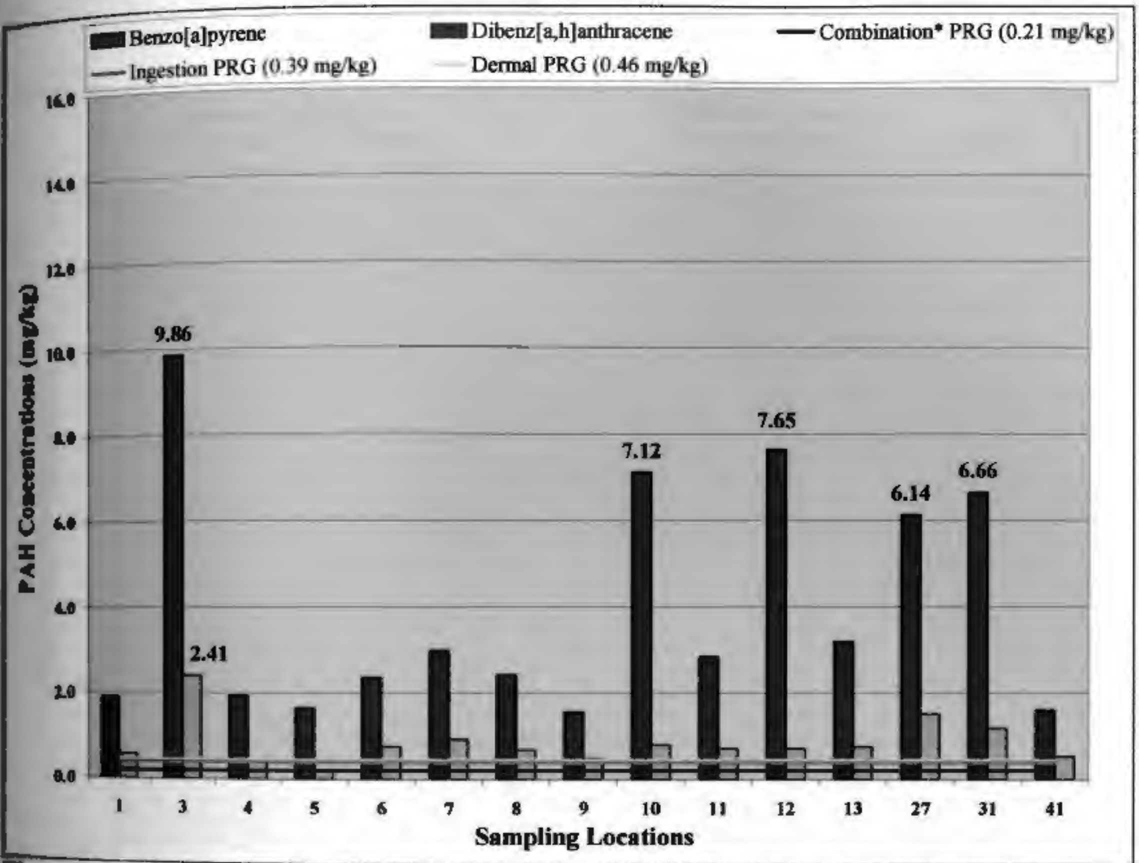

Figure 20. Benzo[a]pyrene and dibenz[a,h]anthracene levels found in the Chattanooga Creek floodplain (mg/kg) compared to EPA Region IX industrial soil PRGs for dermal (0.46 mg/kg), ingestion (0.39 mg/kg) and combination (0.21 mg/kg). *Combination PRG includes inhalation, dermal and ingestion exposure routes.

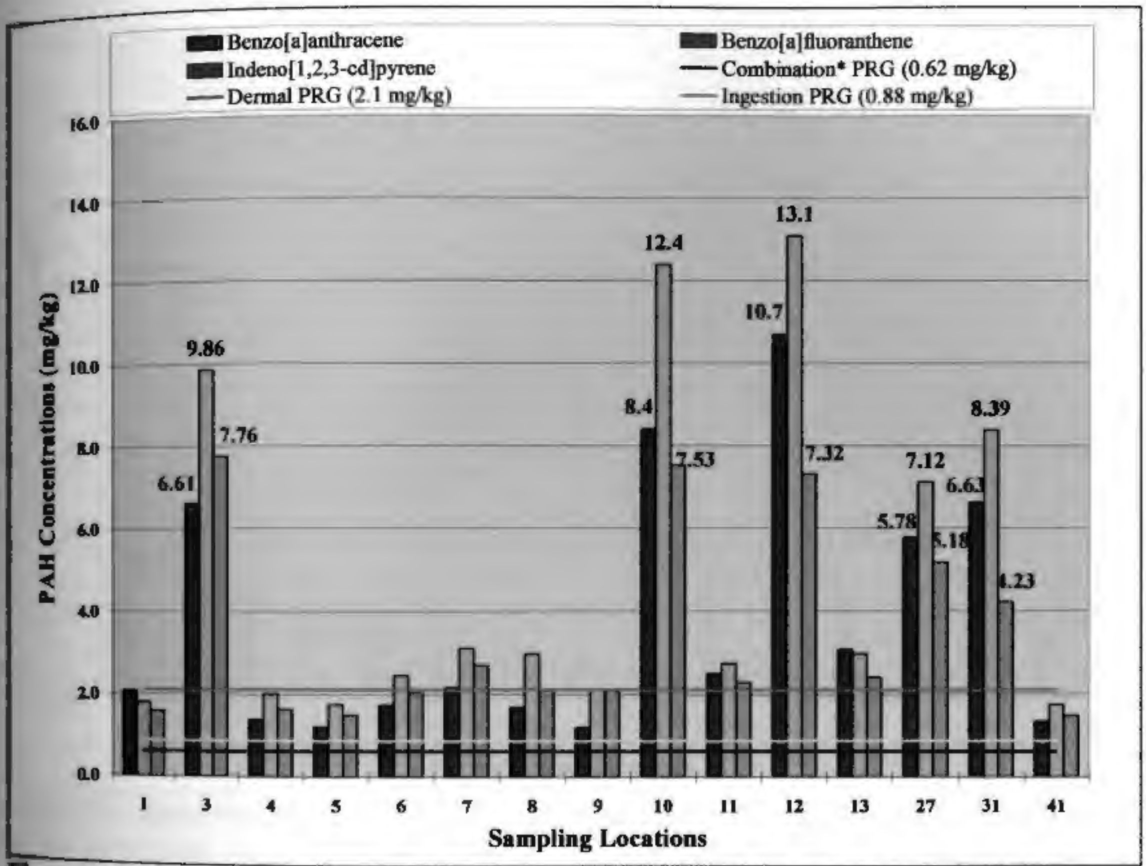

Figure 21. Benzo[a]anthracene, benzo[a]fluoranthene, and indeno[1,2,3-cd]pyrene levels found in the Chattanooga Creek floodplain (mg/kg) compared to EPA Region IX residential soil PRGs for dermal (2.1 mg/kg), ingestion (0.88 mg/kg) and combination (0.62 mg/kg). *Combination PRG includes inhalation, dermal and ingestion exposure routes.

