Managing Waste and Contaminated Soils

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This month’s issue is the first in a two-part series that spotlights new developments concerning the sustainable management of waste, landfills, and contaminated soils. Look for Part Two next month.

**Columns**

**EPA Research Highlights:** Novel Air Measurement Technology Supports Smoke Management Practices for Prescribed Burns  
*by Ann Brown*  
A team of EPA researchers recently traveled to the Flint Hills region of Kansas, to take air measurements during prescribed burns of prairie land that will be used to better determine the impact of smoke in nearby communities.

**YP Perspective:** Taking a Step Forward in Your Career: Facing Fears and Managing Risk  
*by Chris Whitehead*  
Navigating the choppy waters of a career in the environmental industry. While certain aspects will be outside of your control, there are steps you can take to better manage your career.

**PM File:** Order and Sequencing  
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**Sustainable Waste Management: What’s New?**  
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**Reuse of Contaminated Soils as Alternate Daily Cover at Landfills: A Risk to Workers?**  
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**Site-Redevelopment for Commercial Expansion Using Plastic-Dome Forms for Aerated Floor Construction**  
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**Waste Management: A Key Player for Improving Sustainability of the Food–Energy–Water Nexus**  
*by Qingshi Tu, David Palmer, and Ting Lu*

**New for 2018**

**Regulatory Roundup:** Could EPA’s Proposed Rollback of Air Standards for ‘Glider’ Trucks Portend Changes for Other Mobile Source Air Regulations?  
*by William Haak*  
Regulatory Roundup highlights key changes to the U.S. regulatory landscape.
Our March issue of EM is the first of a two-part series highlighting hot topics in waste management (with part two published in April). I try to introduce these issues with relevant and thoughtful commentary. This month will be a stretch for me. Throughout my career, my assignments and jobs primarily related to air quality issues. I was aware of waste management programs, but they were not my area of expertise or focus. In recent years, my work allowed me to learn more about waste programs and appreciate their complexity and importance. As A&WMA members, there are still many opportunities for us to work together to improve waste management policy and practices.

For companies managing waste materials, many of the day-to-day activities are well understood but challenging to implement every day as people, processes, and materials change. Effective operating and change management procedures, used in combination with internal audits and training, are important for proper waste handling, labeling, storage, shipment, and disposal. Many leading companies also audit their waste vendors, to maintain awareness of off-site risks. Despite these programs, government inspectors can still find gaps in programs and practices.

Waste management requirements are not static. Over the past several years, many regulatory changes were proposed and completed. In the United States, the U.S. Environmental Protection Agency (EPA) finalized a Hazardous Waste Generator Improvement Rule and revised Hazardous Waste Export–Import rules in 2016. The implementation of e-manifests, potential rules for pharmaceutical hazardous wastes, and court decisions related to the Definition of Solid Waste Rule all require attention and program evolution for many companies. Globally, governments are moving forward with requirements for tighter management of waste disposal. Changing rules and policies can be confusing and contradictory, both for companies and enforcement agencies.

Minimizing waste generation can be an effective strategy for risk reduction. 3M (my employer) started the Pollution Prevention Pays program in 1975 and has saved more than two million tons of pollution over 40+ years. The adoption of green chemistry in R&D and lean approaches in manufacturing can lead to reductions in waste generation and improvements in the bottom line, but the gains are not easy or immediate. New products and processes often create more waste than established ones, with efficiencies discovered over time. Governments, global companies, and citizens want greener solutions but real challenges related to customer acceptance, requalification of new products, and aggressive competition can hinder greener products as they move to market.

In each of these areas—effective compliance practices, regulatory analysis and program development, and waste minimization—A&WMA members have important successes and challenges to share. When we discuss innovative ideas and make personal connections across sectors and between public and private entities, we can improve compliance outcomes, reduce the potential for environmental contamination, and broaden our personal and professional networks. As always, I encourage all A&WMA members to share their expertise or programming requests with their local Sections and Chapters or with the A&WMA Board and headquarters staff. We are all interested in better environmental outcomes, so let’s continue to work together to find those solutions and opportunities for collaboration.
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Managing Waste and Contaminated Soils

What’s New?

This month’s issue is the first in a two-part series that spotlights new developments concerning the sustainable management of waste, landfills, and contaminated soils. Look for Part Two next month.
Let’s begin this waste-themed issue with a very brief historical perspective on waste management, some of which many of our younger readers may find difficult to believe. Comprehensive U.S. federal regulation of solid and hazardous waste first began more than 40 years ago when Congress passed the Resource Conservation and Recovery Act (RCRA) of 1976, followed by an update eight years later in 1984. EM readers who are currently in the early- to mid-stages of their careers are too young to remember the pre-RCRA era in which all waste was assumed to just “go away.”

Into the early 1970s, there was essentially no recycling or reuse of discarded materials; solid waste was either burned in open municipal dump piles or backyards, or was buried in municipal dumps having no environmental protection.

For example, in New York City, through the mid-1900s, waste was simply barged out to sea and dumped, and the city’s sewage sludge was committed to the ocean depths until 1992! In the pre-RCRA era, factories discharged their toxic waste directly to the ground or into rivers without any controls.

Your author, of a certain age, can recall back in that pre-enlightenment era, going to the town sandpit to drain and change his car’s motor oil (the old oil “went away,” there, didn’t it?); playing “finger hockey” with blobs of mercury on the slate tops of lab benches during high school chemistry class; marveling as the local river flowed blue, yellow, or red, depending on the color dye discharged daily by the local paper mills; and “exploring” the dumping area behind the local factory, including all those barrels of who-knows-what. Unbelievable by today’s standards, but the norm in those days.

The passage of RCRA four decades ago coincided with a rapidly increasing public interest in environmental stewardship. Over the ensuing years, steady progress has been made in reducing the amount of waste generated; reusing and recycling discarded materials; and treating and disposing of the remaining waste in environmentally protective ways. This is true for all types of waste: municipal, industrial, and hazardous.

William McDonough, a former Federal Reserve Chair in New York, once said, “You don’t filter smokestacks or water. Instead, you put the filter in your head and design the problem out of existence.” This perspective on preventing, rather than controlling air and water pollution extends to conceiving ever-better means for waste reduction and sustainable waste management.

