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Sustainable Materials Management in Site Cleanup

Technical Support Project Engineering Forum

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1. Introduction

The U.S. Environmental Protection Agency (EPA) defines green remediation as the practice of considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprint of cleanup actions. EPA developed a methodology to provide quantitative information about the footprint reductions gained by applying green remediation best management practices (BMPs) (U.S. EPA; 2012). The BMPs address five core elements of a greener cleanup:

- Energy requirements
- Air emissions
- Impacts on water
- Impacts on land and ecosystems
- Material consumption and waste generation.

The BMPs can be used for removal or cleanup activities at contaminated sites under Superfund, Resource Conservation and Recovery Act (RCRA), underground storage tank, and brownfields cleanup programs.

2. Overview

In 2006, the management of materials accounted for 42% of the United States' greenhouse gas (GHG) emissions, based on a systems analysis (U.S. EPA; 2009). The systems view of materials management represents U.S. emissions related to the goods and services we create through extraction, harvesting, processing, production, transport, and final disposition. Sites undergoing cleanup provide many opportunities for waste reduction and materials diversion through safe reuse and recycling. These opportunities apply to materials found or generated during the site remediation process and materials purchased for remedy construction and site redevelopment.

Cleanup projects can generate different types of materials including industrial materials such as construction and demolition debris, organic matter such as wood and plants, and other types of solid wastes from project management oversight. When safely reused and recycled, industrial materials salvaged from demolition activities can be appropriately diverted from landfills for use in new building and transportation construction, water infrastructure, and agriculture. Organic materials can be reused for site design and remediation, and other solid wastes like paper, plastic, metals, and glass can be recycled by waste management and material recovery facilities into the same markets.

Materials have a large impact on the environment when a systems view of the life cycle of materials is taken (Exhibit 1). The life cycle typically comprises of resource extraction, material processing, product design and manufacturing, product use, collection, and disposal. Sustainable materials management is an important part of conserving natural resources, reducing waste, and minimizing our footprint on the environment. It describes a collection of integrated strategies that use resources most productively and sustainably throughout their life cycles. Reusing and recycling materials to more sustainably manage them can have significant environmental benefits.

Exhibit 1. The Life Cycle of Materials

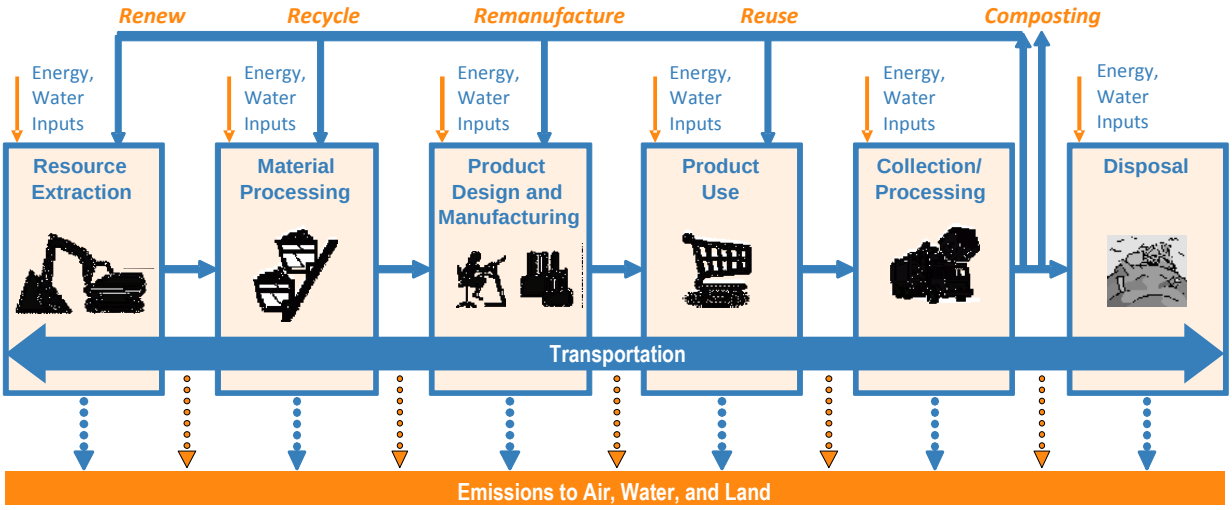

Diagram adapted from *Sustainable Materials Management: The Road Ahead* (U.S. EPA; 2009)

This diagram represents the life cycle of a material from extraction through processing, design, manufacture, use, and ultimate disposition, which may include recovery. Every step in the life cycle consumes energy and resources, and every step results in environmental releases to air, water, and land. In addition, materials and products require transport throughout their life cycle. Transportation uses more energy, consumes more fuel, and results in more emissions to the environment. Thus, the flow of materials contributes to a wide range of environmental impacts. Diverting materials from disposal through reuse, recycling, or composting conserves resources and intercepts environmental pollution along the life cycle of materials, thus contributing to a wide range of environmental impact reductions. Environmental savings from the resource extraction and manufacturing processes are usually greatest, since spent materials offset the extraction and manufacture of natural (virgin) resources (U.S. EPA, 2003; U.S. EPA, 2009).

3. Benefits

Sustainable materials management can have numerous benefits. Detailed examples of the benefits gained at brownfield, Superfund, and other sites are provided throughout this issue paper and in literature cited in closing references.

