EPA

Climate Smart Brownfields Manual

Notice: The U.S. Environmental Protection Agency through its Office of Brownfields and Land Revitalization funded and managed the development of this manual under contract number EP-W-13-014. It has been subjected to the Agency's review and has been approved for publication as an EPA document. This manual does not replace established standards or guidelines. Mention of trade names, products, or services does not convey, and should not be interpreted as conveying, official EPA approval, endorsement, or recommendation.

Cover Photos (top left to bottom right): A wind turbine at the Atlantic County Utilities Authority Wastewater Treatment Plant in Atlantic City, New Jersey; Gold LEED rated City Hall green roof, Seattle, Washington; Solar panels on closed landfill at Ft. Carson Army Base, Colorado; The Shops at White Oak Village on redeveloped former Lucent Richmond Works facility, Richmond, Virginia

Executive Summary

Brownfield revitalization can support community efforts to become more resilient to climate change impacts by incorporating adaptation and mitigation strategies throughout the brownfield cleanup and redevelopment process. This manual will help communities think about climate mitigation, adaptation, and resilience in the context of brownfield cleanup and redevelopment. This includes consideration of projected climate change and potential impact on vulnerable populations when performing brownfield site assessments, evaluating cleanup alternatives, and planning for redevelopment. Early evaluation facilitates forward-looking decisions related to land use, zoning and building codes that increase resiliency. Communities are also encouraged to reduce carbon, greenhouse gas sources, and emissions through sustainable mitigation throughout the cleanup and redevelopment of brownfields and in the reuse of these sites.

This manual also will help brownfield communities better understand the range of climate change mitigation and adaptation strategies that can be applied at and around brownfield sites. It can serve as a resource for communities, grantees and government entities looking to assess, clean up and revitalize brownfields in a way that increases resiliency.

Finally, this manual can serve as a resource to users seeking additional information about increasing resiliency through brownfield revitalization. There is an annotated listing of informational resources and tools at the end of the document.

"[A] resilient city is one that is: first, protected by effective defenses and adapted to mitigate most climate impacts; and second, able to bounce back more quickly when those defenses are breached from time to time."

(City of New York, 2013)

Climate change mitigation: *A human intervention to reduce the human impact on the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhance greenhouse gas sinks.*

Climate change adaptation: *Efforts by society or ecosystems to prepare for or adjust to future climate change and reduce vulnerabilities to the impacts of climate change.*

Climate resilience: *A capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment.*

Adapted from EPA's Glossary of Climate Change Terms

http://www3.epa.gov/climatechange/glossary.html

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Introduction

Brownfield revitalization—the sustainable redevelopment of contaminated and abandoned properties—can support community efforts to become more resilient to climate change impacts by incorporating adaptation strategies throughout the assessment, cleanup and redevelopment process. Climate change adaptation comprises efforts by society or ecosystems to prepare for or adjust to future climate change. Many adaptation strategies afford opportunities to employ mitigation practices—human intervention to reduce the human impact on climate—including strategies to reduce carbon, greenhouse gas (GHG) sources and emissions and to enhance GHG sinks.

Considering climate change in a brownfield revitalization project includes identifying factors such as sea-level rise that may affect long-term suitability of the site; considering how factors, such as increasing temperature, may alter the toxicity of site contaminants; or determining which flora and fauna can be supported at the site in the future as climate conditions change ([Hansen, 2015]). This manual addresses how communities can incorporate climate change adaptation and mitigation strategies into their brownfield revitalization projects.

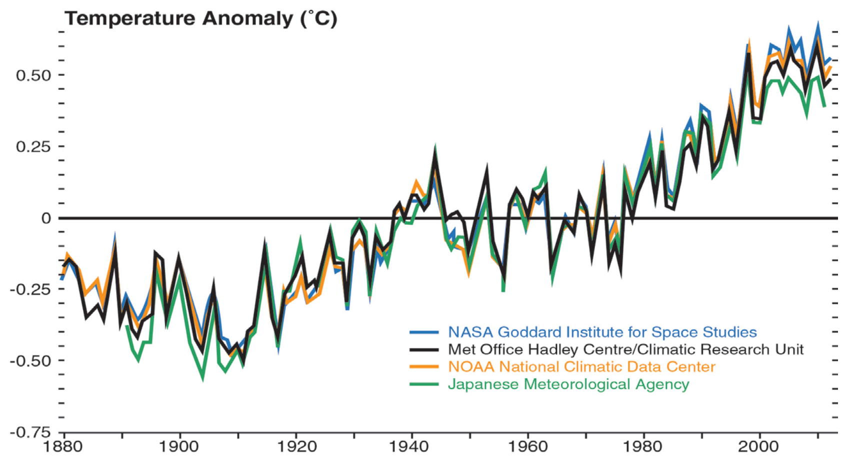


Figure 1. *This graph illustrates the change in global surface temperature relative to 1951-1980 average temperatures. The ten warmest years in the 137-year record all have occurred since 2000, with the exception of 1998. The year 2015 ranks as the warmest on record.*

Source: http://climate.nasa.gov/scientific-consensus/

Climate Change Facts

Every year from 1976 through 2015, the Earth's global land and ocean temperatures have been warmer than the long-term average.

Source: https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature

The combined average temperature over global land and ocean surfaces for February 2016 was 1.21°C (2.18°F) above the 20th Century average of 12.1°C (53.9°F). This was the highest for February during the 1880–2016 period of record—surpassing the previous record set in 2015 by 0.33°C (0.59°F). February 2016 also marked the tenth consecutive month that a monthly global temperature record was broken.

Long-term, independent records from numerous data sources confirm that our world is warming. Although scientists continue to refine future climate projections, observations show that climate is changing and that the warming Earth has experienced over the past 50 years is due primarily to human-induced increases in heat-trapping gases (U.S. Global Change Research Program, 2009). Across the United States, we have seen increased flooding in both coastal and inland cities, hotter and drier weather in western states leading to increased drought and a greater frequency and strength of wildfires, and receding sea ice in Alaska (receding at a rate of 13.4 percent per decade) leading to increased erosion. Figures 1-5 illustrate these trends.

On a global scale, crops and water resources are threatened by climate change. For example, a recent study reported a 20 percent decline in crop production for grain growers in North America, Europe and Australia, due to extreme weather disasters between 1964 and 2007. Water resources will be affected differently in different regions as the climate continues to change. Some regions may experience increased drought, while others may experience more frequent heavy precipitation. Additionally, the expected significant seasonal differences in precipitation rates could reduce water availability when it is most needed and yield an abundance of water when it is least needed (EPA, 2015a).

Why Mitigation and Adaptation Matter for Brownfield Communities

Many members of vulnerable populations, including children, the elderly, low-income communities of color and tribal communities, live close to brownfields and other blighted properties (EPA, 2015b). Brownfield redevelopment presents opportunities to reduce blight and improve the quality of life for vulnerable populations while mitigating the impacts of climate change.

While all populations will be affected by climate change, vulnerable populations will be disproportionately affected as climate change continues to increase the burden they already experience. A report by the Centers for Disease Control National Center for Health Statistics found that heat- and cold-related deaths in the United States are highest among non-Hispanic black populations and low-income populations making less than $42,400 annually. This study also found that heat-and cold-related deaths are significantly greater among elderly individuals in the United States.

Children and the elderly are among the most sensitive to changes in water and air quality. Therefore, as air and water quality degrade with climate change, they will be most susceptible to disease and environmental health impacts (Gamble, et al., 2013) (Sheffield and Landrigan, 2010). Children and the elderly, as well as women and the economically disadvantaged,

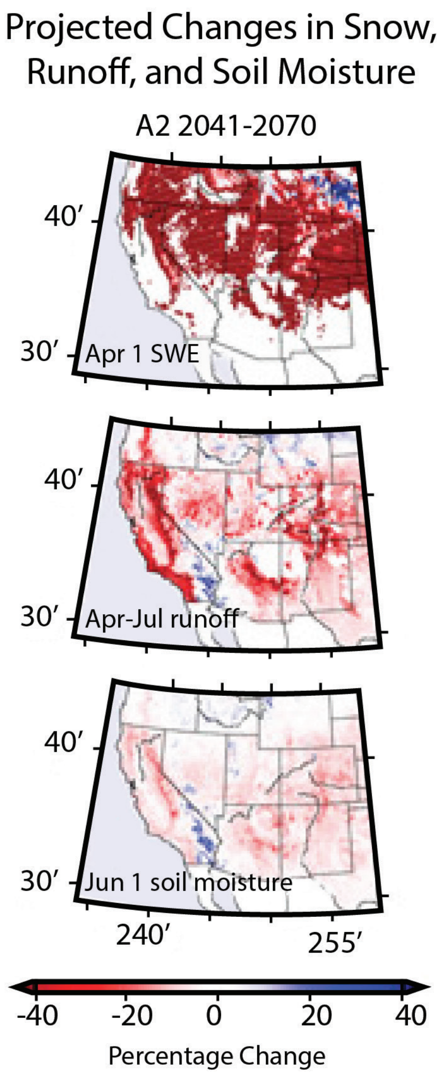


Figure 2. *Declines in snowpack, runoff and soil moisture are projected to occur if GHG emissions remain high. The maps show the percent of change between historical 1971-2000 conditions and conditions expected for mid-century (2041-2070).*

Brownfield cleanups in these areas should consider the potential effects of increasing drought.

Source: (U.S. Global Change Research Program, 2014) are also at higher risk for distress and other adverse mental health consequences from the impacts of climate change, subsequently reducing their ability to adequately cope with and respond to these impacts (U.S. Global Change Research Program, Climate and Health Assessment webpage).

In 2015, there were 10 weather and climate disaster events with losses exceeding $1 billion each across the United States. These events included a drought, two floods, five severe storms, a wildfire, and a winter storm.

Source: www.noaa.gov/climate

Additionally, low-income communities and communities of color are expected to be more negatively affected by climate change since limited resources will reduce their ability to cope with a changing climate. Native American communities are closely tied to reservation boundaries that restrict their ability to relocate to avoid climate change impacts, making them particularly vulnerable (EPA Climate Impacts on Society webpage). Combined climate and non-climate stressors for these vulnerable populations are expected to become more evident as the impacts of climate change interact with existing stressors as well as socioeconomic and demographic factors. (U.S. Global Change Research Program, Populations of Concern webpage).

Incorporating mitigation and adaptation strategies into government planning to promote resiliency is particularly important for small or rural communities that may be physically isolated and unable to easily access emergency supplies, resources and infrastructure. Adaptation will become particularly important for governments in small and rural communities with limited institutional capacity to respond to, plan for, and anticipate climate change impacts (U.S. Global Change Research Program, Rural Communities webpage). By incorporating climate change mitigation and adaptation measures and practices into brownfield assessment,

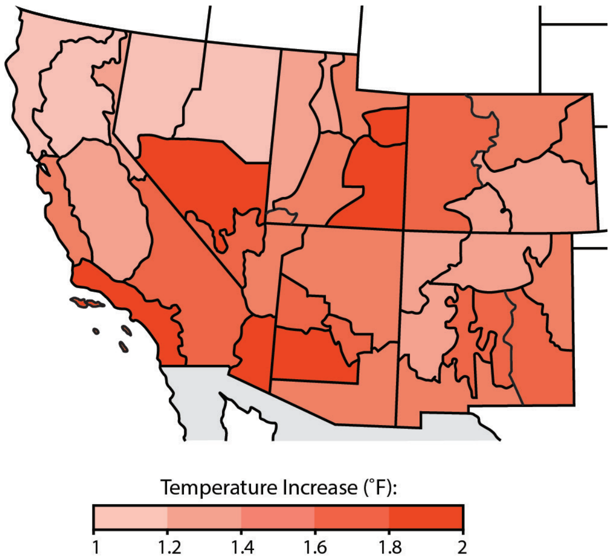


***Figure 3.** Average temperatures across the entire Southwest have increased in recent years, with some areas increasing by up to 2°F. This map shows the average temperature from 2000-2013 relative to the long-term average from 1895-2013.*

Source: (EPA 2015c)

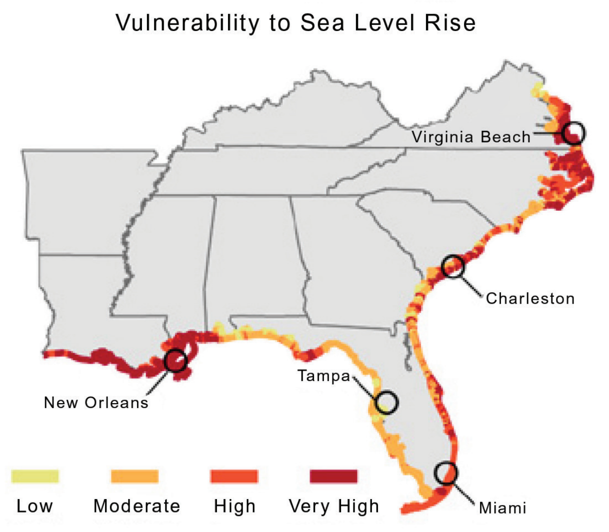


***Figure 4.** This map illustrates the levels of risk that sea level rise poses along Southeast coastlines, taking into consideration the susceptibility to change and adaptation measures. The Coastal Vulnerability Index used here is based on tidal range, wave height, coastal slope, shoreline change, landform and processes, and historical rate of relative sea level rise. Brownfields located in these areas may best be reused as green spaces with green infrastructure elements.*

cleanup and redevelopment projects, communities may avoid future damages from climate-related events and ensure more reliable and resilient community revitalization projects.

To build resilience to climate change, members of the community (including local government, businesses, academic institutions, banks, community leaders, and residents) must pursue climate change adaptation as well as mitigation. This manual addresses how brownfield assessment, cleanup, and redevelopment can be part of climate change resilience solutions and strategies and how communities can ensure that their brownfield projects are climate resilient.

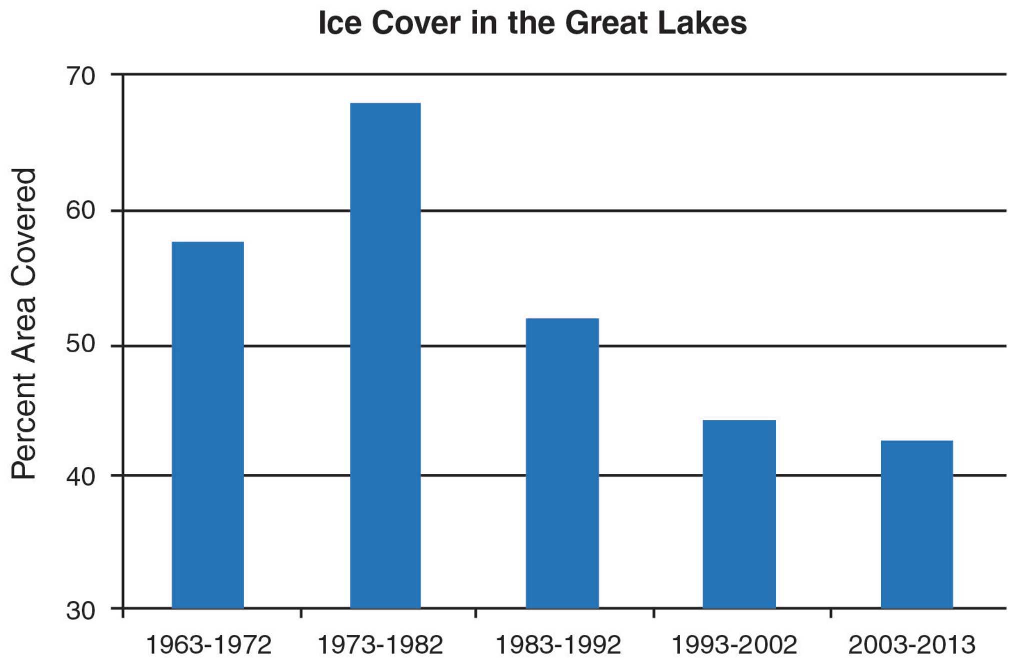


Figure 5. *Winter ice cover in the Great Lakes has changed in recent decades. This figure shows the average maximum ice coverage, by decade, from 1963-2013. Reduced lake ice has contributed to observed increases in summer water temperatures.*

How to Use This Manual

This manual provides tools and strategies that can be implemented during the brownfield cleanup and redevelopment process. To help navigate the climate change resiliency options that can be considered at each step in this process, the manual is organized into five chapters:

- ***Chapter 1: Planning for a Resilient Brownfield Revitalization.*** Chapter 1 explains how your community can initiate or contribute to the discussion of climate change mitigation, adaptation and resiliency when planning a brownfield redevelopment. It includes guidance to consider related to public participation throughout the planning process as well as infrastructure, location, and building designs and streetscape planning that may promote implementation of community revitalization solutions and greater climate change resiliency.

- ***Chapter 2: Assessing Brownfields and the Surrounding Area with a Changing Climate in Mind*.** Chapter 2 provides some guidelines on strategies, technologies and methodologies that should be considered when conducting environmental site assessments of brownfield properties.
- ***Chapter 3: Reducing Climate Impacts through Greener Deconstruction*.** Chapter 3 provides guidance on green demolition, including deconstruction and materials reuse, of existing infrastructure on a brownfield.
- ***Chapter 4: Implementing Greener Cleanups.*** Chapter 4 provides information and guidance on a variety of climate change mitigation and adaptation practices that can promote climate resiliency and reduce the carbon footprint of a brownfield cleanup.
- ***Chapter 5: Redeveloping Brownfields for Climate Resiliency.*** Chapter 5 addresses brownfield reuse and redevelopment options that facilitate meeting mitigation and adaptation goals while creating more sustainable brownfield reuses. Examples include green space, park and recreational space, green infrastructure, clean energy, green building, mixed use and in-fill redevelopment, and community assets and amenities.

Case studies and profiles of climate adaptation and mitigation methods are included in text boxes throughout the manual to help grantees, communities, and government officials envision practical solutions and strategies possible for their community. Appendix A lists examples of adaptation and mitigation strategies for each stage of a brownfield project. Appendix B provides resources for area-wide planning components, and Appendix C contains additional "snapshots" of climate adaptation and mitigation at sites around the country.

Chapter 1: Planning for a Resilient Brownfield Revitalization

The built environment is a primary contributor to GHG emissions and climate change impacts. It dictates the energy needs, transportation requirements (U.S. Department of Energy, 2013), housing and development patterns, and other resource allocations that drive GHG emissions. It is important to plan for the mitigation of these impacts at the earliest stage possible during the brownfield revitalization process. Brownfield communities, grantees, and government officials can address the effects of climate change and its local impacts in concert with their planning to support overall land use and development. Area wide, community wide, and site-specific brownfield assessment, cleanup, and redevelopment planning represent excellent opportunities to address climate change. The planning phase of brownfield redevelopment offers opportunities to consider and reduce local contributions to global climate change (e.g., emissions of CO_2 and other GHG) and recognize the known and projected impacts (e.g., flooding, drought, sea level rise) that require adaptive responses.