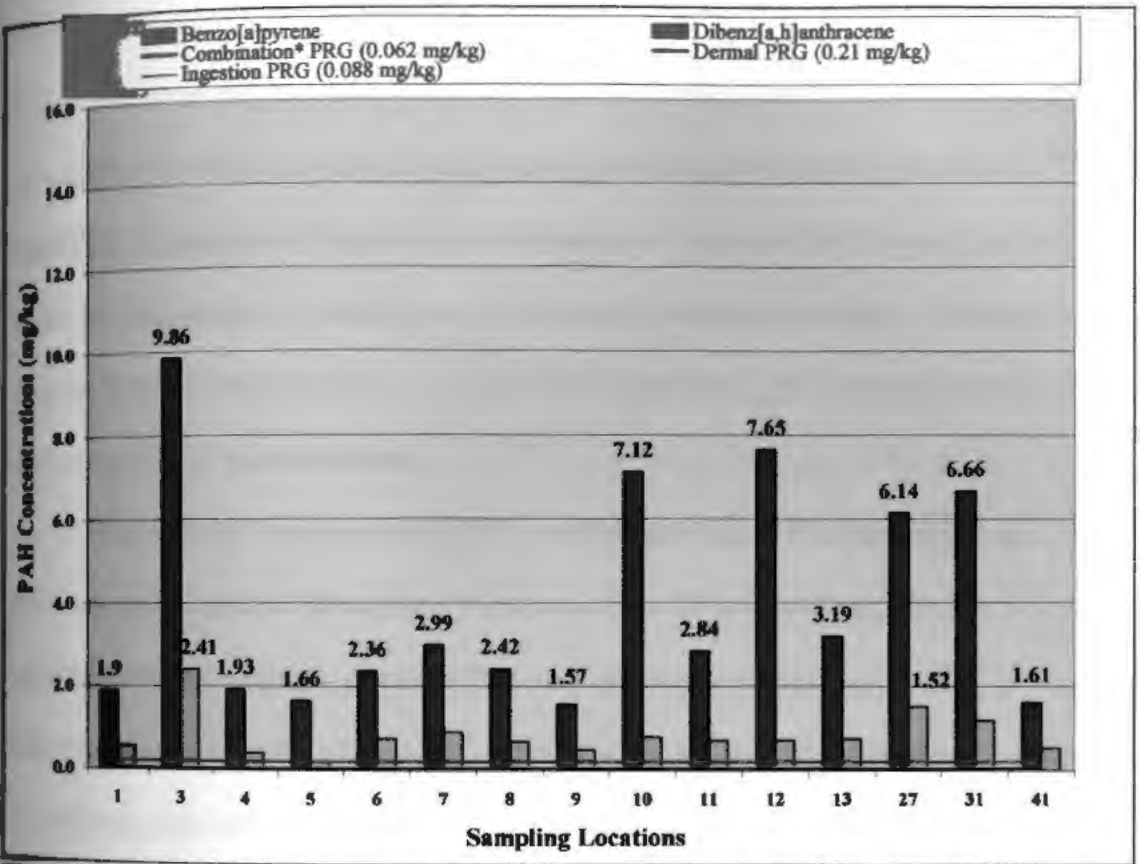

Figure 22. Benzo[a]pyrene and dibenz[a,h]anthracene levels found in the Chattanooga Creek floodplain (mg/kg) compared to EPA Region IX residential soil PRGs for dermal (0.21 mg/kg), ingestion (0.088 mg/kg) and combination (0.062 mg/kg). Combination PRG includes inhalation, dermal and ingestion exposure routes.

Conclusion

Based on the results and analysis stated previously, the TPL greenway should not be constructed without further investigation of the Chattanooga Creek floodplain. The high TEF values and the fact that both residential and industrial PRG levels are exceeded at the 15 sites analyzed, indicate a need for a more in-depth evaluation. The location of three potential hotspots (sites 3, 10, and 12) also signifies a need for possible removal of soil or capping at these locations.

The state of Tennessee and EPA has designated South Chattanooga as an Environmental Justice Community. Because of this, TPL should consider the ramifications of building a greenway that may expose the residents to further contamination. According to the TPL report, the Glover property should be developed "as a linear park and greenway from behind Howard School of Academics and Technology to Hamill Road" (TPL, 2002). The linear park, as suggested by public input and the EPA Grant Community Advisory Committee, should incorporate features such as benches, picnic tables and covered pavilions, and playgrounds. Under these assumptions, the safety of the floodplain on the Glover property is called into question.

ATSDR Health Consultation Analysis

The ATSDR issued a Health Consultation on the Glover property on July 9, 2004 (ATSDR, 2004). The Agency's decision relied on the TPL report and UTC and TTU data. The report includes a number of considerations that need to be taken into account before building a greenway on the Glover property such as frequent flooding events, full site characterization and children's health issues. Despite these considerations, ATSDR concluded "no apparent public health hazard exists for people who may come into contact with PAH contamination in soils at the Glover Site" (ATSDR, 2004).

The ATSDR conclusion of "no apparent public health hazard" appears contradictory considering that preceding sentences suggest the use of effective covers over the PAH contaminated soil, like asphalt or concrete, since softer material may carried away during frequent flooding events. ATSDR maintains that more durable materials would allow users to be lifled above the contaminated soils, "effectively eliminating exposure pathways"(ATSDR, 2004). If floodplain soil PAH concentrations are not a current public health issue, why recommend a raised greenway? The fact that ATSDR suggests a raised greenway path to "eliminate exposure pathways" leads one to believe that there could be probable health risk if exposed to the PAH contaminated soil.

ATSDR also states that the "[Chattanooga Creek Hazardous Substance Monitoring Program] did not uncover enough evidence to dissuade a greenway. Yet, pollution lingers that will require additional investigation before a greenway can be recommended from an environmental public health perspective"(ATSDR, 2004). In the ATSDR consultation, BaP equivalent concentrations ranged from 2.326-14.775 mg/kg and BaP concentrations were as high as 9.86 mg/kg. The report concluded that these values exceed both the ATSDR health screening CREG of 0.1 mg/kg and the EPA PRG for BaP at 0.062 mg/kg (residential soil). Surprisingly, ATSDR did not include the industrial soil PRG (0.21mg/kg), which is also exceeded (see Figure 20). This exclusion is important to note because ATSDR makes an effort to remind the reader "although the Glover Site is near a residential neighborhood, it is not a residential property"(ATSDR, 2004). The greenway may not be residential, but it is certainly not industrial and the results show that residential and industrial soil PRGs values are being exceeded.

Another issue not addressed by ATSDR is one concerning multiple usage of the property. According to the TPL redevelopment plan, the overall greenway path will include structures such as an amphitheater and boat ramps (TPL, 2002). TPL reports that the EPA Grant Community Advisory Committee and the public are interested in having benches, picnic tables, covered pavilions, and playgrounds along the greenway path. ATSDR did not address any multiple use suggestions other than the greenway path itself. The ATSDR report also states that "[t]oddlers…are not expected to wander onto the Glover Site"(ATSDR, 2004). If playgrounds and picnic areas are to be included on the Glover property, it stands to reason that toddlers can be expected to "wander" onto the Glover site.

The ATSDR report addresses the fact that residents have seen children frequent the Glover property, although no ages were reported. The report also acknowledges the fact that "children could be at greater risk than adults…due to lower body weights" (ATSDR, 2004). The risk can be exacerbated by habitual ingestion of substances not normally regarded as edible, and can include mouthing and sucking activities, known as pica behavior (Calabrese et al., 1989; Davis et al., 1990; Stanek and Calabrese, 2000). But, as mentioned previously, the report determines that pica behavior is not of great concern because toddlers are not expected to wander onto the site. The point may be disputable. If picnic areas and playgrounds are offered, as well as resting locations along the greenway, pica behavior may be exhibited.