Environmental Benefits:

- Conserves natural resources
- Reduces energy consumption
- Conserves landfill space
- Reduces environmental impacts across the life cycle by decreasing the demand for virgin products (i.e. reduces the need to extract and process natural resources, and subsequently transport them for manufacturing or other uses).

Economic Benefits:

- Reduces disposal costs and may reduce material hauling costs, thereby reducing overall project costs
- Can reduce purchasing costs since non-virgin materials are often less expensive than virgin resources
- Can enable contractors to be more competitive with their bids given the reduced costs
- Creates employment opportunities and economic activities in the reuse and recycling industries.

Performance Benefits:

- Materials reclaimed, salvaged, or otherwise reused can perform as well as or better than virgin products in many applications.

Menomonee Valley Industrial Center and Community Park Project – Brownfields Site

The 1,200- acre Menomonee Valley revitalization is the largest brownfields cleanup in Wisconsin history. The revitalization leveraged $700 million, created 4,000 new jobs, and built 60 acres of park space and 4 miles of trails. This project used crushed concrete for building foundations and roadway subgrade, and broken concrete for subsurface transmissive layer within the stormwater management infrastructure.

The Industrial Center and Community Park Project was the redevelopment of a 140-acre brownfields site within the Valley. Various types of locally available industrial materials were used in the redevelopment, including foundry sand from the neighboring Falk foundry and nearly 900,000 cubic yards of fill from the reconstruction of the adjacent freeway.

www.renewthevalley.org

4. Materials and Opportunities

Industrial materials likely present the best opportunities for reuse and recycling at cleanup sites. These materials are the byproducts from industry that can be used in construction and land remediation applications in place of newly processed/manufactured products that rely on the extraction of natural resources. Industrial materials may include construction and demolition materials; coal combustion products; iron, steel, and aluminum foundry sands; steel slag; and scrap tires. Construction and demolition materials can contain brick, concrete, masonry, lumber, paving materials, shingles, glass, plastics, aluminum (including siding), steel, drywall, insulation, asphalt roofing materials, electrical components, plumbing fixtures, siding, corrugated cardboard, and land clearing debris (soil, rocks, trees, etc.). Many of these items can be cut to new sizes or refinished and reused, or they can be reprocessed into new products. For example, bricks can be cleaned up for reuse, or metals can be screened out for recycling. Waste consisting of organic matter such as wood and plants may also be generated onsite and used as compost, mulch, and fill materials.

There are many opportunities to safely reuse and recycle various materials at sites being remediated. Sites can have abandoned or unwanted buildings that need demolition. Clean materials salvaged during demolition can be reused onsite, sold through local markets, donated to reuse centers, or recycled offsite. In general, materials should be reused onsite whenever possible. Onsite reuse will offset the need to haul the materials offsite and to purchase other products, thereby reducing costs and environmental impacts from transportation and avoiding upstream impacts from using raw resources and new manufacturing.

Materials that cannot be used onsite should be sent offsite for recycling wherever markets are available within a reasonable distance, so that environmental benefits would not be fully offset by the environmental impacts from transportation. Cleanup sites are often located in urban areas near transportation hubs. Transportation corridors allow site personnel to use current infrastructure and provide easy access to potential markets for materials.

In addition, new construction or renovation provides opportunities to buy recycled content products for buildings and roadways; return, sell, or donate unused materials; and send others for recycling. Some industrial materials can even be utilized to assist with a site remedy; for example, ground up stumps can be reused for a mulch-based permeable reactive barrier.

Worcester, Massachusetts – Brownfields Site

EPA awarded Main South Community Development Corporation (CDC) in Worcester, Massachusetts, a $200,000 brownfields cleanup grant to address contamination discovered on 7.8 acres of the Gardner-Kilby-Hammond neighborhood project. To help keep soil- and building-cleanup costs within Main South CDC's budget, multiple materials from construction and demolition (C&D) were recovered from the abandoned industrial buildings, including: 10,000 cubic feet of concrete, 200 tons of steel, 50,000 board feet of hard yellow pine, and several hundred tons of brick and granite. Salvaged materials were sold through local and global markets, reused onsite for new construction, or recycled, strengthening the local market for C&D materials.

www.epa.gov/brownfields/success/worcester050108.pdf

Project managers must check with applicable state environmental agencies and local authorities for authorized uses of industrial materials and clean C&D materials. The Construction Industry Compliance Assistance Center offers an online tool to help find C&D-related regulatory information for specific states.

http://www.cicacenter.org/solidregs.html

5. Health and Safety Considerations

Various state and local statutes, in addition to federal statutes and regulatory programs (such as the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Oil Pollution Act, National Contingency Plan, RCRA Corrective Action Program, and Land Disposal Restrictions Program) apply to contaminated sites. To prevent environmental problems and/or address any possible liability under CERCLA, it is necessary to coordinate the applicable statutory cleanup requirements and reuse of onsite industrial materials. Thus, it is imperative to ensure (a) compliance with all regulations, (b) that businesses used to manage wastes and materials are approved and in full compliance with all federal and state regulations, and (c) that state and local authorities are consulted for approved beneficial uses.

Materials on cleanup sites can be contaminated, and in those cases, it is necessary to separate hazardous wastes from non-hazardous solid wastes. To determine whether waste is hazardous, a remedial project manager may review the history of the site to identify whether listed hazardous wastes may be present, or conduct an assessment of whether materials express a hazardous characteristic - using for example, the EPA's Toxicity Characteristic Leaching Procedure (Method 1311). Other hazardous waste characteristics to evaluate when

separating wastes include ignitability, corrosivity, and reactivity. Hazardous wastes must be disposed of according to federal and state regulations. Many communities offer recycling of certain waste characterized as hazardous.

