THE GROUNDWORK USA TRUST ACT OF 2015

A Scientific Assessment

Cover Image used with Permission from Groundwork USA

The Groundwork USA Trust Act of 2015
A Scientific Assessment

Prepared in fulfillment of Workshop in Applied Systems Management, Summer 2016
Columbia University, School of International and Public Affairs

Manager: Allison Pace

Deputy Manager: Kaitlin Flahive

Team Members:
Merav Cohen
Erica Golin
Nicole Joseph
Sara Kaddoura
Lacey Gray McCarthy
Zenia Montero
Iara Souza Vicente

Faculty Advisor: Dr. Matthew Palmer, Department of Ecology, Evolution, and Environmental Biology

Acknowledgements

The authors of this report would like to thank our faculty advisor for his dedication and guidance throughout the semester. We also very much appreciate the valuable insights and contributions to our research made by Groundwork USA, Groundwork Hudson Valley, and Groundwork Lawrence.

Images Used with Permission from Groundwork USA, Groundwork Lawrence and Creative Commons

COLUMBIA | SIPA
School of International and Public Affairs

THE EARTH INSTITUTE
COLUMBIA UNIVERSITY

EXECUTIVE SUMMARY

The estimated 500,000 brownfield sites in the United States pose a significant threat to human and environmental health. This contamination discourages redevelopment and hinders social and economic growth. Redevelopment of contaminated brownfields is site-specific and requires thoughtful consideration of human health, ecosystem health, and social justice issues within the community.

At a brownfield site, contaminants can travel through the soil, air, and/or water and ultimately enter human systems through dermal contact, ingestion, or inhalation. To make the site suitable for public use, the contaminants must be managed – either through degradation, stabilization, or extraction. The decision about which techniques to use weighs cost, effectiveness, and duration to determine the best action for the site. Soil vapor extraction, solidification and stabilization, bioremediation, and extraction, the most commonly used techniques, have been used to clean up thousands of sites across the United States, thereby creating significant benefits for their local communities.

The Groundwork Trusts are community organizations whose mission is to "bring about the sustained regeneration, improvement and management of the physical environment". These nonprofits are formed by local organizers and focus on community-oriented solutions. Justice and equity issues are ameliorated by Groundwork Trusts' inclusive and equitable community development projects, generating socially and ecologically sustainable land use.

The Groundwork USA Trust Act of 2015 would increase brownfield remediation by allocating $15,000,000 in federal funding per fiscal year from 2016 to 2021. This would be accomplished through federal grants to eligible nonprofit organizations. The bill, introduced in October 2015 by U.S. Congresswoman Niki Tsongas of Massachusetts now sits with the House Committees on Energy and Commerce, Natural Resources, and Financial Services.

This report details a science-focused analysis of the environmental consequences of brownfields and the remediation processes that the Groundworks USA Trust Act of 2015 would fund. It also expands on the range of performance metrics that can be used to evaluate the success of the program.

TABLE OF CONTENTS

BACKGROUND

A brownfield is "a property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant" (EPA, 2015). The term likely derives from "greenfield", a site that has not previously been developed or polluted (Merriam-Webster, 2016). Beyond landscape contamination, brownfield sites often face issues of both social and environmental justice and have negative effects on quality of life in the region (EPA, 2015).

The US Environmental Protection Agency has estimated there are over 500,000 brownfield locations in the United States and has prioritized the remediation and revitalization of such sites through the Brownfields Revitalization and Environmental Restoration Act of 2001 (EPA, July 2015). This act secured funding for assessing, cleaning, preventing, and fostering sustainable use of brownfield areas (EPA, 2015). Of the estimated 500,000 sites, approximately 36,000 have been assessed (Figure 1). Over 54,149 acres of brownfields have been remediated and made available for reuse by the Environmental Protection Agency's Brownfields Program. Remediation of brownfield sites has resulted in up to a 12.8% increase in property values, encouraging real estate transactions and consequently economic development (Haninger et al., 2012).

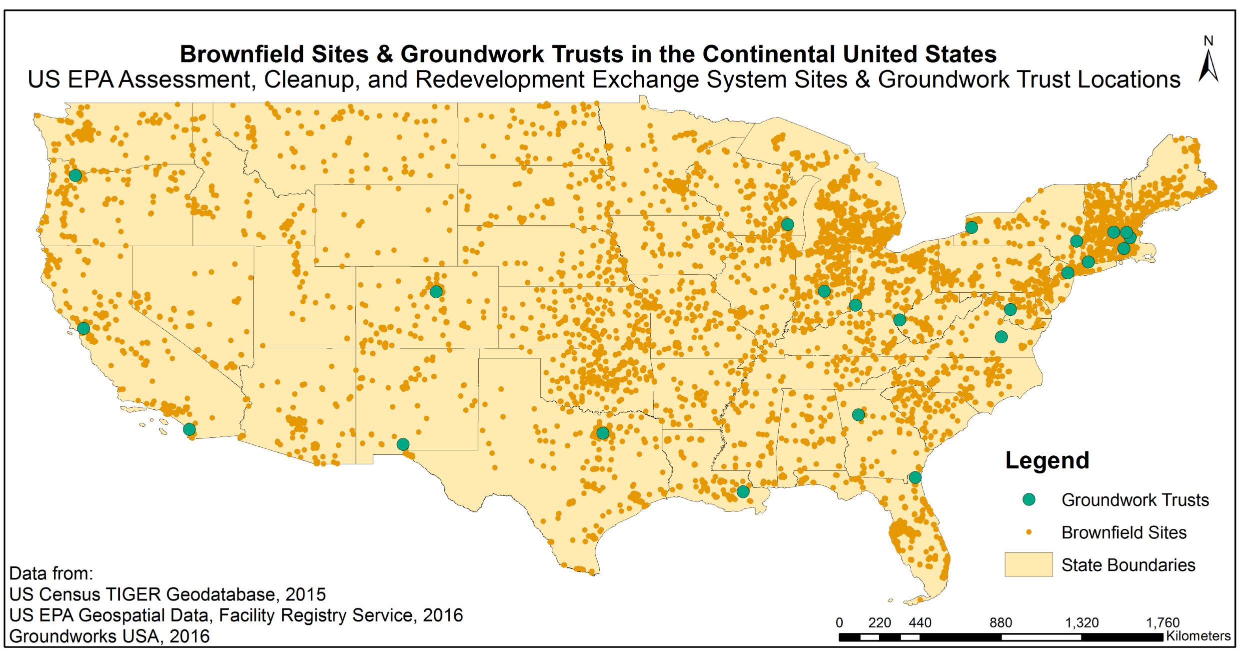

Figure 1: Brownfield Sites & Groundwork Trusts in the Continental United States

Twenty three locally-based Groundwork Trusts have been established throughout the United States to revitalize communities, modeled after successful Groundwork UK programs in the 1980s (Groundwork USA, 2016). Groundwork USA, established in 2001, is a national non-profit organization that aids in the development of and coordination between these Groundwork Trusts (Groundwork USA, 2016). Between 2000 and 2010, Groundwork Trusts have improved 393 acres of brownfields in the USA, focusing on sustainable and equitable community-specific solutions (Groundwork USA, 2016).

Following a 2005 Memorandum of Understanding between the EPA's Office of Solid Waste and Emergency Response and the US Department of the Interior National Park Service's Rivers Trails and Conservation Assistance Program, the EPA and USDI signed an Interagency Agreement pledging federal funding to assist in the development of Groundwork Trusts.

The Groundwork USA Trust Act of 2015 (H.R. 3707) was introduced in October 2015 by USA Congresswoman Niki Tsongas of the 3rd Congressional District of Massachusetts to allocate $15,000,000 per fiscal year (2016-2021) to these brownfield remediation efforts. This act brings attention to the scale of the problem of brownfield contamination throughout the United States, and would support a variety of remediation solutions that will both improve the environment and revitalize communities.

THE PROBLEM

Industrial, commercial, and even residential sites can leave a legacy of pollution and risks that are often invisible to the naked eye. Both government and community-led programs have focused on the redevelopment of brownfields because they pose numerous risks to environmental and public health. Moreover, because sites are often contaminated with numerous contaminants, synergistic effects can amplify the magnitude of problems incurred from brownfield sites.