In that spirit, this month’s issue of EM provides readers the opportunity to learn of several methods and concepts for more responsibly managing our waste. Included in this issue are two articles on the management of contaminated soils, two on municipal landfill issues, and one on the link between waste management on one hand, and food, energy, and water resources on the other.

In the first article, Tim Haley and Tammy Helminski address how to avoid legal and cost liabilities that can ensue with improper disposition of the “dirt” excavated in the course of normal site development projects. Next, in a follow-up to his article published in the March 2017 EM, David Greene provides a timely status update on the new landfill air rules following the change in U.S. Environmental Protection Agency (EPA) leadership and offers compliance recommendations to landfill owners.

The third article, by Stephen Zemba and David Adams, considers the reuse of contaminated soils as landfill. At large landfills, contaminated soils are often used beneficially as daily cover material to cover up each day’s deposits of wastes, rather than using virgin soils to cover the waste. Despite the benefits of using contaminated soils for this purpose, there are potential risks to the landfill workers who apply these soils, and this article provides a useful primer on techniques for assessing those health risks.

Commercial development of former landfill sites often requires a sub-slab mitigation system to prevent the intrusion of sub-surface gases, such as methane and volatile organic compounds (VOCs), into the new structures. In the fourth article this month, Deran Pursoo, Dave Folkes, and Ted Kuehster describe early experience with an innovative, “green,” sub-slab mitigation system constructed of recycled-plastic domes.

The final article broadens our thinking about waste management sustainability. Qingshi Tu, David Palmer, and Ting Lu address the inextricable link that exists among the food, energy, and water sectors, defining this as the “Food–Energy–Water (FEW) Nexus”. The article then illustrates how the recovery and reuse of waste materials can be strategically integrated within the nexus, improving its sustainability.

EM readers are invited to enjoy this issue, while updating on recent developments in sustainable waste management. The focus on waste continues next month with a look at effective approaches for managing contaminated soils and spent electric-vehicle batteries. em

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DIRT IS DIRT, Right?

This article discusses some of the issues facing modern development with respect to dirt movement.
As the ground thaws, construction season comes. Backhoes, excavators, graders, and shovels will turn up and redistribute dirt throughout the country. In some places, development will be smooth; in others, it may take longer and be more costly than anticipated.

Dirt moving often has a significant cost. However, when soil is contaminated, marginally contaminated, impacted, or simply an “environmental concern,” the costs for lawfully addressing this dirt as part of a development can increase substantially. When those costs are anticipated in the beginning of the project, the project usually continues without issue. However, when the assumption is made that dirt is just dirt—when in fact it is not—costs may rise and schedules may halt. The excavation, movement, reuse, and disposal of dirt may be regulated by different agencies.

**Relevant Regulatory Criteria**

One concern is whether the soil at a site may be a “waste,” as that term is used in environmental regulation. In certain circumstances, dirt can be regulated under the Resource Conservation and Recovery Act (RCRA) as hazardous waste, it can be regulated under state law as solid waste, it can be regulated by state law in some other manner (e.g., as “historic fill”), or it may be completely unregulated.

**RCRA**

At the federal level, dirt will constitute hazardous waste when it is generated if the dirt contains a listed waste or if the dirt is characteristically hazardous. To determine whether the dirt contains a listed waste, one must carefully analyze the facts surrounding the contaminated media within the dirt to understand whether it contains a listed waste. Where a waste generator makes a good faith effort to determine the source of contamination, but the necessary records are unavailable or the analysis is inconclusive, one may assume that the source of the contamination is not from a process that would make the dirt a listed waste. However, in other cases where the generator knows the source of contamination, and that source is listed waste, the dirt itself must be treated as a listed hazardous waste using RCRA’s so-called “contained-in” policy.

To be characteristically hazardous, dirt must meet one of the four characteristics under RCRA, 40 CFR §§ 261.20-261.24. These characteristics include corrosivity, toxicity, ignitability, and reactivity. When dirt is characteristically hazardous, it is often due to the presence of heavy metals or solvents (i.e., the soil is toxic), or to significant residual petroleum product contamination (i.e., the soil is ignitable).

Under RCRA rules, and many solid waste rules, waste dirt is usually “generated” when it is excavated, except in some atypical circumstances, such as when the soil is within a RCRA-designated Area of Concern. At most sites, in order to determine whether the dirt itself is hazardous, it is the developer’s obligation to characterize the dirt to ensure that it is treated and handled appropriately under federal law when it...
is excavated. For states that administer RCRA on behalf of the U.S. Environmental Protection Agency (EPA), there may be additional requirements that apply.

**Solid Waste**

If the dirt is not hazardous waste, but is moderately contaminated above background impact levels, it may be considered a regulated solid waste. Solid waste thresholds are typically based on analytical analysis, and can vary from state to state. Usually, as in RCRA, the determination of whether dirt is considered to be a solid waste is made at the time the soil is excavated.

**Other Categories of Moderately Contaminated Soils**

Some states have other classes of moderately contaminated soils. For example, before environmental regulations were prevalent, development in many communities consisted of filling and grading the land with whatever materials were available. In some areas, these fill materials could have included slag, coal ash, riprap, foundry sand, clinkers, cinders, concrete, sediments, solid waste, and construction/demolition debris. Some areas specifically regulate the historic fill, which is generally identified due to the presence of man-made heterogeneous materials scattered throughout an area.

In areas where it is relatively common, some communities have specific requirements when historic fill is uncovered. These programs can take the form of specific reports approved by the local agencies, or by specific construction and handling requirements set forth in regulation or guidance. Where regulated, the state programs vary in administration, but usually allow for moderately impacted fill to remain on site, subject to conditions.

**Clean Fill**

Of course, some dirt really is just dirt. Usually, there are minimal restrictions on the reuse of existing dirt, especially when it is reused on-site. However, even natural soil may carry environmental issues—clean soil material may have seeds, larvae or micro-organisms that, when transported distances, may cause environmental harm in the new location. To prevent this type of harm, the U.S. Department of Agriculture (USDA) has developed strict soil import limitations and domestic quarantine areas (see, e.g., 7 CFR Part 330; 7 CFR Part 301). Additionally, some states have additional limits on the use of imported soil materials.