Further, project managers need to check state environmental agency requirements for authorized safe beneficial uses of materials, and contact local authorities for any restrictions on the use of materials in specific applications. A recommended approach for getting started is to contact your EPA regional industrial materials recycling coordinator, who will have knowledge of state contacts and solid waste programs that typically review and approve industrial materials management.

Fort Ord, California – Former Military Base

The preliminary building assessment revealed asbestos in the vinyl tile flooring and lead-based paint on the exterior siding and some interior finish materials. Contaminated materials were removed and isolated before full-scale deconstruction began.

- ***Contaminant-free materials:*** sold onsite at public sale or donated to Goodwill Industries
- ***Hazardous materials:*** asbestos-containing materials disposed of by certified contractor at approved site; high-value Douglas fir siding warehoused for further research in removal of lead-based paint
- ***Other:*** unpainted drywall composted; representative pieces of dimensional lumber re-graded and strength-tested.

www.huduser.org/Publications/PDF/decon.pdf

6. Examples of Materials Management at Cleanup Sites

The following examples illustrate some of the opportunities for the diversion of various materials from landfilling. The materials may be found at cleanup sites, or used on cleanup sites. The examples illustrate reuse of onsite materials, reuse or recycling of materials offsite, and procurement of construction and other materials containing recycled content.[1] To be protective of human health and the environment, materials should be evaluated for safety (i.e., compared to relevant benchmarks and performance criteria) prior to use, and project managers should check with applicable state environmental agencies and local authorities regarding proposed uses.

- Crushed concrete can be used onsite as a construction aggregate for road base, pipe bedding, or landscaping
- Clean demolition materials can be shipped offsite to used building material resale stores, which sell donated supplies to the general public at reduced prices
- Clean concrete can be shipped offsite for use as aggregate in ready mix concrete
- Concrete that is made with coal fly ash or ground granulated blast furnace slag to displace a portion of traditional Portland cement can be procured for construction purposes. One example is the use of fly ash containing concrete for the construction of the structural elements of a treatment plant
- Reclaimed asphalt pavement can be used as a granular base for new roads
- Shredded scrap tires, crushed concrete, and other onsite clean hard materials can be used in place of borrow for fills
- Iron and steel foundry sands, dry wall, flue gas desulfurization (FGD) gypsum, and compost can be used for soil amendments and manufactured soils
- Reclaimed asphalt pavement, asphalt roofing shingles, glass, and scrap tire rubber can be recycled into asphalt pavements
- Uncontaminated and pest- or disease-free organic debris like wood can be salvaged for use as infill, mulch, or compost
- Compost can be used for stormwater management, to prevent soil erosion and for landscaping
- Composting contaminated soils may provide a less costly alternative to conventional methods of remediating certain contaminants in soil (Unified Facilities Guide Specifications; 2012)
- FGD gypsum can be used for mitigation of phosphorous transport to surface and groundwater.

Barksdale Air Force Base, Louisiana

Containment of 25 acres of construction debris and hazardous waste in an onsite landfill included salvaging 1,000 tons of concrete. The concrete was sorted by aggregate size for use in onsite road construction and stormwater runoff controls. Approximately 700 tons of woody material that was removed during installation of the landfill's cover also was salvaged for beneficial use.

www.cluin.org/greenremediation/subtab_d17.cfm

[1] Additional ideas, material uses, and any applicable performance benefits can be obtained from the available resources referenced at the end of this issue paper.

The Oregon Army National Guard's Camp Withycombe – Brownfields Site

The Oregon Army National Guard's Camp Withycombe won the fiscal year 2009 Secretary of the Army award for environmental restoration efforts by completing the remediation of six former training ranges in preparation for a major Oregon Department of Transportation highway development project. The former ranges accumulated lead bullets during their use for approximately 100 years. With freeway construction set to begin, the National Guard immediately began planning to design a sustainable cleanup that would use green remediation strategies.

The soil treatment system used a dry particle separation and wet gravity separation process to remove bullets and fragments from 30,000 tons of contaminated soil. The system was implemented at a cost of $5.9 million, a cost avoidance of more than $5 million. Nearly 300 tons, or approximately 25,205,000 bullets, were sifted out and reclaimed for recycling. Revenue generated by lead recycling was reinvested into restoration.

More than 50% of the contaminated soil was cleaned and ready to be used in reforestation to refill a mountain. The soil treatment system used a closed loop water system that filtered and recycled its own water, reducing demand and preventing the discharge of contaminated water. The system also boasted a stormwater collection component, which collected and directed it into the closed loop system as process water. Upon completion of soil washing, the system treated the process water so it could be recycled for irrigation during natural resources restoration.

http://www.army.mil/article/36028/camp-withycombe-green-remediation-techniques-result-in-5-million-cost-avoidance

7. Best Management Practices for Site Assessment and Planning

Material management goals should be integrated into existing site-specific planning processes to evaluate opportunities and document decisions. The following BMPs are recommended during remedial site assessment and planning phases:

- Survey onsite buildings and infrastructure to determine the potential to reuse existing structures and equipment; if structures or their portions cannot be reused as is, determine individual material components and approximate quantities that could be reused or recycled
- Include a requirement or demonstrated performance level for reuse and recycling of all uncontaminated C&D material in contract documents such as requests for proposals, bid specifications, and subcontracts and in administrative documents such as corrective action plans or grants; the requirement/level should align with existing state and local requirements or recommendations
- Structure incentives that reward diversion of materials away from landfills beyond a minimum goal of 50%, and establish a construction waste management plan that includes materials tracking and documentation
- Consult EPA's C&D materials recycling web page for tools and resources for project managers and contractors (www.epa.gov/cdmaterials)
- Contact local recyclers and waste haulers to determine what materials can be recycled
- Check with applicable state environmental agencies and local authorities for authorized uses of industrial materials
- Evaluate onsite reuse and/or recycling opportunities versus shipment offsite for reuse and/or recycling
- Communicate with contractors about how they will track and report the amount of waste that is recycled, reused, or disposed. If needed, provide tracking forms to project managers and haulers to make data reporting easier
- Design new construction to utilize standard material sizes and minimize cut-offs[2]
- Design new construction for future deconstruction[3]
- Evaluate opportunities for the purchase and use of recycled content products for onsite construction
- Designate the use of products with recycled content during the design process for onsite construction and conduct environmentally preferable purchasing
- Contract with suppliers that will take back scraps and whose products meet performance specifications, whenever the cost of their products is reasonable and the products are available within a reasonable time or distance.

[2] Cut-offs are excess material that is generated when materials of standard production sizes are cut down to fit custom design dimensions.
[3] Deconstruction means the selective disassembly of buildings to facilitate the reuse or recycling of valuable materials.

Fort Worth Post Office, Texas

Environmentally preferred products used by the United States Postal Service to construct the 8th Avenue Station in Forth Worth included:

- 20% recycled-content concrete with fly ash
- Recycled-content gypsum board and ceiling tiles
- 90% post-consumer recycled-content steel
- Recycled-content dock bumpers and floor mats (contains recycled tires)
- Recycled-content plastic toilet partitions, tree grates, and workroom bumpers.

www.epa.gov/epp/pubs/case/usps2.htm

8.0 Best Management Practices for Construction

The following BMPs are recommended during construction and remedy implementation, which may include demolition of pre-existing structures:

- Implement deconstruction techniques, preserve usable portions of existing structures but dismantle unusable parts, and recover clean materials for reuse and/or recycling
- When construction site parameters allow, encourage contractors to require and incentivize workers to sort uncontaminated materials for reuse or recycling as they are removed or debris is produced. This practice results in greater diversion but may depend on site conditions such as storage space. Materials may need to be consolidated prior to collection by a recycler who then separates them offsite (if this option is available). Source segregation can reduce costs because recycling and waste management companies often charge less for pre-sorted versus comingled materials. Source segregation can also provide a safer working environment and increase recyclability/reuse potential of materials
- Use signs to designate collection points for recyclables
- Salvage uncontaminated materials with potential recycle, resale, donation, or onsite infrastructure value
- Link a deconstruction project with a construction or renovation project to facilitate reuse of clean salvaged materials
- Divert at least 50% (by weight) of the uncontaminated C&D materials generated onsite and include this goal in the site waste management plan; for example, the U.S. Department of Defense, including the U.S. Army Corps of Engineers, specifies that all defense installations/military projects must divert at least 50% (by weight) of C&D materials from disposal or incineration according to their Integrated (Non-Hazardous) Solid Waste Management Policy.
- Optimize product ordering to prevent excess supplies from arriving at the site
- If materials are reused, specify that contractors ensure that state and local engineering performance standards are met for material end uses. These standards often include or specify national standards for performance, such as those from ASTM International and the American Association of State Highway and Transportation Officials
- Return durable packaging and unused goods from construction to suppliers or manufacturers.

Upper Arkansas River, Colorado – Superfund Site

Historic mining near Leadville, Colorado, occurred at the headwaters of the Arkansas River. Releases of mine waste, and contaminated water and sediments with elevated levels of metals have impaired productivity of agricultural land adjacent to the river. Low pH and enriched metal concentrations resulted in large areas of phytotoxicity, evident by barren and sparsely vegetated areas. The contaminated floodplain and irrigated meadows are designated as Operable Unit 11 of the California Gulch Superfund Site.

Impacted soil areas were treated with soil amendments that beneficially used industrial byproducts. Soil treatment included the use of biosolids, lime, woody materials for compost, and high rates of phosphorous fertilizer.

- Lime amendment was procured from a sugar beet processing facility near Longmont and transported to the site; the lime was mixed with organic amendments (biosolids compost or cow manure compost) to reduce soil acidity, supporting increased plant viability and metal insolubility
- Composted organic matter was transported from a feedlot source and incorporated along with woody materials as additional plant nutrients
- Wood chips were added to reduce nitrogen (nutrient) leaching and increase water holding capacity

The remedy resulted in reduced bioavailability of zinc and other metals, neutralized soil to support healthier ecosystems, reduced erosion and river channel degradation, and re-established vegetation, including native plants.

http://www.epa.gov/region8/superfund/co/calgulch/index.html
http://www.clu-in.org/greenremediation/subtab_d13.cfm

Emeryville, California – Brownfields Site

The City of Emeryville provided $1,175,000 in EPA brownfields revolving loan funds to GreenCity LLC to assist with cleanup costs associated with the GreenCity Lofts property, a former paint factory. Demolition of the former paint factory and warehouse buildings was necessary before construction of the lofts could begin. The project team employed C&D waste recycling practices including deconstructing (hand dismantling) the buildings on the former industrial property as an alternative to traditional demolition. As a result, 94.6% of the demolition waste was recycled, exceeding the nearby City of Oakland's legal requirement by 45%. In addition, 21,569 tons of excavated soil were diverted from disposal and used as beneficial cover at a local Class II landfill, reducing project costs by an estimated $496,708 in eliminated tipping fees.