Built Environment

Human-modified places such as homes, schools, workplaces, parks, industrial areas, farms, roads, and highways.

Consider a community's brownfield challenges and potential climate change impacts holistically. Research your area to develop a plan that will inform the assessment, cleanup and reuse of your brownfield properties to achieve the following goals:

- Revitalize the community.
- Protect the environment.
- Build and strengthen community resiliency to the effects of climate change.
- Plan for equitable development.

The following sections provide information on the importance of public participation in planning, community-wide planning and improving resiliency through local leadership including building codes for infrastructure development, offering tax credits, rebates, and discounts, and zoning.

Importance of Public Participation

Successful, effective and meaningful planning can only be done when there is strong public participation throughout the brownfield redevelopment process. Climate change impacts will cross community and regional lines, making solutions dependent upon meaningful participation of numerous stakeholders from federal, state, local, and tribal governments, science and academia, the private sector, non-profit organizations, and the general public. Effective adaptation measures are closely tied to specific local conditions. Effective public involvement needs to take into account existing social networks and be tailored to all affected stakeholders. For this reason, every sector of the community should be invited to become involved in brownfield cleanup and redevelopment planning to ensure an equitable and sustainable redevelopment.

To ensure, comprehensive community involvement, consider creative approaches beyond existing city council and public meeting such as school, sports or civic events or community health fairs as possible locations for engagement as well as settings like the library, local church or community garden or food bank that might reach volunteers or segments of at-risk populations.

Successful community revitalization hinges on all members of a community benefiting from a cleaner environment and increased economic development. The impacts of climate change often affect minority neighborhoods that are disproportionately affected by environmental contamination due to their proximity to brownfields and industrial hazards. In addition, brownfields can be located near waterways or on low-lying land that is prone to flooding (EPA Region 2, 2013) (Bautista et al., 2014) (New York City Environmental Justice Alliance Waterfront Justice Project webpage). Redevelopment solutions must be inclusive of all affected populations and consider designs that improve resiliency and equitably distribute investments and the human health and economic benefits of redevelopment. Successful community revitalization begins with a strong planning component that considers all affected populations and ensures that people are not displaced during efforts to increase the climate resiliency of the community. Designing appropriate and substantive adaptation and mitigation strategies for brownfield revitalization requires a bottom-up participatory approach. This allows planners to obtain critical and community-specific information as well as provide marginalized communities with a voice in these difficult decisions. Planning for resilient brownfield revitalization can provide a vehicle for community empowerment and self-determination (Kaswan, 2012).

Community-wide Planning Perspective

A community that has numerous brownfields can consider ways brownfields slated for assessment or cleanup can contribute to a livable community that is safer and more vibrant. A brownfield reuse can promote transportation choices such as walking or cycling and better access to public transport. It can also provide accessible green space that improves a community's livability and sustainability. If a community is affected by frequent or severe flooding, redevelopment could incorporate stormwater management and green infrastructure techniques.

When planning for assessment and cleanup, it is important to identify community priorities related to assessment, cleanup and long-term revitalization of brownfields. Planning should also include an evaluation of existing environmental conditions, local market potential, and needed infrastructure improvements (EPA, 2012a). Components of effective planning are listed below. A more detailed explanation of many of these components, along with available resources and tools that may assist communities during planning, is provided in Appendix B.

- Identify and map climate resilience (e.g., protected wetlands, cooling centers, stormwater and green infrastructure, and buffer zones such as those along the Menomonee River in Milwaukee, Wisconsin) making sure to engage the community and first responders in this process.
- Consider the impact of both current and projected climate-related conditions (e.g., sea level rise, proximity to a flood plain, and the frequency and severity of major storm events and droughts) on the long-term safety, stability and suitability of the proposed land reuses. For example, evaluate hydro-climatic statistics and hydrologic-hydraulic models related to floods, intense rainfall, high stream flow, and water temperature, can facilitate water infrastructure planning, ecosystem protection, and flood hazard mitigation[1].
  - Use relevant and authoritative data sources, such as EPA, the National Oceanic and Atmospheric Administration (NOAA), National Climate Data Center, U.S. Department of Agriculture, U.S. Geological Survey (USGS), and U.S. Army Corps of Engineers.

Scenario planning workshops can be conducted in communities (bringing together many departments, external stakeholders, and quasi-city agencies) to inform vulnerability assessments. Read about Philadelphia's successful scenario planning workshop example.

1 ASTM E3032-15 Standard Guide for Climate Resiliency Planning and Strategy

- Determine from the meteorological record the long-term average for each climate variable, scale of past extreme events, and recent trends of change in past 30 years.

- Conduct a risk screening of vulnerabilities to climate change impacts and assess which properties need more resiliency measures (e.g., hospitals, schools, community centers, places of worship, emergency response stations).
- Engage vulnerable and underserved populations to identify their needs and priorities for cleanup and reuse through facilitated advisory committees, public meetings, design charrettes, roundtable sessions, etc.

As already emphasized, the brownfield planning process should engage all segments of the community. Stakeholder and community involvement is crucial for development of a sustainable, meaningful, and useful plan that can be referenced and implemented throughout the community revitalization process.

More than 1,000 mayors signed on to the U.S. Conference of Mayor's Climate Protection Agreement, committing to: (1) strive to meet or beat Kyoto Protocol targets in their own communities; (2) urge their state governments, and the federal government, to enact policies and programs to meet or beat the GHG emission reduction target suggested for the United States in the Kyoto Protocol; and (3) urge the U.S. Congress to pass the bipartisan GHG reduction legislation.

Vulnerability – the degree to which a site is susceptible to or unable to cope with, adverse effects of climate change, including climate variability and extremes.

Helpful References

- A Guidebook to Community Engagement: Involving Urban and Low-Income Populations in an Environmental Planning Process
  http://www.canr.msu.edu/uploads/375/65790/GuidebooktoCommunityEngagement_FINAL_Sept2014.pdf
- Community Engagement: Sustainability Principles
  http://www.sustainablecitiesinstitute.org/topics/equity-and-engagement/community-engagement-sustainability-principles
- Strategies for Meaningful Community Engagement
  http://fresc.org/wp-content/uploads/2015/02/Best-Practices-for-Community-Engagement.pdf
- Creating Equitable, Healthy, and Sustainable Communities: Strategies for Advancing Smart Growth, Environmental Justice, and Equitable Development
  https://www.epa.gov/smartgrowth/creating-equitable-healthy-and-sustainable-communities

Improving Resiliency through Local Leadership

State and local jurisdictions can increase the resiliency of a community by establishing or updating zoning ordinances, coastal and wetland management plans, water management plans, hazard mitigation plans, and landowner incentives.

Brownfield Revitalization in Climate-Vulnerable Areas (EPA 2016a) includes several examples of city policies and plans relevant for resiliency and adaptation:

- Stormwater Management Incentives
  - Green roof tax credits and rebates (Philadelphia, Pennsylvania)
  - Green roof tax credit program (Nashville, Tennessee)
  - Stormwater Fee Discount for Non-residential Property Owners (Toledo, Ohio)
- Land Use and Building Codes and Regulations
  - Compensatory Floodplain Storage Regulations (Dallas, Texas)
  - Floodplain Management Regulations to Help the City Earn Community Rating System (CRS) Status (Des Moines, Iowa)
  - 2013 Building/Plumbing Code Changes (New York, New York)
- Comprehensive Plans
  - Comprehensive Plan Resilient Land Use Element (Scott, Louisiana)
  - Port of New Orleans Resiliency Manual 2013 (New Orleans, Louisiana)
- Integrated Water Management/Flood Mitigation/Wastewater Resiliency
  - Greater New Orleans Urban Water Plan (New Orleans, Louisiana)
  - City of Tulsa Flood Park along Mingo Creek (Tulsa, Oklahoma)
  - Bee Branch Flood Mitigation Plan (Dubuque, Iowa)
  - Wastewater Resiliency Plan (New York, New York)
  - Fargo Flood-Related Sales Tax (Fargo, North Dakota)
  - Sales Tax Abatement Program for Flood Resiliency (New York, New York)

Municipal and City Leadership

Local leadership can influence successful mitigation and resiliency impacts by promoting the establishment of standards and goals for urban design, stormwater management, floodplain management, and other significant areas of city planning that can improve the resilience of brownfield cleanup and redevelopment. Cities can implement policies that promote climate-resilient brownfield assessment, cleanup, and reuse and consider climate change conditions in development decisions. The site conditions and reuse opportunities identified in the planning stage can inform policy development and lead to effective implementation strategies for reducing a community's carbon footprint and GHG emissions as well as promote other climate change mitigation and adaptation strategies. For example, local leadership can inform changes in flood zone boundaries to protect existing development and natural barriers. Local leadership also can influence building requirements and highlight the importance of green space and wetlands to improve flood management (National Wildlife Federation, 2014). The City of Philadelphia, Pennsylvania, is in the process of climate resiliency planning. The Mayor's Office of Sustainability convened the Climate Adaptation Working Group (CAWG), a group of 10 agencies and departments that is assessing the city's vulnerabilities and opportunities to prepare for climate change. The CAWG is identifying relatively low-barrier, high-impact internal actions that can be taken while the city tackles larger issues of how to assess and minimize risks to environmental health, neighborhood investments, and quality of life (Mayor's Office of Sustainability and ICF International, 2015). When applied to brownfields, Philadelphia's planning process provides an excellent example of how effective planning can lead to climate change adaptation and mitigation at the municipal and city level.

Municipal and City Leadership on Climate Change Adaptation

In 2008, Mayor Michael Bloomberg convened the New York City Panel on Climate Change which released several reports, including one in 2010 that addresses climate adaptation in the city and development of a risk management response.

Infrastructure Development and Building Codes

Brownfield revitalization is influenced and guided by the local government's infrastructure and building codes, which can encourage implementation of climate change mitigation and adaptation techniques. Building codes, for example, can require that infrastructure be planned and built to avoid or minimize future damage from flooding, drought, and other projected weather events resulting from climate changes. Building codes also can reduce carbon emissions from commercial and residential buildings by specifying minimum requirements for building components such as insulation, water use, heating and cooling systems, lighting, windows, and ventilation systems. Effective building code requirements may vary regionally due to climate differences; for example, building codes in the south may require more insulation to reduce energy consumption from cooling systems. Most state and local building codes are based on the requirements of model building codes created by private standard-setting bodies. The two most commonly used codes are the International Energy Conservation Code (IECC) for residential buildings, and the American Society of Heating, Refrigerating, and Air Conditioning Engineers' ASHRAE 90.1 code for commercial buildings. A climate zone map developed by the U.S. Department of Energy's Building America program serves as a framework for energy efficiency requirements in the national model energy codes (U.S. Department of Energy, 2013).

Local governments may consider incorporating the requirements of the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) certification program into local building codes. LEED imposes more stringent environmental standards than the IECC or ASHRAE codes and includes certain minimum green building requirements, such as minimum energy performance, energy and water metering, and floodplain avoidance. LEED also awards credits for buildings that include optional environmentally friendly features, such as a green roof to reduce the heat island effect. LEED offers different levels of certification depending on the total number of credits a project earns. Policymakers can use the new LEED Climate Resilience Screening Tool to identify which LEED rating systems and credits enhance resilience, providing a reference for policies and building standards in vulnerable areas. Encouraging LEED features in brownfield redevelopment will provide another opportunity for strengthening the resilience of the project and potentially serve as a resource for the community as it pursues larger scale climate change resiliency. More on green building strategies is discussed in Chapter 5.

Local Leadership through Infrastructure Requirements

In 2012, Maryland Governor Martin O'Malley issued the "Climate Change and Coast Smart Construction Executive Order" directing that all new and reconstructed state buildings, facilities, and infrastructure be planned and built to avoid or minimize future flood damage.

Local leadership can go beyond national requirements and implement additional building codes tailored to the needs of the community and the projected climate change impacts. Building codes for new buildings may set elevation requirements or flood proofing techniques to increase adaptation capabilities in areas prone to floods. For example, New York City adopted FEMA's standards for building elevation requirements according to determined flood risk for particular areas. When the new Flood Insurance Rate Maps (FIRMs) are updated in 2016, the state and New York City will further update the Building Code to reference the new elevations and to require freeboard of 1 to 2 feet above these elevations. New York City has also enhanced its flood resistant construction standards in the aftermath of Hurricane Sandy. To reduce damage from hurricanes, local government can require new construction to include wind resistance measures.

Tax Credits, Rebates, and Discounts

Local government also may mitigate climate change with brownfield revitalization by offering incentive programs, such as tax credits or rebates, to property owners and developers that install green roofs or incorporate green infrastructure and other stormwater runoff mitigation features (e.g., pervious or permeable pavements and gray water recycling). By offering incentives, local governments can facilitate inclusion of climate change mitigation and adaptation strategies in the initial designs and plans for brownfield redevelopments. For example, the District Department of the Environment (DDOE)'s RiverSmart Rewards program provides financial incentives to property owners in Washington, DC, for installing green infrastructure that reduces stormwater runoff District property owners and tenants who install systems that retain stormwater runoff can receive discounts of up to 55 percent on stormwater fees. DDOE also offers a Stormwater Retention Credit (SRC) Trading program where properties generate SRCs for voluntarily installing green infrastructure that reduces stormwater runoff. Property owners trade their SRCs to those who use them to meet regulatory requirements. This revenue creates incentives to install green infrastructure that provides climate change adaptation and mitigation benefits.

Similar discount programs have been implemented across the country in cities such as Portland, OR, Seattle, WA, Philadelphia, PA, and Chicago, IL. In Portland, ratepayers can receive up to a 100 percent discount on their

City	Subsidy Program
Seattle, WA	Seattle Public Utilities' Rainwise Program provides rebates to property owners who install rain gardens or cisterns on their property. Rebates can be as high as $3.50 per square foot of impervious area managed.[2]
Louisville, KY	Louisville Metropolitan Sewer District offers a Capital Recovery Stipend, which provides customers rebates up to $1.50 per square foot of impervious area managed.[3]
Palo Alto, CA	City of Palo Alto Storm Drain Utility offers rebates to residents, businesses, and city departments for the installation of qualifying green infrastructure measures.[4]
Montgomery County, MD	The Water Department's Rainscapes Rewards Rebate program provides rebates to both residential (up to $2,500) and commercial property owners (up to $10,000) for installation of green infrastructure measures.[3]
Milwaukee, WI	Milwaukee Metropolitan Sewerage District (MMSD) offers reduced stormwater fees for property owners who manage stormwater on-site. MMSD's Green Infrastructure Partnership Program will pay up to 50 percent of the cost of capturing stormwater on-site.[6]
Washington, D.C.	D.C.'s District Department of Environment's RiverSmart Homes, RiverSmart Communities and Green Roofs programs offer capital cost-share incentives to private property owners for installing green infrastructure projects.[7]

[1] Noah Garrison and Karen Hobbs, Rooftops to Rivers II: Green Strategies for Controlling Stormwater and Combined Sewer Overflows, Natural Resources Defense Council, 2011.
[2] Seattle Public Utilities, "Rainwise Detail Sheet 1," www.seattle.gov/util/groups/public/@spu/@usm/documents/webcontent/02_008087.pdf (accessed October 22, 2014).
[3] Metropolitan Sewer District, "MSD Drainage Service Charges," www.msdlouky.org/pdfs/DrainageServiceChargesAugust2013.pdf (accessed October 22, 2014), 4.
[4] City of Palo Alto, "Collect Cash While Saving Water Helping the Environment and Reducing Run-off," www.cityofpaloalto.org/civicax/filebank/ documents/39740 (accessed October 22, 2014).
[5] Montgomery County Department of Environmental Protection, "RainScapes Rewards Rebate," www.montgomerycountymd.gov/DEP/water/ rainscapes-rebates.html (accessed October 22, 2014).
[6] Milwaukee Metropolitan Sewer District, "Green Infrastructure Partnership Program," www.freshcoast740.com/Learn/Funding-Programs/GIPartnership-Program (accessed October 22, 2014).
[7] District of Columbia Department of the Environment, "Stormwater Management," green.dc.gov/node/10372 (accessed October 22, 2014).

Table 1. *Examples of Municipal Green Infrastructure Subsidy Programs (National Resources Defense Council, 2015)*

onsite stormwater management charges through the Clean River Rewards program if they manage stormwater on their property. Philadelphia's land use and permit regulations require new development and redevelopment projects that disturb more than 15,000 square feet of land to install (and maintain) green infrastructure sufficient to manage the first inch of stormwater that falls on the site. Property owners who reduce the amount of impervious or impermeable surfaces and install green infrastructure projects on their property to manage stormwater onsite can receive stormwater credits that permanently reduce water bills. Such approaches increase a site's ability to adapt to changing climate conditions and help mitigate GHG emissions. It is especially important to ensure that the cleanup and integrity of brownfields are not jeopardized as a result of climate change impacts such as flooding or drought.

Some communities have modified tax credits, such as the Low Income Housing Tax Credit or Historic Preservation tax credit, to encourage developers to go beyond modern resilience standards in their new or reconstructed development. Similarly, communities have used sales tax abatement programs to promote resilience to increased flooding by providing tax relief to property owners who incorporate climate adaptation strategies into their structures (e.g., by weatherizing buildings). New York City is a leader in this and has implemented an Open Industrial Uses Sales Tax Exemption Program, which promotes resilience to increased flooding due to climate change impacts by providing $10 million in sales tax abatements in $100,000 increments to qualifying industrial businesses seeking resiliency retrofits.

Find out about incentives and tax credits for renewable energy in your state at: http://www.dsireusa.org/

Zoning

Zoning ordinances and local government land use planning play significant roles in both mitigating GHG emissions and adapting to the impacts of climate change. Zoning and land use planning provide the blueprint for the development of a community's built environment and therefore impact the reuse options available for brownfields. Zoning laws can dictate density of development, require the siting of greenspace and open space, restrict construction in flood plains and other weather-sensitive areas, and reduce spread-out development. When developed intentionally, they can serve as another strong climate change mitigation and adaptation strategy for brownfields.

Zoning ordinances that promote compact development often result in the co-location of residential and commercial buildings as well as transit (Urban Land Institute, 2012) (Thrun, et al., 2016). There is evidence that high-density development results in fewer GHG emissions than low-density development by reducing the vehicle miles traveled (VMT) (Urban Land Institute, 2010). The number of car trips also may be reduced when communities use zoning and land use planning to make walking, biking and public transit safe and convenient. Smart Growth America noted in its report, *Growing Cooler: The Evidence on Urban Development and Climate Change* (Smart Growth America, 2008), that compact development (mixed land uses, complete streets, etc.) reduces VMT by 20 to 40 percent. *Quantifying the Third Leg: The Potential for Smart Growth to Reduce Greenhouse Gas Emissions* (Natural Resources Defense Council, 2008) estimates that smart growth policies such as compact development may reduce VMT by 10 to 30 percent in 20-30 years, reducing overall GHG emissions by 2-5 percent in the same time period.