ECOSYSTEM HEALTH

In the transition from heavy industry to service-based economies, many cities experience brownfield remediation issues (National Institute of Environmental Health Sciences, 1998). A variety of industrial and commercial facilities including landfills, agricultural sites, hospitals, light and heavy manufacturing, and gas stations release harmful substances into the landscape. Contaminants of agricultural sites include volatile organic compounds (VOCs), metals, and pesticides. Contaminants of iron and steel mill sites include VOCs, metals, acids, and solvents. Gas and petroleum refineries and dispensaries produce fuels and fuel byproducts, which can spill and remain as pollutants.

Many contaminants associated with brownfield sites are not easily broken down by the natural environment and therefore persist for long periods of time (EPA, 2016). Environmental risks include soil and water contamination and the loss of land productivity and biological diversity. Metals, for example, cannot be broken down and therefore can remain in the environment for long durations. In a process known as bioaccumulation, contaminated plants may be consumed by animals and concentrations of a toxin increase in higher trophic levels, potentially including humans, as they consume contaminated food sources (Nordberg, 1974).

HUMAN HEALTH

Adverse effects on human health associated with contaminants found at brownfield sites range from mild rashes to increased rates of cancer. The level and type of contamination vary by site, depending on prior land use, and consequently, so do health risks. Inhalation, ingestion, and dermal contact are the three routes through which exposure may occur (Figure 2). The intake rate and duration of exposure affect the dose to which a person is exposed and therefore the health effects that are present as a result of the exposure.

A 2002 study found that residents of Southeast Baltimore living near brownfields have statistically higher risks of developing specific health issues, adjusting for other known risk factors (Litt et. al., 2002). Specifically, the authors found a statistically higher mortality rate from cancer in areas of brownfields with the highest degree of hazard potential, based on chemical and physical site characteristics (Litt, et.al., 2002),

In order to protect human health, residential reuse must comply with non-hazard thresholds for residential soil and residential air (Ellerbusch, 2005).

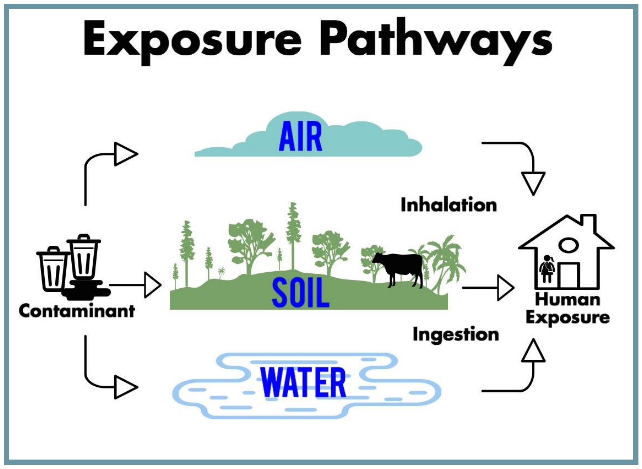

Figure 2: Pathways of Contaminant Exposure, Adapted from CDC, 2005

CONTAMINANT PROFILES

We analyzed data from the US EPA and found the most frequent contaminants at 36,207 assessed brownfield sites were lead at 9,259 sites (25.6%), volatile organic compounds (VOCs) at 7,483 sites (20.7%), and asbestos at 5,760 sites (16%) (Figure 3). Some sites assessed under the EPA Cleanups in My Community Program contained two or more chemical contaminants. Other common contaminants include polychlorinated biphenyls (PCBs), arsenic, cadmium, and mercury. Each of these can pose major risks to human and ecosystem health (Ding, 2006). The following profiles describe two contaminants commonly found on brownfield sites and their effects on human health.

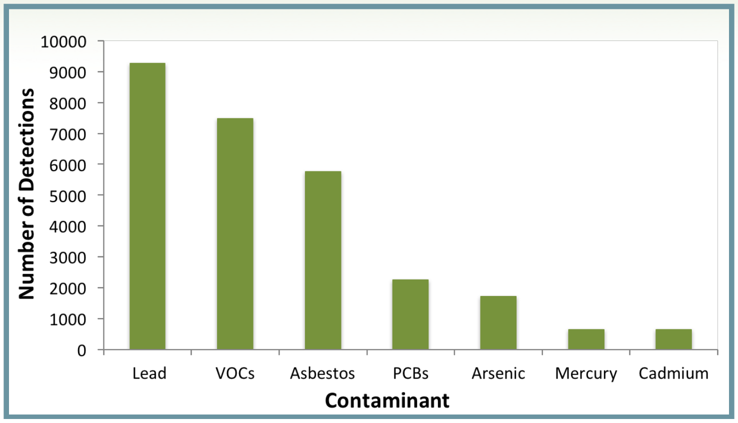

Figure 3: Contaminant Detection on 36,207 Brownfield Sites
Data from EPA Cleanups in My Community, 2016

SOCIAL AND ECONOMIC PROBLEMS

Brownfield sites drain government resources. They often generate little or no tax revenue and the hazards associated with them (such as injury and disease risk from contact with contaminants) consume local health department resources (Hersh, 2010). Brownfields often contain abandoned buildings and warehouses, which can be a magnet for crime. Crime rates on blocks with easily accessed abandoned

Polychlorinated Biphenyls (PCBs)

Polychlorinated biphenyls (PCBs) were used commonly between 1950 and 1979 in the United States in paints, wood coatings, caulking, and electrical appliances including fluorescent light fixtures and transformers (Schnapf LLC, 2013). They are a group of manmade organic compounds that are chemically stable and fire-resistant and therefore work as excellent insulators. However, because they are so stable they accumulate in the environment and are easily cycled between air, water, and soil (CDC, 2014).

PCBs cause a wide range of negative environmental effects. Plants can absorb PCBs and accumulate the compound in their tissues. When the contaminant is then consumed by animals, it can decrease reproductive rates and cause deformities in various species of birds and fish (Brown et al., 2013.). The contaminants can be transferred through the food chain and may accumulate in higher concentrations at higher trophic levels (Nelson, 2015). PCBs can pose serious human health risks to those people who consume PCB-contaminated foods such as fish (Nelson, 2015). Another primary mechanism of exposure for humans is inhalation of PCB-contaminated dust. Health effects associated with PCBs include increased rates of liver cancer, possible lower birth weights, and most commonly skin irritations such as acne (CDC, 2012). The US Environmental Protection Agency classifies PCBs as probable human carcinogen.

Mercury

Mercury is a naturally occurring heavy metal that easily volatilizes to a highly toxic vapor (EPA, 2015). It is found naturally in coal and other fossil fuels, and is found in mercury thermometers, medical equipment, batteries, electrical switches, dental fillings, and fluorescent light bulbs, which are still used today (EPA, 2015; Baird, 2012; Besser, 2009). Plants that burn fossil fuels and municipal waste are the biggest contributors to mercury in the atmosphere in the USA (Barid, 2012).

The metal can build up in fish over time because it is easily absorbed through their gills (Baird, 2012). As these fish are consumed by other animals, their mercury levels also increase. Studies have shown reduced reproduction and altered behaviors in many bird species that live close to bodies of water and consume contaminated fish (USGS, 2000). Points of contamination for humans can include ingestion from eating contaminated foods like fish, dermal absorption through the skin, and inhalation of vapors. Human health impacts include respiratory issues like pneumonitis, neurobehavioral effects including mood changes and tremors, other neurological issues such as loss of hearing and reduced vision and numbness of limbs, and even death (Baird, 2013; Besser, 2009).

buildings can be twice as high as similar blocks without abandoned buildings (Spelman, 1993).

Brownfield sites disproportionately impact low-income and minority communities. A study by the Commission for Racial Justice of the United Church of Christ found that relative to all population groups, minorities were more than twice as likely to live in zip codes containing hazardous waste sites (Yacovone, 2016). The Council for Urban Economic Development found areas within a one-mile radius of brownfields had poverty rates that were double the national average (Paull, 2008). Environmental and health implications associated with these sites discourage businesses and individuals from investing in the area, sustaining the economic inequalities already in place (Hersh, 2010).