According to Stanek and Calabrese, soil ingestion by children can result in significant exposure to toxic substances at contaminated sites (Stanek and Calabrese, 2000). Stanek and Calabrese estimate that soil ingestion among children ages 1-4, over a 7, 30, 90, and 365 day period, are 133 mg/day, 112 mg/day, 108 mg/day and 106 mg/day, respectively (Stanek and Calabrese, 2000). A report by the Center for Disease Control gives estimated soil ingestions of 1.5-3.5 year olds to be approximately 10g/day and 5 years old to be 100 mg/day (Calabrese et al., 1989). A study done in Washington State determined that about 30% of the 100 2-7 year old children studied swallowed dirt at least once a day with a median daily range of 25.3-81.3 mg/day (Davis et al., 1990). Calculating the amount of PAH ingested through pica behavior should be addressed by the ATSDR and not be discounted.

Although it is understood that greenway users present limited frequency and duration exposure scenarios (which ATSDR addresses), more extensive research sbould be conducted. The community most likely to use the property has been designated an environmental justice community. Members of such designated communities have already been heavily burdened with unfair health risks. The TDEC declared that it will "protect, preserve and ensure human health, environmental protection and quality of life" (TDEC, 2000), therefore the building of a greenway without further investigation and an in-depth health review should not commence under current floodplain conditions.

Superfund Redevelopment and SRI Pilot Grant Recipient Analysis

Superfund Redevelopment Site

The EPA has made a number of case studies on various Superfund Redevelopment sites around the nation available on the internet. The case studies deal with many issues including: listing procedures, contamination events, past site usage, health hazards, and community, local, state, and federal government involvement. In order to stay within the scope of the thesis, the Superfund Redevelopment site section focused on Superfund sites that were redeveloped for potential recreational reuse. By comparing other redevelopment projects to the Chattanooga Creek floodplain case study, patterns emerge.

The EPA reports, as of June 24, 2004, over 300 Superfund sites in reuse; 248 having been cleaned and 51 in progress (EPA, 2004e). The EPA's reuses of Superfund sites are separated into 6 categories: commercial, recreational, ecological, public services, residential, and agricultural. The sites are placed into each category based on their primary purpose, as many sites are redeveloped to accommodate more than one reuse option (EPA, 2004f).

The reuse of the 315 sites breaks down as follows: 176 are used for commercial purposes, 39 for recreational, 35 for ecological, 31 for public service, 24 as residential and 10 for agricultural reuse. Figure 23 shows the percent reuse for all six categories. Commercial reuse is defined as any reuse that will generate a large amount of economic benefit for the surrounding communities. Commercial reuses are regarded as retail stores and other businesses bringing employment into the area. Commercial redevelopment also stimulates other development projects in the area. Recreational reuse offers

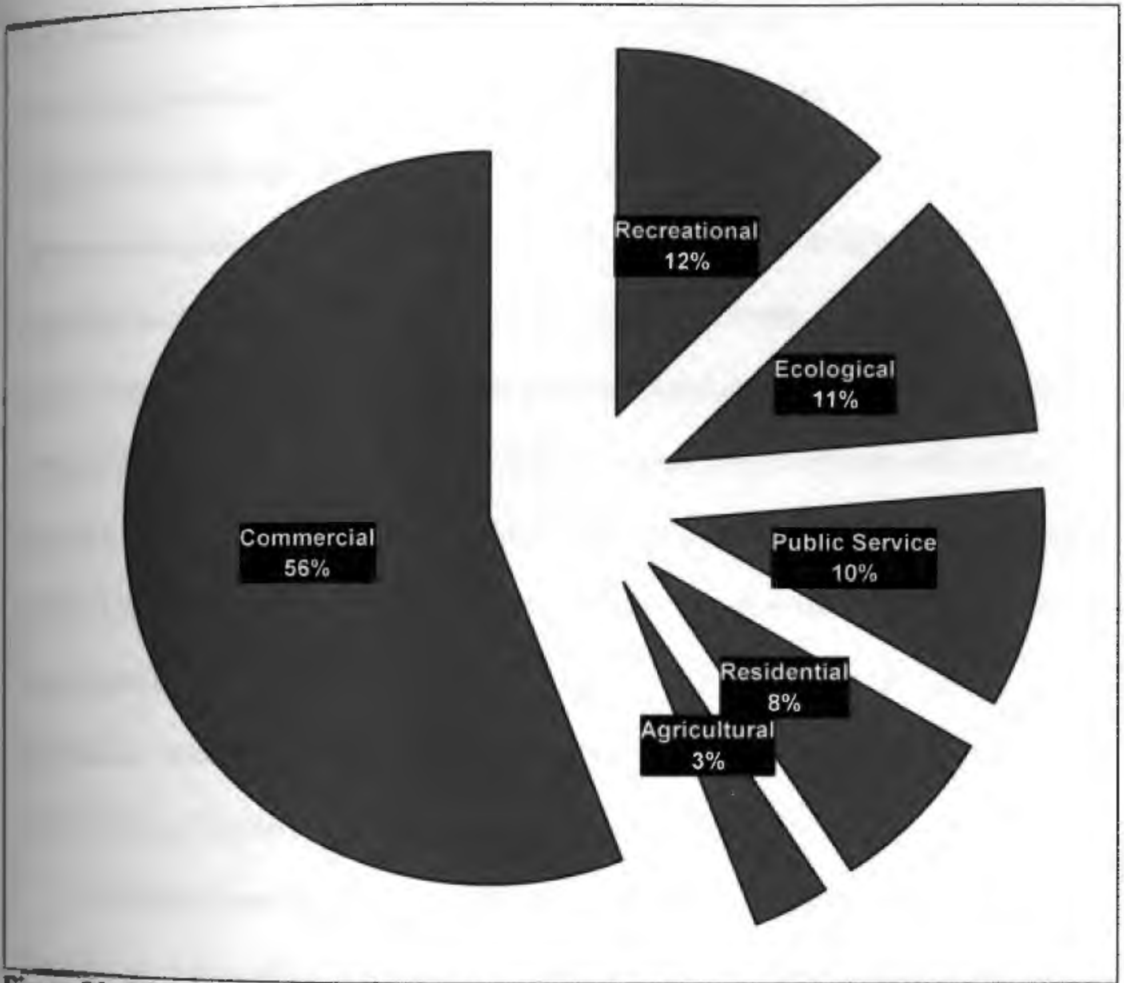

Figure 23. EPA Superfund claimed redevelopment site reuse as of June 29, 2004 (EPA 2004e).

communities indoor and outdoor leisure activities. Some examples are trails, picnic areas, and golf courses. Similar to recreational reuse is ecological reuse. Ecological reuse is where NPL sites are replanted and restored to provide wildlife habitat. The sites can also be developed to encourage recreational activities such as hiking, biking, and bird watching, but the main purpose is to provide wildlife sanctuary. The public services reuse category is used when government agencies (local, state, or federal) redevelop the property in the interest of public need. Airports, community buildings such as libraries and schools, and other public service utility buildings are examples. Residential reuse is the most restricted reuse option for Superfund sites. The sites may accommodate homes, apartments, parks, playgrounds and open spaces. Finally, the least used option, agricultural, is the redevelopment of a site for farmland and pasture for livestock. Once the primary use has been chosen, the remedial action is initiated.