Brownfield redevelopment projects can help lessen the impact of climate change when positively influenced by local zoning that incentivizes or requires a certain percentage of green space in the design plans and eventual development. Trees and other plants help reduce net GHG emissions by sequestering carbon dioxide. A

Snapshot: Atlantic Station Redevelopment in Midtown Atlanta Yields VMT Reductions

A study was conducted in Atlanta, Georgia, to evaluate the impact of building a very dense, mixed-use development at an abandoned steel mill as compared to spreading the equivalent amount of commercial space and number of housing units at three suburban locations. Analysis was conducted using travel models and supplemented by the EPA's Smart Growth Index.

Analysis found that the infill location at Atlantic Station would generate about 36 percent less driving and emissions than the outlying comparison sites. The results were so compelling that the development was deemed a transportation control measure by the federal government for the purpose of improving the region's air quality. The Atlantic Station project in Midtown Atlanta has become a highly successful reuse of central city industrial land. An early evaluation of travel by residents and employees of Atlantic Station suggests even larger VMT reductions than projected originally. On average, Atlantic Station residents are estimated to generate eight VMT per day, and employees to generate 11 VMT per day. These estimates compare favorably with a regional average VMT of more than 32 miles per person per day, among the highest in the nation. http://www.smartgrowthamerica.org/documents/growingcoolerCH1.pdf

healthy tree canopy also can provide shade to buildings, which limits the need for air conditioning and reduces overall energy use. Greenspace that includes green infrastructure components can reduce stormwater runoff and reduce the severity of flooding events. Green infrastructure is discussed in greater depth in Chapter 5.

Zoning ordinances can discourage inefficient practices and restrict the location of buildings in vulnerable areas such as flood plains. Effective zoning requirements incorporated into a strong master plan will improve a community's climate change adaption and mitigation efforts.

Brownfield reuse planning is the perfect opportunity to evaluate and modify existing zoning ordinances to promote smart growth and transit oriented development. The adoption of such policies will lead to fewer VMT, reduced stormwater runoff, and reduced GHG emissions.

For additional information on land use planning and smart growth principles see: http://www.epa.gov/smartgrowth

For additional information on planning tools for climate resiliency, see: https://www.epa.gov/land-revitalization/climate-resilience-planning-tool. The EPA Climate Resilience Planning Tool outlines nationally applicable examples of relevant regulatory standards, incentives, and guidelines as well as non-regulatory projects, programs, and approaches to inform planning goals and increase climate resiliency.

For additional information on building codes relevant to revitalization and climate change adaptation, a forthcoming document "Smart Growth Code Fixes for Climate Adaptation" (tentative title) will be published on www.epa.gov/smartgrowth. This will be a resource with detailed information on zoning and building codes that can help communities adapt to climate change while gaining other environmental, economic, social, and health benefits.

Chapter 2: Assessing Brownfields and the Surrounding Area with a Changing Climate in Mind

Once a brownfield site is chosen for redevelopment, Phase I and Phase II environmental site assessments (ESAs) are conducted to determine the extent of any contamination at the property and to assess potential public health and environmental risks. Following the ESAs, potential cleanup options that consider the intended use and redevelopment of the site are evaluated.

The assessment phase of the brownfield project may offer several opportunities for identifying potential climate change impacts and evaluating mitigation and adaptation strategies for long-term solutions. Such opportunities arise from asking questions during Phase I and Phase II ESAs, incorporating relevant ASTM guidelines for greener cleanups, and considering redevelopment options in light of your community's challenges and redevelopment goals.

The assessment phase offers significant opportunities to identify how you can invest in your community's success by implementing climate change resiliency measures.

Phase 1 Environmental Site Assessment

The Phase I ESA of a brownfield site must be conducted in compliance with the All Appropriate Inquiries (AAI) rule. A Phase 1 ESA comprises the historical investigation and preliminary inspection of the site, but presents an opportunity to evaluate current and on-going climate change impacts and to consider future impacts to the site or area. For example, an investigation of the site history can include an investigation of site vulnerabilities based on historical and recent climate patterns and events (e.g., floods and drought). Similarly, the preliminary site inspection offers a chance to look for visual evidence, such as drainage issues that can be exacerbated by increased precipitation. The site inspection is also a good time to identify possible impacts to adjacent or nearby water bodies and to consider opportunities for permeable pavement in a reuse plan.

Considering the climate change concerns identified, communities should consider potential risk factors, taking into account the conditions of the project area, such as proximity to the ocean, infrastructure vulnerabilities, property affected by a revised FEMA flood plain map, vulnerability related to changes in frequency and intensity of precipitation events, vulnerability of soil type due to moisture and hydraulic changes, ground and surface drinking water vulnerabilities. Historical and current climate stressors and impacts should be researched as part of this effort. The *U.S. Climate Resilience Toolkit* (NOAA) is an excellent resource for this type of data. Other sources of helpful information include:

- Assessing Health Vulnerability to Climate Change: A Guide for Health Departments (Centers for Disease Control and Prevention, 2014)
- EPA's Communities and Utilities Partnering for Water Resilience Website
- EPA's Community-Based Water Resiliency Tool

Questions to Consider During a Phase I ESA

1. *What are the historical weather/climate-related impacts to this property? Flooding issues? Drought?*
2. *What are the current and projected weather/climate-related impacts to the property?*
3. *Walk the site. Are there any vulnerabilities evident? Based on projected climate impacts in the area, will the structures, soil, vegetation, and other elements be resilient?*
4. *Will existing water infrastructure be resilient to climate changes?*
5. *Is the historic school, railroad spur, mill, foundry, mine, or other type of brownfield close to areas where wildfire or flooding risks are likely to increase?*

Phase 2 Environmental Site Assessment

The Phase II ESA involves the sampling and analysis activities to identify the types, concentrations, and extent of contaminants at a brownfield site. It typically involves collection of soil and groundwater samples for analysis at offsite laboratories. The Phase II ESA also may include sampling of other mediate (e.g., sediment, surface water, soil gas, indoor air), identifying the location of underground storage tanks and other buried objects, and evaluating demolition material for asbestos, lead-based paint, or other toxic products. Phase II offers opportunities to consider some best management practices (EPA, 2016b) for addressing climate mitigation during the brownfield site investigation (EPA, 2016b). The ASTM Standard Guide for Greener Cleanups (ASTM E2893-16) can be a great resource for identifying options for establishing climate change mitigation and adaptation strategies related to this phase of a brownfield cleanup project. Many of these strategies address mitigation, especially those focused on reducing carbon emissions through use of renewable energy through minimizing transportation to and from the site.

Phase II ESA Strategies for Climate Mitigation

1. *Use renewable energy*
2. *Incorporate remote sensing capabilities*
3. *Maximize reuse of existing wells where appropriate and/or design wells for future reuse*
4. *Use field test kits whenever possible*
5. *Use local laboratories when possible*
6. *Use appropriate sized equipment for the project*

Analysis of Brownfield Cleanup Alternatives

If during the site assessment, contamination is found to exceed risk-based cleanup requirements for proposed reuse, cleanup options should be identified and their effectiveness evaluated. An Analysis of Brownfield Cleanup Alternatives (ABCA) is required of EPA Cleanup and Revolving Loan Fund (RLF) grant recipients. The ABCA provides an excellent opportunity for brownfield communities to evaluate the resilience of the remedial options in light of reasonably foreseeable changing climate conditions (e.g. sea level rise, increased frequency and intensity of flooding and/or extreme weather events, etc.) (EPA, 2014a).

In addition to evaluating the effectiveness, the ease of implementation and cost of each remedial action, an ABCA also should include a discussion of observed and forecasted climate change conditions and the associated site-specific risk factors. An ABCA typically includes a description of background and current conditions of the brownfield site (maps, previous uses, assessment findings, and reuse goals), applicable regulations and cleanup standards, an evaluation of cleanup alternatives and a recommended remedial action. Both current and forecasted climate changes may impact the effectiveness of a remedial alternative. For example, increased flooding of a site could compromise an engineered cap and expose contamination. Conducting an ABCA with a climate focus can help ensure the chosen remedial option is more adapted to climate change.

An example of an ABCA completed for the 900 Innes Avenue site in San Francisco, California (U.S. Army Corps, of Engineers, 2013), can be found at http://sfrecpark.org/wp-content/uploads/Final-ABCA-900-Innes-Ave-Site-Report.pdf.

Brownfield redevelopment can take a long time to become a reality. Developing an interim use before a brownfield is cleaned up and fully redeveloped can help mitigate ongoing blight and demise of the property and reduce negative impacts caused by severe weather events. Mobile food stands, community gardens with raised beds, farmers markets, solar installations (temporary or permanent), public event spaces and temporary parks are potential options for interim uses.

For example, an interim hiking trail along the Atlanta BeltLine (Figure 6) was developed while design and construction plans moved forward on the old rail corridor. Ultimately, more than 1,700 tons of contaminated soil was remediated in preparation for the Atlanta BeltLine, a sustainable redevelopment project that provides a network of public parks, multi-use trails and transit along a historic 22-mile railroad corridor circling downtown.

Figure 6. *Atlanta BeltLine interim hiking trail*

Chapter 3: Reducing Climate Impacts through Greener Demolition

Cleveland Resource Recovery - Cleveland, OH

Deconstruction can be a more targeted and environmentally-sustainable method of demolition than typically occurs following a brownfield assessment. Reuse and recycling of building materials can save landfill space, reduce methane emissions from landfills, and reduce demands on materials production and transportation, therefore also reducing carbon and GHG emissions.

Description and Rationale

Demolition traditionally is the most common method of removing buildings and structures. However demolition can result in significant amounts of debris disposed of in landfills, and the heavy equipment operated emits GHGs. Furthermore, traditional demolition techniques may not be protective of the environment or the community.

Deconstruction of uncontaminated buildings and structures allows for recovery of reusable materials and diverts some or nearly all building waste from landfills as part of sustainable materials management. Material reuse reduces the need to harvest virgin materials, which is an energy intensive process resulting in GHG emissions. The harvesting of trees for wood products, in particular, decreases our planet's capacity to absorb CO_2 (Sheehan, 2000). While deconstruction may take more time than demolition and may require additional training and materials handling planning, the benefits may be worth it, particularly where valuable building materials can be recovered and safely reused. Where markets exist for material reuse, deconstruction can prevent materials from being added to our landfills and result in a more sustainable project that limits emissions. By diverting materials from landfills, a community can reduce potentially harmful impacts from flooding of a landfill after a weather-event.

Diverting building waste from landfills is becoming easier across the nation. In EPA Region 9, locally available construction and demolition recyclers are making it possible for contractors to obtain diversion rates above 80 percent (EPA Region 9). Carefully considering site materials and how they can be reused or recycled is one way to reduce our environmental impact and contribute to a more sustainable and resilient community.

Deconstruction, when conducted safely and appropriately, can facilitate reuse and recycling of uncontaminated materials and provide opportunities for training and job development. When multiple structures in a community need to be removed, planning deconstruction of multiple structures at one time can reduce the impact from extended use of heavy equipment and reduce emissions. Green deconstruction projects identify ways to minimize or eliminate fossil-fuel burning equipment and maximize usage of renewable energy sources whenever possible. Careful, advance planning of deconstruction work also helps reduce fugitive dust emissions, water quality degradation, water use, and erosion.

Whenever building materials are reused, it results in one less item being sent to a landfill as waste. It also translates into energy and waste savings as less new building materials needs to be created.

Implementation

Several factors affect the suitability of deconstructing buildings on brownfields: the condition of the building and materials, the types and quantities of potentially reusable and recyclable materials, the presence of hazardous material, and access to building reuse and recycling markets. If access to local reuse and recycling markets is lacking, the cost to transport materials long distances to these markets can affect the feasibility of a deconstruction that is protective of the environment and promotes climate change mitigation. Local disposal costs, timeframe to deconstruct, and labor costs are additional factors that need to be considered when assessing the feasibility deconstruction.

There are four basic steps in a deconstruction project:

1. Create an inventory of materials that can be reused or recycled.
2. Identify local reuse partners to enhance the reuse potential.
3. Identify ways to reuse deconstructed materials in the redevelopment.
4. Deconstruct where possible.

There are several useful tools available to assist in the inventory process and feasibility assessment. These are briefly described at the end of this chapter along with links to access the tools. By identifying materials that can be utilized in new buildings or recycled in other ways, the effort to reduce and recycle construction and demolition materials effectively employs EPA's Sustainable Materials Management (SMM) approach. SMM is a systemic approach to using and reusing materials more productively over their entire lifecycles. Materials management is estimated to comprise 42 percent of total U.S. GHG emissions (EPA, 2009).

An assessment of a material's market value may be influenced by the size of the structure or quantity of material, the type and condition of material, and the salvage or recycling potential. There are several examples of brownfield projects where only a few materials types were reused, but in large quantities. Common materials from brownfield sites that have been reused or recycled include:

- Concrete
- Iron beams
- Timber
- Brick
- Steel
- Windows
- Roofing
- Flooring
- Lighting and plumbing

It may be useful to apply EPA's Waste Reduction Model (WARM) to demolition projects on brownfields. WARM calculates the benefits of alternative materials management decisions, focusing on end-of-life perspective. Many material types are recognized in this model including bricks, asphalt, glass, shingles, concrete, copper wire, drywall and PVC. The calculator can help construction managers determine how much energy can be saved and how many GHGs can be reduced by recycling particular material types.

Recycling or reusing materials can also save substantial amounts of money and reduce overall project costs depending on a variety of factors such as location, local economics and availability of collection centers. Identifying local reuse partners early in the project can help increase the reuse potential of materials onsite as well as potentially reduce costs and energy expended looking for reuse or recycle options at the end of the project. The value of used building material donations can be substantial enough to pay for the costs of

Snapshot: Former Carrier/Bryant Manufacturing Corporation Brownfield Redevelopment Project – City of Indianapolis, Indiana

- *Prior use: Machine and tool manufacturing facility and a heating and air conditioning manufacturing and warehouse facility.*
- *Abandoned in 2004.*
- *Acquired by City of Indianapolis in 2012.*
- *Waste streams recycled or diverted from landfill disposal:*
  - *Approximately 8,400 tons of steel salvaged for recycling/ reuse.*
  - *Approximately 36,000 tons of concrete crushed and reused onsite for backfilling and grading.*
  - *Approximately 11,000 gallons of used #4 heating oil pumped from existing USTs and sent for repurposing/ reuse at local fuel processing facilities.*
  - *Approximately 14 pallets of undisturbed, unpainted bricks salvaged for local community reuse.*

deconstruction (TheReusePeople.org). In many cases, the after-tax benefit of donating salvaged materials to local collection centers can outweigh the costs of demolition. Habitat for Humanity has locations throughout the United States, and many local organizations operate ReStores, which sell reusable and surplus building materials, furniture and appliances to the public. Below is a list of a few potential partners to consider in preparation for your deconstruction project:

- Habitat for Humanity
- The ReUse People
- PlanetReuse
- Lifecycle Building Center (Atlanta, Georgia)
- The Loading Dock (Baltimore, Maryland)
- Rebuilding Exchange (Chicago, Illinois)

Access to local reuse and recycling markets may be limited for some communities, especially tribal and rural communities. Reuse and recycling reduces CO_2 production from the manufacture of new materials, but more GHG may be produced in transporting materials to a recycling facility or multiple sites for reuse than to a landfill. Local disposal costs should be considered when assessing the feasibility of a building deconstruction project. Even if a full deconstruction is not practical or feasible, recycling and reuse of some materials should always be considered. When multiple structures are being considered for demolition or deconstruction, brownfield property owners could also explore potential benefits of establishing collection centers in high-supply areas to decrease transportation costs.

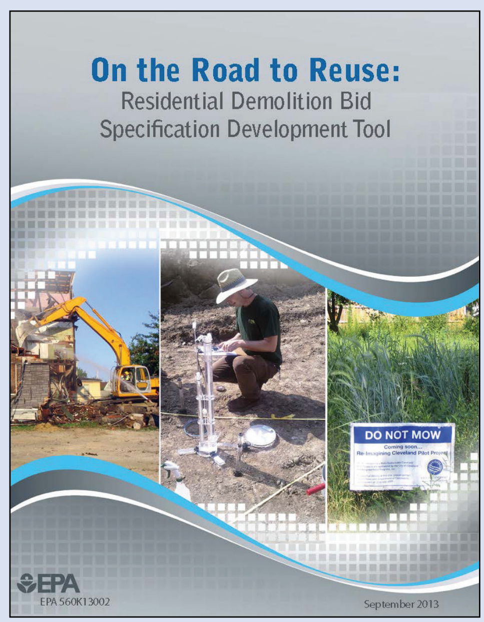
Snapshot: Ottawa Street Power Station in Lansing, Michigan

Construction waste management was significant, achieving 96.5 percent waste diversion, by weight, including 1,677 tons of metal, 29,051 tons of concrete, 162 tons of wood/drywall, and 14 tons of cardboard diverted from landfill. About 75 percent of the building's existing brick was cleaned and reused, as well as 95 percent of existing masonry on the building.

Source: www.aisc.org/newsdetail.aspx?id=28640

Helpful References

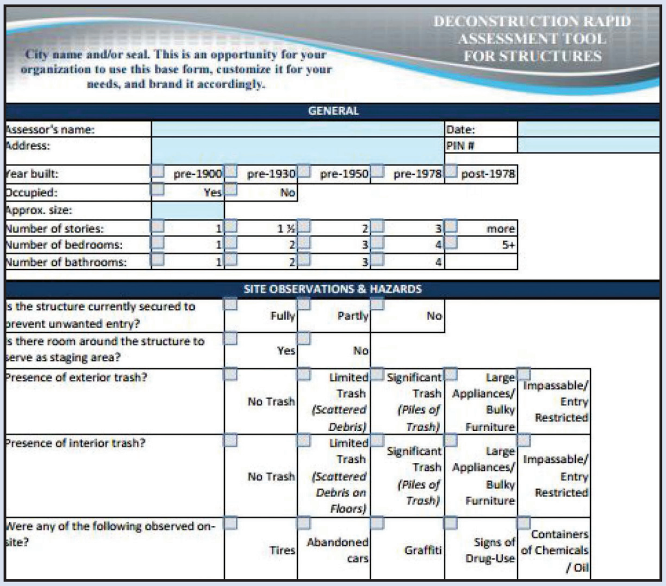
On the Road to Reuse Residential Site Demolition Tool (EPA, 2013)



Bid specification development tools are available for use by cities, counties or land banks undertaking large-scale residential demolitions. Anticipate the environmental issues and concerns so you can factor them into the planning and procurement process. Develop contract language for a bid package that instructs contractors on specific technical requirements to achieve improved environmental results in a demolition project. – includes information about materials salvaging and reuse, deconstruction, and recycling.

Deconstruction Rapid Assessment Tool

This tool is designed to help contractors assess the potential value of materials that could be recycled by deconstructing a structure rather than demolishing it. The tool enables organizations to triage building stock slated for demolition by generating a data set to help identify priority structures for deconstruction and salvage. The assessment process identifies candidates for deconstruction by examining information on a building's condition and salvageable material inventory. Whether the project scope is a few structures in a neighborhood, or an entire city's blight program, a rapid assessment can help managers make critical decisions regarding the allocation of resources and time.