Brownfields are often unsightly, featuring characteristics such as decrepit structures, overgrown vegetation, litter, and vandalism. These lots can cause entire neighborhoods that may otherwise appear healthy to be perceived as run down and neglected ("Impacts of Brownfield Redevelopment," n.d.). It becomes difficult for citizens to take pride in or care about their communities when they appear neglected, and neglect lowers both morale and spirit (Hersh, 2010).

THE SOLUTION

The Groundwork USA Trust Act of 2015 aims to address the problem of brownfields, which by definition are very diverse. Despite the commonality of severe contamination among brownfield sites, the contamination types and sources vary greatly and often overlap. Therefore, brownfield remediation often addresses several forms of contamination at once.

Modern science and technologies provide a broad range of remediation techniques. Some

Figure 4: Former brownfield turned into a community playground, Image Credit: Groundwork Lawrence

well-known technologies have been used for decades with predictable results and innovative techniques are continuously emerging. The range of possibilities makes deciding among the techniques a nuanced and complex process.

REMEDIATION

There are an estimated half a million brownfield sites and the EPA has identified and collected data on approximately 36,000 of them. Once a site has been identified and assessed, potential remediation options are considered. Decision-makers must consider remediation technologies' ability to achieve compliance with environmental statutes and protect human health and the environment. The key parameter is the type of contamination on the site, which is determined by the previous uses of the land and the period of time in which they operated. An abandoned laundromat leaves behind a pollution signature very different than the one of a major power plant (EPA-CIMC).

Remediation efforts work to degrade, stabilize, or extract contaminants through a multitude of methods. These methods include physical, chemical, and biological techniques, which are often used in combination.

RISK ASSESSMENT

Risk assessments determine the level of hazard at a brownfield site, with respect to the types and levels of contaminants present and the populations that are likely to be exposed to these contaminants.

Toxicity Standards

The level of contamination correlated to adverse health effects varies based on age and lifestyle factors. There are different standards for adults than for children, and risk levels also differ depending on one's body weight, the frequency and duration of exposure, and the route(s) of exposure. Therefore, in determining the safe level of contaminant, exposure risk assessors must use the most conservative estimate. Compound exposure, or simultaneous contact with multiple contaminants, may increase adverse health effects. As brownfields often contain more than one contaminant, it is necessary to calculate the combined risk. Although the risks associated with brownfield contaminants are assessed by qualified environmental professionals, these risk assessments are often conducted by multiple agencies. If there is inadequate communication, coordination, and discussion, the data and subsequent risk assessment could potentially be negatively affected. Disagreements may also arise between different agencies on what the safe standard may be for a particular site (Public Health Assessment Guidance Manual Appendix G, 2005).

Sampling and Risk Assessment

Each brownfield contaminant evaluation and risk assessment is done in two phases. Phase I involves the review of records related to the site's past use and possible contaminants, as well as an inspection visit. Phase II, an in-depth evaluation of the conditions at the site, is enacted if the Phase I assessment determines that contaminants are present on site that may pose a risk. During Phase II, any combination of measurements of soil, soil vapor, sediment, and groundwater are collected and analyzed in laboratories. A confirmation of contaminants among the samples warrants an assessment of risk to human health and the environment. Then, if the contaminant levels are unacceptable, a plan is made for cleanup. The Phase II assessment is useful for confirming the degree of contamination and the risks, but is insufficient for confirming the quantity of waste and the cleanup costs (NYS Department of Environmental Conservation, 2015).

Figure 5: Brownfield, Image Credit: Creative Commons

The process of remediating then follows three steps: i) evaluating the profiles of contaminants of the site in question; ii) choosing the most appropriate remediation technique, evaluating both budget and effectiveness issues; and iii) evaluating the success of the chosen technique.

COMMON REMEDIATION TECHNIQUES

The United States EPA keeps records of remediation projects. Based on the Fourteenth Superfund Remedy Report, the four most frequently-used remediation techniques are i) Soil-Vapor Extraction; ii) Solidification/ Stabilization; iii) Bioremediation; and iv) Excavation (Superfund Remedy Report, 2013). The premise for drawing inferences about brownfield remediation based on Superfund decision data is that brownfields often contain contaminants that are the same or similar in nature to those found at Superfund sites. The frequency at which the remediation methods have been used previously should indicate their general utility for other brownfields. These methods are designed to uphold the EPA's mission of protecting human health and the environment (Superfund Remedy Report, 2013). We consider a range of these techniques below.

Soil-Vapor Extraction (SVE)

This remediation technique consists of extracting volatile and semi-volatile compounds from the soil using a vacuum (Figure 6). Volatile Organic Compounds (VOCs) and similar contaminants have high vapor pressures, which allows them to easily evaporate (volatilize) to a gaseous state when pressure is decreased. To utilize SVE, holes are bored into the contaminated soil and extraction wells are installed. The extraction wells induce the surrounding air to flow into it, lowering the pressure surrounding the well and causing contaminants to volatilize and be vacuumed out

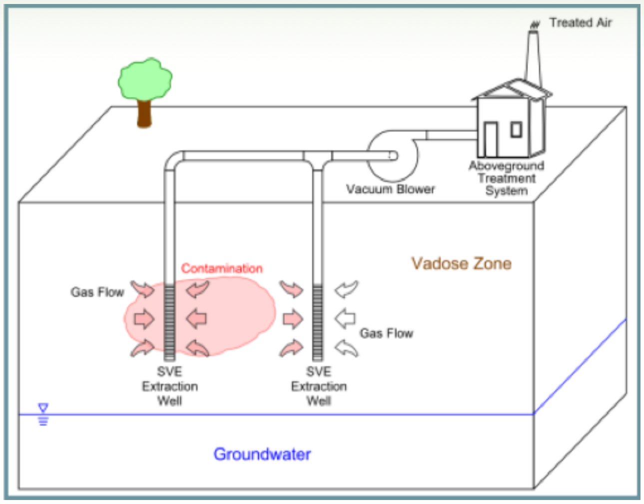

Figure 6: A Schematic Representation of Soil Vapor Extractions, Image Credit: Creative Commons

of the soil (Suthersan, 1996). The contaminated gases can then either be stored or treated by activated carbon filtration, biofiltration, or by exposure to high temperatures. In the case of carbon filtration, VOCs adhere to granular activated carbon, creating an end product of carbon granules that need to either be replaced or replenished (A Citizen's Guide to Activated Carbon Treatment, 2012).

Air permeability of soil, volatility of contaminant, water content, and organic content determine whether SVE will be effective. SVE projects are typically completed in one to three years, with site-specific costs that typically range from \$400-1500 per cubic meter of contaminated soil. Significant costs are added when gas is filtered or treated off-site or when groundwater pumping is necessary. SVE is not effective for heavy metals, oils, polychlorinated biphenyls (PCBs), or dioxins since they do not volatilize easily. Through the process of SVE, contaminants are first extracted and then degraded. (FRTR, 2016)

Solidification and Stabilization

Solidification and stabilization processes trap or contain contaminants in a medium, either in-situ (on site) by injecting chemicals or ex-situ (off site) by mixing chemicals with excavated medium. This technique uses both physical and chemical processes, and typically takes less than one year. Solidification and stabilization can limit the potential for future use of the brownfield, because these processes add materials which can alter both the topography and hydrology of a site (A Citizen's Guide to Solidification and Stabilization, 2012). There are two widely used methods, the reagent/ injector head systems method and the in-situ vitrification method.

The Reagent/Injector Head Systems Method: This method consists of drilling a well and injecting chemical solutions. For example, Portland Cement is often used as a binder in a reaction that alters the chemistry of lead at a site (Hekall, 2012). In this technique, a calcium silicate hydrate gel binds with lead, allowing it to be contained inside cement. Methods involving binders and reagents work to bind the pollutants together and isolate them, or to activate a reaction whose byproduct will be harmless. It is necessary to consider soil properties, moisture content, targeted contaminants, and durability when determining if this technique would succeed. An underlying impermeable barrier is typically used to prevent leakage of the waste. This method has shown to be effective in 95% of cases by reducing mobility of contaminated waste within the sites. Its effectiveness on organic compounds such as VOCs, SVOCs and pesticides is currently limited. Implementation of binder/reagent injections typically costs $70-250 per cubic meter of contaminated soil (A Citizen's Guide to Solidification and Stabilization, 2012).