Although there were several Superfund Redevelopment sites that were suitable for comparison, it was difficult to obtain information regarding the individual sites. Initially, the EPA webpage Superfund contact person was emailed regarding attainment of the necessary information. After no response, the EPA regions with appropriate comparison sites were contacted. Numerous attempts (via phone and email) were made to contact seven EPA regions (Regions I-VI and IX) to request the information of interest. Of the seven regions contacted, four responded.

Communication with the contact person for the Region II site was extremely difficult and he was relatively inflexible. He stated that the information could not be emailed, faxed, or burned to a disc due to "company policy" and that the information would need to be picked up (in New Jersey) or copied and mailed for approximately

$600. The necessary information was not available on-line and after numerous futile emails asking for reference information, to facilitate an inter-library loan, the information was deemed unobtainable. Although further attempts could have been made, in the interest of time and the notion that persons from an environmental justice community may not have the access or ability to continue correspondence, contact was terminated.

The Region III site contact person listed on the web page was incorrect, despite a June 29th, 2004, website update (EPA, 2004g). Upon being contacted, she forwarded the inquiry on to an appropriate contact person. After several months and no reply, the information was also deemed unobtainable. To pursue the information further was again, not reasonable for any person, including persons from an environmental justice community, assuming persons from such communities have limited access to long-distance phone lines, email, and surplus time. Upon contacting the person in charge for a Region IV site, it was determined that the Region IV site in question did not have substantial PAH contamination. Therefore, the site was not considered a viable comparison option.

Finally, Ms. Diana Hinds, the PAB Oil and Chemical Services, Inc. site contact person from Region VI, provided much needed information. Ms. Hinds burned a CD complete with both the RI and ROD reports as well as photographs of the site and tables of PAH concentrations found on-site. The information provided by Ms. Hinds was used for the Superfund Redevelopment site and Chattanooga Creek floodplain comparison.

PAB Oil and Chemical Services (1999)

PAB Oil and Chemical Services, Incorporated, operated as a disposal facility for oil-based drilling mud and other waste between 1978 and 1983. In 1983, PAB went out of business and abandoned the site (EPA, 2004a). PAB is located in a rural area encircled by agricultural terrain, but residential use of the surrounding land has increased. The site was placed on the NPL in March 1989. The RI report found that cPAHs contributed to a cancer risk of approximately 2E-04 for trespassers exposed to sludge and surface water at the site (EPA, 1993a). An excess cancer risk to potential future on-site residents was 9E-04, and the report considered exposure to cPAHs through dermal contact or ingestion of the surface soil, sludge, and sediments to be the main exposure pathways (EPA, 1993a). The report concluded that the inability to quantify some pathways, such as dermal contact with PAHs, and the lack of toxicity data for numerous chemicals was likely to underestimate the potential risks found at the site (EPA, 1993a).

The PAB site ROD confirmed the RI findings and concluded that once remediation was complete, cPAH concentrations would be reduced to within the acceptable cancer risk range of 10^{-6} to 10^{-4} and noncarcinogenic PAHs would be reduced to a HI <1 (EPA, 1993a). The report added that any residual PAH concentrations remaining above the Remedial Action Objective (RAO) of 3 mg/kg or HI>1 would be addressed during the stabilization/solidification treatment process (EPA, 1993a).

In 1995, TRC Environmental Solutions, Incorporated, began remedial investigation of the PAB site and determined that there was no longer PAH remedial work necessary for associated soils. Locations that showed nondetect levels for cPAHs well above the RAO in 1991 (based on instrument insensitivity), now showed cPAH levels below 3 mg/kg and a HI<1 (TRC, 1996). Improvements in cPAH detection limits allowed for clarification of the 1991 cPAH nondetect values lowering the total PAH level to the acceptable level required by the RAO. As a result, the remediation still continued due to other contamination, but was no longer necessary for PAH remediation. As of January 7, 2005, no official Public Health Assessment had been posted for the PAB site.

When comparing the Chattanooga Creek floodplain site to PAB, it is important to note that the floodplain was not part of the NPL listing nor was it included in the ROD remediation plan. However, the floodplain is part of the reuse plan for the Chattanooga Creek Superfund Site. Another issue arises from the use of "background" levels as a means for comparison. Literature reviews of background total PAH contamination levels show concentrations ranging from 0.01 mg/kg in rural soils to 100 mg/kg in industrial areas (mainly attributed to road dust) (LaGoy and Quirk, 1994; Menzie et al., 1992). Consistently, these "background" PAH levels are higher than EPA established remediation goals. Essentially stating that regardless of the total PAH level determined at or near a Superfund site, the remediation goals are set unrealistically low and are therefore of limited use. As a result, EPA is less likely to remediate a site solely based on PAH contamination, knowing that the remediation goal is relatively unachievable.

As seen at the PAB site, total PAH levels were initially thought to be high enough to trigger remediation, but were then discovered to be below the RAO of 3 mg/kg upon a more detailed investigation. Other contaminants (arsenic and barium) were in need of remediation, ultimately leading to the elimination of most of the PAH concern.

Chattanooga floodplain concerns lie in two different arenas: first, a concern regarding further exposure for an already at-risk community, and second, redeposition either from the floodplain to the creek or vice versa. Having unrealistic and unachievable remediation goals as well as knowing that the floodplain is not being considered as an NPL site leads one to believe that remediation may not occur based on PAH contamination alone. The Chattanooga Creek floodplain should be investigated for other contamination such as heavy metals. Detection of other contamination may result in remediation of the floodplain, as seen at PAB Oil and Chemical Services, Inc.

When evaluating PAB and Chattanooga Creek, several similarities exist. At both sites, active community involvement brought about official NPL designation. The PAB site and the Chattanooga Creek site both discharge into a major river system. Both sites have unsuccessfully tried to indict PRPs and both sites pose potential health risks to trespassers and transients and require 5-year check-ups. Unfortunately, fencing and warning sites are not installed or maintained along Chattanooga Creek and the floodplain has not been thoroughly investigated for the extent of contamination, despite ATSDR recommendations to do so. The citizens surrounding PAB are primarily farmers and middle-class residents who have brought personal lawsuits against PAB for cleanup. The class disparity is a major difference between PAB and Chattanooga Creek. The residents of Alton Park and Piney Woods are lower class, minorities that constantly struggle to have any affect on the outcome of the Chattanooga Creek studies. Although both sites have potential greenways as part of the redevelopment plan, PAB may provide a cleaner, safer area to do so as a result of remediation.

Table 6. PAB and Chattanooga Creek Floodplain Comparison Results.

	PAB	Chattanooga Creek Floodplain
EPA Region	VI	IV
Official Superfund Site	YES	NO
Method of Assessing Health Risk	RAO for total cPAH concentration	total cPAH concentration
Contamination Level Found On-Site	>3 mg/kg (1992) <3 mg/kg (1995)	Highest value = 48.22 mg/kg
Public Health Hazard	YES (1992) NO (1995)	NO
Remediation due to other Contamination	YES	NO
Community Involvement	YES (Middle-Class Caucasian)	YES (Lower-Class Minorities)
Trespassing	YES	YES
Fencing/Warning Signs	YES	NO
Reuse	Unknown	Greenway

Superfund Redevelopment Initiative Pilot Grant Recipients

Due to the expenses attributed to developing a reuse plan, many communities are in need of financial assistance. Because of the financial need, EPA developed the SRI pilot grant in 1999. Communities eligible for the SRI grant are awarded up to $100,000 in financial or service assistance in order to determine future site usage. To qualify for an SRI grant, an applicant must be a state, city, town, or county, or a federally recognized tribe and cannot be a PRP (EPA, 2004e). The applicant must have a site within its jurisdiction that is either on the NPL list or a proposed NPL candidate and the remedial process must be incomplete (EPA, 2004e).