**How to Handle Your Dirt**

Understanding the risks associated with the dirt at your development site usually requires learning about your dirt prior to excavation, as the regulatory waste criteria are typically triggered when the soil is excavated. So how do you know if your dirt is impacted?

In many transactions, a Phase I Environmental Site Assessment is performed to evaluate the risk of any past releases of hazardous substances or petroleum at the property. Additionally, these Phase I reports should also identify when soil staining or other minor leaks or releases exist at the property. Even if not noted in the Phase I report, evidence of shallow soil contamination may be visible as discolored soil or distressed vegetation at the property.

Where impacted soil exists, laboratory analysis of soil is often helpful. Laboratory data can be used to justify either an offsite disposal or reuse strategy. In some development, it is often advisable or required to develop data to ensure the soil meets state standards for the proposed use. For example, planned residential developments usually require cleaner dirt than planned industrial developments. Soil testing data is often used to evaluate risks and costs for soil handling. (Note, however, that this kind of analysis does not always answer the question of whether the dirt is characteristically hazardous under RCRA-required test methods. See 40 CFR §§ 261.20-261.24.)

Using soil testing data, developers can plan for the ultimate use of the soil. Some soil must be disposed (as in a landfill), some soil can be reused without limits, and some soils may only be reused subject to conditions prescribed by applicable regulatory authorities. Developers should consult with their
Dirt Is Dirt, Right? by Tim Haley and Tammy Helmski

example, a developer who moved contaminated soils from one area to another area has been held as liable under CERCLA as the owner at the time of disposal. Furthermore, developers may lose available CERCLA liability defenses by utilizing soil management practices that constitute “disposal” or otherwise exacerbate existing environmental conditions.

As a result, failing to identify the risks and incorporate lawful handling and disposal requirements into a project can give rise to significant additional and unanticipated costs for development.

Conclusion
Dirt is not always just dirt. Identifying and anticipating potential issues with dirt in a development project in advance is one strategy to minimize potential environmental liabilities and unanticipated delays. Because the regulatory structure varies across the states, it is important that the developer knows the dirt for the project site and also engages competent legal counsel to assist in developing a strategy to resolve environmental issues with the dirt in compliance with applicable laws.

Implications of Mishandling
Regulatory agencies typically have authority to bring enforcement actions against those who violate dirt-handling rules. Enforcement actions may come with a civil penalty or injunctive order requiring restoration or other earthwork to address real or perceived environmental harms caused by mishandling the dirt. EPA is authorized to issue fines over US$71,000 each day of RCRA violations for mishandling soils that are hazardous waste (40 CFR §19.4), though most penalties are for less than that amount. Similarly, states can impose monetary penalties and/or injunctive orders for mishandling soils under applicable state laws.

Additionally, those who move dirt have been found to be liable parties under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). CERCLA is a strict liability statute with joint and several liability features that can result in one potentially responsible party paying for one hundred percent of all cleanup costs. For example, a developer who moved contaminated soils from one area to another area has been held as liable under CERCLA as the owner at the time of disposal. Furthermore, developers may lose available CERCLA liability defenses by utilizing soil management practices that constitute “disposal” or otherwise exacerbate existing environmental conditions.

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References
2. Id. at 9.

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Where Do the New Landfill Air Regulations Stand?

A look at the confusion stemming from regulatory uncertainty of new rules limiting air emissions from municipal solid waste landfills.
In late summer 2016, the U.S. Environmental Protection Agency (EPA) published updated regulations limiting air emissions from municipal solid waste (MSW) landfills, specifically, revised New Source Performance Standards (NSPS) for new landfills under 40 CFR 60, Subpart XXX, and Emission Guidelines (EG) for existing landfills under 40 CFR 60, Subpart Cf. However, less than a year later, the agency switched from having formally issued these wide-ranging new rules, affecting over 1,000 landfills nationally, to imposing a legal stay on the rules in order to review an administrative petition submitted by the landfill industry. The rules’ course changed again on August 29, 2017, when the stay expired without substantial comment by EPA regarding the reconsideration issues that dictated the stay. With the stay now lifted, these rules are again legally in-effect; yet significant questions remain. What is more, the earlier versions of the same NSPS/EG rules (Subparts WWW and Cc) are also still in effect, further compounding the confusion surrounding applicability, compliance deadlines, and requirements (see Table 1 for cursory comparison between the old and new rules).

These uncertainties can confound compliance planning by state and local regulators, as well as by the solid waste industry, a large and ubiquitous segment of the U.S. economy. How can landfill owners work to maintain compliance under the current conditions of significant regulatory uncertainty, and how can federal, state and/or local regulators implement the new rules?

Impact on Landfill Owners and Regulators

In the course of their work, responsible landfill owners pursue a variety of challenging goals. Principal obligations include

<table>
<thead>
<tr>
<th>Provision in Rule</th>
<th>Previous NSPS (Subpart WWW) and EG (Subpart Cc)</th>
<th>New NSPS (Subpart XXX) and EG (Subpart Cf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rule Applicability Trigger</td>
<td>2.5 million Mg waste mass and 2.5 million m³ waste volume</td>
<td>No change</td>
</tr>
<tr>
<td>Landfill Gas Control Trigger–NMOC emissions threshold (for active MSW landfills)</td>
<td>50 Mg/yr</td>
<td>34 Mg/yr</td>
</tr>
<tr>
<td>Landfill Gas Control Trigger–NMOC emissions threshold (for closed MSW landfills)</td>
<td>50 Mg/yr</td>
<td>No change</td>
</tr>
<tr>
<td>Gas wellhead monitoring parameters</td>
<td>Temperature, pressure, oxygen</td>
<td>Temperature, pressure (Note that oxygen must be recorded but is no longer subject to numeric limits or reporting)</td>
</tr>
<tr>
<td>Frequency of monitoring the required gas wellhead parameters</td>
<td>Monthly</td>
<td>No change</td>
</tr>
<tr>
<td>“Wet” Landfills (Leachate or other specified liquids are recirculated)</td>
<td>Not addressed</td>
<td>No stated requirements, except recirculated leachate must be recorded back 10 years</td>
</tr>
<tr>
<td>Surface Emission Monitoring of Methane</td>
<td>Quarterly</td>
<td>Quarterly, with increased requirements including additional cover penetration monitoring and GPS location marking of exceedances with ±4 meter accuracy. These additional requirements add significant time and expense for the landfill</td>
</tr>
<tr>
<td>Landfill Gas Treatment (processing of LFG for subsequent sale for beneficial use)–Definition</td>
<td>Unclarified</td>
<td>Clarified: compression, dewatering, and filtration, (states may require monitoring plan)</td>
</tr>
<tr>
<td>Reporting submission format including test reports</td>
<td>Unspecified</td>
<td>Electronic as specified (some submittals not currently supported)</td>
</tr>
</tbody>
</table>