In-situ Vitrification Method (ISV): This method uses an electric current to melt soil or other earthly materials at extremely high temperatures (1,600-2,000 °C or 2,900-3,650 °F). It immobilizes most inorganic contaminants by containing them into solids. ISV breaks organic compounds down into less harmful organic byproducts, similar to obsidian or basalt rock. In order for ISV to occur, the soil must contain at minimum 1.4% of its total weight in alkalis (sodium or potassium), so the reactions can result in a solid. It is effective in both inorganic (e.g. metals) and organic (e.g. VOCs and PCBs) contaminants. Utilizing in-situ vitrification typically costs $350 per cubic meter of contaminated soil (A Citizen's Guide to Solidification and Stabilization,2012).

Bioremediation

Bioremediation involves the use of living organisms to remediate contaminants. Phytoremediation, one specific type of bioremediation, uses vegetation to degrade, stabilize, or extract contaminants (Figure 7). Phytoremediation warrants consideration for cleaning up brownfields at which there are relatively low concentrations of contaminants at shallow depths (Brownfields Technology

Primer, 2001). Phytoremediation is most effective over a large cleanup area and is believed to be an effective method for remediating heavy metals (such as lead and cadmium), PCBs, petroleum waste, nutrient waste (phosphates and nitrates), and others (Brownfields Technology Primer, 2001). Contaminant type, local environment, and climate are all factors that dictate which type of plant species is used at a specific-site (Brownfields Technology Primer, 2001). Phytoremediation may be effective over a relatively long period of time with low initial costs because it relies on solar energy and can be completed on-site. This method typically costs $153 per cubic meter of contaminated soil over a period of 30 years (Brownfields Technology Primer, 2001). Three specific types of phytoremediation are phytodegradation, phytostabilization, and phytoextraction.

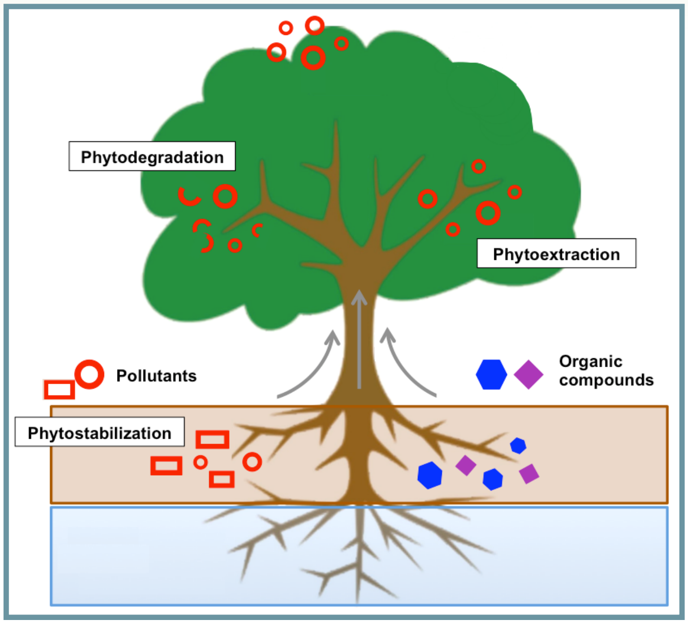

Figure 7: Phytoremediation Processes, Adapted from Wikimedia Commons

Phytodegradation: Phytodegradation refers to the process through which plants take up contaminants through their roots and use enzymes to break them down into different substances, which are then incorporated into the plant's tissues and soil (Brownfields Technology Primer, 2001). This can be used to degrade organic compounds such as trichloroethylene (TCE) and pentachlorophenol (PCP) using the plant species cottonwood or wheatgrass (Kühl, 2010).

Phytostabilization: Phytostabilization is a method through which plants take up contaminants through their roots and render contaminants immobile through the process of absorption (Brownfields Technology Primer, 2001). This is effective for remediating metals such as mercury and lead with plant species such as Indian mustard and common wheat (Kühl, 2010).

Phytoextraction: Phytoextraction involves the uptake of contaminants through the roots of plants and then the contaminants are translocated to other parts of the plant. The plant tissue is then harvested and removed, and those tissues are processed as contaminated waste. The targeted contaminants are most often elements (Brownfields Technology Primer, 2001). Chromium, for example, is a transition metal that can be remediated using the plant species alpine pennycress and duckweed (Kühl, 2010).

Excavation

Excavation is the physical removal of the contaminant from the site. This process usually requires the use of sieves, bulldozers, and other tools to remove contaminated soil or other contaminated media, and the contaminated soil is transported elsewhere (Brownfields TSC, 2016). The excavation and disposal processes do not degrade or stabilize the contaminant, but the removal can mitigate adverse effect and potential risks. Faster remediation processes are usually much costlier, and excavation, along with the disposal of the contaminated medium, is generally much faster and considerably more expensive than microbiological remediation, for example. For total petroleum hydrocarbons (TPH), excavation will take up to 3 years and in-situ microbiological remediation will take up to 10 years. Despite a higher cost, remediation via excavation allows for the land to be used productively by the community sooner (Meuser, 2013).

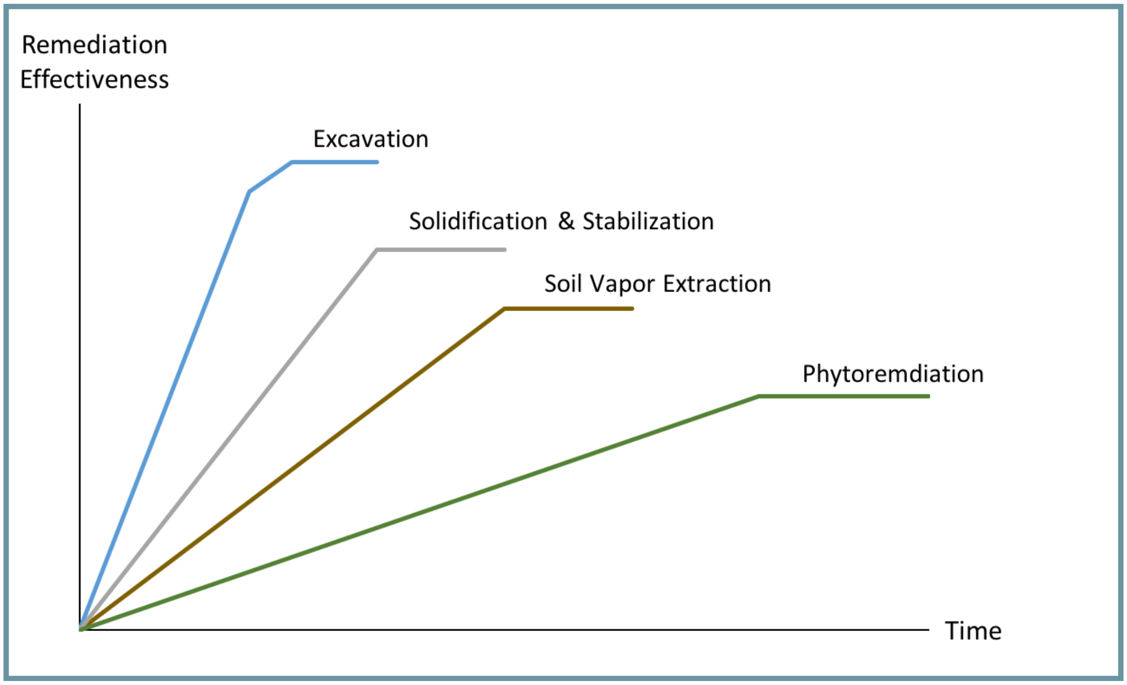

Figure 8: Schematic Relationship between Remediation Time and Gained Remediation Objective
Adapted from Meuser, 2013