DECONSTRUCTION RAPID ASSESSMENT TOOL FOR STRUCTURES

City name and/or seal. This is an opportunity for your organization to use this base form, customize it for your needs, and brand it accordingly.

GENERAL

Assessor's name:				Date:	
Address:				PIN #	
Year built:	pre-1900	pre-1930	pre-1950	pre-1978	post-1978
Occupied:	Yes	No			
Approx. size:					
Number of stories:	1	1 ½	2	3	more
Number of bedrooms:	1	2	3	4	5+
Number of bathrooms:	1	2	3	4	

SITE OBSERVATIONS & HAZARDS

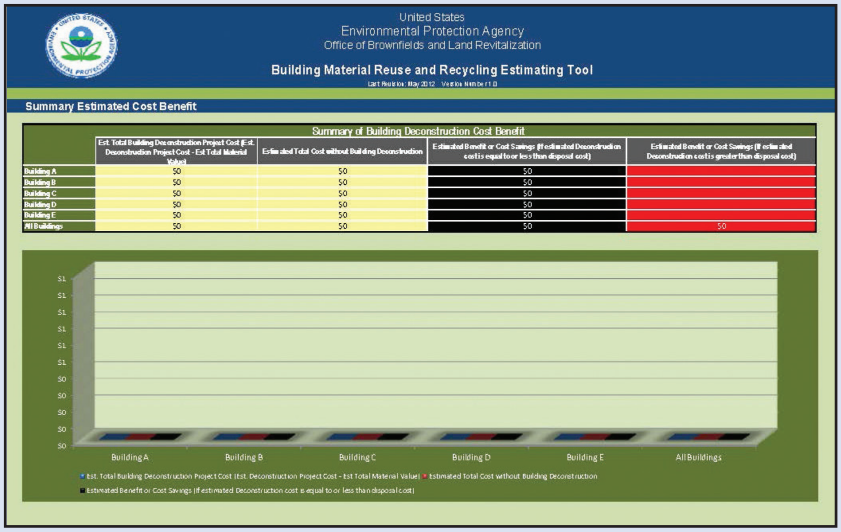
Is the structure currently secured to prevent unwanted entry?	Fully	Partly	No		
Is there room around the structure to serve as staging area?	Yes	No			
Presence of exterior trash?	No Trash	Limited Trash (Scattered Debris)	Significant Trash (Piles of Trash)	Large Appliances/ Bulky Furniture	Impassable/ Entry Restricted
Presence of interior trash?	No Trash	Limited Trash (Scattered Debris on Floors)	Significant Trash (Piles of Trash)	Large Appliances/ Bulky Furniture	Impassable/ Entry Restricted
Were any of the following observed on-site?	Tires	Abandoned cars	Graffiti	Signs of Drug-Use	Containers of Chemicals / Oil

Checklist for Assessing the Feasibility of Building Deconstruction for Tribes and Rural Communities

The checklist is a tool for assessing the technical and economic feasibility of building deconstruction, regardless of a community's size and geographic location. Used in conjunction with the *Building Material Reuse and Recycling Estimating Tool*, this checklist will help tribes and rural communities determine potential costs and benefits of reuse, recycling, and disposal options for various types of deconstruction materials.

Building Material Reuse and Recycling Estimating Tool

After completion of the checklist, the information collected (e.g., type, quantity, condition, and value of deconstruction materials; transportation and labor costs; regulatory considerations) is then entered into the *Building Material Reuse and Recycling Estimating Tool* to calculate the quantities and types of materials that can be reclaimed and recycled.



Chapter 4: Implementing Greener Cleanups

During the cleanup phase of a brownfield project, there are many ways to incorporate climate change resiliency strategies into remediation plans and cleanup operations. One strategy involves reducing environmental impacts by treating soil onsite and avoiding removal of contaminants. Others include reducing waste generation and material use, using renewable energy to power remediation activities, and intentional planning and management of site operations.

In addition to reducing the footprint of a brownfield cleanup, it is important to consider long-term resilience of a remedy to climate change impacts. A particular site's vulnerability – the degree to which it is susceptible to or unable to cope with, adverse effects of climate change, including climate variability and extremes – may impact a cleanup's resiliency. A site's vulnerabilities should be determined during the ESA outlined in Chapter 2. Climate change impacts potentially affecting the vulnerability of a cleanup are listed in Table 2.

Temperature	Precipitation	Wind	Wildfires
• Increased occurrence of extreme temperatures. • Sustained changes in average temperatures. • Decreased permafrost.	• Increased heavy precipitation events. • Increased flood risk. • Decreased precipitation and increasing drought. • Increased landslides. • Sea level rise.	• Increased intensity of hurricanes. • Increased intensity of tornados. • Increased storm surge intensity.	• Increased frequency and intensity.

Table 2. *Climate Change Impacts Potentially Affecting Cleanup Vulnerability*

In addition to providing information on climate change mitigation and adaptation, this chapter includes case studies highlighting some of these methodologies, providing examples of practical application that might be useful for your cleanup planning.

Green Remediation: What It Is and Why It Is Important

Figure 7. *Five core elements of a greener cleanup*

Cleaning up or "remediating" brownfield sites can generate waste, emit GHGs and require a considerable amount of energy and other resources. Green remediation is the application of more environmentally friendly, sustainable cleanup practices that lessen the overall environmental impact of the cleanup phase of brownfield revitalization while ensuring it remains protective. Green remediation reduces the environmental "footprint" of remediation. EPA's Methodology for Understanding and Reducing a Project's Environmental Footprint uses 21 metrics and a seven-step process to quantify energy, air, water, and materials and waste comprising the environmental footprint of a remedy. The metrics correspond with the five core elements of a greener cleanup: materials & waste, land & ecosystems, water, air & atmosphere, and energy (Figure 7). The methodology suggests how to reduce the footprint during cleanup selection, design, implementation, and operation. EPA has made available Spreadsheets for Environmental Footprint Analysis (SEFA) to help estimate each of the metrics on a site-specific basis.

Implementing Greener Cleanups

Green remediation strategies can increase the net benefit of a cleanup, saving project costs and expanding the universe of long-term property use or reuse options without compromising the cleanup goals (EPA, 2008a). EPA's Green Remediation Focus Page on the CLU-IN website offers resources, case studies, and BMP factsheets that can provide additional guidance on making a brownfield remediation project greener.

Another great resource for climate change mitigation and adaptation is the ASTM Standard Guide for Greener Cleanups (E2893-13), a step-by-step guide to implementation of green remediation. The heart of the standard is the BMP process, a protocol for identifying, prioritizing, selecting, and implementing greener BMPs to reduce the environmental footprint associated with cleanup activities. Its flexibility allows the user to apply the standard to all project phases and to any cleanup, small and large, voluntary and rigorous. For example, a project manager could focus on BMPs that reduce water use in arid lands, while in other areas particulate emissions may be a higher environmental priority (Association of Redevelopment Initiatives, 2015). The ASTM Standard Guide has a Microsoft Excel table of more than 160 BMPs organized into 10 categories (Figure 8) with several filters that allow the user to add and sort the BMPs. It also includes an option to assist with the green BMP selection and provide quantitative metrics to estimate potential environmental footprint reductions. By using this resource, communities can help maximize their climate resiliency efforts during brownfield redevelopment.

Figure 8. *Categories of BMPs in the ASTM Standard Guide for Greener Cleanups*

Many states have incorporated use of the ASTM Standard Guide into their brownfield cleanup practices and policies. Massachusetts, for example, is incorporating Greener Cleanup goals into its regulations and referencing the Standard Guide in policy as a way to achieve regulatory requirement (Massachusetts Department of Environmental Protection, 2014). The Massachusetts Contingency Plan has been revised to require evaluation of the relative consumption of energy resources as well as the potential damages to natural resources during the remedy selection process (Simon, et al., 2014).

Minimizing emission of air pollutants such GHGs and particulate matter resulting from cleanup activities, including those needing fossil or alternative fuel, is a core element of green remediation.

Practical Application

Incorporating some of the following mitigation and adaptation strategies, grouped by EPA's five core elements of green remediation, can increase the resiliency of a brownfield cleanup to climate change impacts.

Reduce Energy Use

Brownfield cleanups can involve significant consumption of gasoline, diesel and other fuels by mobile and stationary sources. Greener brownfield cleanups should consider the following climate change mitigation BMPs:

- Minimize generation of GHGs.
- Minimize generation and transport of airborne contaminants and dust.
- Use heavy equipment efficiently.
- Maximize use of machinery with advanced emission controls.
- Use cleaner fuels to power machinery and auxiliary equipment.
- Sequester carbon onsite (e.g., soil amendments, revegetation).
- Reduce fuel consumption to reduce air emissions.
- Maximize use of renewable energy.

To use heavy equipment more efficiently, idling time should be reduced. Unnecessary idling can occur during a cleanup when loading or unloading materials, operating auxiliary equipment and cooling or heating the interior of a vehicle or cab. A "no idling" policy can be implemented through corporate policy and onsite signage that displays idling time requirements that meet or exceed those of state or local agencies. An idle reduction plan can significantly reduce air emissions as well as reduce fuel consumption by about one gallon per truck per hour (EPA, 2010a).

Machinery equipped with advanced emission controls, diesel-fueled equipment should be properly maintained or retrofitted. This can yield significant fuel and emission reductions during site cleanup. Cleaner fuels, such as biodiesel, can be used instead of conventional diesel or in differing blends with conventional diesel to reduce emissions and other air pollutants from power machinery and auxiliary equipment used for activities including excavating waste rock, segregating and transferring soils for onsite use, constructing surface water diversions, and installing a soil cap system. (See the profile for Elizabeth Mine, as an example.) Using cleaner fuels in mobile sources of emissions, especially heavy machinery, can be a particularly effective way to reduce air emissions.

While using cleaner fuels can be an effective mitigation strategy, reducing fuel consumption altogether is a much more impactful strategy for reducing air emissions. This can be achieved by limiting transportation of materials to and from a site. Consider the following action steps to limit transportation (EPA, 2008b):

- Recycle and reuse materials onsite.
- Purchase materials from local suppliers (reduce delivery fuels).
- Select local providers for field operations (reduce transportation time to site).
- Coordinate outside services and service providers (minimize equipment transportation).

Most Commonly Used BMPs

- *Use biodiesel as fuel source*
- *Use onsite or nearby sources of fill material*
- *Use native species for vegetative cover*
- *Reclaim uncontaminated material for reuse, salvage value or recycling*
- *Use onsite generated renewable energy (e.g., solar, wind, landfill gas)*
- *Incorporate wetlands, bioswales and other natural resources into cleanup*
- *Use biodegradable hydraulic fluids in equipment*
- *Use local staff to minimize resource consumption*
- *Use dedicated materials for sampling*
- *Re-vegetate excavated or disturbed areas quickly*

- Choose the closest waste receiver, evaluate other transport methods, and identify opportunities for resource sharing with other waste haulers (reduce fuel use during transfer to soil and materials).

Snapshot: Carbon Savings of Biofuels Depends on How They are Produced

Converting rainforests, peatlands, savannas, or grasslands to produce food crop–based biofuels in Brazil, Southeast Asia, and the United States creates a "biofuel carbon debt" by releasing 17 to 420 times more CO_2 than the annual greenhouse gas (GHG) reductions that these biofuels would provide by displacing fossil fuels. In contrast, biofuels made from waste biomass or from biomass grown on degraded and abandoned agricultural lands planted with perennials incur little or no carbon debt and can offer immediate and sustained GHG advantages. (Fargione, et al., 2008)

Use of renewable energy sources provides a significant opportunity to reduce the environmental footprint of remediation activities. Projects can incorporate renewable energy into a brownfield cleanup by powering equipment through onsite renewable energy sources and by purchasing commercial energy from renewable sources. Renewable sources of energy include solar, wind, hydropower of rivers and streams or the tidal influences of the oceans, and sustainable biomass such as untreated woody waste, agricultural waste, animal waste, energy crops, landfill gas, wastewater methane and anaerobic digestion.

Modular renewable energy systems that meet low-energy demands should be considered for field equipment, small site cleanups, and construction or operational activities associated with site reuse (EPA, 2011). For example, a wind turbine could be used to power a groundwater circulation well. Implementing renewable energy sources to supply the power for the energy needs of the site is an excellent way to reduce emissions and prepare the property for further climate resiliency efforts.

Reduce Water Use and Impacts to Water Sources

Reducing water use and limiting impacts to water sources also decrease the environmental footprint of brownfield remediation. Cleanup at many sites involves high consumption of water for treatment processes such as soil washing and the dewatering of contaminated sediments. Management plans for stormwater runoff control during site cleanup are required. A greener brownfield cleanup should consider the following BMPs to protect water sources:

- Minimize water use and depletion of natural water resources.
- Capture, reclaim, and store water for reuse (e.g., recharge aquifer, drinking water irrigation).
- Minimize water demand for revegetation (e.g., native species).
- Employ BMPs for stormwater.

Water can be captured, reclaimed and stored by installing a rainwater collection system. Captured rainwater, rather than potable water, can be used onsite for applications such as dust control during construction activities. Potable water use can also be minimized by capturing and treating gray water for reuse.

BMPs for stormwater management may include installing and maintaining silt fences and basins to capture sediment runoff along sloped areas. Gravel roads, porous pavement, and separated permeable surfaces can also be used rather than impermeable materials, to maximize infiltration of rainwater into the soil.

Snapshot: Old Base Landfill, Former Naval Training Center-Bainbridge, Port Deposit, Maryland

Cleanup Objectives: *Contain an unlined landfill containing nearly 38,000 cubic yards of soil contaminated with pesticides and asbestos debris.*

Green Remediation Strategy: *Employed BMPs for controlling stormwater runoff and sediment erosion during construction of a landfill cover:*

- *Installed a woven geotextile silt fence downgradient of construction to filter sediment from surface runoff.*
- *Added a "super-silt fence" (woven geotextile with chain-link fence backing) on steep grades surrounding the landfill.*
- *Constructed berms and channels to divert stormwater to sediment ponds.*
- *Emplaced erosion control blankets to stabilize slopes and channels until vegetation was established.*
- *Hydroseeded the landfill cover with native seed to foster rapid plant growth.*

Results:

- *Effectively captured sediment at supersilt fence despite heavy rain of Hurricane Floyd.*
- *Avoided damage of infrastructure used in site redevelopment.*
- *Reestablished 100 percent vegetative cover within one year.*

Source: (EPA, 2008)

Materials Management and Waste Reduction

Waste reduction through reuse and material recycling is another way to decrease the environmental footprint of a brownfield cleanup. Site cleanup can generate significant volumes of waste, and much of it could be recycled or salvaged for reuse rather than disposed of in landfills (EPA, 2013b). A greener brownfield cleanup should consider the following BMPs to reduce, reuse, and recycle material and waste:

- Minimize consumption of virgin materials.
- Minimize waste generation.
- Use recycled products and local materials.
- Beneficially reuse waste materials (e.g. concrete made with coal combustion products replacing a portion of the Portland cement).
- Segregate and reuse or recycle materials, products, and infrastructure (e.g. soil, construction and demolition debris, buildings).

Waste materials can be reused or recycled in a number of ways. Some specific examples of how a brownfield remediation project could achieve this BMP include (EPA, 2008; EPA, 2013b):

- Salvaging uncontaminated and pest- or disease-free organic debris for use as infill, mulch, compost, habitat creation, etc.
- Salvaging uncontaminated materials with potential recycle, resale, donation, or onsite infrastructure value such as steel, concrete, granite and storage containers.
- Using onsite or offsite industrial materials such as crushed concrete and shredded scrap tires for cleanup construction

Land Management

Green remediation strategies for land and ecosystems capitalize on a "whole-site" approach that accelerates cleanup while returning a site to its natural conditions. BMPs focus on opportunities to preserve natural land features, maintain open space, sequester carbon, enhance biodiversity, increase wildlife habitat, and minimize surface and subsurface disturbance. Efficient land management can reduce the environmental footprint and incorporate both mitigation and adaptation strategies into a brownfield cleanup project. Some BMPs that should be considered include:

NYC Clean Soil Bank

Promotes sustainable soil reuse (recycling) and simultaneously solves a series of soil management problems:

- *Eliminates soil disposal costs for brownfield developers.*
- *Shortens soil transport distances, lowers highway congestion and reduces truck emissions.*
- *Eliminates reliance on inner-city, soil transfer stations and lowers associated environmental justice community impacts.*
- *Eliminates soil purchase costs for City and brownfield developments that need clean soil.*

- Minimize areas requiring limitations on future activity or use.
- Minimize unnecessary soil and habitat disturbance or destruction.
- Use native species to support habitat.

To minimize areas requiring activity or use limitations in the future, one green remediation strategy is to evaluate cleanup methods that permanently destroy contaminants. This may provide numerous benefits across the spectrum of energy use, water management and waste reduction. Permanently removing contaminants reduces or eliminates the need for onsite monitoring and subsequent operation and maintenance of a cap or cleanup method. By permanently destroying contaminants, a site's full redevelopment potential may be reached, which may include opportunities for open space, increased biodiversity, and green infrastructure elements to help both mitigate climate change and adapt to future climate change impacts.

Soil and habitat disturbance can be minimized by covering ground surfaces in construction and maintenance corridors with mulch and metal grates to prevent soil compaction by heavy machinery. Tree clearing should also be minimized throughout a cleanup project. This will provide both climate mitigation benefits (carbon sequestration) and climate adaptation benefits (soil stability, natural erosion control and water absorption and filtration, reduced urban heat island effect, etc.). Further climate change adaptation and mitigation benefits can be achieved by incorporating wetlands, bioswales and other types of vegetation into the overall remedial approach to enhance existing natural resources, manage surface drainage, prevent soil and sediment runoff and promote carbon sequestration.

Selecting and installing native, drought-resistant plants (and avoiding invasive species) can foster rapid recovery in disturbed areas, increase the site's ability to adapt to changing climate impacts, and support local pollinators. Drought-resistant plants can survive longer periods of drought in an arid climate or the emergence of drought conditions in traditionally wetter climates.

Bioremediation and Phytoremediation: Lesser-Used Technologies on Brownfield Cleanups

Natural system technologies such as bioremediation and phytoremediation can help reduce the environmental footprint of a cleanup. Bioremediation uses naturally occurring biological processes to degrade contaminants in soil, sediment, and groundwater. By enhancing the effects of these biological processes through various amendments derived from waste products, bioremediation reduces the consumption of virgin natural resources while using waste products. One example is the introduction of enzymes that commonly exist in agricultural or industrial byproducts (e.g., manure compost and spent-mushroom compost) to stimulate microbial degradation of contaminants (EPA, 2010b). Another example is from a brownfield cleanup by the Rhizome Collective, Inc. in Austin, TX where an illegal dump containing 5,000 cubic yards of debris was cleaned up. This cleanup involved the construction of floating islands of recovered plastic to create habitat for life forms capable of bioremediating residual toxins in an onsite retention pond (EPA, 2008).