*Note: *Not an exhaustive listing; e.g., Subpart XXX applicability carries notification reporting timelines.
protecting the environment, complying with regulations, maximizing the economic value of the landfill asset, maintaining good relationships with neighbors, keeping their employees safe, and caring for large complex pieces of equipment, all while supporting communities by providing a critical public service. Complications resulting from unsettled air regulations are an unwelcome distraction, as landfill owners attempt to deal with uncertain compliance requirements and timeframes, as well as with uncertain compliance costs.

Similarly, complications have also resulted for state and local regulators, entities charged with implementing the new regulations. This is especially true for implementing the new EG rules for existing landfills (Subpart Cf) for two reasons: (1) existing landfills nationally far outnumber new landfill sites; and (2) states are required both to develop and enact state-specific implementation plans for the EG and to obtain approval from EPA for those state rules. States’ preparation of EG implementation rules was due by May 30, 2017 (i.e., nine months after the new EG rule’s promulgation date) and, in turn, approval by EPA was required within four months or by September 28, 2017. The states would subsequently have six months to incorporate EPA comments, if any. The deadline for preparation of state EG implementation rules has long passed, but, owing to the unsettled nature of the rules, many states and local regulators do not have EG implementation rules in place for existing landfills. In fact, the vast majority of states have not even developed EG rules and submitted them to EPA for approval.¹

**Rule Update**

As indicated above, the new NSPS/EG rules were issued on August 29, 2016, and went into effect on October 28, 2016. On October 27, 2016, an industry group filed administrative and judicial petitions for reconsideration of the rules. Included in the petitioners’ statement of issues were concerns surrounding surface-emissions monitoring, landfill liquids-addition reporting, the use of the social cost of methane by EPA in assessing costs and benefits of the new regulations, impacts on the design plans for gas collection and control systems (GCCS), and a particular option to determine the need for a GCCS installation, known as Tier 4, that reduces operating flexibility instead of allowing more flexibility, among other issues.² Basically, the focus of this petition was on the structure of the new rules and resulting complications for compliance, not on the stringency of the rules.

The presidential election of November 2016 brought an administration with a different philosophy regarding EPA’s mission and a different approach to rulemaking. On May 5, 2017, EPA announced, in a letter to the petitioners, that it would reconsider several portions of the rules in response to the petition:

> “1) tier 4 surface emission monitoring; 2) annual liquids reporting; 3) corrective action timeline procedures; 4) overlapping applicability with other rules; 5) the definition of cover penetration and 6) design plan approval.”

**Figure 1.** Landfill gas extraction wellheads.  
Source: Image courtesy of SCS Engineers.
Despite having issued this letter seven months after the effective date of the new rules (October 28, 2016), the new administration’s EPA issued a 90-day stay of the rule in order to review issues presented in the industry petition submitted in October 2016. By the next month, the National Resources Defense Council (NRDC) filed a motion to vacate the stay. Although there was hope that some of the issues presented in the petition could be resolved or otherwise addressed, the stay expired on its own without EPA comment. Since the expiration of the stay, EPA has, however, issued a few, pertinent public statements, including:

• Regarding rule development and resolving issues of concern: EPA will “continue to work with states and stakeholders as we develop a path forward on these separate but related actions.”
• Regarding development by the states of required implementation plans for the new EG rules: According to EPA, development of EG implementation plans by states under the U.S. Clean Air Act “are not subject to sanctions”; and “Since the agency is reconsidering various issues regarding the landfill regulations, at this time we do not plan to prioritize the review of these state plans, nor are we working to issue a Federal Plan for states that failed to submit a state plan.”
• On January 11, 2018, the agency withdrew extension of the stay and will continue with reconsideration of the rules.

Figure 2. Landfill gas system energy project components.
Source: Image courtesy of SCS Engineers.
Accordingly, it appears that state regulators can choose, without fear of EPA-imposed consequences, to adopt a "wait-and-see" posture, postponing state implementation of the new rules until after EPA clarifies them.

**The Path Forward**

The landfill industry is continuing to work with EPA administratively to get a longer-term stay to work out needed rule changes. At this time, industry representatives are hopeful both these related goals can be achieved.

As noted above, EPA has indicated that it will not enforce or penalize state and local regulators for missing specified, EG-rule implementation timelines. This tolerance is particularly important because it may prevent potentially outdated rules from becoming fixed (i.e., rules currently effective, but which may change following federal revisions). It will also delay the time period before new EG rules will become effective.

What are landfill owners to do in this limbo period? At the time of this writing, the following actions should be considered:

- Continue maintaining compliance with the state's current landfill air regulations, while the new regulations are being worked out.
- Diligently monitor for further developments and announcements from EPA.
- Determine if your state regulator has formal, "delegated authority" from EPA for implementation of NSPS Subpart XXX, which is applicable to new landfills. If so, this can also allow your state substantial autonomy from EPA in implementing EG rules for existing landfills.
- Very importantly, keep in regular contact with your state/local agency, staying up-to-date with their evolving plans for implementing these rules.
- Communicate regularly with industry colleagues to ensure a common understanding of the evolving new regulations.
- Comply with any new regulations the state issues in good faith and on a timely basis.
- Be aware that resolving the issue involving "the overlapping applicability with other rules," as noted in EPA’s May 5 letter, may require significantly more time to fix than resolving the other issues involved with the rules.