The goal of the SRI pilot program is to ensure that EPA and its partners (local governments, communities, developers, and others stakeholders) have the necessary tools and information needed to fully explore future site uses. The hope is to provide communities with the opportunity to productively reuse sites in their neighborhoods (EPA, 2004a). Since 1999, over 70 communities have been selected to receive pilot funding or services. As of June 24, 2004, (the last site update) 10 SRI grants were offered in 1999, 40 in 2001, and 19 in 2002. The year 2000 falls within a transition period where EPA announced an open proposal process. Therefore, the 40 pilots announced in 2000 are considered 2001 grants.

In July of 1999, ten local governments were awarded SRI grants, one site from each of the ten EPA regions. Of the ten, only one site is useful as a comparison with Chattanooga Creek based on recreational site reuse and PAH contamination. McCormick and Baxter Creosoting Company in Portland, Oregon, located in EPA Region X, was placed on the NPL due to contamination from wood-treating chemicals, including PAHs and heavy metals. The ATSDR Public Health Assessment of McCormick and Baxter is of interest because of the similarities with the Chattanooga Creek floodplain. Both have reuse options of a greenway and actively involve the surrounding communities.

McCormick and Baxter Creosoting Company (1999)

The McCormick and Baxter Creosoting Company was a wood treatment facility from 1944 to 1991. As a result, the surrounding soils were heavily contaminated with coal-tar creosote (a mixture of more than 300 compounds including PAHs). Soil contaminants migrated off-site and entered the Willamette River leading to extensive sediment and water pollution (EPA, 1999a). PAH levels at McCormick and Baxter in the on-site and off-site soils were recorded to be as high as 4,900 mg/kg (phenanthrene) and 1.3 mg/kg (benzo(b)fluoranthene) respectively (ATSDR, 1999b). Table 7 lists the maximum concentrations of carcinogenic PAHs found at McCormick and Baxter. ATSDR concluded that PAHs found in the site soil were at levels that could lead to "low increased risk of cancer" in workers (ATSDR, 1999b).

Table 7. Maximum Concentrations of cPAHs Found at McCormick and Baxter (ATSDR, 1999b).

Contaminant	Maximum Concentration (mg/kg)
Benzo(a)anthracene	420
Benzo(a)pyrene	210
Benzofluoanthenes	1000
Chrysene	1900
Dibenz(a,h)anthracene	22
Indeno(1,2,3-cd)pyrene	56

The ATSDR reports evidence exists that trespassers have breached the perimeter security fence and entered the McCormick and Baxter site on multiple occasions (ATSDR, 1999b). Trespassing is considered as a means of exposure and a completed exposure pathway until remediation is complete. Once remediation is complete, future users may still be exposed to soil contaminants if the protective soil cover is breached (ATSDR, 1999b). Children have also been seen playing along the riverbank and two cases of skin burns were reported (ATSDR, 1999b). ATSDR reported that dermal exposure to contaminants in the area would continue until remediation was complete, although no correlation between trespassing and cancer risk was provided(ATSDR, 1999b). ATSDR did report that plant workers had a low to moderate increased cancer risk for workers exposed to PAHs through soil ingestion, inhalation, and dermal routes(ATSDR, 1999b). ATSDR concluded that the site poses no apparent public health hazard for other exposed populations but mentioned that the site should not be developed or accessed by the public until remediation measures were completed that effectively removed further exposure from occurring (ATSDR, 1999b).

The community has been actively involved with the reuse process for McCormick and Baxter. The city of Portland held a number of public meetings as well as mailed newsletters and informational materials to the public (EPA, 1999a). A local citizens advisory committee was formed and has conducted a number of meetings regarding reuse proposals (EPA, 1999a). The official ATSDR report has also been subjected to public comment. The report is available on-line, easily accessible and very detailed.

The Chattanooga Creek floodplain is not part of the TP site investigation. As a result, a detailed ATSDR health report has not been conducted for the floodplain. There have been several Health Consultations, but no official Public Health Assessment. The Health Consultation is a mere seven pages and concludes that, based on the PAH evidence provided by UTC and TTU, "no apparent public health hazard exists…[from] PAH contamination in soils at the Glover site" (ATSDR, 2004). The consultation does mention that flooding events do have the potential to redistribute PAHs across the proposed greenway system and that PAH pollution is still a potential public health concern (ATSDR, 2004). ATSDR also reports that "dark-colored seeps of PAHs" are located throughout the site and "numerous puddles with an oily sheen are present" (ATSDR, 2004). Trespassers (due to the lack of fencing surrounding the site) and future greenway users may still come into contact with the PAHs. Like the McCormick and Baxter site, children and trespassers on the floodplain may experience serious injury. A greenway addition only encourages area usage and, without proper remediation, may result in hazardous conditions.

Community involvement at both sites was influential and essential to the proper reuse of both properties. Much like McCormick and Baxter, the Chattanooga Creek floodplain final decision will be presented to the public through a number of public meetings. Because the ATSDR merely issued a Health Consultation, there is concern as to whether there will be a proper public comment period. If no comment period is provided, then an in depth, formal health assessment is encouraged.

The strongest similarity between the two sites is that regardless of the level of PAH contamination, the ATSDR remained consistent with its ruling of "no apparent health risk." The McCormick and Baxter on-site soil samples did have higher cPAH values than the Chattanooga Creek floodplain. However, a more accurate comparison would be the Chattanooga Creek floodplain and McCormick's off-site soil sampling results. McCormick and Baxter's off-site soil sampling results for comparable cPAH values were all nondetects. Therefore, the Chattanooga Creek floodplain has higher cPAH values. In either case, ATSDR ruled no apparent health risk. Although risk has been attributed to PAH exposure (ATSDR noted exceptions for McCormick and Baxter's past workers and Chattanooga Creek's purposed raised greenway option), the exact amount of exposure necessary to cause risk has yet to be determined.

Table 8. McCormick and Baxter and Chattanooga Creek Floodplain Comparison Results.

	McCormick and Baxter	Chattanooga Creek Floodplain
EPA Region	X	IV
Official Superfund Site	YES	NO
Method of Assessing Health Risk	Maximum cPAH Concentration	Maximum cPAH Concentration
Contamination Level Found On-Site	1900 mg/kg	13.1 mg/kg
Public Health Hazard	NO	NO
Public Comment Period	YES	NO
Remediation due to other Contamination	YES	NO
Community Involvement	YES	YES
Trespassing	YES	YES
Fencing/Warning Signs	YES	NO
Reuse	Greenway	Greenway

The first round of EPA SRI pilot grants served as a model for the proposal process. Most of the 1999 recipients had entered into cooperative agreements with the EPA and activities had already begun. In order to broaden the SRI program, the EPA announced an open proposal process at the end of 1999. Interested applicants submitted proposals by April 7, 2000, indicating possible types of reuse activities and the type of EPA support needed (EPA, 2004a). In July of 2000, 40 pilot grants were approved. Of the 40, the Niagara Mohawk Power Corporation in Saratoga Springs, New York, and the Central Wood Preserving Site in Slaughter, East Feliciana Parish Police Jury, Louisiana, were appropriate comparison sites.