Phytoremediation uses plants to remediate contaminated soil, sludges, sediments, and groundwater through contaminant removal, degradation and/or containment (EPA, 2001). Trees and other vegetation can absorb, transform or contain a variety of contaminants including organics, pesticides, oil and some metals (EPA, 2012b). In addition to the remedial benefits, phytoremediation promotes increased carbon storage in the plants helping to reduce GHG emissions. This helps reduce air pollution in the brownfield community and moderate rising temperatures associated with climate change. Trees and other vegetation also help to stabilize the soil and protect against erosion from increasingly extreme weather events as well as provide natural stormwater management (Arbor Day Foundation, 2010). Phytoremediation works best where contaminant levels are low and shallow and where the plants are specifically chosen for the contaminant type and concentration as well as for the local climate (EPA, 2012b).

Bioremediation and phytoremediation are not appropriate for every brownfield cleanup as these approaches do not work for all contaminants. However they can prove beneficial in some cases to address lingering contamination after human health requirements are met.

Helpful References

- Green Remediation Best Management Practices: Bioremediation (EPA, 2010b)
  https://clu-in.org/greenremediation/docs/GR_factsheet_biorem_32410.pdf
- A Citizen's Guide to Phytoremediation
  https://clu-in.org/download/citizens/a_citizens_guide_to_phytoremediation.pdf

Onsite Remediation

Wherever practical and possible, remediation should be conducted onsite to further limit transportation and fuel usage as well as provide other environmental climate benefits such as reducing waste, promoting reuse of materials, and reducing costs. This approach has been implemented at numerous brownfield sites across the United States, including two in Chicago, Illinois: Back of the Yards Preparatory High School and the Whitney Young Library.

Snapshot: Back of the Yards Preparatory High School

Formerly an auto salvaged yard with an earthen floor, the site contained numerous leaking tanks, buried auto parts, and hazardous lead waste. Initial cost saving measures that also happen to be green BMPs called for reusing materials onsite.

Green Remediation Strategies:

- *In situ treatment of hazardous waste lead*
  - *~355 cubic yards of material diverted from hazardous waste landfill.*
  - *In situ treatment rendered material inert, lowering the environmental burden and eliminating the need to move hazardous materials.*
- *Reuse of clay pool spoils for berms and site cap*
  - *~20,000 cubic yards of material diverted from hazardous waste landfill.*
  - *Materials and soil management reduced costs for disposal and importing of 3,676 truckloads of clean fill.*
- *Reduced energy use and associated air pollutants, GHG's from trucks*
  - *Used local landfill.*
  - *Reduced haul-off and imported and virgin material use.*
  - *Used local laboratory for the frequent confirmation samples; local labor pool.*
- *Water – Onsite management of 1.4M g/yr of stormwater*
- *Waste/Materials Management*
  - *Minimized imported and virgin material use.*
  - *Reduced landfill impact.*

Snapshot: Whitney Young Library

The former site of a dry cleaners shop was redeveloped into the Whitney Young Library after onsite remediation.

Green Remediation Strategies:

- *In situ treatment of contamination using chemical oxidation*
  - *~22,000 cubic yards material diverted from landfill*
  - *In situ treatment rendered material inert and allowed materials to be capped in place*
- *Reduced energy use and associated air pollutants and GHG's*
  - *Used local landfill and laboratory, minimizing impacts from transportation*
  - *Reduced haul-off and import of clean fill.*
  - *Eliminated 4,043 trucks from streets.*
- *Integrated onsite stormwater management into final site design*
- *Waste and materials management*
  - *Minimized imported and virgin material use*

Reduced landfill impact by diverting 480 tons of concrete from landfill to recycling.

Chapter 5: Redeveloping Brownfields for Climate Resiliency

The redevelopment phase of a brownfield project provides the visible end product of community planning and commitment to climate change resiliency and mitigation. Each brownfield redevelopment also provides the opportunity to improve the connectivity of various elements of the built environment to meet the economic, environmental, and local health and welfare needs of revitalizing communities. Throughout the brownfield revitalization process, particular attention should be paid to equitable development to prevent displacement and ensure the neighborhood meets the needs of longtime residents.

Every aspect of redevelopment, whether improving or expanding connections to existing energy, transportation and infrastructure, the built environment (including housing, mixed-use development, schools, commercial areas, and walkable neighborhoods), and parks, green space and natural areas, can contribute to climate change mitigation and adaptation. Planning decisions guide redevelopment outcomes, especially regarding the built environment which is a primary contributor to GHG emissions and climate change impacts. Redevelopment options that align with and promote community climate resiliency should be considered early in the brownfield redevelopment process to ensure successful. By planning ahead, communities, grantees, and government entities are more equipped to reduce local contributions to global climate change (e.g., CO_2 and GHG emissions) and limit known and projected impacts (e.g., flooding, drought, sea level rise) and potential outcomes (e.g., response costs, population displacement, increased health and welfare issues, disrupted economic activity) while advancing brownfield redevelopment for safe reuse and job creation.

A brownfield redevelopment project can consider these reuse options to reduce emissions of GHGs and positively contribute to more climate change resilient communities.

Potential Green Infrastructure Benefits (EPA, 2014b)

- *Improved water quality*
- *Reduced municipal water use*
- *Ground water recharge*
- *Flood risk mitigation*
- *Increased resilience to climate change impacts such as heavier rainfalls, hotter temperatures, and higher storm surges*
- *Reduced ground-level ozone*
- *Reduced particulate pollution*
- *Reduced air temperatures in developed areas*
- *Reduced energy use and associated GHGs*
- *Increased or improved wildlife habitat*
- *Improved public health from reduced air pollution and increased physical activity*
- *Increased recreation space*
- *Improved community aesthetics*
- *Cost savings*
- *Green jobs*
- *Increased property values*

Green Infrastructure

Climate change impacts along with land use changes can affect the amount of stormwater runoff that needs to be managed by stormwater infrastructure. Green infrastructure reduces the burden of storm events on local water infrastructure. It uses landscape features to store, infiltrate and evaporate stormwater to reduce the amount of water entering sewers, reducing the discharge of pollutants into water bodies. Building green infrastructure on underused and vacant properties such as brownfields can be an innovative environmental solution that goes beyond conventional regulatory solutions for controlling stormwater runoff. Green infrastructure can also provide a number of important environmental and socio-economic benefits to communities (See text box). Additionally, green infrastructure can help to improve quality of life for residents by encouraging recreational activity, improving public health and bringing the community together in public spaces (EPA, 2014c).

Green infrastructure provides a framework and methodology for implementing flood risk and flood loss reduction. It also can enhance drought mitigation in arid and semi-arid environments where stormwater management is used for aquifer recharge. Such techniques incorporate ecosystem benefits and help build a community's resilience to the impacts of climate change (FEMA, 2015). Incorporating green infrastructure can also reduce the demand on municipal and domestic water treatment systems and result in significant cost savings to municipalities. Stormwater flows can be greatly reduced, lowering energy needs for treating and moving drinking water and wastewater, and reducing energy costs (EPA webpage: Spend Less Energy Managing Water).

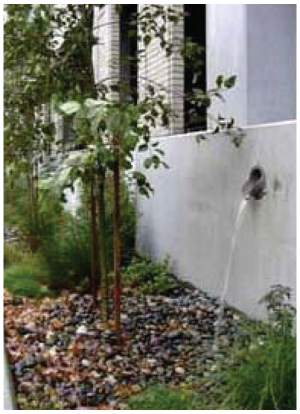
For more information on green infrastructure, visit EPA's Green Infrastructure webpage.

On a larger scale, green infrastructure includes preserving and restoring natural landscape features such as forests, floodplains and wetlands, and reducing the amount of land covered by impermeable surfaces. On a smaller scale, it involves a variety of elements such as urban tree canopy, bioswales, green streets, permeable paving and open spaces, that help create more sustainable environments that can support a community's climate mitigation and adaptation efforts. Brownfield revitalization presents the perfect opportunity to consider implementing many of these elements.

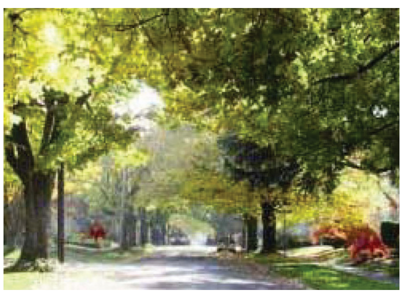
Table 4 contains examples of green infrastructure with a brief explanation, and their benefits. To see projects that have incorporated combinations of these elements, visit the Sustainable SITES Initiative's website.

Table 4. *Examples of Green Infrastructure*

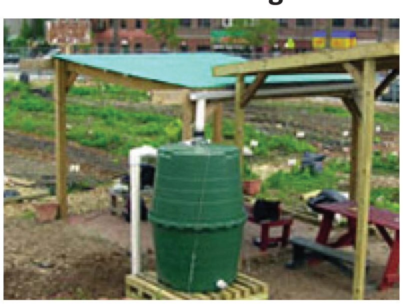
Green Infrastructure Element	Explanation	Benefits
Green roof  	Made up of a top vegetative layer that grows in an engineered soil, which sits on top of a drainage layer. A green roof can be intensive, with thicker soils that support a wide variety of plants, or extensive, with a light layer of soil and minimal vegetation. They are particularly cost-effective in dense urban areas where land values are high and on large industrial or office buildings where stormwater management costs are likely to be high.	The growth media and vegetation of green roofs enable rainfall infiltration and evapotranspiration of stored water.

<table>
<tr><th>Green Infrastructure Element</th><th>Explanation</th><th>Benefits</th></tr>
<tr><td>Downspout disconnection
</td><td>Reroutes rooftop drainage pipes to rain barrels, cisterns, or permeable areas to keep rainwater from draining to the storm sewer.

For a tutorial, visit: http://www.mmsd.com/downspout-disconnection</td><td>Keeps excess water out of sewers and prevents combined sewer overflows from occurring.

Can lower energy use by municipal wastewater treatment systems.</td></tr>
<tr><td>Urban tree canopy
</td><td>The layer of leaves, branches and stems of trees that cover the ground when viewed from above.

The size of an urban tree canopy can be increased by planting trees in public spaces.

The size of an urban tree canopy can be increased by planting trees in public spaces.</td><td>▪ Reduces and slows stormwater runoff by intercepting precipitation in their leaves and branches.
▪ Increases the permeable surface area in the city, which in turn reduces runoff and relieves stress on stormwater infrastructure.
▪ Reduces the heat island effect. The heat island effect worsens one of the greatest public health threats caused by climate change--extreme heat waves.
▪ Increases carbon sequestration, lowers energy use for air conditioning, and improves health and quality of life, which impacts everything from student achievement to mental health.</td></tr>
<tr><td>Rainwater harvesting
</td><td>Collection and storage of rainfall for later use.</td><td>Slows and reduces runoff and provides a source of water. Rainwater harvesting could be particularly valuable in arid regions, where it could reduce demands on increasingly limited water supplies.</td></tr>
</table>

Green Infrastructure Element	Explanation	Benefits
Bioswales 	Vegetated, mulched, or xeriscaped channels that provide treatment and retention of stormwater as it is transported from one place to another.	Slows stormwater flow allowing it to infiltrate and be filtered. As linear features, they are particularly well-suited for placement along streets and parking lots.
Rain gardens 	Shallow, vegetated basins that collect and absorb runoff from rooftops, sidewalks and streets. Also known as bioretention or bioinfiltration cells, these versatile features that can be installed in almost any unpaved space.	Mimics natural hydrology by infiltrating, and evaporating and transpiring—or "evapotranspiring"—stormwater runoff.
Planter boxes 	Urban rain gardens with vertical walls and either open or closed bottoms. They are ideal for space-limited sites in dense urban areas and as a streetscaping element.	Collect and absorb runoff from sidewalks, parking lots and streets helping to mitigate impacts from stormwater runoff and flooding.
Green parking 	Parking lot designs that integrate elements such as permeable pavements, rain gardens and bioswales. For an example of green parking, visit: http://www.mass.gov/eea/agencies/dcr/water-res-protection/ipswich-river-watershed/permeable-paving-parking-lot.html	Helps mitigate the urban heat island effect and promote a more walkable built environment.

Green Infrastructure Element	Explanation	Benefits
Permeable pavement  	Paving that has pores or openings that allow water to pass percolate through to the subsoil. It's available in the form of permeable asphalt, concrete, and pavers. In areas where soil does not drain freely, permeable pavement can be used in combination with pipe underdrains or stormwater infiltration trenches to slow runoff and reduce stress on the combined sewer system.	■ Reduces the rate and quantity of stormwater runoff. ■ Reduces stress on the sewer system. ■ Increases groundwater recharge. ■ Permits "treatment" of pollution by trapping and degrading oils and other pollutants. ■ Filters silt and debris.
Land conservation and community open space 	Protection of open spaces and sensitive natural areas within and adjacent to a city while providing recreational opportunities for city residents.	■ Promotes walking and biking within neighborhoods and to adjacent neighborhoods. ■ Lowers the urban heat island effect, absorbs carbon dioxide and particulate matter, provides oxygen and habitat, and creates pleasant community spaces (Benepe, 2013).
Urban agriculture 	The practice of cultivating, processing and distributing food in or around a village, town or city.	■ Increases stormwater absorption, which helps reduce stormwater flow and resulting water pollution. ■ Supports creation of farms and edible gardens. ■ Supports community engagement.

Renewable Energy

Brownfield redevelopment provides an excellent opportunity to consider renewable energy technologies as part of a project design that will reduce emissions and support energy needs during weather events. Brownfield sites are increasingly being looked to as potentially providing feasible opportunities to construct and operate smaller scale renewable energy projects to meet energy needs (Benjamin, 2014). Where renewable energy development is aligned with the community's vision for the site, EPA encourages such development on current and formerly contaminated lands, landfills, and mining sites.

The most common renewable energy technologies incorporated into brownfield redevelopment are wind and solar systems. Their benefits are summarized in Table 5. Wind and solar installations vary in size and have been shown to be viable projects across all EPA and state remediation programs (EPA, 2016c). Community solar installations provide power and/or financial benefit to, or is owned by, multiple community members (U.S. Department of Energy, 2011). Community solar power systems help bring solar power to renters, those with shaded homes, and those who cannot afford to install a residential system.

Table 5. *Summary of the Benefits of Wind and Solar Energy Systems*

Wind	Solar
Offsets GHG, SO_2, and NO_2 emissions as well as particular matter	Offsets GHG, SO2, and NO2 emissions as well as particular matter
Enhances energy security as we face greater energy needs and increasingly stronger threats to our current energy power-sector from climate change impacts	Already part of our daily lives (powering small consumer items (i.e. calculators, watches) to larger, more complicated systems (i.e. water pumps, lights, appliances, machines) and many road and traffic signs are now powered by photovoltaic (PV)
Application: available in a wide range of sizes to fit almost any energy need (American Wind Energy Association, 2001)	Application: small-scale systems on a rooftop to large-scale systems covering several acres, reducing the environmental footprint of the site and helping the community become more resilient in the face of climate change

Other renewable energy options for brownfield sites include geothermal systems, which use heat stored in the Earth to generate electricity, and combined heat and power (CHP), which comprise onsite electricity generation that captures the heat that would otherwise be wasted to provide useful thermal energy (e.g., steam or hot water) for use in space heating, cooling, domestic hot water and industrial processes. These technologies have been shown to be effective at reducing energy needs, increasing energy efficiency and reducing GHG emissions (The New York State Energy Research and Development Authority). Construction of geothermal or CHP systems during a brownfield redevelopment could provide heating, cooling, and electricity for newly constructed or renovated buildings.

EPA's RE-Powering America Initiative provides a great source of information for those interested in learning more about past projects, technical resources and potential opportunities for various renewable energy sources on brownfields and other potentially contaminated lands.

Using data from the RE-Powering America's Energy Initiative to calculate equivalencies in EPA's GHG Equivalency Calculator, renewable energy on brownfields in the United States is shown to potentially educe an estimated 805,141 metric tons of CO_2 emissions annually.

This is equivalent to CO_2 emissions from 73,462 homes' energy use for one year, and to GHG emissions from 288,581 tons of waste sent to landfill.

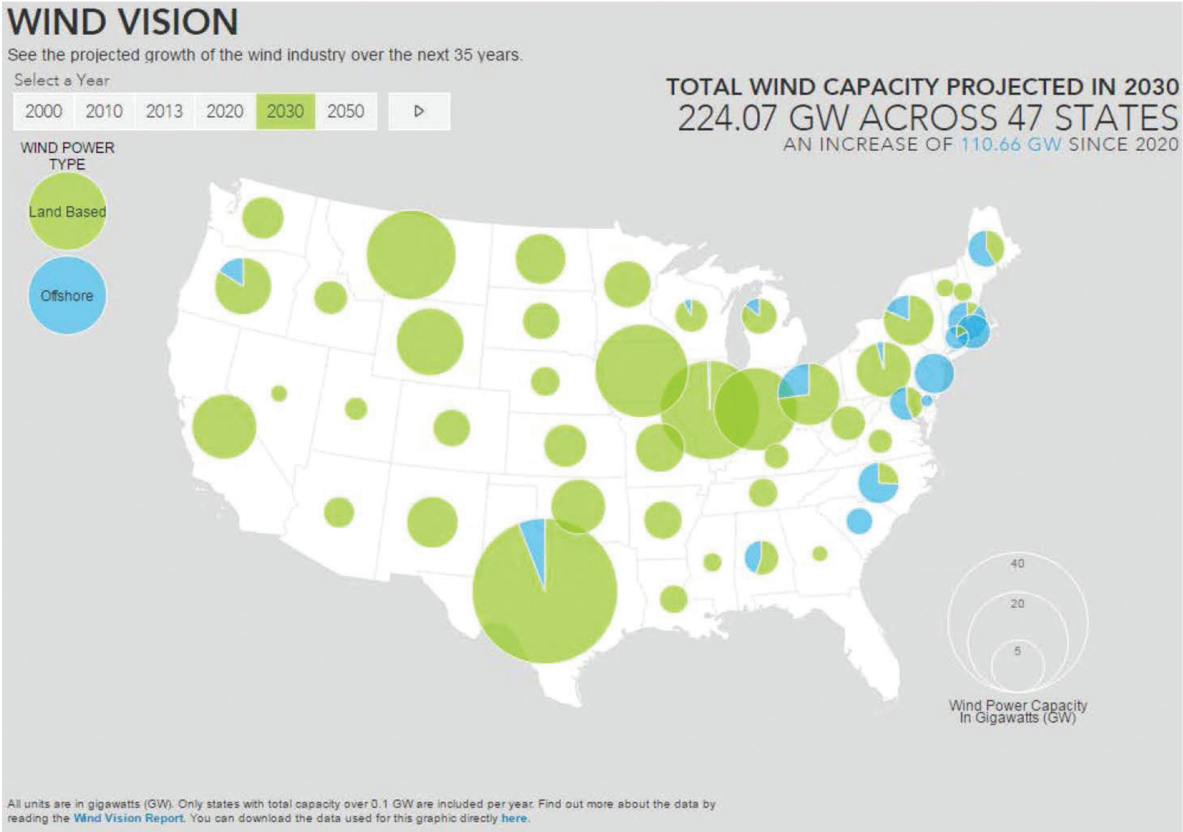


Figure 9. *Potential for America's Wind Energy Future SOURCE: http://energy.gov/articles/new-interactive-map-shows-big-potential-america-s-wind-energy-future*

Local Leadership for Renewable Energy

Municipalities can adopt policies to support growth of renewable energy technologies in their communities. Encouraging use of renewable energy on former brownfields is a powerful way to make site-specific changes in a way that makes communities more resilient to projected climate changes. Local governments have a strong role to play in the generation of power from renewable sources. Through zoning and local permitting, a municipality can control where energy generation is allowed and make it easier for renewable energy to be incorporated into brownfield redevelopment projects. For example, the City of Lackawanna, New York, allowed for the development of an urban wind farm on a brownfield at the old Bethlehem Steel site while neighboring towns considered a ban on wind turbine installations (Office of the New York State Comptroller, 2008). Local governments can also encourage installation of renewable energy technologies through financial incentives, especially for lesser-used technologies that have shown to provide great benefit, such as CHP.