Table 1: Comparison of Remediation Techniques, Data Sources: A Citizen's Guide to Solidification and Stabilization, 2012, Brownfields Technology Primer, 2001, Federal Remediation Technologies Roundtable (n.d.), Suthersan, 1996

Remediation technique		***Pollutants on which it works***	***Pollutants on which it does not work***	***Costs ($/ cubic meter)***	***Time (years)***
Soil Vapor Extraction		*VOCs, SVOCs*	*Heavy metals, PCBs, Dioxins*	*400- 1500*	*1 to 3*
Solidification/ Stabilization	*Binder/ Reagent Injections*	*Heavy metals, PCBs, Dioxins*	*VOCs, SVOCs, Pesticides*	*70 - 250*	*less than 1*
	In-situ vitrification	*Heavy metals, PCBs, Dioxins, VOCs, SVOCs, Pesticides*	*None*	*350*	*less than 1*
Phytoremediation		*Heavy metals, VOCs, SVOCs, PCBs*	*None, but may reintroduce contaminants if not harvested*	*153*	*30*

SITE-DEPENDENT DECISION MAKING

The science of brownfield remediation will continue to develop, and the decision-making process must include cost-benefit analyses. It is important to consider factors such as contaminant profile, the costs, and the time that it takes to remediate a brownfield in order to address the problem most successfully.

Binder/reagent injections are often the most cost-effective, however this technique cannot address important pollutants such as VOCs, SVOCs and pesticides (Table 1). In this case, the next best option would be soil vapor extraction, which works within a timely period as well. The effectiveness of various remediation techniques all increase with time, but the rate of increase and ultimate effectiveness varies considerably (Figure 8; Table 1).

GROUNDWORK USA TRUSTS

The Groundwork USA Trust Act allocates funding to community organizations to remediate brownfield sites throughout the United States. The ultimate goal of the Groundwork Trusts funded by this bill is to "transform environmental liabilities in community assets" (Groundwork USA, 2013). In order for a remediation project to be considered successful, a site must not only be safe according to government standards, but also become a vibrant center for the community or a viable location for economic enterprises.

Case Study: Manchester Street Park

Lawrence, Massachusetts

An example of successful brownfield redevelopment with Groundwork Trusts is Manchester Street Park in Lawrence, Massachusetts. The five-acre brownfield site, on the banks of Steven's Pond, was originally used as a railroad yard for the Greater Lawrence Industrial Park and later housed a coal fired power plant. The site was also home to a large incinerator and was considered to be nuisance to members of the local community (Lindberg, 2011). The brownfield site featured legacy contamination of arsenic, dioxin, and benzo(a)pyrene (EPA, 2009; Lindberg, 2011). The remediation process first identified the locations on site in which contamination concentrations exceeding state thresholds. These areas were capped with a physical separation that stabilized the contaminants in place and prevented any human contact. The area was then topped with three feet of clean soil to support vegetation and allow for recreational use. Leveling of the ground was required by the site's development plans, therefore the top layer of contaminated soil was excavated and moved to fill lower areas on the site, before it was covered with the separation layer and clean soil (TRC, 2008).

Today, the park hosts green space complete with permeable pavement, playground equipment and even a community garden (Lindberg, 2011). The park is part of the Spicket River Greenway, a linear green space linking low-income neighborhoods and several other existing parks. Recognized in 2010 with the national Brownfield Renewal Award for Social Impact, Manchester Street Park serves as a model for other communities, and acts as a stimulus for the redevelopment of underutilized buildings and contaminated sites (Groundwork Lawrence, 2010). Overall, the local government and community volunteers have largely contributed to the site's success through extensive involvement in activism, fundraising, planning and ongoing input from nearby neighborhoods' residents (Groundwork Lawrence, 2010). Groundwork Lawrence also promotes local residents' involvement and interaction with the park through various activities, such as growing fresh produce in the park's community gardens (Groundwork Lawrence, n.d.).

Figure 9: Manchester Street Park, Image Credit: Groundwork Lawrence

In the 15 years of Groundwork USA, the Trusts have achieved significant success. Over 550 acres of brownfield sites were improved, 3,755 acres of green spaces were rehabilitated, and 1,109,031 feet of river habitats have been cleaned. From the social perspective over 736,878 community volunteer hours, 2,488 schools, and 7,325 community partners (e.g. associations, local business) were engaged in the remediation process. The remediation of

Figure 10: Groundwork USA Youth Science Program
Image Credit: Permission from Groundwork USA

brownfields positively contributed to the economy, generating $84,627,574 in economic activity (Groundwork USA, 2013).

MEASURING SUCCESS

Obtaining meaningful measurements of success of an environmental policy is a complex task. Environmental, social and economic factors must be addressed to go beyond surface metrics. Although it is important to consider the complexities inherent in these issues, measuring the program's success requires prioritizing specific factors that are indicative of overall success.

Environmental Success

The goal of brownfield remediation is not to restore a contaminated site into a pristine condition, but to remediate contamination to safe levels to make the site available for reuse (EPA, 2016). Therefore, the fundamental measure of brownfield revitalization projects is the success or failure of the project in stabilizing or removing contaminants to government-approved safety levels.

The increase in environmental services and green spaces in cities are additional indicators to evaluate the success of a brownfield remediation initiative. Groundwork USA Trust Act has improved over 1,185 acres of open space, planted over 127,416 individual trees and restored 297,665 feet of river habitat (Groundwork USA, 2013). However, these numbers do not demonstrate the actual changes within local ecosystems after redevelopment. For example, asking if the amount of individual trees planted contributed to the urban tree canopy or resulted in increased bird populations on the site or how riverbank restoration improved local aquatic ecosystems may give way to deeper analysis of the true ecological success of a remediated site.

Social Success

Determining the extent of a project's social impact is also challenging. Causal relationships between infrastructural changes, volunteer work and the abstract but important "sense of community" are difficult to measure. Also, finding data to conduct such analyses is challenging, especially because the variables involved often go beyond the scope of standard

Figure 11: Children Playing at former brownfield,
Image Credit: Groundwork Lawrence

governmental social databases such as census data.

Some social impacts of brownfield remediation projects have indeed been quantified. The latest official report from Groundwork USA shows a total of 1,321,876 people benefited. The report also shows a total of 3,610 amenities installed and over 308,726 volunteer hours mobilized on revitalization actions (Groundwork USA, 2013). The challenge, once again, is to understand what deeper changes on the social fabric were promoted by the project's actions.

In a study on brownfield remediation and violence reduction, concrete data on landscape changes associated with brownfield redevelopment was related to a suite of health and crime statistics (Branas et al. 2011). Through statistical analysis, the authors analyzed correlations between vacant green lots and health and crime indicators. Gun assault events were found to be significantly reduced within a 660-foot buffer of redeveloped spaces (Branas et al., 2011). This study illustrates how deeper metrics of success can be constructed through analysis of publicly-available data and could be applied more broadly.

Economic Success

The evaluation of the economic revitalization of a remediation project requires objective parameters to determine how a remediated brownfield affects a neighborhood's economy. The data currently available do not provide a precise picture of such parameters. Groundwork USA reports that projects have created at least 1,350 jobs, promoted 10,770 weeks of environmental training and involved 3,066 partners, some of whom are local businesses (Groundwork USA, 2013). While these numbers certainly indicate positive outcomes, they lack the depth to fully characterize the economic revitalization. For a deeper understanding, one could investigate the characteristics of these jobs. For example, how many of these jobs were permanent jobs? Some data addressing these questions are accessible from government databases (e.g. employment statistics and real estate registries) but an analysis establishing relationships between these parameters and the brownfield remediation projects remains to be completed.

Some of the keys aspects in evaluating the economic benefits of restoration are property values, tax incentives, reliefs/abatements, private investment, final use of site, return on investment and cleanup costs (Bacot and O'Dell 2006). For example, increased real estate values on a former brownfield site and its surrounding areas can hasten gentrification. These changes in a given area often negatively affect existing social dynamics (Essoka, 2010). The improvements and their impact on living conditions may attract wealthier stakeholders that could benefit from the new dynamics and environmental services provided by the remediation. Residents who suffered the ill effects of the contamination prior to the cleanup may be forced to move out of the neighborhood and are therefore excluded from the benefits. This creates a gap between one of the objectives of the policy (community engagement) and the actual results.