The GreenCity Lofts in Emeryville, California

www.epa.gov/brownfields/success/emeryvilleca_cd_ss_final.pdf

Elizabeth Mine, Vermont – Superfund Site

The Elizabeth Mine is an abandoned copper mine located in the Village of South Strafford within the Town of Strafford, Orange County, Vermont. Past operations at the property consisted of mining, copper smelting, and ore processing. Water resources have been negatively impacted by acid rock drainage.

The green remediation strategy for this site for materials and waste included the reuse of onsite materials rather than importing natural resources for remedy construction and site restoration, establishing programs for recycling of waste materials, and initiating a procurement process for environmentally preferable products.

Results:

- ***Construction of the soil cap****:* reused rip-rap that was originally emplaced around an adjacent waste rock excavation area (known as "TP-1A"); used approximately 1,000 cubic yards of soil that had been previously used as temporary backfill in TP-1A, as well as other borrow materials from the site for cap construction
- ***Construction materials****:* recycled construction materials and incorporated a product recycling evaluation into procurement sourcing, wherever applicable; approximately 30 cubic yards of geomembrane liner made of recyclable high-density polyethylene (HDPE) and 96 HDPE liner cores (each 20 feet in length by 6 inches in width) were recycled in 2011
- ***Erosion control and stormwater quality****:* emplaced tubular devices ("socks") filled with organic materials such as recycled compost on ground surfaces along the TP-1A soil cap perimeter; in one year compared to typical silt fencing, this resulted in 50% less surface water runoff, returned more nutrients to the subsurface, and involved less maintenance
- ***Stabilization of steep slopes****:* used salvaged onsite wood debris
- ***Project-wide consumable waste****:* implemented a recycling program that resulted in the recycling of approximately 40 cubic feet of cans, 44 cubic feet of paper, 1,800 cubic feet of plastics, and 28 cubic feet of glass during 2011
- ***Borrow materials****:* used a 4.7-acre onsite area to develop borrow materials for the cap system and as-needed manufactured topsoil; over one year, the area produced approximately 93,000 cubic yards of earthen fill (including over 87,000 cubic yards of till/soil and 4,300 cubic yards of boulders), which avoided nearly 6,200 trucks trips (each with a capacity of 15 cubic yards) traveling on local roads in order to import the materials and averted approximately 945,000 pounds of associated CO_2 emissions.

http://www.clu-in.org/greenremediation/subtab_d36_120322.cfm

9.0 Best Management Practices for Operation and Maintenance

The following BMPs are recommended during site operation and maintenance (O&M):

- Use regenerated granular activated carbon (GAC) for use in carbon beds; if the GAC was pool-regenerated, ensure that contaminants on the regenerated GAC are not present at unacceptable levels [4]
- In instances in which coconut shell-derived GAC is produced within reasonable distance from the project site, use it as a more sustainable alternative to coal-based activated GAC
- Use products, packing material, and equipment that can be reused or recycled
- Use remediation system evaluations as opportunities to incorporate practices that involve reuse and recycling of industrial materials and purchasing of products with recycled content as a means to maximize resource efficiencies while potentially reducing project costs and optimizing remedy effectiveness
- Use techniques for continuous process monitoring, control, and optimization, to maximize capacity of treatment media and minimize frequency of media replacement
- Divert waste generated during operation and maintenance activities, including C&D materials generated during renovation of structures, from disposal in landfills.

Exhibit 2 provides an overview of process flow for integrating sustainable materials management in site cleanup projects.

10. Tools and Resources

EPA*'s "Industrial Materials Recycling Tools & Resources"* document, updated February 2011, brings together many helpful resources to implement the beneficial use of industrial materials, some of which are highlighted below.

- ✓ Agency and trade organization programs that focus on recycling of individual industrial materials
- ✓ State regulatory frameworks
- ✓ Risk assessment resources
- ✓ Potential applications of industrial materials with relevant case studies
- ✓ Environmental and economic benefits resources
- ✓ Performance standard specifications and guidelines
- ✓ Industrial materials suppliers.

http://www.epa.gov/wastes/conserve/imr/pdfs/tools1-09.pdf

[4] Spent GAC that is sent back for regeneration can be "pooled" into large-volume batches prior to being regenerated. Since the pooled GAC may come from multiple industrial and municipal sources, it is possible for multiple types of contaminants to be present on the spent GAC; it is also possible for inorganic contaminants to be present.

EPA's Office of Resource Conservation and Recovery (ORCR) is developing a methodology to evaluate the encapsulated beneficial uses of products containing coal combustion residuals (CCRs), such as coal fly ash in concrete and the byproducts of FGD systems in wallboard. The methodology aims to enable users/consumers to determine if encapsulated beneficial uses of CCRs are comparable to analogous products without the CCRs or byproducts of FGD systems. In the future, ORCR will also develop a conceptual model to evaluate the potential risks from unencapsulated beneficial uses of CCRs. http://www.epa.gov/epawaste/conserve/imr/

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► Resources for Locating C&D Recyclers, Reuse Stores, and Material Exchange Networks