Snapshot: Renewable Energy Development in Lakewood, Colorado

The State of Colorado and a coalition of seven local governments provided financial support through a Revolving Loan Fund (RLF) grant from EPA's Brownfields program to remediate contamination at a former shopping mall in Lakewood, paving the way for renewable energy development. After the environmental cleanup was complete, the developer converted the site into a new mixed-use development where parking meters are powered by solar panels, street lights are powered by wind turbines, and all of the electricity needed by the parking garages is provided by a 1.75 megawatt array of solar PV panels installed on top of the parking structures. This urban brownfield site became walkable mixed-use development that integrates renewable energy with LEED-certified green buildings (EPA Region 8, 2009).

Green-Building Techniques and the Built Environment

A brownfield redevelopment project containing commercial, residential or other types of facilities (e.g., educational and healthcare) can incorporate green building techniques into the design. Green building is the practice of creating healthier, more resource-efficient models of construction, renovation, operation, maintenance, and demolition. It aims to reduce air and water pollution, stormwater runoff, waste, and unhealthy indoor environments, and transform buildings into a sustainable part of the landscape. Green building techniques can be instrumental in addressing climate change impacts by more effectively controlling stormwater, reducing waste and emissions, and designing smarter infrastructure that allows for climate adaptation and mitigation.

Green building techniques and strategies generally include preservation of green space, development of green roofs and a variety of energy efficiency and water efficiency measures as well as measures that support passive survivability. Although each technique is discussed separately below, an integrated approach provides the best opportunity to achieve the most GHG reductions because no single strategy can do this alone, and different green building components often interact with one another to influence overall energy consumption.

Green Roofs

Green roofs help retain stormwater longer, decreasing the stress on sewer systems during peak flow periods. They also moderate the temperature of the stormwater and act as a natural filter for water that happens to run off. The plants on a green roof help to cool cities during hot summer months, reducing the urban heat island effect. Green roofs also mitigate this effect by covering black rooftops, which are some of the hottest surfaces in the built environment. In addition, green roofs can mitigate GHG emissions, capturing airborne pollutants and atmospheric deposition, thus improving air quality and communities' ability to adapt to future impacts of warmer summers. Finally, green roofs provide greater insulation to buildings. This reduces the amount of energy needed for heating and cooling, since much of the heat gained or lost in a building is through the rooftop. Developments on former brownfield sites can consider incorporating this strategy for both climate change mitigation and adaptation.

For more information about green roofs visit EPA Region 8's Green Roof webpage at http://www2.epa.gov/region-8-green-building/green-roof or Green Roofs for Healthy Cities—North America, Inc., at http://www.greenroofs.org/index.php/about/greenroofbenefits

Energy Efficiency

Developers and building owners can reduce the use of electric and gas heating and cooling systems of homes, businesses and other buildings by incorporating insulating construction elements such as high-performance windows, ventilated "attic" space, high-performance glass, and brick façade. The decreased need for electric and gas heating and cooling will consequently decrease GHG emissions.

Green insulation (e.g., closed-cell spray polyurethane foam) increases energy efficiency while also reducing the environmental footprint of construction materials since their production, transport and installation often uses less energy and fewer raw materials as traditional insulation products (Greenguard Environmental Institute).

More information about insulation materials and renewable energy can be found at the Office of Energy Efficiency & Renewable Energy's Building Envelop Projects webpage and their Building Technologies Office webpage, respectively, at http://energy.gov/eere/buildings/listings/building-envelope-projects and http://energy.gov/eere/efficiency/buildings.

Lighting Efficiency

Lighting efficiency optimizes artificial and natural lighting to reduce energy usage. Also, the conservation measures to minimize the amount of the time that lights are in use will reduce energy use. These include behavioral change, building design (often to create more natural lighting), and automation, such as timers and sensors (Center for Climate and Energy Solutions).

Passive Survivability

More frequent and severe storms as well as stronger, longer-lasting heat waves will strain utility providers and increase the frequency of climate-related power outages. "Passive survivability" is a building's ability to maintain habitability without relying on external utility systems for power, fuel, water, or sewer services, as well as being better able to withstand floods, severe weather, and temperature extremes (EPA, 2013c). Passive survivability combines many of the green building strategies discussed in this manual and can be accomplished through passive and active means. Improved energy efficiency combined with passive heating, cooling, ventilation, and natural lighting strategies can be employed. Additionally, an onsite renewable energy source, rainwater harvesting, treatment, and storage; and wastewater systems can also be incorporated into this strategy for passive survivability.

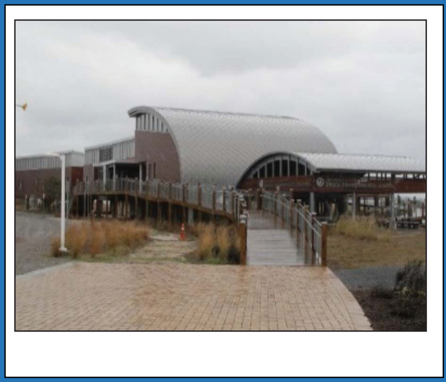
Snapshot: Passive House–Village Centre in Brewer, Maine

- *Affordable housing project designed to be one of the largest passive house developments in the country*
- *Located on former brownfield site*
- *Participating in a pilot program to help define climate-specific passive house standards for the Passive House Institute*

Snapshot: Passive Building–Chesapeake Bay Foundation's new Brock Environmental Center in Virginia Beach, Virginia

This building is one of the country's leading examples of sustainability, and includes a wide array of resilient design features.

- *Wind and solar energy*
- *Energy conservation features*
- *Natural ventilation*
- *Use of daylighting*
- *100 percent water use from harvested rainwater*
- *Green infrastructure elements*
- *Elevated well above sea level*



Other Climate Adaptation Measures for Buildings

Outside of the most common green building techniques, there are a couple of additional climate adaptation measures that can be implemented to better protect properties located in areas vulnerable to climate change. Where appropriate, protect buildings from flooding by adding protective measures such as sea walls, dikes, reinforced buildings, or elevating land using fill or "soft" measures such as living shorelines with natural elements to provide a buffer against storm surges and sea level rise (EPA, 2013 and Sovacool, 2011). While these types of measures often come at a high initial installation cost, they will save money in the long term by reducing or eliminating recovery costs from damage by floods and storms to infrastructure and properties in vulnerable areas and on vulnerable properties such as brownfields.

Community Amenities and Social Structures

When brownfield redevelopment includes transit, complete streets, and LEED buildings, these methods contribute to climate mitigation and adaptation and reap the following benefits:

- Increased resiliency to extreme weather events and climate change impacts because of greater connectivity to critical facilities, especially for vulnerable populations who may not have access to a vehicle during emergencies (Russak, 2015 and U.S. Department of Transportation, 2016).
- Increased resiliency to extreme weather events and climate change impacts because of greater self-sufficiency and an ability to support the community's needs temporarily without access to outside resources.
- Job-training opportunities and ultimately careers in clean energy industries (and other sectors associated with climate resiliency) for low-income and under- or unemployed residents.
- Access to healthy food and community gathering spaces such as waterfronts, parks and recreational areas, which all promote carbon capture and storage.
- Increased social cohesion with added and improved gathering spaces and opportunities for engaging with the community through wider sidewalks and curb cuts, dedicated bike lanes, well-lit roadways and corridors, and connected green spaces, which all promote walking and biking to help reduce GHG emissions (Smart Growth America)(UN Environment, 2016).

Transportation strategies are closely tied to GHG emissions and should be strongly considered whenever possible in a brownfield redevelopment. Shifts in modes of transportation from driving to walking, bicycling, and transit are key mitigation strategies. To encourage this shift, many communities require improved infrastructure to support an increase in pedestrians, bicyclists, and transit users (Smart Growth America, 2016). Brownfield redevelopment projects can incorporate sidewalks in their plans to allow for pedestrian traffic, outdoor public spaces to encourage community gatherings, and bicycle parking, bike share rentals, and bike trails to encourage biking throughout the community. The ultimate goal is to create complete streets in neighborhoods and cities by combining strategies (Figure 10) that link housing, employment and commercial activity with transit-oriented designs, green infrastructure, and high-density multi-use development that includes housing, offices, and shops. By providing and encouraging less energy-intense transportation options, harmful emissions that exacerbate climate change impacts are reduced. In Portland, Oregon, new transit investments and improvements to bicycling and walking infrastructure have resulted in per capita CO2 emissions reductions of 12.5 percent, and Portland's land use policies yield carbon savings worth between $28 and $70 million annually[1].

1 http://www.smartgrowthamerica.org/complete-streets/complete-streets-fundamentals/factsheets/climate-change

There is no singular design prescription for complete streets; each one is unique and responds to its community context. A complete street in a rural area will look quite different from a complete street in a highly urban area, but both are designed to balance safety and convenience for everyone using the road. For maximum impact and cost effectiveness, complete street implementation should be considered as early as possible in a brownfield redevelopment and should engage the community in the planning process to gain a clearer understanding of needs, desires, and existing vulnerabilities that may be addressed through intentional planning and design. For example, an aging population in communities may require more visible signage, properly timed signals, and wider sidewalks that can be easily accessed by people with disabilities.

Figure 10. *Common elements of complete streets*

For examples of complete street implementation across the country, visit the Complete Streets slideshow "Many Types of Complete Streets."

Resource Guide

Resources to Aid in Planning, Designing, or Implementing Climate Resiliency Measures

- Community-based examples for improving ordinance regulations, development incentives, programs and projects: https://www.epa.gov/sites/production/files/2016-01/documents/bf_revitalization_climate_vulnerable_areas_012616_508_v2_web.pdf
- Community Resource Planning Guide: http://www.nist.gov/el/resilience/guide.cfm
- Essential Smart Growth Fixes for Communities: https://www.epa.gov/smartgrowth/essential-smart-growth-fixes-communities
- Adapting to Urban Heat: A Tool Kit for Local Governments: http://www.adaptationclearinghouse.org/resources/adapting-to-urban-heat-a-tool-kit-for-local-governments.html
- Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use: http://www.georgetownclimate.org/resources/adaptation-tool-kit-sea-level-rise-and-coastal-land-use
- Climate change vulnerability and impact assessments modules: http://www.unep.org/ieacp/climate/
- UKCIP Adaptation Wizard: http://www.ukcip.org.uk/wizard/
- Social vulnerability index factsheet: http://svi.cdc.gov/Documents/FactSheet/SVIFactSheet.pdf
- Drought monitor: http://www.drought.gov/drought/
- Presidential Drought Preparedness Memo: https://www.whitehouse.gov/the-press-office/2016/03/21/presidential-memorandum-building-national-capabilities-long-term-drought
- Impacts of drought on public health: http://www.cdc.gov/features/drought/
- Drought planning for communities: http://drought.unl.edu/Planning/PlanningProcesses/DroughtReady-Communities.aspx
- Planning and Drought: https://www.flickr.com/photos/completestreets/sets/72157617261981677/
- Brownfield Grants and Funding: http://www.epa.gov/brownfields/grant_info/index.htm
- Setting the Stage for Leveraging Resources for Brownfields Revitalization: https://www.epa.gov/sites/production/files/2016-04/documents/final_leveraging_guide_document_4-19-16.pdf
- Financing Disaster Resiliency Measures: http://www.cdfa.net/cdfa/cdfaweb.nsf/ordredirect.html?open&id=webcast73.html
- Checklist: How to address changing climate concerns in Brownfields AWP Project: https://www.epa.gov/brownfields/brownfields-bf-awp-climate-adaptation-checklist
- Checklist: How to address changing climate concerns in an analysis of brownfield cleanup alternatives (ABCA): https://www.epa.gov/sites/production/files/2015-09/documents/epa_oblr_climate_adaptation_checklist.pdf
- State and Local Climate and Energy Program: https://www.epa.gov/statelocalclimate/local-climate-and-energy-program

- Technical Assistance to Brownfields Communities (TAB) Program: http://www.epa.gov/brownfields/tools/#tab
- Brownfield Revitalization in Climate-Vulnerable Areas: https://www.epa.gov/sites/production/files/2016-01/documents/bf_revitalization_climate_vulnerable_areas_012616_508_v2_web.pdf
- Environmental Finance Centers: http://www2.epa.gov/envirofinance/efcn
- Smart Growth for Coastal Waterfront Communities: http://www2.epa.gov/smart-growth/smart-growth-coastal-and-waterfront-communities
- Using Smart Growth Strategies to Create More Resilient Communities in the Washington, D.C., Region: http://www.epa.gov/smartgrowth/using-smart-growth-strategies-create-more-resilient-communities-washington-dc-region
- Create Safe Growth Strategies in the San Francisco Bay Area: http://www.epa.gov/smartgrowth/creating-safe-growth-strategies-san-francisco-bay-area
- Flood Resilience Checklist: http://www.epa.gov/smartgrowth/flood-resilience-checklist
- Planning for Flood Recovery and Long-Term Resilience in Vermont: https://www.epa.gov/smartgrowth/planning-flood-recovery-and-long-term-resilience-vermont
- Transportation Vulnerability Assessment tools: https://www.fhwa.dot.gov/environment/climate_change/adaptation/publications/index.cfm
- Renewable energy potential on contaminated sites: mapping tool: http://www.epa.gov/renewableenergyland/rd_mapping_tool.htm
- Minnesota's Greener Practices for Business, Site Development and Site Cleanups: A Toolkit: https://www.pca.state.mn.us/quick-links/greener-practices-business-site-development-and-site-clean-ups-toolkit
- Illinois greener cleanups matrix: http://www.epa.illinois.gov/topics/cleanup-programs/greener-cleanups/
- Rockefeller 100 Resilient Cities program: http://www.100resilientcities.org/#/-_/
- U.S. EPA Climate Adaptation Resources and Guidance: https://www.epa.gov/climatechange/climate-adaptation-resources-and-guidance

Resources to Identify Current and Potential Changing Climate Conditions

- NOAA's Digital Coast helps communities address coastal issues: http://coast.noaa.gov/digitalcoast/
- National Climate Assessment summarizes the impacts of climate change on the United States: http://nca2014.globalchange.gov/
- Climate Resources on Data.gov has data related to climate change that can help inform and prepare America's communities, businesses, and citizens: http://www.data.gov/climate/
- U.S. Global Change Research Program lists resources by and for federal agencies to support the planning and implementation of measures to adapt to climate change: http://www.globalchange.gov/resources/federal-agency-adaptation-planning-resources
- U.S. Geological Survey Climate Land Change Science Program strives to understand the Nation's most pressing environmental, natural resource, and economic challenges by providing the information and tools necessary and identifying possible solutions: http://www.usgs.gov/climate_landuse/lcs/

- EPA's Climate Change Web page: http://www.epa.gov/climatechange/
- EPA Office of Water's Stormwater Calculator Climate Assessment Tool estimates the annual amount of rainwater and frequency of runoff from a specific site anywhere in the United States: http://www.epa.gov/nrmrl/wswrd/wq/models/swc/
- Climate Change Adaptation on FedCenter.gov supports federal agency climate adaptation planning: https://www.fedcenter.gov/programs/climate/
- Water Utility Scenario Based Projected Climate Changes Map provides easy –to-access scenario-based climate change projections drawn from the Climate Resilience Evaluation and Awareness Tool: http://www.epa.gov/crwu/view-your-water-utilitys-climate-projection-scenario-based-projected-changes-map
- Coastal Storm Surge Scenarios Water Utilities has a map that illustrates hurricane strike frequency and worst-case coastal storm surge inundation scenarios: http://www.epa.gov/crwu/see-coastal-storm-surge-scenarios-water-utilities
- NOAA Coastal Inundation:
  - What is inundation and why communities should be concerned? http://www.stormsurge.noaa.gov/
  - Training course on coastal inundation mapping: https://coast.noaa.gov/digitalcoast/training/inundationmap.html
- Climate Change a Growing Threat to Human Health: New USGCRP Report: http://www.globalchange.gov/news/climate-change-growing-threat-human-health-new-usgcrp-report
- U.S. Climate Resilience ToolKit contains information on tools to build climate resilience in communities: http://toolkit.climate.gov/
- EPA's Building Climate Resilience at Your Utility Web page provides access to the Climate Resilience Evaluation and Awareness Tool 3.0, a climate risk assessment and planning application for water, wastewater, and stormwater utilities: http://water.epa.gov/infrastructure/watersecurity/climate/creat.cfm
- emPower Map (Medicare and Medicaid) identifies areas at risk for power outages from storms and to assist communities in creating more resilience for these populations: http://empowermap.phe.gov/
- ICLEI City GHG Tracking and Reporting Protocols: http://icleiusa.org/ghg-protocols/
- Transportation adaptation and planning: http://nca2014.globalchange.gov/report/sectors/transportation
- CREAT Tool: http://www.epa.gov/crwu/assess-water-utility-climate-risks-climate-resilience-evaluation-and-awareness-tool
- FEMA Flood Map Service Center: http://msc.fema.gov/portal
  - Use the MSC to find your official flood map, access a range of other flood hazard products, and take advantage of tools for better understanding flood risk.
- Understanding Your Risks: Identifying Hazards and Estimating Losses: http://www.fema.gov/media-library/assets/documents/4241
- Maryland's CoastSmart Communities Scorecard: http://dnr2.maryland.gov/ccs/coastsmart/Documents/scorecard.pdf
  - A community self-assessment tool. This tool has been prepared by the Chesapeake & Coastal Service to provide Maryland's coastal communities with a practical method to assess their preparedness for the impacts of coastal hazards and increased future impacts due to a changing climate.