Neither the data nor the research available today is sufficient to measure the success and outcomes of brownfield remediation projects at the national scale. The existing data and research point towards significant merits and accomplishments of the Groundwork Trusts, but it is necessary to establish deeper indicators to measure the success of each grant. Therefore, it is necessary to develop a comprehensive set of indicators to evaluate the brownfield remediation projects both individually and collectively. This aims to measure not only success or failure, but rather to establish a scale through which policy managers can extract lessons to continuously improve implementation.

LEGISLATION

Local Groundwork Trusts are linked by the Groundwork USA national program office (Groundwork USA), which has been funded for eight years by the federal government through programs under the National Park Service Rivers, Trails and Conservation Assistance Program and the Environmental Protection Agency. Trusts work with Groundwork USA's national office and local communities to implement cost-effective remediation projects that benefit the quality of life, the economy, and the environment. Notably, the success of brownfield remediation depends on the involvement of community members in determining most desired and functional land-use.

Establishment of the Groundwork USA Trust Program and Criteria for Selection of Awards: The bill establishes the Groundwork USA Trust Program, which authorizes the Secretary of the Interior, with consultation of the national Groundwork USA office, to award grants to eligible organizations. Criteria for selection considers many factors including: the demographics and population in which the organization serves; the organization's experience with community and environmental improvement activities; if the organization's community or government received funding or assistance from the EPA Brownfields Program or National Park Service and demonstrated success; commitment to learn and partner with Groundwork USA; and potential to facilitate the creation of economic and environmental improvements from transforming brownfields. The bill highlights preference of applicants with strong potential to stimulate the community's economy and rejuvenate the environment by addressing brownfields, engage the community, and with plans to use or reuse infrastructure.

Furthermore, preference will be given to applicants with a strong ability to leverage funds and that can address environmental health issues within its community.

Groundwork USA Trust Program Fund Use: The organization receiving an award may use the grant money in several ways to transform brownfields and to benefit the community. Organizations can use the money to provide training and support to operations and staff and to reclaim, clean, and revitalize brownfields. Money also can be used for educating the community about the environment, food security, and health and fitness. Moreover, awarded organizations can use the money to engage local businesses and municipal governments in the cleanup process. Funds can be used in inner city rejuvenation and aid in smart growth strategies. Furthermore, money can be used to expand operations to benefit a larger area beyond its municipality of residence, increase staff, and develop information systems to serve its community and region.

Administration: The bill authorizes $15,000,000 for each of the fiscal years 2016 through 2021 in appropriations to carry out the Groundwork USA Trust Program. An individual grant award cannot exceed $400,000 for any fiscal year. The Secretary may not reserve more than fifteen percent of the amount available for administrative costs. Finally, each grant recipient must submit an annual report with information that the Secretary or the Groundwork USA national office may require.

CONTROVERSIES

The remediation of brownfield sites ameliorates risks to human and environmental health, but remediation is not always without controversy. There are inherent uncertainties in assessing risks and determining an acceptable level of safety, as well as concerns of social and economic fairness and justice.

DEFINING A BROWNFIELD SITE

The definition of a brownfield site in the act is vague. Moreover, the bill does not specify limits or levels of contamination which would constitute a site of being a brownfield. This ambiguity allows for many derelict and contaminated lands to fall under the definition of brownfields, and thus, funding for many community organizations to remediate blighted environmental lands. The EPA's Superfund program has a more stringent definition of what constitutes a superfund site. A site is deemed a "superfund" site if it scores 28.5 or higher on EPA's Hazard Ranking System. The superfund site is then placed on the National Priorities List, and only then is the site eligible for Superfund Trust Fund-financed remedial actions (EPA, Superfund). With more specific brownfield site qualifications, there would be less room for error and miscommunication when dealing with governing bodies during the cleanup process.

HOW CLEAN IS CLEAN?

A brownfield may be considered clean when it receives a decision of "No Further Action" from a government agency, which indicates that a site is safe for reuse without any further cleanup action. As outlined by the U.S. Department of Energy, a decision of No Further Action is issued if contaminated substances are not being released and are not expected to be released, a substance released is not hazardous, the release of a substance is permitted by the EPA or authorized state, or the release of a substance is non-threatening to human health and non-threatening to the environment (U.S. Department of Energy, 1996). If groundwater is contaminated but is shown to have migrated from outside the facility, that also warrants a decision of No Further Action (U.S. Department of Energy, 1996). Even after a No Further Action decision, further investigation may be necessary based on updated analysis of the site. Site-specific conditions, such as the expectation that contaminated materials will be released in the future, determine reevaluation. For example, groundwater in the site's vicinity may continue to be monitored (U.S. Department of Energy, 1996). As technological advances enable better detection tools and scientific research determines new potential hazards, brownfields must be re-assessed to determine safety, even if previously issued a Decision of No Further Action.

APPROPRIATE REUSE OF LAND

The EPA and the states set standards to which a cleanup must conform. Cleanup is dictated by intended future use of a property and the availability of funds (NYS Department of Environmental Conservation, 2015). Remediation must be safe, but only needs to meet a minimum threshold required for the intended use. Appropriately controlled levels of contamination, if determined to be low risk to future use, can be left on-site. The control of contaminants required for residential property is stricter than that of industrial property as individuals, especially children, are likely to spend more time in residential properties (NYS Department of Environmental Conservation, 2015).

DECISION-MAKING

If the interests of all parties involved in the remediation of a brownfield site are not carefully considered, there may be tension between stakeholders, often at the expense of low-income and minority communities.

In the context of brownfields, a stakeholder is "...any person or group that has an interest in the outcome of a brownfield redevelopment project" (American Planning Association, 2010: 53). Many individuals in the community could be directly or indirectly affected by the wide range of impacts associated with brownfield development, including neighborhood groups, small business owners, elected officials, health advisors, planning agencies, and zoning boards (American Planning Association, 2010). Competing interests among stakeholders may result in tension. For example, an economic tradeoff may entail choosing between remediating a site quickly at a high price for

Case Study: Kiddie Kollege,

Franklin, New Jersey

Kiddie Kollege was a daycare center built on a former thermometer factory in Franklin, New Jersey. Environmental cleanup was not adequately completed before infants and toddlers entered the daycare facility, and airborne mercury levels were found to be 30-50 times the acceptable limit (Helfer, 2016). Mercury exposure raises the risk of adverse effects later in life, and parents were advised to “pursue personal-injury lawsuits” if health problems manifested for their children (Helfer, 2016). Mercury contamination is not only dangerous to human health, it is expensive. The cleanup of Kiddie Kollege cost $2 million for demolition and installation of monitoring wells, plus $4 million in fines. In 2014 the New Jersey Superior Court ruled that both the current owners and past owners of the site were liable for the cost – the property owners who bought the site should have done proper historical research or examined the New Jersey Department of Environmental Protection’s contaminated sites list to learn of the mercury contamination, and the owner of the thermometer factory should not have abandoned the site without proper remediation. According to a Department of Environmental Protection spokesman, the events at Kiddie Kollege resulted in tighter enforcement of contamination laws, including strict cleanup deadlines and supervision through licensed environmental professionals (Helfer, 2016). The site is currently vacant, as the structure was demolished, and the lawsuit between past and present owners continues (Green, 2014).

commercial development (high financial return-on-investment) or remediating a site more slowly and at a lower cost for use as a community space (low financial return-on-investment). Commercial sites may receive remediation faster than recreational areas because they have the potential to earn back the money invested in cleanup.

ENVIRONMENTAL JUSTICE

While many stakeholders argue that redevelopment has a positive community impact, environmental justice advocates are quick to note that this may not always be the case. Responsible decision-makers must consider the effects of brownfield remediation on vulnerable populations, such as youth, the elderly, the disabled, and low-income and minority communities.