Niagara Mohawk Power Corporation (2001)

Ms. Maria Jon, from EPA Region II, was helpful in acquiring necessary information regarding the Niagara site. Niagara Mohawk Power Corporation (NMPC) is a seven-acre site that has been used for a variety of purposes. Beginning in 1853, the site was used for coal gas manufacturing and then by various companies until the late 1940's. Since 1950, the property has been used for an electric substation, natural gas facilities, vehicle and equipment repair, storage facilities, and offices (EPA, 2001c). By 1990, NMPC was placed on the NPL list. The NMPC (a PRP) has offered to help develop a rails-to-trails path and assist with site clean up (EPA, 2001b).

The identified human health risks at the NMPC site were possible exposure to contaminated soils by industrial workers and excavators, recreational wetland use by adolescents, and future health risks to adults and children if the site was developed for residential use through contact with and ingestion of contaminated soil (EPA, 1992b). PAH concentrations in surface soils had concentrations ranging from 5.45 to 433 mg/kg total PAHs (EPA, 1992b). Despite the PAH results, the noncarcinogenic risks for children via soil ingestion were due to antimony, iron, and arsenic, while the carcinogenic risks to workers and future residents were attributed to benzene and arsenic (EPA, 1992b). Site-specific RAOs would most likely remove any concern linked to PAH contamination through remediation of the antimony, iron, benzene and arsenic. Similar to previously mentioned sites, the PAH contamination was remediated by way of processes attributed to other chemicals of concern. Unfortunately, the Chattanooga Creek floodplain is not on the NPL or being considered for Superfund cleanup. As a result, indirect remediation of PAH contamination will not occur unless further investigations are conducted with the hopes of identifying other chemicals of concern such as heavy metals.

Table 9. NMPC and Chattanooga Creek Floodplain Comparison Results.

	NMPC	**Chattanooga Creek Floodplain**
EPA Region	II	IV
Official Superfund Site	YES	NO
Method of Assessing Health Risk	Total PAH Concentration	Total PAH Concentration
Contamination Level Found On-Site	433 mg/kg	523 mg/kg
Public Health Hazard	YES	NO
Remediation due to other Contamination	YES	NO
Reuse	Rails-to-Trails	Greenway

Central Wood Preserving (2001)

In 2001, Central Wood Preserving (CWP), located in EPA Region VI, was awarded a 2001 SRI grant with the hopes of increasing recreational areas in the community. Located in Slaughter, East Feliciana Parish, Louisiana, CWP preserved wood using creosote from the late 1950's until 1973, and then replaced creosote with wolmanac (a solution of copper, chromium, and arsenic salts) (EPA, 2001d). Wolmanac was used until the company declared bankruptcy in 1991 (EPA, 2001d). On May 10, 1999, EPA added the CWP site to the NPL (EPA, 2001d).

Louisiana State Highway 959 divides CWP into a North and South property. Bordering the properties are woodlands on the north and south, an unnamed creek and wetlands to the east-southeast, and residential property to the northwest and northeast (EPA, 2001d). The community surrounding CWP is primarily poor African Americans living in low to middle income housing. The nearest residences were less than 25 feet from the site before removal, but approximately 140 people continue to live within a mile radius of the site (ATSDR, 2002).

The ATSDR report stated that 43 composite samples (0-6" soil depth) of surface soils were collected from the property in July 1993 (ATSDR, 2002). In September 1993 and December 1994, additional surface soil samples were collected, although the number of samples collected was not reported. Nine additional soil samples were collected in January of 1999 (ATSDR, 2002). TEF values were obtained from the maximum concentrations of cPAHs found in the on-site soils during the sampling events. ATSDR concluded that the levels of cPAHs detected in the North property (BaP equivalent TTEC= 402 mg/kg) on-site soils presented a public health hazard (ATSDR, 2002). cPAH concentrations found on the South property (BaP equivalent TTEF=102 mg/kg) were not high enough to be designated a public health hazard (ATSDR, 2002). The report does say "the site (South property) is partially fenced…[but]…is too distant from the nearest homes for young children to trespass unless accompanied by an adult. Remediation activities should eliminate soil exposure pathways in the future" (ATSDR, 2002). With a BaP equivalent TTEC value of 89 mg/kg, the Chattanooga Creek floodplain is below the CWP South property TTEC value, but is highly accessible to children and trespassers, and is virtually the backyard for many residents. Therefore, a reevaluation of the safety of the Chattanooga Creek floodplain should be considered, addressing all reasonable routes of exposure (dermal, ingestion, inhalation).

The ATSDR also reports on the on-site soil and sediments of an Unnamed Creek. The report states:

> Samples collected near or in the creek are referred to as soil/sediment samples because both are impacted by contamination carried overland to the Unnamed Creek. Although creek sediments may differ in composition from bank samples, exposure to either media independent of the other is unlikely. A trespasser who would come in the area of the creek would

come into contact with both creek sediments and nearby soils (ATSDR, 2002).

The on-site soil/sediment BaP equivalent value was 1,488 mg/kg and warranted a public health hazard designation. ATSDR also recommended that the South property fence be repaired and off-site migration of site related contaminants needed to be prevented (ATSDR, 2002). The report planned a review of post remedial soil and sediment sampling to help ensure measures are protective of public health (ATSDR, 2002). The removal of Chattanooga Creek sediment and not surrounding soils seems contradictory to the above ATSDR statement. The CWP value of 1,488 mg/kg is a combination value of both soil and sediment found on-site. Although screening of the floodplain had a much lower BaP equivalent value (90 mg/kg), the idea of trespasser access and no fencing still raises concern. If access to the Chattanooga Creek is allowed via the floodplain, remediation of the surrounding soil should be considered.

At the time of writing, it was not known whether the CWP community was officially designated an environmental justice community, but based on the facts provided in the Public Health Assessment, it seems likely that the surrounding community deserves such designation. The EPA issued a Community Involvement Plan in July 1999, which discussed issues, concerns, and informational needs of the community. In July 2000, the Office of Public Health (OPH) conducted a Needs Assessment that surveyed nine households and 30 participants, all of which were African American. The active steps culminated in a commitment on the part of OPH and ATSDR to follow up on actions and ensure that the actions were implemented. The proactive steps demonstrated by Region VI lend support to the conclusion that the concerns voiced by the South Chattanooga community should be investigated further before opting to invite the community onto floodplain soils.

Table 10. CWP and Chattanooga Creek Floodplain Comparison Results.

	CWP	**Chattanooga Creek Floodplain**
EPA Region	VI	IV
Official Superfund Site	YES	NO
Method of Assessing Health Risk	BaP Equivalent	BaP Equivalent
Contamination Level Found On-Site	N=402 mg/kg S=102 mg/kg	90 mg/kg
Public Health Hazard	N=YES S=NO	NO
Remediation due to other Contamination	YES	NO
Community Involvement	YES	YES
Trespassing	YES	YES
Fencing/Warning Signs	YES	YES
Reuse	Recreational Space	Greenway

American Creosote Works (2002)

Finally, a site in Pensacola, Florida, was awarded a $50,000 SRI grant in 2002 (EPA, 2002d). American Creosote Works (ACW) was a wood treatment facility from 1902 to 1981, when ACW filed for bankruptcy (EPA, 2002d). The surrounding community consists of predominately white, low to middle income residents between the ages of 45 and 65 (ATSDR, 1992). The city was looking into reusing the site for recreational purposes.