Energy Efficiency Rebates and Tax Credit Programs

- The Department of Energy's Database of State Incentives for Renewables & Efficiency (DSIRE) is the largest and most up-to-date listing of state, federal, local, and utility incentives and policies that support renewable energy and energy efficiency projects. http://www.dsireusa.org/
- Directory of energy efficiency programs leveraging ENERGY STAR: https://www.energystar.gov/buildings/tools-and-resources/directory-energy-efficiency-programs-leveraging-energy-star
- Special Offers and Rebates from ENERGY STAR Partners: http://www.energystar.gov/rebate-finder
- Reuse materials: http://thereusepeople.org/retail (only have warehouses in California)
- General to look into more deeply: http://www.epa.gov/brownfields/tools/index.htm

Resources for Assessing Brownfields

- ASTM E1527-13 Most recent guide for Phase 1 Assessments: http://www.astm.org/cgi-bin/resolver.cgi?E1527-13
- Targeted Brownfields Assessments: https://www.epa.gov/brownfields/targeted-brownfields-assessments-tba

Resources for Demolition and Deconstruction

- Building Material Reuse Association: https://bmra.org/
- Construction & Demolition Recycling Association: http://www.cdrecycling.org/
- Fact sheet of case studies: https://www.epa.gov/smm/fact-sheets-sustainable-design-disassembly-and-deconstruction-buildings
- Iowa Green List: Identify locations where you can recycle/reuse deconstructed materials. Searchable by material type and city within Iowa: http://www.iowadnr.gov/Environmental-Protection/Land-Quality/Waste-Planning-Recycling/Iowa-Green-List
- Reusing materials onsite:
https://clu-in.org/greenremediation/profiles
- Waste Reduction Model (WARM) resource for planners and organizations seeking to reduce emissions through waste reduction and management: https://www.epa.gov/warm
- Repurposed Materials locations across the country: http://www.repurposedmaterialsinc.com/about-us

Resources for Redeveloping Brownfields

- Cultivating Green Energy on Brownfields: http://www.nalgep.org/uploads/pdf/publi02.pdf
- Case Studies on Transit and Livable Communities in Rural and Small Town America:
http://www.reconnectingamerica.org/assets/Uploads/2010LivabilityCaseStudies.pdf
- Road Safety for All: Lessons from Western Europe: http://www.aarp.org/content/dam/aarp/research/public_policy_institute/liv_com/2013/road-safety-for-all-lessons-from-western-europe-AARP-ppi-liv-com.pdf
- North Carolina Complete Streets Planning and Design Guidelines: http://www.completestreetsnc.org/wp-content/themes/CompleteStreets_Custom/pdfs/NCDOT-Complete-Streets-Planning-Design-Guidelines.pdf

- UNEP Global Outlook on Walking and Cycling: http://www.unep.org/transport/sharetheroad/PDF/globalOutlookOnWalkingAndCycling.pdf

Green Infrastructure

- Delta Institute green infrastructure templates: http://delta-institute.org/2015/09/delta-releases-green-infrastructure-toolkit-for-property-owners-and-municipalities/
- Stormwater: http://cfpub.epa.gov/ncea/global/recordisplay.cfm?deid=309540
- Stormwater Management for development projects: http://epa.ohio.gov/dsw/storm/index.aspx
- Guide to integrating green infrastructure and sustainable communities plans: http://www.epa.gov/smartgrowth/enhancing-sustainable-communities-green-infrastructure
- Chicago's Green Alley Handbook: http://www.cityofchicago.org/content/dam/city/depts/cdot/Green_Alley_Handbook_2010.pdf
- Design guidelines: http://www1.toronto.ca/city_of_toronto/city_planning/urban_design/files/pdf/greening_p-lot_guidelines_jan2013.pdf
- Green infrastructure for climate resiliency:
  http://water.epa.gov/infrastructure/greeninfrastructure/climate_res.cfm
  http://www2.epa.gov/communityhealth/green-infrastructure-wizard
- Implementing stormwater infiltration practices at vacant parcels and brownfield sites:
  http://water.epa.gov/infrastructure/greeninfrastructure/upload/brownfield_infiltration_decision_tool.pdf

Green Building

- Sustainable Design and Green Building Toolkit for Local Governments: https://www.epa.gov/smartgrowth/sustainable-design-and-green-building-toolkit-local-governments
- Resilient Design Institute case studies: http://www.resilientdesign.org/category/case-studies/
- USGBC: http://www.usgbc.org/leed#rating
- Green Building and Climate Resilience: http://www.usgbc.org/resources/green-building-and-climate-resilience-understanding-impacts-and-preparing-changing-conditi
- Designing your building to be energy efficient: http://www.energystar.gov/buildings/service-providers/design/step-step-process/design-be-energy-efficient
- Passive-House International Certification: http://www.passivehouse-international.org/
- Renewable energy: Combined Heat and Power model: http://www.iowaeconomicdevelopment.com/Energy/CHP
- Green and cool roofs, as well as other heat island reduction strategies: https://www.epa.gov/heat-islands/heat-island-compendium
- Green and cool roofs, as well as other heat island reduction strategies: https://www.epa.gov/heat-islands/heat-island-compendium
- Businesses: http://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/understand-metrics/eligibility

Citations

American Wind Energy Association, 2001. Wind Energy Applications Guide. January 1.

Arbor Day Foundation, 2010. How Trees Can Retain Stormwater Runoff. Tree City USA® Bulletin. No 55.

Association of Redevelopment Initiatives, 2015. Renewal & Redevelopment. September.

Bautista et al., 2014. New York City Environmental Justice Alliance Waterfront Justice Project. T*he International Journal of Justice and Sustainability*. Vol. 20, Issue 6. June.

Benepe, 2013. Parks as Green Infrastructure, Green Infrastructure as Parks: How Need, Design and Technology are Coming Together to Make Better Cities. April 17.

Benjamin, 2014. Developing Renewable Energy Projects on Brownfields: Mitigating Environmental Risks & Liabilities. Farella Braun & Martel LLP.

Brown, 2011. Ambitious Plans for a Building Where Sears Served Atlanta. *New York Times*. August 16.

Centers for Disease Control and Prevention, 2014. Assessing Health Vulnerability to Climate Change A Guide for Health Departments. National Center for Environmental Health. Arie Ponce Manangan , Christopher K. Uejio, Shubhayu Saha, Paul J. Schramm , Gino D. Marinucci, Claudia Langford Brown , Jeremy J. Hess, and George Luber, authors.

EPA, 2001. Brownfields Technology Primer: Selecting and Using Phytoremediation for Site Cleanup. EPA 542-R-01-006. July.

EPA, 2008a. Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites. EPA 542-R-08-002. April.

EPA, 2008b. Green Remediation: Best Management Practices for Excavation and Surface Restoration. EPA 542-F-08-012. December.

EPA, 2009. Opportunities to Reduce Greenhouse Gas Emissions through Materials and Land Management Practices. EPA 530-R-09-017. September.

EPA, 2010. Green Remediation Best Management Practices: Clean Fuel & Emission Technologies for Site Cleanup. EPA 542-F-10-008. August.

EPA, 2010b. Green Remediation Best Management Practices: Bioremediation. EPA 542-F-10-006. March.

EPA, 2011. Green Remediation Best Management Practices: Integrating Renewable Energy into Site Cleanup. EPA 542-F-11-006. April.

EPA, 2012. Brownfields Area-Wide Planning Program Fact Sheet. EPA 560-F-12-182. July.

EPA, 2012b. A Citizen's Guide to Phytoremediation. EPA 542-F-12-016. September.

EPA, 2013a. On the Road to Reuse: Residential Demolition Bid Specification Development Tool. EPA 560-K-13-002. September.

EPA, 2013b. Green Remediation Best Management Practices: Materials and Waste Management. EPA 542-F-13-003. December.

EPA, 2013c. Using Smart Growth Strategies to Create More Resilient Communities in the Washington, DC, Region. November.

EPA, 2014a. Checklist: How to Address Changing Climate Concerns in an Analysis of Brownfield Cleanup Alternatives (ABCA). EPA 560-Q-14-001. April.

EPA, 2014b. Enhancing Sustainable Communities with Green Infrastructure. EPA 100-R-14-006. October.

EPA, 2014c. Green Infrastructure: Land Revitalization Success Stories. September.

EPA, 2015a. Stormwater Management in Response to Climate Change Impacts: Lessons from the Chesapeake Bay and Great Lakes Regions (External Review Draft) October 7.

EPA, 2015b. Population Surrounding 12,216 Brownfield Sites that Received EPA Funding. September.

EPA, 2015c. Climate Change Indicators in the United States: A Closer Look: Temperature and Drought in the Southwest.

EPA, 2016a. Brownfield Revitalization in Climate-Vulnerable Areas, Community-Based Examples for Improving Ordinance Regulations, Development Incentives, Programs, and Projects. January.

EPA, 2016b. Green Remediation Best Management Practices: Site Investigation and Environmental Monitoring. EPA 542-F-16-002. September.

EPA, 2016c. RE-Powering America's Land Initiative: Project Tracking Matrix. April.

EPA Region 2, 2013. EPA Region 2 Climate Change Adaptation implementation Plan.

EPA Region 8, 2009. RE-Powering America's Land: Siting Renewable Energy on Potentially Contaminated Land and Mine Sites Belmar Mixed Use Development, Lakewood, Colorado Success Story Mixed Use Development with Rooftop Solar Array Replaces Contaminated Site. March.

EPA Region 9. Calculating Effectiveness: Calculating Effectiveness: Calculating Effectiveness: The Waste Management Plan.

EPA Region 9, 2013. Analysis of Brownfield Cleanup Alternatives: 900 Innes Avenue, San Francisco, California. 20074.063.095.1340.

Fargione, et al., 2008. Land Clearing and the Biofuel Carbon Debt. *Science*. Vol. 319, Issue 5867.

FEMA, 2015. Climate Resilient Mitigation Activities: Green Infrastructure Methods. Fact Sheet.

Gamble, et al., 2013. Page 8.

Hanson, 2015. Implications of Climate Change in Contaminated Site Remediation. Presentation at SURF 31: Climate Change and Resiliency within Remediation. December 18.

Kaswan, 2012. Domestic Climate Change Adaptation and Equity. Environmental Law Reporter, Vol. 42. University of San Francisco Law Research Paper no. 2013-05.

Massachusetts Department of Environmental Protection, 2014. Greener Cleanups Guidance WSC #14 – 150. October 20, 2014.

Mayor's Office of Sustainability and ICF International, 2015. Growing Stronger: Toward a Climate-Ready Philadelphia. November.

National Resources Defense Council, 2008. Quantifying the Third Leg: The Potential for Smart Growth to Reduce Greenhouse Gas Emissions. Amanda M. Eaken and David B. Goldstein, authors. Proceedings from the 2008 ACEE Summer Study on Energy Efficiency in Buildings. American Council for an Energy-Efficient Economy: Washington, DC www.aceee.org

National Resources Defense Council, 2015. Wanted: Green Acres, How Philadelphia's Greend Acre Retrofit Program is Catalyzing Low-Cost Green Infrastructure Retrofits on Private Property. NRDC Issue Brief. Alisa Valderrama and Paul Davis, authors. January.

National Wildlife Federation, 2014. Climate-Smart Conservation: Putting Adaptation Principles into Practice.

Office of the New York State Comptroller, 2008. Green Best Practices: How Local Governments can Reduce Energy Cost and Minimize Impact on Global Climate Change. Research Brief. April.

Russak, 2015. Advantaging Communities: Co-Benefits and Community Engagement in the Greenhouse Gas Reduction Fund. September.

Sheehan, 2000. Zero Waste and Climate Change Zero Waste, Recycling and Climate Change. Grass Roots Recycling Network. October.

Sheffield and Landrigan, 2010. Global Climate Change and Children's Health: Threats and Strategies for Prevention. *Environmental Health Perspectives*. Vol. 119. October 14.

Simon, et al., 2014. ASTM Greener Cleanup Standard Guide: An Introduction. EPA Webinar presentation offered April 24, 2015.

Smart Growth America. Best of Complete Streets: Complete Streets Help Create Livable Communities.

Smart Growth America, 2008. Growing Cooler: The Evidence on Urban Development and Climate Change. Reid Ewing, Keith Bartholomew, Steve Winkelman, Jerry Walters, and Don Chen, authors.

Smart Growth America, 2016. The Best Complete Streets Policies of 2015. April.

Sovacool, 2011. Hard and Soft Paths for Climate Change Adaptation. *Climate Policy.*

Thrun, et al., 2016. Exploring the Cross-Sectional Association between Transit-Oriented Development Zoning and Active Travel and Transit Usage in the United States, 2010–2014. *Frontiers in Public Health*. Vol 4. June 3.

UN Environment, 2016. Global Outlook on Walking and Cycling Policies & Realities from Around the World. ISBN No: 978-92-807-3616-8. September.

Urban Land Institute, 2010. Land Use and Driving: The Role Compact Development Can Play in Reducing Greenhouse Gas Emissions, Evidence from Three Recent Studies.

Urban Land Institute, 2012. Shifting Suburbs: Reinventing Infrastructure for Compact Development.

U.S. Department of Energy, 2011. A Guide to Community Solar: Utility, Private, and Non-profit Project Development. January.

U.S. Department of Energy, 2013. Transportation Energy Future Series, Effects of the Built Environment on Transportation: Energy Use, Greenhouse Gas Emissions, and Other Factors. March.

U.S. Department of Transportation, 2016. Climate Change and Environmental Justice: Considerations for Transportation Decision-making. June.

U.S. Global Change Research Program, 2009. Global Climate Change Impacts in the United States. Cambridge University Press.

U.S. Global Change Research Program, 2014. Georgakakos, A., P. Fleming, M. Dettinger, C. Peters-Lidard, Terese (T.C.) Richmond, K. Reckhow, K. White, and D. Yates, 2014: Ch. 3: Water Resources. Climate Change Impacts in the United States: The Third National Climate Assessment, 69-112.

Appendix A. Example Strategies to Adapt to or Mitigate Climate Change Impacts for Each Stage of a Brownfield Revitalization Project

Stage of Brownfield Project	Strategy	Adaptation	Mitigation
Planning	Adopt climate-conscious building codes	✓	
	Offer tax incentives/rebates	✓	✓
	Zoning ordinances	✓	✓
	Update floodplain management plans	✓	✓
	Update coastal and wetland management plans	✓	✓
	Update hazard mitigation plans	✓	✓
	Engage the community in planning	✓	✓
Assessment	Conduct climate-focused Phase 1 and 2 ESAs	✓	✓
	Identify interim uses	✓	✓
	Evaluate reuse options that are climate conscious	✓	✓
	Identify potential risk factors and vulnerabilities	✓	✓
	Follow assessment-relevant ASTM Guidelines for Greener Cleanups		✓
	Conduct analysis of Brownfield Cleanup Alternatives (ABCA)	✓	✓
Demolition	Identify opportunities for deconstruction		✓
	Plan early		✓
	Reduce energy use		✓
	Reuse/recycle materials		✓
Cleanup	Reduce energy use and emissions		✓
	Reduce water use and impacts to water sources	✓	✓
	Reduce waste and manage materials sustainably		✓
	Minimize unnecessary soil and habitat disturbance or destruction	✓	✓
	Use native species to support habitat	✓	✓
	Select onsite remediation approaches		✓
Redevelopment	Install green infrastructure	✓	✓
	Incorporate renewable energy development	✓	✓
	Incorporate green building techniques (e.g., green roofs, energy and lighting efficiency, passive survivability, flood protection)	✓	✓
	Complete streets	✓	✓
	Incorporate multi-modal transit	✓	✓
	Promote accessibility and community social cohesion	✓	✓

Appendix B. Area-Wide Planning Components and Some Helpful Resources

Foundational planning is essential for sustainable and well-informed brownfields and community revitalization projects. When planning a brownfield assessment and cleanup, it is important to collect information and identify community priorities related to near- and long-term revitalization. Stakeholders will need to evaluate current environmental conditions, local market potential, and necessary infrastructure improvements as well as expectations for the future, including impacts of climate change (EPA, 2012). Communities can explore relevant tools and resources to incorporate climate change mitigation and adaptation in their vision and implementation of community revitalization.

- Identify and map climate resilience assets (e.g., protected wetlands, cooling centers, stormwater and green infrastructure, and buffer zones) such as those along the Menomonee River in Milwaukee, Wisconsin), making sure to engage the community and first responders, who often know best where the assets are, in this process.
  - Best Practices in Local Mitigation Planning: Identify Community Assets http://mitigationguide.org/task-5/steps-to-conduct-a-risk-assessment-2/2-identify-community-assets/
- Consider observed and projected climate conditions (e.g., sea level rise, site proximity to a flood plain, likelihood of increased major storm events, drought conditions, etc.) as they relate to long-term safety, stability and suitability of the proposed land reuses and whether the proposed reuses are appropriate for the brownfield site(s) and other land in the project area.
  - Relevant and authoritative data should be used. Examples include NOAA, NCDC, USDA, USGS, EPA, and USACE
  - Evaluate hydro-climatic statistics and hydrologic-hydraulic models related to floods; intense rainfall; high stream-flows, and water temperature. This will facilitate water infrastructure planning, ecosystem protection, and flood hazard mitigation
  - Obtain past meteorological records to determine the long-term average for each climate variable, scale of past extreme events, recent trends of change in past 30 years
  - **Storm risk:**
    - NOAA's Storm Events Database: Contains data from January 1950 to current year.
  - **Flood risk:**
    - FEMA Flood Map Service Center: Determine whether project is located within the 500-year FEMA National Flood Insurance Program flood zone[1] (0.002 chance of annual recurrence.)
    - Sea Level Rise and Coastal Flooding Impacts: Interactive map shows how various levels of sea level rise will impact an area.
  - **Hurricane risk:**
    - Wind Zones in the United States: Map on page 6 of FEMA's *Section I: Understanding the Hazards* can help determine if a site is located within a hurricane-susceptible region.

1 ASTM E3032-15 Standard Guide for Climate Resiliency Planning and Strategy

- Hurricane Statistics: The State Climate Office of North Carolina contains information on tropical cyclones across the state and includes a link to North Carolina's Hurricane Database.

– **Drought risk:**

  - Historical Palmer Drought Indices: NOAA maps can help determine whether the project is located in areas that have experienced moderate, severe, or extreme drought conditions for more than 25% of the time in the past 10 years.
  - National Integrated Drought Information System: An interagency, multi-partner approach to drought monitoring, forecasting, and early warning, led by NOAA includes maps that show where droughts are occurring in the United States and the seasonal drought outlook.
  - U.S. Drought Monitor: Provides a weekly big-picture assessment of the current state of drought in the United States.
  - Drought Risk Atlas: Can provide planners with a detailed understanding of local drought climatology, answering questions such as how frequently drought visits a particular location, how long it has lasted, and how bad it has been.
  - Drought Management Database: Continually updated repository of strategies for dealing with drought by several different sectors and from many different angles.
  - Drought Impact Reporter: Continually updated archive of the effects of drought.
  - National Drought Mitigation Center: Includes an overview of key concepts related to drought and drought planning and an extensive collection of state and local drought plans and resources.