Low-income and minority communities are already disproportionately impacted by the location of brownfields, and remediation does not necessarily improve the quality of life for these communities. Increased property values can lead to increased rent and increased demand to live in certain neighborhoods, and in this way brownfield cleanup may intensify gentrification and displacement of low-income and minority communities (American Planning Association, 2010). Another problem arises as communities are not always granted the opportunity for involvement as expected when receiving a redevelopment grant. For example, the city of Portland, Oregon decided to focus a brownfield grant on the Albina region in the northeastern part of the city. The city formed a Community Action Council and held public forums, however only seven local property owners submitted applications for property assessment. This was partially due to a lack of education about the brownfields program. Many members of the community feared liability or felt they lacked the development expertise to participate. Portland ultimately decided these assessments were not cost effective, and no assessments were performed. This left locals with a sense of distrust about the local government, and with a belief that the brownfields program was "a promise, not a project" (NEJAC, 2006).

SUMMARY

Brownfield remediation is nuanced and inevitably intertwined with both scientific and socioeconomic controversies. Site assessments gauge whether contaminants are present and the level of risk associated with them, and the assessment is complicated by site-specific and population-specific factors. Cleanup may be considered complete when a decision of No Further Action is determined by the EPA or state authorities, and even still there may be conditions present that warrant the continued monitoring and analysis of conditions on or near the site. The process of revitalizing a brownfield must have considerable community engagement to ensure it meets the needs of those using the site, and to avoid unintended consequences, especially in the realm of environmental justice.

There are many technologies that can be utilized to remediate a brownfield. Decision-makers must consider the type of site, the extent of the contaminants, cost, and effectiveness. Contamination rarely occurs in isolation, so a mix of different techniques and technologies are often used to remediate a single brownfield. Remediation efforts are improving with scientific research that further improves conditions for human and ecosystem health. With the presence of many successfully remediated brownfield sites, it is evident these areas can become vibrant spaces for urban communities.

The Brownfield USA Trust Act of 2015 would implement a federal funding stream to help revitalize degraded community spaces across the United States. Modern society is increasingly interested in settling within largely urbanized areas, with younger generations especially drawn toward city centers. Increasing desire for urban living in today's society could help drive the redevelopment of these degraded areas that pose high risks to human and environmental health.

REFERENCES

Axelrod, D., Adams, K., Chowdhury, F., D'Amico, L., Douglas, E., Hudson, G., … Weber, K. (2013). America's Children and the Environment, 3rd Edition (No. EPA 240-R-13-001) (pp. p. 151–158). U.S. Environmental Protection Agency. Retrieved from https://www.epa.gov/sites/production/files/2015-06/documents/ace3_2013.pdf.

Bacot, H., & O'Dell, C. (2006). Establishing Indicators to Evaluate Brownfield Redevelopment. Economic Development Quarterly, 20(2), 142–161. http://doi.org/10.1177/0891242405285749.

Baird, C., & Cann, M. (2012). Environmental Chemistry. W. H. Freeman. Besser, R. E. Childrens Exposure to Elemental Mercury. Retrieved from http://www.atsdr.cdc.gov/mercury/docs/mercuryrtcfinal2013345.pdf.

Brown, T. M., Kuzyk, Z. A., Stow, J. P., Burgess, N. M., Solomon, S. M., Sheldon, T. A., & Reimer, K. J. (2013). Effects-Based Marine Ecological Risk Assessment At A Polychlorinated Biphenyl-Contaminated Site In Saglek, Labrador, Canada. *Environmental Toxicology and Chemistry, 32*(2) pp. 453-467.

Center for Disease Control (CDC) (2014). Polychlorinated Biphenyls- ToxFAQs. In Center for Disease Control (CDC) (Ed.), (Vol. CS249955-AC).

Center for Disease Control (CDC) (2012). Cadmium- ToxFAQs. In Center for Disease Control (CDC) (Ed.), (Vol. CAS#7440-43-9).

Ding, E. (2006). Brownfield Remediation for Urban Health: A Systematic Review and Case Assessment of Baltimore, Maryland. The Undergraduate Research Journal. Retrieved from http://www.jyi.org/issue/brownfield-remediation-for-urban-health-a-systematic-review-and-case-assessment-of-baltimore-maryland/.

Eisen, J. B. (2011). Finality in Brownfields Remediation and Reuse. Southwestern Law Review, 41, 773–796.

Ellerbusch, F. (2005). Residential redevelopment of brownfields: Is human health being protected? (Ph.D.). Rutgers The State University of New Jersey - New Brunswick and University of Medicine and Dentistry of New Jersey, United States -- New Jersey. Retrieved from http://search.proquest.com/docview/305374082/abstract/59C6AE6EBDA542F3PQ/1.

Essoka, J. D. (2010). The Gentrifying Effects of Brownfields Redevelopment. The Western Journal of Black Studies, 34(3), p.299–315.

Examples of Successful Redevelopment from the Brownfield Site Assessment Program. (n.d.). [Programs and services]. Retrieved August 18, 2016, from http://www.tceq.state.tx.us/remediation/bsa/SuccessStories.html.

Federal Remediation Technologies Roundtable. (n.d.). Remediation Technologies Screening Matrix and Reference Guide, Version 4.0 [Government]. Retrieved August 18, 2016, from https://frtr.gov/matrix2/top_page.html.

Green, J. (2014, May 30). Kiddie Kollege mercury clean-up costs in Franklin go to past, present property owners NJ.com. Retrieved August 18, 2016, from http://www.nj.com/gloucester-county/index.ssf/2014/05/mercury_clean-up_cost_for_kiddie_kollege_goes_to_realtor_former_thermometer_maker.html.

Groundwork USA. (2015). Groundwork USA Network's Youth Programs 2014-2015. Groundwork USA. Retrieved from http://groundworkusa.org/groundwork-usa-networks-youth-programs-2014-2015/.

Groundwork USA. (n.d.). About Us. Retrieved from http://groundworkusa.org/about-us/
Haninger, K., Ma, L., & Timmins, C. (2012). Estimating the Impacts of Brownfield Remediation on Housing Property Values (SSRN Scholarly Paper No. ID 2469241). Rochester, NY: Social Science Research Network. Retrieved from http://papers.ssrn.com/abstract=2469241.

Hefler, J. (2016). Toxic Kiddie Kollege long gone, but N.J. parents' fears, legal battles rage on philly-archives. Retrieved August 18, 2016, from http://articles.philly.com/2016-07-18/news/74537950_1_kiddie-kollege-day-care-mercury-beads-becky-baughman.

Hekal, E. E., Kishar, E. A., Mohamed, M. R., Mahmoud, M. K., & Mohamed, B. A. (2012). Inertization of lead by using blended cement pastes. HBRC Journal, 8(3), 153–158. http://doi.org/10.1016/j.hbrcj.2012.10.001.

Hersh, R., Morley, D., Schwab, J., & Solitaire, L. (2010). Creating Community-Based Brownfields Redevelopment Strategies. American Planning Association, Community Health and Research Center. Retrieved from https://www.planning.org/research/brownfields/.

Hollander, J., Kirkwood, N., & Gold, J. (2010). Principles of Brownfield Regeneration: Cleanup, Design, and Reuse of Derelict Land. Island Press.

Hula, R. C., & Bromley-Trujillo, R. (2010). Cleaning Up the Mess: Redevelopment of Urban Brownfields. Economic Development Quarterly, 24(3), 276–287. http://doi.org/10.1177/0891242410365711.

Impacts of Brownfield Development. (n.d.). Retrieved August 18, 2016, from http://www.cmap.illinois.gov/about/2040/supporting-materials/process-archive/strategy-papers/brownfields/impacts.

Kühl, K. (2010). From Brownfields to Greenfields: A Field Guide to Phytoremediation. Retrieved from http://urbanomnibus.net/2010/11/from-brownfields-to-greenfields-a-field-guide-to-phytoremediation/.

Lindberg, L. (2005). Leveraging Funds Through Community Development Block Grants. National League of Cities. Retrieved from http://www.nlc.org/documents/Find%20City%20Solutions/Research%20Innovation/Housing%20-%20CD/leveraging-funds-through-cdbg-cpb-apr11.pdf

Litt, J. S., Tran, N. L., & Burke, T. A. (2002). Examining urban brownfields through the public health “macroscope”. Environmental Health Perspectives, 110 (Suppl 2), 183–193.