Fencing surrounds ACW and the site was bordered on the north and west by an industrial and commercial area and on the south and east by residential neighborhoods (ATSDR, 1992). Pensacola Bay lies approximately 2,000 feet south of the site (ATSDR, 1992). The nearest residences are 100 feet from the site and approximately 1,000 residents live in the neighborhood (ATSDR, 1992). Soil ingestion from trespassing was identified as the main human PAH exposure pathway (ATSDR, 1992).

Most of the soil contamination at the ACW site was from pentachlorophenol and creosote. The off-site contamination was linked to overflows from on-site wastewater lagoons (ATSDR, 1992). On-site and off-site contamination from PAHs had occurred and the concentration of BaP exceeded EPA Region VI health-based comparison value of 7.5 mg/kg in three of the 19 on-site surface soils samples (highest value= 23 mg/kg) (ATSDR, 1992). None of the 31 off-site composite surface soil samples (0-1ft depth) had BaP values above the health-based comparison value, although PAHs were detected (ATSDR, 1992). There were no health-based comparison values available (ATSDR, 1992). If 7.5 mg/kg BaP was used as the Region IV health-based comparison value, 2 out of 15 surface and both subsurface soil samples from the Chattanooga Creek floodplain would have exceeded 7.5 mg/kg, indicating a lack of EPA region ARAR consistency.

ATSDR concluded that the ACW site was not sufficiently posted with warning signs and that children trespassing on the site were likely to be exposed to PAHs via ingestion (ATSDR, 1992). The report also stated "planned remediation at [ACW] is likely to expose contaminated surface and subsurface soils, increase the off-site transport of PAH contaminated dust…and increase nearby residential exposure" (ATSDR, 1992). The Chattanooga Creek floodplain has many trespassers with no warning signs or fencing to prohibit access despite ATSDR recommendation.

The ACW ATSDR report recommended that remediation occur on-site and access be strictly limited (ATSDR, 1992). Off-site remediation of surface soils near ACW needed to occur "as soon as possible" and effective dust control techniques during remediation needed to be employed to prevent further off-site migration of PAHs (ATSDR, 1992). The ATSDR recommendations suggest that the levels of PAHs present in the ACW on-site and off-site surface soils represent a public health risk. The health risk concerns resulted in immediate soil remediation and measures to discourage site trespassing. The ATSDR report concluded:

> the site is a public health hazard due to the risk of adverse health effects from long term exposure to hazardous chemicals in the air, soil, and ground water. The soil at this site should be remediated as soon as possible. Until soil remediation is complete, an adequate number of warning signs should be posted to prevent continued vandalism of the fence and site trespass (ATSDR, 1992).

In contrast to the ACW site, the Chattanooga Creek floodplain ATSDR report declared "no public health risk" from PAH exposure with a BaP value of 9.86 mg/kg and the government has not enforced posted signage or fencing surrounding the site. This shows inconsistency between EPA regions and ATSDR rulings. An interesting note is that the ACW site is not surrounded by a minority population. Whether racial differences were the cause of governmental discrepancy needs further investigation and was outside the scope of the thesis.

Table 11. ACW and Chattanooga Creek Floodplain Comparison Results.

	ACW	Chattanooga Creek Floodplain
EPA Region	IV	IV
Official Superfund Site	YES	NO
Method of Assessing Health Risk	Maximum BaP value	Maximum BaP value
Contamination Level Found On-Site	23 mg/kg	9.86 mg/kg
Public Health Hazard	YES	NO
Remediation due to other Contamination	YES (ASAP)	NO
Community Involvement	YES (low-income Caucasian)	YES (low-income Minority)
Trespassing	YES	YES
Fencing/Warning Signs	YES	NO
Reuse	Recreational	Greenway

Although the Superfund Redevelopment sites and SRI pilot grant recipients discussed in this section are merely a snapshot of the over 240 sites currently in reuse, the sites used for comparison illustrate the irregularity between EPA regions, the difficulty in obtaining necessary information, and the inconsistencies in cleanup protocol. In order to a have a truly fair and efficient cleanup and reuse program, all sites should have the same remediation standards based on proposed site reuse. The standards need to be updated on a regular basis to stay current with advances in science and be appropriate for the intended reuse (residential, recreational, public services, commercial, agricultural, or ecological). To remediate a site that will be paved over for a parking lot may not be the best use of time or money, but a site welcoming visitors and guests to picnic, play, and explore the wilderness it provides, should be remediated to assure adequate protection of human health.

IV. Recommendations

Environmental Justice

South Chattanooga, Tennessee, has been the object of numerous investigations due to its large minority population living in close proximity to hazardous waste sites. The number and magnitude of hazardous waste sites in this community suggests that its residents have been exposed to a disproportionate amount of pollution. Today, South Chattanooga is widely recognized as an environmental justice community.

Data from the 2000 census of South Chattanooga supports the environmental justice designation. The census determined that 95% of South Chattanooga residents were African American and 40% of the total population was under the age of 20. The census also determined the median household income to be less than $13,000 compared with the Chattanooga Metropolitan Statistical Area median household income of $50,000. Public housing projects, constructed in the late 1950's and 1960's during Chattanooga's Urban Renewal Project, constitute a majority of the residential property found in South Chattanooga.

The Urban Renewal Project was an attempt to revitalize downtown Chattanooga and was in conjunction with Interstate 24 construction. The project relocated predominately "low income Negro families" into public housing projects constructed on inexpensive land purchased in the heavily industrialized area of South Chattanooga. By 1985, 18.7% of South Chattanooga was zoned residential, 15.4% zoned industrial and 64% zoned undeveloped. In 2005, most of the undeveloped land was still zoned industrial, thereby dictating the future usage of the undeveloped land. Local zoning and land use planning offices, while recognizing the problem of incompatible land uses in this area, have failed to take action to rectify the problem.

- **The City of Chattanooga should rectify South Chattanooga's incompatible zoning in order to ensure that the environmental justice community is protected from further exposure to industrial pollution.**

Flooding

Chattanooga Creek has experienced numerous flooding events both before and after remediation. A May 2003 flood on the Tennessee River resulted in a 2-mile wide overflow of Chattanooga Creek. Contamination from the Creek was likely redistributed into the floodplain during these events. Dr. Larry McKay, a professor at The University of Tennessee, Knoxville, confirms that toxic chemicals are being carried into the floodplain with every heavy rain that causes the Creek to overflow (McKay et al., 2005). In order to reuse Chattanooga Creek, access must be offered. The safety of the floodplain for use as a recreational greenway is therefore called into question.

- **A reassessment of the Chattanooga Creek floodplain safety must be completed before supporting any type of greenway path construction.**

CCHSMP grant and ATSDR Health Consultation

Due to persistent flooding of Chattanooga Creek and lingering questions about the adequacy of past and proposed removal actions, South Chattanooga citizens were not convinced that the Chattanooga Creek floodplain was safe enough to accommodate public use without additional remediation. To address this concern, EPA's Office of Environmental Justice awarded the *Chattanooga Creek Hazardous Substances Monitoring Program* grant, which involved environmental sampling of a portion of the floodplain adjacent to the Superfund site.