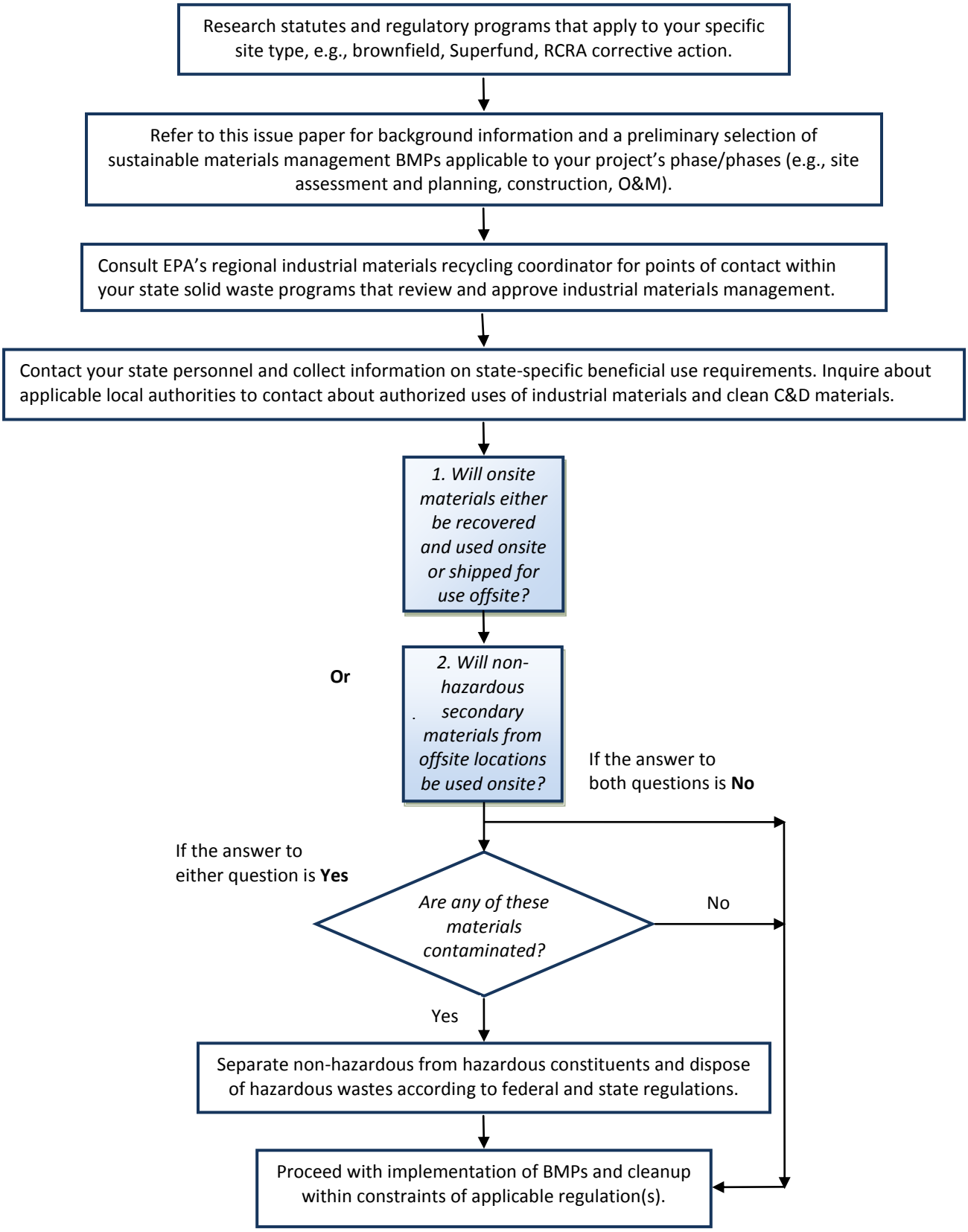
When choosing businesses to manage waste and materials, it is important to ensure they are reputable and in full compliance with state regulations (which may include licensing or registration) as well as local government requirements. State and local authorities must also be consulted for approved beneficial uses.

The Whole Building Design Guide's Construction Waste Management database contains information on companies that haul, collect, and process recyclable debris from construction projects. Created in 2002 by the Government Service Administration's Environmental Strategies and Safety Division to promote responsible waste disposal, the database is a free online service for those seeking companies that recycle construction debris in their area. The database is searchable by state, zip code, or material(s) recycled. http://www.wbdg.org/tools/cwm.php

The Construction Materials Recycling Association (CMRA) website, under the "Find a Recycler" section, provides a list of C&D recyclers. CMRA is a 501(c)(3) organization that promotes the recycling of construction and demolition materials. www.cdrecycling.org/

The Building Materials Reuse Association (BMRA) is a non-profit educational and research organization whose mission is to facilitate building deconstruction and the reuse and recycling of recovered building materials. BMRA's online directory is a resource for finding reuse stores such as Habitat for Humanity, deconstruction contractors, architects and more. The directory is browsable by state and searchable by zip code, city, state, and keyword. http://bmra.org/home

Exhibit 2. Sustainable Materials Management for Green Remediation: Process Flow



The Construction Industry Compliance Assistance Center is an EPA-funded environmental compliance assistance website for contractors and builders/developers. The website contains a C&D materials State Resource Locator, where contractors can find state and municipal recycling programs. www.cicacenter.org

Materials and waste exchanges are markets for buying and selling reusable and recyclable commodities. Some are physical warehouses that advertise available commodities through printed catalogs, while others are simply websites that connect buyers and sellers. Some exchanges are coordinated by state and local governments. Others are wholly private, for-profit businesses.
http://www.epa.gov/wastes/conserve/tools/exchange.htm and
http://mxinfo.org/list.cfm