Martineau, D., Lemberger, K., Dallaire, A., Labelle, P., Lipscomb, T. P., Michel, P., & Mikaelian, I. (2002). Cancer in wildlife, a case study: beluga from the St. Lawrence estuary, Québec, Canada. Environmental Health Perspectives, 110(3), 285–292.

Merriam-Webster. (n.d.). Definition of GREENFIELD. Retrieved August 18, 2016, from http://www.merriam-webster.com/dictionary/greenfield.

Meuser, H. (2013a). Soil Remediation and Rehabilitation (Vol. 23). Dordrecht: Springer Netherlands. Retrieved from http://link.springer.com/10.1007/978-94-007-5751-6.

Meuser, H. (2013b). Treatment of Contaminated Land. In Soil Remediation and Rehabilitation (pp. 127–162). Springer Netherlands. Retrieved from http://link.springer.com/chapter 10.1007/978-94-007-5751-6_4.

National Environmental Justice Advisory Council. (2006). Unintended Impacts of Redevelopment and Revitalization Efforts in Five Environmental Justice Communities. U.S. Environmental Protection

Agency. Retrieved from https://www.epa.gov/sites/production/files/2015-02/documents/redev-revital-recomm-9-27-06.pdf.

Nelson, J. K. (2015). Fish and polychlorinated biphenlys. Mayo Clinic: Nutrition and healthy eating. Retrieved August 18, 2016 from http://www.mayoclinic.org/healthy-lifestyle/nutrition-and-healthy-eating/expert-blog/fish-and-pcbs/bgp-20150729.

New Jersey Department of Environmental Protection. (2008). Proposed Plan - Draft Remedial Action Selection Report. Trenton, New Jersey: New Jersey Department of Environmental Protection, Site Remediation Program. Retrieved from http://www.nj.gov/dep/srp/community/sites/accutherm/accutherm_rasr.pdf.

New Jersey Department of Health and Senior Services. (2007). Kiddie Kollege Franklinville, Gloucester County Mercury Fact Sheet #5. New Jersey Department of Health and Senior Services, Consumer and Environmental Health Services. Retrieved from http://www.nj.gov/health/eohs/gloucester/franklin_township/kiddie_kollege/kk_fs_5ver4.pdf.

New York State Department of Environmental Conservation. (2015). Brownfield Redevelopment Toolbox: A Guide to Assist Communities in Redeveloping New York State's Brownfields. New York Department of Environmental Conservation. Retrieved from http://www.dec.ny.gov/docs/remediation_hudson_pdf/bftoolbox.pdf.

Pearsall, H. (2010). From Brown to Green? Assessing Social Vulnerability to Environmental Gentrification in New York City. Environment and Planning C: Government and Policy, 28(5),872–886. http://doi.org/10.1068/c08126.

Schilling, J., & Vasudevan, R. (n.d.). Strategic Lessons in Sustainable Community Building: The Groundwork USA Network. Center for Community Progress; Groundwork USA. Retrieved from http://groundworkusa.org/strategic-lessons-in-sustainable-community-building-2/.

Spelman, W. (1993). Abandoned buildings: Magnets for crime? Journal of Criminal Justice, 21(5), 481–495. http://doi.org/10.1016/0047-2352(93)90033-J.

Suthersan, S. S. (1997). Remediation engineering [electronic resource] : design concepts. Boca Raton, Fl: CRC-Lewis Publishers.

Tulve, N., Olsen, M., Broder, M., Firestone, M., Mulford, E., Sheldon, L., … Zartarian, V. (2016). Guidelines for Human Exposure Assessment (Peer Review Draft). U.S. Environmental Protection Agency. Retrieved from https://www.epa.gov/sites/production/files/2016-02/documentsguidelines_for_human_exposure_assessment_peer_review_draftv2.pdf.

U.S. Department of Energy. (1996). RCRA corrective action determination of no further action. USDOE Assistant Secretary for Environment, Safety, and Health, Washington, DC (United States). Retrieved from http://digital.library.unt.edu/ark:/67531/metadc664317/metadata/.

U.S. Environmental Protection Agency. (2001). Brownfields Technology Primer: Selecting and Using Phytoremediation for Site Cleanup (No. EPA 542-R-01-006). Washington, D.C.: U.S. Environmental Protection Agency. Retrieved from https://nepis.epa.gov/Exe/ZyPDF.cgi10002V5B.PDF?Dockey=10002V5B.PDF.

U.S. Environmental Protection Agency. (2010). From Brown to Green: Restoring Ecosystems on Former Brownfields. U.S. Environmental Protection Agency. Retrieved from https://nepis.epa.gov/Exe/ZyPDF.cgi/P1009IXO.PDF?Dockey=P1009IXO.PDF.

U.S. Environmental Protection Agency. (2011). Brownfields Success Story, Uncovering a Long-Buried Prize in Downtown Yonkers: “Daylighting” the Saw Mill River (Data and Tools No. EPA 560-F-11-023). U.S. Environmental Protection Agency. Retrieved from https://www.epa.gov/brownfields/brownfields-uncovering-long-buried-prize-downtown-yonkers-daylighting-saw-mill-river.

U.S. Environmental Protection Agency. (2012a). A Citizen’s Guide to Activated Carbon Treatment (No. EPA 542-F-12-001). U.S. Environmental Protection Agency. Retrieved from https://clu-in.org/download/Citizens/a_citizens_guide_to_activated_carbon_treatment.pdf.

U.S. Environmental Protection Agency. (2012b). A Citizen’s Guide to Solidification and Stabilization (No. EPA 542-F-12-019). U.S. Environmental Protection Agency. Retrieved from https://clu-in.org/download/Citizens/a_citizens_guide_to_solidification_and_stabilization.pdf.

U.S. Environmental Protection Agency. (2013). Superfund Remedy Report, 14th Edition (No. EPA 542-R-13-016). U.S. Environmental Protection Agency. Retrieved from https://nepis.epa.gov/Exe/ZyPDF.cgi/P100H3NF.PDF?Dockey=P100H3NF.PDF.

U.S. Environmental Protection Agency. (2015). EPA Targeted Brownfields Assessments, The Basics (Fact Sheet No. EPA-560-F-15-192). U.S. Environmental Protection Agency. Retrieved from https://www.epa.gov/sites/production/files/2015-09/documents/tba_0403.pdf.

U.S. Environmental Protection Agency. (n.d.-a). Basic Information about Mercury [Overviews and Factsheets]. Retrieved August 18, 2016, from https://www.epa.gov/mercury/basic-information-about-mercury.

U.S. Environmental Protection Agency. (n.d.-b). Brownfield Overview and Definition [Overviews and Factsheets]. Retrieved August 18, 2016, from https://www.epa.gov/brownfields/brownfield-overview-and-definition.

U.S. Environmental Protection Agency. (n.d.-c). Brownfields Road Map to Understanding Options for Site Investigation and Cleanup, 5th Edition (No. EPA 542-R-12-001). Retrieved from https://brownfieldstsc.org/roadmap.

U.S. Environmental Protection Agency. (n.d.-d). Summary of the Small Business Liability Relief and Brownfields Revitalization Act [Data and Tools]. Retrieved August 18, 2016, from https://www.epa.gov/brownfields/summary-small-business-liability-relief-and-brownfields-revitalization-act.

U.S. Environmental Protection Agency, & OSWER. (n.d.). Superfund Site Assessment Process [Overviews and Factsheets]. Retrieved August 18, 2016, from https://www.epa.gov/superfund/superfund-site-assessment-process.

U.S. Geological Survey. (2000). Mercury in the Environment Fact Sheet 146-00. United States Geological Survey. Retrieved from https://www2.usgs.gov/themes/factsheet/146-00/.

Yacovone, K. (2011). Brownfields and the Poor: Is Cleanup a Hazardous Waste of Time? An Analysis of the United States' Efforts at Remediation and Their Applicability to Brazil. Fordham International Law Journal, 35(1), 201.

Image Credit: Groundwork Lawrence