– **Tornado and high wind risk:**

  - Tornado Activity in the United States: Map on page 3 of FEMA's *Section I: Understanding the Hazards* shows the number of recorded tornadoes per 1,000 square miles.
  - U.S. Tornado Climatology: Series of maps of the United States shows the number tornadoes per month in each state.

– **Wildfire risk:** Determine whether the project is located in a county that is designated by red or black on FEMA map.

  - Wildfire Activity by County: Map of the United States shows, by county, the frequency of wildfires at least 300 acres in size.
  - FEMA Western United States Wildfire Situation Map: Map shows where wildfires are occurring, their size, and current wind speed direction.

– **CREAT Climate Scenarios Projection Map:** EPA's Climate Resilience Evaluation and Awareness Tool (CREAT) Climate Scenarios Projection Map provides easy-to-access scenario-based climate change projections drawn from CREAT.

■ Conduct a risk screening of vulnerabilities to climate change impacts, assessing which properties are in need of more resiliency measures (e.g., hospitals, schools, community centers, places of worship, emergency response stations)

– **Flood Vulnerability Assessment Map:** Flood hazard information from FEMA has been combined with EIA's energy infrastructure layers as a tool to help state, county, city, and private sector planners assess which key energy infrastructure assets are vulnerable to rising sea levels, storm surges, and flash flooding.

- Integrated Rapid Visual Screening for Buildings: Software-facilitated procedure for assessing the risk to buildings from natural and human-caused hazards that have the potential to cause catastrophic losses.
- Vulnerability Assessment Scoring Tool: The U.S. Department of Transportation tool helps state departments of transportation, metropolitan planning organizations, and other organizations implement an indicator-based vulnerability assessment of their transportation assets.
  - Climate Change & Extreme Weather Vulnerability Assessment Framework: State and municipal transportation agencies can use this guide to assess the vulnerabilities of their transportation infrastructure.
  - Coastal Resilience Index: The exercise helps communities discuss and discover their climate-related vulnerabilities.
  - Climate Change Vulnerability Assessment Tool for Coastal Habitats: Guidance document and spreadsheet tool help calculate numerical vulnerability scores for habitats. Scores indicate the degree to which various habitats may be vulnerable to current and future climate stressors.
  - General Methodologies of a Vulnerability Assessment: Describes the key steps of a vulnerability assessment.
  - Examples of Risk Assessments Conducted on Infrastructure: Seven-phase process developed in the United Kingdom for assisting transportation decision-makers in addressing climate change impacts on highways.
- Engaging with vulnerable populations, minorities, underserved populations through facilitated advisory committees, public meetings, design charrettes, round table sessions, and other means to gather information related to stakeholder needs and priorities for area cleanup and reuse. As already emphasized, the brownfield planning process should engage all segments of the community. Stakeholder and community involvement is crucial for development of a sustainable, meaningful, and useful community planning resource that can be referenced and implemented throughout the community revitalization process.

Appendix C. Snapshots

Recycling and Demolition

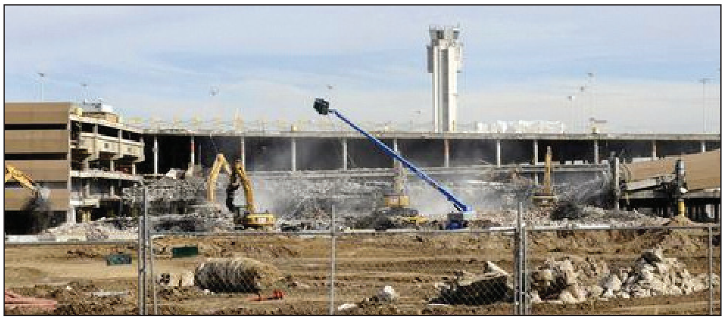
Deconstruction of Nashville Thermal Transfer in Nashville, Tennessee

- *Dismantlement of the thermal waste-to-energy facility resulted in 98.5% reuse and recycling of equipment, demolition wastes and deconstruction materials.*
- *Over 100 Internet auction events sold over 1,000 tons of equipment and materials, diverting them from a landfill and brining in over $980,000 in revenue.*
- *Hundreds of dump truck loads of crushed aggregate were transferred offsite for use as backfill.*
- *Crushed asphalt was used offsite for perimeter road.*
- *The site is proposed for a new Nashville Sounds Baseball Stadium.*

Equipment sold at auction.

Deconstruction of Stapleton International Airport in Denver, Colorado

- *The recycling project at Stapleton, described as the "World's Largest Recycling Project," has become a model for brownfield projects nationwide.*
- *Products resulting from the operations at Stapleton range from sand to "Staplestone" - large concrete blocks suitable for retention walls, barriers, and other landscaping projects.*
- *6.5 million tons of concrete and asphalt hardscape, enough aggregate to build the Hoover Dam, were demolished and removed.*
- *Stockpiles of recycled hardscape will remain onsite until all recycled products have been sold.*
- *Concrete and asphalt from Stapleton have been reused in state and municipal road projects and at the Rocky Mountain Arsenal. A great deal of the recycled specification aggregate also is being reused at the re-development site itself.*



Deconstruction of Stapleton International Airport.

Cleanup and Deconstruction at a Former Paint Factory in Emeryville, California

- *A former paint factory was demolished in 2004 and the site remediated to prepare for much needed affordable housing.*
- *The project team hand dismantled the buildings on the former industrial property as an alternative to traditional demolition.*
- *94.6% of deconstruction wastes were recycled.*
- *21,569 tons of excavated soil were used as beneficial cover at local Class II landfill, saving $496,708 in tipping fees.*

GreenCity Lofts. Collecting.

GreenCity Lofts.

Cleanup and Redevelopment of the Former Lucent Richmond Works Facility in Richmond, Virginia

- *Storage and use of chlorinated solvents at this facility from 1972 - 1989 contributed to the onsite groundwater contamination.*
- *Over 700,000 square feet of old and dilapidated manufacturing buildings were left idle.*
- *Cleanup and redevelopment of this site achieved a 93% overall recycling rate (84,500 tons of construction and demolition material).*
- *77,000 tons of concrete were crushed onsite and reused for foundations, sidewalks, and structural support for The Shops at The .*

The Shops at White Oak Village.

- *7,500 tons of aluminum, steel, iron, copper, and other ferrous and non-ferrous metals were recycled.*
- *Saved approximately $3.6 million by recycling and reusing demolition materials.*

Demolition Followed by Mechanical Separation of Debris at the Allen-Morrison Corporation in Lynchburg, Virginia

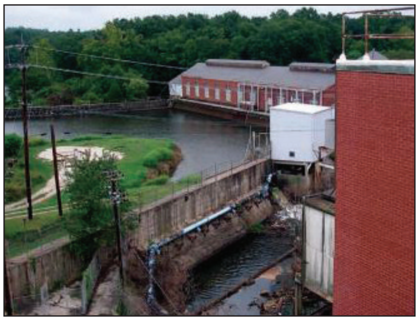
- *Allen-Morrison Corporation, a metal sign manufacturing facility, abandoned the property.*
- *The City of Lynchburg sought technical support from EPA to conduct a material reuse inventory of site materials that may be appropriate for reuse and recycling and assess the feasibility of deconstruction.*
- *The assessment determined that deconstruction of the entire facility would not be cost effective and that demolition followed by mechanical separation of demolition debris into recyclable materials would be more appropriate. Portions of the facility were deemed suitable for deconstruction with a high potential for salvageable value.*

Allen-Morrison facility.

- *Materials possessing an industrial heritage could be reused to revive citizens' appreciation for the site's history (e.g., onsite reuse of sliding doors, skylights, paint-mixing vessels, sprinkler systems, signs, and shelving units).*
- *The City of Lynchburg is creating a public park on the site to serve both the neighborhood and the larger community.*

Langdale Mill in Valley, Alabama

- *The 500,000–square-foot former textile mill is located on the Chattahoochee River.*
- *The City of Valley held visioning charrettes and discussions to determine a redevelopment strategy that will encourage sustainable development, generate local jobs and promote the site's history of industrial prowess.*
- *An inventory tool developed through a 2008 EPA Sustainability Pilot Program Grant estimated the salvage and reuse value of building materials at $163,400.*
- *Deconstruction of the mill will produce an estimated 109,000 board feet of lumber, 290,000 pounds of metal, and 63,000 bricks could be recovered for recycling and reuse.*



Langdale Mill.

- *The city started a farmers market on the property giving citizens access to locally grown produce and drawing attention to the opportunity for mixed-use redevelopment.*

Cleanup

Sustainable Materials Management at Sanford Gasification Plant, Seminole County, Florida

- *Clean soil was separated from contaminated soil, which minimized the treatment load while averting import of 1,600 cubic yards of non-native soil for site restoration.*
- *5,000 cubic yards of extracted trees and stumps were chipped and sent to local landscapers for mulch, avoiding shipment of 800 tons of material to landfills.*
- *Installed a solar-powered backup energy system for perimeter air monitoring during remedy construction.*
- *3.7 million gallons of water from onsite dewatering operations were used for soil stabilization.*
- *Diesel vehicles and machinery were operated using 20% biodiesel, averting 177 tons of CO2 emissions*
- *A gravity drain network overlaying recycled concrete diverted 500 feet of an onsite creek during remedy construction, reducing need for diesel pumps.*
- *Recycled concrete was used for riprap to armor the creek bed and limit erosion.*

Gravity drains to divert creek flow.

Stabilized creek bed.

Restoring Streams and Rivers Impacted by Acid Rock Drainage at the Elizabeth Mine in South Strafford, Vermont

- *Emissions of air contaminants were reduced through use of biodiesel. Use of 6,500 gallons of B-20 instead of conventional diesel was estimated to reduce particulate matter by 12%, hydrocarbons by 20%, carbon monoxide by 12%, nitrogen oxides by 2%, sulfur dioxide by 20% and carbon dioxide by 16%.*
- *Capping materials included approximately 1,000 cubic yards of soil that had been previously used as temporary backfill in one of the excavation areas.*
- *Recycled consumable waste generated onsite, including cans, plastics, and glass. Biodegradable instead of polyethylene sandbags were used to prevent erosion and control stormwater runoff.*
- *Wood debris was salvaged from onsite to for slope stabilization.*

Elizabeth Mine steam and river restoration.

Improving Water Quality and Aquatic Life Habitat at the De Sale Restoration Area in Butler County, Pennsylvania

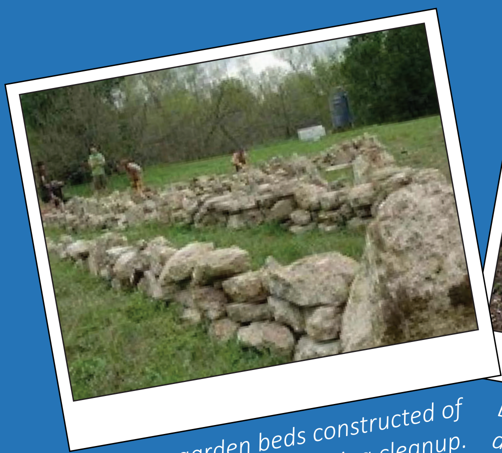
- *Voluntary cleanup of the Seaton Creek watershed focuses on passive treatment of acid mine drainage (AMD) from land impacted by over 100 years of bituminous coal mining. Passive treatment relies on gravity flow rather than pumps, avoiding possible air emissions, to convey AMD to settling ponds, vertical-flow ponds, constructed wetlands and horizontal-flow limestone beds comprising the treatment systems.*
- *Treatment incorporates locally obtained byproducts from other industrial sectors, such as agricultural compost in vertical-flow treatment ponds and coal ash, to stabilize and reclaim the mine lands contributing to AMD.*
- *Construction materials were reused and existing onsite treatment components were repurposed, for example, ponds constructed for a former AMD chemical treatment system were used as components of the passive treatment system.*
- *Manganese and iron oxides are recovered from the AMD treatment process for sale to local and regional ceramic artists.*
- *Constructed wetlands in the treatment systems are used as a "nursery" to supply plants, cuttings and seeds for future treatment wetlands at other nearby AMD sites.*
- *Returns treated water to its natural hydraulic course. Populations of fish, including pan fish, large-mouth bass and catfish, to Seaton Creek after a 70-year absence.*

AMD-damaged area in Seaton Creek Watershed.

Constructed wetlands within the passive treatment system.

Removal of the 3.6-Acre Grove Landfill in Austin, Texas

- *The cleanup involved removing 5,000 cubic yards of illegal dumped debris and treating the contaminated soil and surface water.*
- *Discarded metal and concrete were salvaged for potential onsite use or for sale.*
- *Where possible, cleanup equipment was powered by biofuel made locally from discarded vegetable oil or through small-scale solar photovoltaic panels.*
- *Wood debris was chipped for use as mulch on recreation trails and for erosion control measures throughout the site.*
- *Floating islands were constructed in a nearby pond from recovered soda bottles to form habitats for organisms capable of bioremediating residual toxins.*
- *A portion of the remediated site was used as a location to create compost from discarded food waste and provided matured compost for application onsite as well as in City Gardens.*



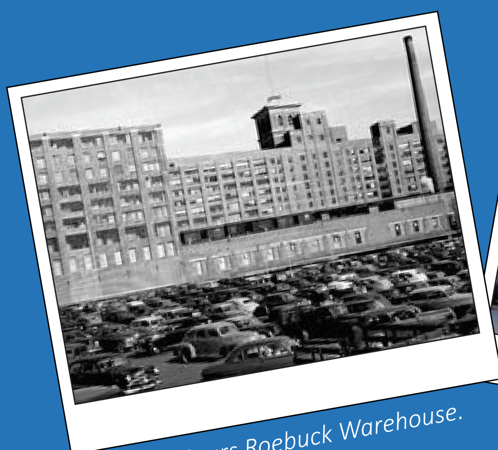
Onsite garden beds constructed of concrete salvaged during cleanup.

Bricks collected during cleanup form a fire pit and meeting area for the education center.

Redevelopment

Adaptive Reuse at Ponce City Market in Atlanta, Georgia

- *The largest adaptive reuse project in Atlanta's history transformed a 2.1 million square foot, historic Sears Roebuck warehouse into a mixed-use development for office, retail and residential living.*
- *The Market directly connects to the Atlanta BeltLine, a former railway corridor used as a multi-use trail, reducing the need for automobiles.*
- *Redevelopment revitalized a blighted site.*
- *The city removed and auctioned the office equipment that had piled up inside the warehouse, raising more than $100,000 (Brown, 2011).*



Former Sears Roebuck Warehouse.

Ponce City Market Redevelopment.

Construction of Solar Farm at Closed Landfill in Rutland, Vermont

- *7,700 solar panels were installed on 15 acres of the Rutland City landfill.*
- *The Stafford Hill Solar Farm can generate 2 MW of electricity, enough to power about 2,000 homes during full sun, or 365 homes year-round.*
- *The entire circuit can be disconnected from the grid in an emergency to provide critical power from a 4 MW battery to an emergency shelter at Rutland High School[1].*
- *Transforms space that would otherwise be unusable into something that is critical to the community in times of need.*

Stafford Hill Solar Farm.

1 http://www.greenmountainpower.com/innovative/solar_capital/stafford-hill-solar-farm/

Addressing Vulnerability to Flooding at the Spaulding Rehabilitation Hospital in Boston, Massachusetts

- *Situated on a former brownfield on the waterfront, the site's vulnerability to flooding was a major concern and priority during the planning.*
- *The hospital building was raised much higher than required by code: The first floor is 30 inches above the 500-year flood elevation.*
- *Extensive berms will deflect flooding from Boston Harbor and the Little Mystic River.*
- *The berms are constructed of large blocks of granite uncovered during the site excavation.*
- *An extensive drainage network will allow floodwaters to dissipate quickly.*
- *The entire first floor of the building could be flooded with only minor damage and while enabling the upper floors of the building to remain fully occupied and operational.*

Spaulding Rehabilitation Hospital. (Steinkamp Photography, courtesy Perkins + Will)

Green Infrastructure Constructed at Former Gas Station in Wilmington, Delaware

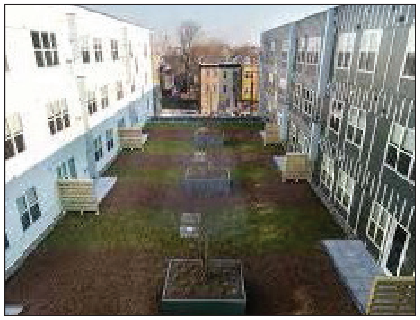
- *An abandoned gas station, vacant for more than five years, was transformed into the Brandywine Village Green with Wilmington's historic district of Brandywine Village.*
- *The Brandywine Village Green brings a pleasing green space and a needed parking lot to the city.*
- *The parking lot is constructed from a permeable paving material that collects stormwater in piping beneath the parking lot. The water is piped to the nearby bioswale where the water is absorbed into the ground.*
- *Peat moss below the parking lot and bioswale absorbs contaminants that may have been transported by the stormwater.*

Bioswale and parking lot of the Brandy-wine Village Green.

LEED Platinum Development at Former Coal Yard in North Philadelphia, Pennsylvania

- *Redevelopment of the 2-acre former coal yard was a joint venture between the nonprofit community organization Asociación de Puertorriqueños en Marcha and Jonathan Rose Companies, a green real estate company.*
- *The Paseo Verde Apartments' green and sustainable design became the first project in the country to earn LEED Platinum for Neighborhood Development certification from the U.S. Green Building Council.*
- *It is a 120-unit mixed-income multifamily rental development in the ethnically and economically diverse neighborhood.*
- *The apartment building is adjacent to a commuter rail station and near neighborhood services. Gardens, gathering spaces, and medical and fitness facilities support residents' health and wellness.*
- *Site was rezoned from industrial to CMX-3 mixed use, a somewhat denser classification than many of the surrounding blocks, to support the city's efforts to lean towards a more transit-oriented development neighborhood.*
- *A transportation program that emphasizes choices rather than costly parking garages saved costs. Paseo Verde supplies only 0.4 parking spaces per apartment, offers more bike storage spaces than parking spots within its ground-floor garage, hosts an onsite car-sharing vehicle, and provides information for residents about the area's plentiful transit options.*

Paseo Verde Apartments.



Green-roof courtyard at Paseo Verde.

- *Green infrastructure features include rain gardens, wide sidewalks with permeable paving, and green-roof courtyards that permit private decks for some apartments.*
- *The "blue roofs" atop Paseo Verde South's apartments collect water during storms of up to a 100-year magnitude, and then slowly release it afterwards.*
- *Each unit includes gas instant-on water heaters that heat water as it is used instead of continuously throughout the day; high-performance Energy Star appliances; and separately metered energy that allows residents to track (and reduce) their energy use.*
- *Common areas are powered by solar panels atop the Transit Village, which reduces the building's operating costs.*

United States
Environmental Protection
Agency

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