► Material and Application Specific Information

EPA has established "Criteria for the Safe and Environmentally Protective Use of Granular Mine Tailings Known as "Chat"" in transportation construction projects carried out in whole or in part with federal funds in the Oklahoma, Kansas, and Missouri tri-state mining region.
http://www.epa.gov/osw/nonhaz/industrial/special/mining/chat/

"Using Recycled Industrial Materials in Buildings" (2008) is a fact sheet developed by EPA to provide information about the use of recycled industrial materials in buildings as an alternative to virgin materials and building products.
http://www.epa.gov/wastes/conserve/imr/pdfs/recy-bldg.pdf

"Using Recycled Industrial Materials in Roadways" (2009) is a fact sheet developed by EPA that discusses the use of industrial materials in roadways and other infrastructure projects as an alternative to virgin materials and construction products.
http://www.epa.gov/osw/conserve/imr/pdfs/roadways.pdf

The Federal Highway Administration and the Recycled Materials Resource Center developed *User Guidelines for Waste and By-Product Materials in Pavement Construction* to provide information and guidance on engineering evaluation requirements, environmental issues, and economic considerations to determine the suitability of using recycled materials in pavement applications.
http://www.fhwa.dot.gov/publications/research/infrastructure/structures/97148/intro.cfm and
http://rmrc.wisc.edu/user-guidelines-2/

The Use of Soil Amendments for Remediation, Revitalization, and Reuse (2007) was developed by EPA to provide information on the use of soil amendments as a cost-effective *in situ* process for many types of disturbed or contaminated landscapes. It focuses on amendments that are generally residuals from other processes and have beneficial properties when added to soil, such as municipal biosolids, animal manures and litters, sugar beet lime, wood ash, coal combustion products such as fly ash, log yard waste, neutralizing lime products, composted biosolids, and a variety of composted agricultural byproducts, as well as traditional agricultural fertilizers.
http://clu-in.org/download/remed/epa-542-r-07-013.pdf
EPA also has a website on agricultural and horticultural applications using industrial materials.
http://www.epa.gov/wastes/conserve/imr/ag.htm

The Northeast Waste Management Officials' Association (NEWMOA) has developed fact sheets on various waste/use combinations.
http://www.newmoa.org/solidwaste/bud.cfm

The Industrial Resources Council is composed of industry trade associations representing coal combustion products, foundry sands, iron and steel slag, wood and pulp materials, rubber materials, and C&D materials. Their website contains information about industrial materials and their applications.
http://www.industrialresourcescouncil.org

"An Innovative Alternative Reclamation Technique to Stabilize Coal Mine Refuse Using an Alkaline Clay By-product" is a paper by T. Kovalchuk of the Pennsylvania Department of Environmental Protection that was presented at the 32nd Annual National Association of Abandoned Mine Land Programs Conference in 2010. It discusses a field trial demonstrating a coal mine refuse reclamation technique using alkaline clay and compost to neutralize acidic soils, establish sustainable vegetative cover, and minimize acidic leachate.
http://www.clu-in.org/products/tins/tinsone.cfm?num=20562210

► Tools for Contractors

The Contractor Toolkit For Recycling and Using Recycled Industrial Materials was developed by EPA, the Associated General Contractors of America, and the Industrial Resources Council to provide a collection of resources to assist contractors who want to recover C&D materials generated at their job sites, or contractors who want to use industrial materials in the construction or renovation of a structure. http://www.agc.org/cs/recycling_toolkit

The U.S. Department of Housing and Urban Development's "Guide to Deconstruction" provides an overview of deconstruction with a focus on community development opportunities. The guide describes project profiles and case studies that show the components of deconstruction and its benefits, and presents ways to make it part of a community revitalization strategy.
http://www.huduser.org/Publications/PDF/decon.pdf

The Deconstruction Institute's "A Guide to Deconstruction" provides guidance to deconstruction managers, supervisors and workers who are planning or who are already conducting deconstructions. The guide can also be helpful to resale stores or redistributors of building materials. http://www.deconstructioninstitute.com/files/learn_center/45762865_guidebook.pdf

EPA's Office of Superfund Remediation and Technology Innovation offers the *Green Response and Remedial Action Contracting and Administrative Toolkit* to EPA remedial project managers, on-scene coordinators, and procurement offices to help prepare contracts and administrative documents that foster strategies for green response actions and long-term remediation at contaminated sites. http://www.cluin.org/greenremediation/docs/Greener_Cleanups_Contracting_and_Administrative_Toolkit.pdf

► Guides for Specifying and Purchasing for Contracts and Administrative Documents

Environmentally Preferable Purchasing (EPP) provides procurement guidance including information about environmental attributes to look for in construction products. The Environmentally Preferable Purchasing Program helps federal agencies identify and purchase environmentally preferable products and services. http://epa.gov/epp/pubs/products/construction.htm#a

U.S. EPA Comprehensive Procurement Guidelines (CPG) contains information about construction and transportation products containing recycled content. Although the CPGs are primarily for federal procuring agencies, the information is useful to state and local governments and the private sector. The webpage includes access to a Product Supplier Database that lists manufacturers, vendors, and suppliers for each item and specifies EPA's recommended recycled-content ranges. http://www.epa.gov/epawaste/conserve/tools/cpg/index.htm