While the new rules became effective back in 2016, the concerns with the rules raised at the time still remain unresolved. Despite this, we can expect resolution though it may take some time to fix. The fog should be lifting, yielding changes that are expected to be more workable for both the landfill industry and state/local regulators. In the meantime, stay tuned and stay informed.

**References**

1. Based on conversations with EPA officials, two states have submitted draft EG rules to the agency as of early December 2017. Many states have been working on EG rules, but only two appear to have progressed to the draft submittal stage of the process.
2. 82 FR 24878, and referenced in May 5, 2017, reconsideration letter to petitioners from EPA Administrator.

**More Information**

A primer on techniques for assessing the potential health risks to U.S. landfill workers using methods developed under the Superfund program.
Beneficial reuse of waste materials at landfills is practiced in numerous states across the United States. Landfill regulations require the covering of disposed municipal solid waste (MSW), both on a temporary basis as daily covering of newly deposited wastes and on a long-term basis through landfill capping and closure. Consequently, landfill operations typically require an abundant supply of cover material. The traditional alternatives include clean soils, foams, and tarps, all of which represent costs to landfill operators and utilization of potentially valuable materials that could be used in landscaping and other applications. Substituting waste materials as cover provides the benefit of displacing a needed commodity—cover soil—with a material that would otherwise be disposed of as a waste material.

Table 1 provides a summary list of waste materials that are known to have been approved for beneficial reuse at landfills (typically as daily cover material). These and other materials can be accepted at MSW landfills if they pass the categorical tests used by the U.S. Environmental Protection Agency (EPA) for determining hazardous wastes (i.e., ignitability, corrosivity, reactivity, toxicity, and “listed” wastes), as set out under the Resource Conservation and Recovery Act (RCRA). But in theory, the wastes can still contain high levels of contaminants, so long as the RCRA characteristic tests are satisfied.

Contaminated soils represent a category of waste that is a frequent candidate for beneficial reuse at landfills. According to an EPA-funded project on material reuse, at least 15 states have made determinations that allow for beneficial use of contaminated soils at landfills (see Table 2). Sending contaminated soils to landfills has long been a management strategy in hazardous waste site remediation work, as disposal in a landfill eliminates potential exposure pathways through which the general public might contact the soils. If the purpose of sending the soils to the landfill is to prevent people from contacting contaminants, are there potential risks to the workers at landfills who are applying these soils for beneficial reuse as daily cover?

Analyzing Risk
There are potential considerations of regulatory jurisdictions in addressing this question. Determinations of the need to landfill contaminated soils are frequently dictated by state or federal programs designed to regulate contaminants in soil at hazardous waste disposal sites (rather than at MSW landfills). In this context, the term “hazardous” typically pertains to public health protection as rooted in EPA’s Superfund program, which philosophically is designed to protect individuals from any significant health risks. Landfill owners, like all employers, are subject to the requirements of the Occupational Safety and Health Administration (OSHA), which has specific requirements for protecting workers from excessive exposure to chemical contaminants. Arguably, landfill workers are subject to a variety of different job hazards, some of which may be more significant (in terms of risk) than potential contact with contaminated soils.

Discussion of the applicability of contaminated (hazardous) site program regulations to MSW landfill workers involves policy considerations beyond the scope of this article. However, it is worth considering the potential implications of applying risk-based hazardous waste site regulations to landfill workers (or any other category of workers subject to OSHA requirements). To do so, consider a simplistic example comparison of risk-based concentrations of contaminants in the air at a landfill. Table 3 compares the OSHA Permissible Exposure Levels (PELs) to the EPA’s Regional Screening Levels (RSLs) for industrial air, which are risk-based. The values differ by several orders of magnitude, reflecting the greater degree of protection afforded by EPA risk assessment methodologies.

Table 1. Materials approved for beneficial reuse at landfills in 1 or more states.

<table>
<thead>
<tr>
<th>Material</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto Shredder Residue</td>
<td>Foundry Sand—Green Sand</td>
</tr>
<tr>
<td>Circulating Fluidized Bed Ash</td>
<td>Glass</td>
</tr>
<tr>
<td>Coal Bottom Ash</td>
<td>Gypsum Wallboard</td>
</tr>
<tr>
<td>Coal Fly Ash</td>
<td>Slag—Foundries</td>
</tr>
<tr>
<td>Construction and Demolition Debris</td>
<td>Slag—Steel</td>
</tr>
<tr>
<td>Contaminated Soil</td>
<td>Stormwater Sediments</td>
</tr>
<tr>
<td>Dredge Material</td>
<td>Street Sweepings</td>
</tr>
<tr>
<td>Drinking Water Treatment Sludge—Aluminum</td>
<td>Waste Tires</td>
</tr>
<tr>
<td>Drinking Water Treatment Sludge—Ferric</td>
<td>Waste-to-Energy Ash</td>
</tr>
<tr>
<td>Drinking Water Treatment Sludge—Lime</td>
<td>Wastewater Treatment Plant Filter Sand</td>
</tr>
<tr>
<td>Flue Gas Desulfurization Sludge</td>
<td>Wood Ash</td>
</tr>
<tr>
<td>Foundry Sand</td>
<td></td>
</tr>
</tbody>
</table>

Source: http://www.envcap.org/statetools/brsl/.
Calculating Potential Exposure

Notwithstanding the above discussion of regulatory authority, and making the assumption that it is appropriate to use EPA risk assessment methods to establish acceptable risk-based levels of contaminants in soils that can be handled by landfill workers, how specifically should the levels be established? Application of risk assessment methods entails myriad assumptions about how workers come in contact with soils and the degree and intensity of exposure. For simplicity, one might initially select “off the shelf” risk-based screening concentrations that have been derived using standard default assumptions and protective risk-based target levels. Alternatively, one might attempt to apply risk assessment equations tailored to the activities that landfill workers engage in when managing and applying cover soils.