The results of the Chattanooga Creek floodplain sampling showed total PAH and cPAH levels well above several government guidelines (CREG, BaP Equivalents, and residential and industrial soil PRGs). Although guidelines are not legally enforceable, the guidelines are the only guidance government agencies provide for Superfund site assessment.

- **Guidelines must be established that represent achievable remediation objective(s).**
- **The guidelines should be universally applied in all EPA Regions.**
- **The guidelines should be organized according to potential remedial site re-use (i.e. residential, public services, recreational, commercial, ecological or agricultural).**
- **Once established, guidelines should be reviewed on a regular basis and revised when necessary.**

Despite guideline exceedance and related community concern, ATSDR issued a Health Consultation that declared no apparent public health hazard existed from contact with floodplain soil PAH contamination. In order to comply with EO 12898, all federal agencies are required to identify and address the effects agency programs, policies and activities have on the distribution of environmental impacts on minority and low-income populations (EO 1994). According to TDEC, federal and state environmental laws, rules, regulations and policies must ensure the fair and equitable treatment and empowerment of all Tennessee residents (TDEC, 2000). The Tennessee Department of Health (TDOH) and ATSDR did not consider the impact of a no apparent public health hazard ruling on the environmental justice community of South Chattanooga. ATSDR did not consider the impact of cumulative effects of low-risk exposure to a population that has previously been exposed to a disproportionate amount of risk. ATSDR also neglected to allow for an adequate public comment period on the issued Health Consultation.

- **ATSDR and TDOH should reevaluate the conclusion of no apparent public health hazard in order to comply with EO 12898 and Tennessee environmental justice principles.**
- **ATSDR must address the issue of cumulative effects of continual low-risk exposure to the environmental justice community of South Chattanooga.**
- **ATSDR should allow for an adequate public comment period on the issued Health Consultation.**

Case Study Comparisons

Five Superfund projects from various EPA Regions were analyzed using the case study method. Major discrepancies between Superfund remediation projects were discovered. The primary causes for discrepancy were a lack of guideline consistency, inconsistent interpretation of relevant environmental laws, and indeterminable risk associated with PAH mixtures.

Dermal contact with and incidental ingestion of contaminated soils were determined to be major routes of potential exposure to PAHs at all locations. Trespassing was a major problem and risk of exposure for children was identified as a primary concern. Because PAHs are ubiquitous in the environment, agencies have been reluctant to determine the exact amount of risk attributed to PAH mixture exposure. As a result, none of the five sites were placed on the NPL or remediated based solely on PAH contamination, although PAH remediation often resulted from subsequent cleanup. The Chattanooga Creek floodplain soil sampling results show PAH levels exceeding several of the guidelines used by the five comparison Superfund projects but the Chattanooga Creek floodplain was not remediated.

- **Agencies need to establish cohesive cleanup guidelines to reduce the disparities between Superfund projects.**

- **Regulatory Agencies must develop universally accepted interpretations of relevant regulatory terms to provide uniformity within EPA Regions and Superfund Projects.**

- **Federal and State Agencies must determine the health risks associated with PAH mixture exposure.**

- **Health risks linked to exposure must be routinely reviewed and revised when appropriate to stay current with the latest scientific research.**

- **Agencies must also consider the synergistic, potentiation, and antagonistic effects of PAH exposure and address the effects in agency reports.**

The Chattanooga Creek floodplain was not considered one of the three distinct areas of contamination in the TP RI/FS. By not considering the floodplain as a potential Superfund location, adequate remediation did not occur. Although remediation of a section of Chattanooga Creek was cleaned to a visually confirmed level, the soils and seams surrounding Chattanooga Creek were not remediated. Since the TP RI/FS, no substantial sampling has been performed outside of the *Chattanooga Creek Hazardous Substances Monitoring Program* grant, and the grant data are higher than the values presented in the TP RI/FS. The higher PAH values could be due to possible PAH redistribution during flooding events.

- **The floodplain should be listed as an official Superfund (either State or Federal) site in order to ensure further characterization of floodplain contamination.**

- **Remediation based on a "visible" standard should not be accepted. Adequate technology exists to verify that remediation and removal of contaminates has occurred. Appropriate scientific methods should be implemented to confirm remediation success.**

Unlike the five comparison Superfund projects examined, the Chattanooga Creek floodplain does not have effective measures to control site access. The measures that are in place (one cable and one gate) are ineffective. The EPA, TDEC, and ATSDR acknowledge that trespassing occurs and is a problem at the site. Residential neighborhoods lie in close proximity to the site and children have been seen on site.

- **Fencing and warning signs need to be installed to prevent site access and inform people of the dangers associated with the site.**
- **ATSDR and EPA should not discount the probability that children will have access to floodplain soil and need to take appropriate measures to accommodate the fact.**

Federal and State Agencies have failed to identify and address the effects programs, policies and activities have on the South Chattanooga environmental justice community. The government perpetuates the longstanding practices of unfair treatment and environmental racism towards the South Chattanooga community by not complying with EO 12898. South Chattanooga's struggle is by no means unique. Gaining an understanding of the complexities associated with Superfund remediation and environmental justice communities provides a means to hold Federal and State agencies accountable. The intent of the recommendations suggested in this thesis is to encourage Agency compliance with EO 12898 and to prevent the unfair treatment of minority and low-income individuals living in the community.

V. Conclusion

The South Chattanooga and Chattanooga Creek floodplain case study illustrates the complexity of the Superfund site remediation process. Inconsistent guidelines and overall community frustrations often lead to roadblocks and misunderstandings. In order to have a successful remediation process, a balance between addressing community concerns and government obligation must be found.

Understanding that an environmental justice community's perception of risk is directly related to the reports the government provides is imperative. When scientific research establishes that Chattanooga Creek floodplain soil contamination levels are well above government guidelines it is only natural for South Chattanooga citizens to respond by questioning public safety and demanding answers. Providing uniform guidelines that reflect current scientific research and accurately represent possible community health risk is essential in facilitating a productive relationship between government agencies and the public.

The South Chattanooga community deserves to be protected from further health risks. South Chattanooga citizens have already been subjected to years of contamination and have been recognized as an environmental justice community. Both Federal and State governments have the responsibility to protect the South Chattanooga citizens as stated in EO 12898, regardless of cost. It was the government that placed South Chattanooga citizens at risk through public housing projects, permit issuances, and uncontrolled waste management. Thus, the government needs to protect the community from further risk. The government needs to address the problems associated with the

Chattanooga Creek floodplain through indepth research, detailed health studies, and possible remediation before authorizing the construction of a public greenway.

In 1992, EPA stated it "should increase the priority that it gives to issues of environmental [justice]" (EPA, 1992d). By March 1, 2004, the Office of Inspector General found that EPA had not consistently ensured that minority and low-income populations were provided the actions that would benefit and protect them as intended by EO 12898 (OIG, 2004). EPA Region IV and ATSDR have not protected the citizens of South Chattanooga under EO 12898. This thesis confirms that the South Chattanooga citizens have not been protected under EO 12898 and has identified the multiple factors that impede remediation of the Chattanooga Creek floodplain and hindered efforts by South Chattanooga residents to achieve environmental justice.

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