The *Federal Green Construction Guide for Specifiers* provides information about procuring green building products and construction/renovation services within the Federal government, including sample specification language for building deconstruction and salvage. EPA partnered with the Federal Environmental Executive and the Whole Building Design Guide to develop this guide. http://www.wbdg.org/design/greenspec.php

WasteCap Resource Solutions, Inc. provides sample construction waste management specifications that are master specifications that can be edited for specific projects. WasteCap Resource Solutions, Inc. is a nonprofit, industry supported 501(c)(3) organization that provides waste reduction and recycling assistance to businesses. http://www.wastecapwi.org/services/construction-and-demolition-specifications/

► Recovering C&D Materials for Land Revitalization

EPA created "Recover Your Resources: Reduce, Reuse, and Recycle Construction and Demolition Materials at Land Revitalization Projects" (2009) to provide information on commonly recovered C&D materials at land revitalization projects, best practices, case studies, and other resources. http://www.epa.gov/brownfields/tools/cdbrochure.pdf

► State Program Requirements and Beneficial Use Determinations

The National Center for Manufacturing Sciences developed the State Beneficial Use Program Locator tool that identifies individual state rules and programs related to secondary materials use. Users are able to select a state (or states) of interest and obtain helpful beneficial use information. This tool was developed under a grant with EPA's National Compliance Assistance Centers program. http://www.envcap.org/statetools/brsl/

The Northeast Waste Management Officials' Association created a Beneficial Use Determinations (BUD) Database to help states share information and improve the efficiency of their BUD approval processes. The database includes over 1,500 BUDs issued by over 25 states. The BUD database is accessible to state and federal government only, and is searchable by material type or use, and provides details about requirements for approval where available. For more information and to obtain a username and password, please contact Jennifer Griffith at jgriffith@newmoa.org. http://www.newmoa.org/solidwaste/bud.cfm

► Regulatory Information

"RCRA in Focus: Construction, Demolition, and Renovation" (2004) provides information about how RCRA applies to the generation of construction and demolition materials. http://www.epa.gov/osw/inforesources/pubs/infocus/rif-cd.pdf

EPA provides resources to aid in the process of identifying hazardous waste and makes available links to codifications of rules in the *Federal Register*, which define solid waste, identify the types of wastes that are excluded from RCRA, list the specific wastes that have been determined to be hazardous, and define *characteristic hazardous wastes*. http://www.epa.gov/osw/hazard/wastetypes/wasteid/index.htm

"Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," also known as SW-846, contains the analytical and test methods that EPA has evaluated and found to be among those acceptable for testing under RCRA Subtitle C. This guidance sets forth acceptable, but not required, methods for the regulated and regulatory communities to use to evaluate solid waste. http://www.epa.gov/epawaste/hazard/testmethods/index.htm

"Land Disposal Restrictions for Hazardous Wastes" is a brochure providing a snapshot of the EPA's Land Disposal Restrictions (LDR) Program. The LDR program ensures that land disposed waste does not pose a threat to the human health and the environment by prohibiting land disposal of hazardous wastes unless the constituent hazardous chemicals are immobilized or destroyed.
http://www.epa.gov/osw/hazard/tsd/ldr/snapshot.pdf

More about LDR and the applicable treatment standards can be found in 40 CFR Part 268, as well as in *Land Disposal Restrictions: Summary of Requirements*.
http://www.epa.gov/osw/hazard/tsd/ldr/ldr-sum.pdf

► Quantifying the Environmental Benefits from Materials Diversion

EPA's "Methodology for Understanding and Reducing a Project's Environmental Footprint" report presents green remediation metrics associated with contaminated site cleanup, and a process to quantify those metrics in order to achieve a greener cleanup. Use of the methodology can provide quantitative information about the footprint reductions gained from the use of best practices for waste and materials.
http://www.cluin.org/greenremediation/methodology/

The Waste Reduction Model (WARM) calculates and totals life cycle GHG emissions avoided through alternative waste management practices (reduced, recycled, combusted, or composted) in comparison to a baseline scenario (landfilled) for various materials.
http://www.epa.gov/warm

The Recycled Content (ReCon) Tool estimates the life cycle GHG emissions and energy impacts from purchasing and/or manufacturing materials with varying degrees of post-consumer recycled content.
http://www.epa.gov/climatechange/wycd/waste/calculators/ReCon_home.html

The Greenhouse Gas Equivalencies Calculator expresses quantities of GHGs in easier to comprehend metrics such as number of cars, gallons of gasoline, acres of forest, etc.
http://www.epa.gov/cleanenergy/energy-resources/calculator.html

More Jobs, Less Pollution: Growing the Recycling Economy in the U.S provides environmental and economic benefits information for implementing a bold national recycling and composting strategy in the U.S. The report was prepared by the Tellus Institute for the Blue Green Alliance, a coalition of labor unions and environmental groups.
http://www.recyclingworkscampaign.org/2011/11/more-jobs-less-pollution/

The Engineering Forum Greener Cleanup Subcommittee offers broad assistance in implementing EPA's *Principles for Greener Cleanups* at Superfund sites:
http://www.epa.gov/superfund/remedytech/tsp/engforum/gcs/

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http://www.wbdg.org/ccb/browse_cat.php?c=3. See Section 02 54 21, Bioremediation of Soils Using Windrow Composting,
http://www.wbdg.org/ccb/DOD/UFGS/UFGS%2002%2054%2021.pdf

For more information about sustainable materials management during site cleanup, contact:

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To learn more about EPA's green remediation strategies, visit *Green Remediation Focus* online:
http://cluin.org/greenremediation