In either case, it is important to consider the basics of risk assessment methods. The first step entails the identification of plausible pathways whereby individuals might contact contaminants. Typically, workers are assumed to contact contaminants in soil via three pathways:

- Incidental ingestion, frequently associated with hand-to-mouth contact;
- Dermal contact, whereby contaminants are absorbed from soil adhering to skin; and
- Inhalation of soil suspended in the air as dust.

Generically, potential exposure to a contaminant via the ingestion and dermal pathways is calculated in the form of dose, which is essentially the amount of a contaminant contacted per body weight. In equation form:

\[
Dose = \frac{(\text{Concentration in Soil} \times \text{Contact Rate} \times \text{Exposure Frequency/Duration})}{(\text{Body Weight} \times \text{Averaging Time})}
\]

The contact rate assumes different forms. For incidental ingestion, it simply is the daily rate that soil is swallowed. For dermal contact, it depends on both the level of soil adhered to skin and the fraction of the contaminant absorbed from it.

Note that potential exposure and risk via dust inhalation is calculated differently to match conventions developed for toxicity data. For inhalation, potential exposure is estimated as the average concentration of the contaminant in air inhaled over time, and unit risk factors and reference concentrations that characterize inhalation toxicity data are expressed in terms of concentration units.

Given exposure estimates for these pathways, potential risks to health are evaluated for two broad categories. Incremental Cancer Risk (ICR) is estimated for contaminants known or suspected to cause cancer in humans. For each potential carcinogen, risk is calculated as the product of the lifetime average daily dose and the contaminant-specific cancer slope factor, or potency, which is an estimate of chemical’s capacity to initiate or promote cancer:

\[
\text{Incremental Cancer Risk (ICR)} = \frac{\text{Lifetime Average Daily Dose} \times \text{Potency}}{\text{Body Weight} \times \text{Averaging Time}}
\]

### Table 2. States that allow the reuse of contaminated soils at landfills.

<table>
<thead>
<tr>
<th>Florida</th>
<th>New York</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hawaii</td>
<td>North Carolina</td>
</tr>
<tr>
<td>Iowa</td>
<td>North Dakota</td>
</tr>
<tr>
<td>Kentucky</td>
<td>South Dakota</td>
</tr>
<tr>
<td>Maryland</td>
<td>Texas</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>Virginia</td>
</tr>
<tr>
<td>Michigan</td>
<td>Wyoming</td>
</tr>
</tbody>
</table>


### Table 3. A comparison of EPA Regional Screening Levels (RSLs) and OSHA Permissible Exposure Limits (PELs).

<table>
<thead>
<tr>
<th>Chemical</th>
<th>OSHA PEL (μg/m³)</th>
<th>EPA RSL for Industrial Air (μg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>10</td>
<td>0.0029</td>
</tr>
<tr>
<td>Chromium VI</td>
<td>5</td>
<td>0.00015</td>
</tr>
<tr>
<td>Lead</td>
<td>50</td>
<td>0.15</td>
</tr>
</tbody>
</table>
The chance for adverse health effects other than cancer is characterized through the calculation of a Hazard Quotient (HQ), expressed for ingestion and dermal exposure pathways as the ratio of the average daily dose divided by the chemical-specific reference dose, which is derived from toxicological studies to correspond to exposure levels that can be tolerated with no significant chance of adverse health effects:

\[
\text{Noncancer Hazard Quotient} = \frac{\text{Average Daily Dose}}{\text{Reference Dose}}
\]

Risk assessment equations can be rearranged to calculate permissible risk-based concentrations of contaminants in soil for given target risk levels and exposure assumptions. Common target risk levels are ICRs of 1 per million and 10 per million, and HQs of 0.1 and 1. Exposure parameters are typically selected based upon professional judgment to estimate likely degrees of exposure, such as reasonable maximum or central tendency estimates. Variability and uncertainty are inherent to each parameter, and as a means of encouraging uniformity, adoption of consensus-based standard default values has evolved over time.

**Risk Assessment**

Two examples of consensus-based approaches to risk assessment that explicitly examine worker exposure to soil are the Massachusetts Department of Environmental Protection’s Shortform risk assessment spreadsheets (construction worker scenario) and EPAs Regional Screening Level (RSL) calculator (composite worker scenario). Table 4 provides risk-based concentrations in soil that meet highly protective and moderately protective target risk criteria using these two approaches, by employing the default exposure assumptions built into each program. The lower of the two values for the ICR and HQ calculations is presented as the risk limiting value, with values based on ICR italicized. Within each program, values differ by a factor of 10 simply based on the same order of magnitude difference between the highly and moderately protective target risk criteria. Between the programs, however, risk-based values can differ substantially. Reasons for these differences vary among chemicals, but generically include:

- Choices of toxicity values, for example, whether ethylbenzene is treated as a carcinogen, or whether a reference dose is considered for lead;
- Critical exposure parameters such as the duration of exposure, which for the EPA composite worker is 25 years, but only 6 months for the Massachusetts construction worker; and
- Other differences in exposure assumptions and contaminant-specific parameters.

### Table 4. Risk-based concentrations in soils estimated for worker protection (mg/kg).1

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Highly Protective2</th>
<th>Moderately Protective2</th>
<th>Background</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ICR=1e-6, HQ=0.1</td>
<td>ICR=1e-5, HQ=1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MADEP Shortform3</td>
<td>EPA RSL</td>
<td>MADEP Shortform3</td>
</tr>
<tr>
<td>Arsenic</td>
<td>19</td>
<td>3.0</td>
<td>190</td>
</tr>
<tr>
<td>Benzene</td>
<td>600</td>
<td>5.1</td>
<td>6,000</td>
</tr>
<tr>
<td>Benzo(a)pyrene</td>
<td>30</td>
<td>2.1</td>
<td>300</td>
</tr>
<tr>
<td>Beryllium</td>
<td>42</td>
<td>230</td>
<td>420</td>
</tr>
<tr>
<td>Chromium (VI)4</td>
<td>310</td>
<td>6.3</td>
<td>3,100</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>3,100</td>
<td>25</td>
<td>31,000</td>
</tr>
<tr>
<td>Lead5</td>
<td>100</td>
<td>n/a</td>
<td>1,000</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>4,900</td>
<td>17</td>
<td>49,000</td>
</tr>
<tr>
<td>Toluene</td>
<td>49,000</td>
<td>4,700</td>
<td>490,000</td>
</tr>
<tr>
<td>Xylenes</td>
<td>24,000</td>
<td>250</td>
<td>240,000</td>
</tr>
<tr>
<td>Zinc</td>
<td>2,900</td>
<td>35,000</td>
<td>29,000</td>
</tr>
</tbody>
</table>

**Notes:**

1 All concentrations in mg/kg.
2 Italicized risk-based concentrations based on incremental cancer risk (ICR), otherwise the basis is the non-cancer hazard quotient (HQ).
3 Background levels have been published by the MA Department of Environmental Protection and represent upper percentile levels typically found in soils.
4 Background levels for chromium are not distinguished by valency. In most soils, chromium is present predominantly in the trivalent state (see the ATSDR toxicological profile for chromium, [https://www.atsdr.cdc.gov/toxprofiles/tp7-c6.pdf](https://www.atsdr.cdc.gov/toxprofiles/tp7-c6.pdf)), but the hexavalent fraction can be substantial in certain industrial wastes.
Insights from these two example approaches include:

• The importance of choices on exposure parameters and chemical toxicity values, which despite many years of effort to move toward consensus-based values, can still reflect programmatic and regional differences; and
• Some of the estimated risk-based concentrations are comparable to or lower than typical background levels found in uncontaminated soil (examples of which are included in Table 4; e.g., arsenic and benzo(a)pyrene). That is, the worker risk from handling contaminated soils may be no greater than if handling common soil.

Summary
In summary, contaminated soils are used as daily cover material at solid waste landfills nationally. While this is an important beneficial use of such contaminated materials, there are potential risks to the workers at landfills who are working with these soils. The protective nature of risk assessment methods and assumptions can lead to low limits on the concentrations of certain contaminants. Care should be taken to evaluate whether “off the shelf” risk-based concentrations for workers, such as EPA RSLs, are appropriate to apply directly to landfill workers. It may be desirable to modify default exposure assumptions to specifically consider how soils are handled and managed by workers, both in terms of frequency of contact, amounts typically contacted, and duration of exposure.

For example, if cover soils at a landfill are typically applied at the end of day, workers spend only a fraction of their time handling these soils relative to other tasks. In that case, the levels of assumed soil contact could be reduced/pro-rated to the fraction of time contaminated soils are handled during the workday. Also, to reconcile potential philosophical conflicts with OSHA regulations, target risk criteria could be raised to allow for a lessened, but still reasonable level of protection compared with public health-based criteria. For example, risk-based levels for workers could be derived based on the 100 per million upper limit of the Superfund incremental cancer risk range, and target hazard quotients could be raised above 1 in cases in which reference doses embody large safety factors.

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In Next Month’s Issue…

To Be Continued …

The April issue will continue on from this month’s theme with part two of our two-part series on sustainable waste management, looking at everything from contaminated sites to electric vehicle batteries.
Site-Redevelopment for Commercial Expansion
Using Plastic-Dome Forms for Aerated Floor Construction

A case study application of a new methane mitigation system used in the redevelopment of a former landfill site in Arizona.
The redevelopment of sites for commercial expansion sometimes requires that the new structures incorporate a soil gas mitigation system beneath the structure to prevent soil gases from intruding into the structure's interior. For example, when redeveloping a former landfill site, a sub-structure/slab mitigation system may be needed to vent residual landfill methane gas. Another example of when a sub-structure/slab mitigation system might be necessary is in locales where subsurface radon levels are high.

**Traditional Methane Mitigation Systems**

Traditional methane mitigation systems include sub-slab and raised-floor systems. Traditional sub-slab systems include a network of perforated/slotted horizontal pipes embedded in gravel under the floor to provide preferred pathways for soil gases to be collected and transferred through vertical pipes that discharge to the atmosphere above building rooftops. Geotextile may also be installed above gravel and then overlain by an impervious membrane to serve as a vapor barrier and impede upward movement of soil gases toward the concrete slab and building interior.

Traditional raised-floor systems include concrete piers and/or steel piles with beams and forms to create a floor system above the subgrade. A mechanical ventilation system, with inlet vents around the periphery of the building between the floor and subgrade, is then installed to exhaust subsurface air between the building foundation and raised floor to the atmosphere.

**Novel Mitigation System Using a Plastic-Dome Matrix**

An emerging, low-cost methane mitigation system uses a sub-slab matrix of thermoplastic, structural domes to provide improved sub-floor aeration and collection of soil gas beneath building floor slabs. This new plastic-dome matrix system is referred to by its commercial name, Cupolex, manufactured by Pontarolo Engineering (http://www.cupolex.com).

Aerated flooring systems using the new, plastic-dome matrix system are similar to raised-floor systems, but use structural thermoplastic domes made from recycled polypropylene to create a large void space beneath the building's first-floor concrete floor slab. This novel design results in minimal resistance to sub-slab airflow. Each structural dome interlocks with its neighbors to create a permanent self-supporting formwork and moisture barrier. The arch geometry of the plastic domes results in a sturdy foundation using less concrete volume and puts the concrete under compression instead of tension.

Compared to traditional perforated pipe and gravel methane mitigation systems, plastic-dome matrix systems typically use less concrete for floor slab completion and improve methane collection and venting by eliminating sub-slab gravel that impedes airflow in traditional systems. Compared to traditional raised-floor systems, plastic domes provide equal structural integrity and result in similar, but less expensive, large interconnected sub-slab void space.

Plastic-dome matrix forms can be used to accommodate a range of site conditions, including low-bearing capacity soils, expansive soils, predicted settlement, and bridging over utilities. These forms can be part of an effective system to mitigate soil gas containing methane, radon, and/or volatile organic compounds (VOCs).

**Testing and Inspection**

Testing for proper operation of plastic-dome matrix active-mitigation systems can be evaluated by simple measurements of the vent riser vacuum levels and airflow rates, whereas traditional mitigation systems may require vacuum field extension tests, which are more complex. Prior to pouring the concrete floor slab over the mitigation system, the elements of the aeration system normally require formal inspection.

For inspection, plastic-dome matrix systems include three elements that must be evaluated prior to concrete placement (the subgrade, the plastic-dome forms, and steel reinforcement). By contrast, traditional sub-slab systems include inspection of at least six elements (the subgrade, perforated/slotted pipe, gravel quality and placement, sand/geotextile quality and placement, impermeable membrane installation, and steel reinforcement).

**Installation**

Aerated flooring system materials using the plastic-dome matrix system are manufactured to ISO 9001:2000 standards and can be installed by hand with high cost-efficiency. On average, two laborers can set 1,500 square feet of these forms in approximately one hour. One pallet of delivered, plastic-dome forms can replace the transport of approximately seven trucks of gravel or fill to perform mitigation of the same coverage area. Based on project magnitude, using the plastic-dome forms instead of hauling gravel and fill can also greatly reduce on-site construction related traffic. After plastic-dome forms have been installed, steel reinforcement is placed directly on the forms, and, after the system has been inspected, a concrete floor slab is poured and conventionally finished.

The under-slab void space created by the plastic-dome formwork can also provide options for utility, conduit, and pipe installation resulting in faster and more cost-effective construction. Plastic-dome matrix systems can be used to create temporary stormwater detention storage volume
beneath development streets and sidewalks for storm water management. Using plastic-dome elements as part of building construction can also help activate and assign credits to U.S. Green Building Council Leadership in Energy and Environmental Design (LEED)-certified buildings.

**Case Study: Plastic-Dome Matrix Aeration System in Arizona**

Expanding business in fast-growing cities has led to unique site selections for commercial development in order to match consumer demand. In Tempe, AZ, for example, a former industrial parcel and landfill near the intersection of Highway Loops 101 and 202 is now an expanding multi-million-dollar shopping, restaurant, and entertainment center.

As with most former landfill sites containing municipal, agricultural, industrial, and construction wastes, the site in Tempe includes large tracts of land that are underutilized and are, therefore, attractive for commercial redevelopment. Besides being cost-effective, reuse of the former landfill also reduces development pressure on nearby undeveloped property. Development challenges at the former landfill include the management and remediation of fluids and/or gases from contaminated soils and the potential for subsidence as subsurface waste decomposes.

At the site in Tempe, significant soil cleanup was performed by removing contaminated soils as part of site remediation. Field investigation results nevertheless indicate the remaining soils can emit low concentrations of methane, requiring developers to implement mitigation systems to prevent methane intrusion into new structures being developed on-site. Instead of traditional mitigation systems, new developments at the entertainment center in Tempe are opting to use new plastic-dome matrix technology to control methane mitigation.

A new 20,000-square-foot building at the site includes a plastic-dome matrix beneath the west and central portions of the building, and a traditional gravel layer beneath the east foundation of the building. Vacuum test results at this building allow air pressure losses and sub-slab air exchange rates for aerated floor and traditional mitigation systems to be compared. A radon fan was temporarily installed on a central riser pipe (RP-1) while all other riser pipes and inlets were capped. Airflow was measured at RP-1 and vacuum was measured at all locations. The air inlet pipes were then uncapped and their flow rates measured. Comparative results are presented in Table 1, demonstrating the better air flow performance of the sub-floor plastic-dome matrix system over the traditional, sub-floor gravel layer.

Air inlets IP-7 and IP-8 installed in the gravel bed on the east side of the building have significantly lower vacuum levels than the plastic-dome matrix aerated-floor inlets (IP-1 through IP-6), indicating greater airflow resistance through the gravel bed than through the plastic-dome matrix’s void space. Flow measurements with each inlet uncapped indicate the inlet pipes installed in the gravel bed area (IP-7 and IP-8) have, as expected, lower airflow than the aerated floor inlets.

**Post-Tensioned Slabs**

One-way and two-way post-tensioned floor slabs are frequently used (often with piers or piles) for lower-bearing capacity soils, to bridge over weak areas, or areas expected to be prone to settlement. Traditional grade beam construction divides the building sub-slab into many isolated areas that are complex to vent. Post-tensioned slabs having large, easily

<table>
<thead>
<tr>
<th>Pipe Description</th>
<th>Building Location</th>
<th>Vacuum (in.)</th>
<th>Flow Rates (cfm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RP-1</td>
<td>Central</td>
<td>-1.525</td>
<td>288.85</td>
</tr>
<tr>
<td>RP-2</td>
<td>Central</td>
<td>-0.210</td>
<td>closed</td>
</tr>
<tr>
<td>IP-1</td>
<td>West</td>
<td>-0.166</td>
<td>35.34</td>
</tr>
<tr>
<td>IP-2</td>
<td>West</td>
<td>-0.162</td>
<td>54.98</td>
</tr>
<tr>
<td>IP-3</td>
<td>Central</td>
<td>-0.165</td>
<td>71.12</td>
</tr>
<tr>
<td>IP-4</td>
<td>Central</td>
<td>-0.120</td>
<td>50.61</td>
</tr>
<tr>
<td>IP-5</td>
<td>Central</td>
<td>-0.123</td>
<td>54.54</td>
</tr>
<tr>
<td>IP-6</td>
<td>Central</td>
<td>-0.107</td>
<td>44.94</td>
</tr>
<tr>
<td>IP-7</td>
<td>East</td>
<td>-0.064</td>
<td>9.16</td>
</tr>
<tr>
<td>IP-8</td>
<td>East</td>
<td>-0.050</td>
<td>no measured flow</td>
</tr>
</tbody>
</table>

Note: 1Vacuum measurement in inches water column, a non-SI unit for pressure measurement.
ventilated, sub-slab void space for soil gas mitigation can be easily constructed by combining the Cupolex plastic-dome forms with another recycled thermoplastic element from the same manufacturer, called Pontex. Pontex is used in slab design as a reinforced internal rib to create one or two directional structural slabs. The channels thus created provide support of post-tensioning cables, as shown in the photo of the framework used for a methane mitigation system in Colorado on the first page of this article.

Conclusion
Commercial site redevelopers facing the challenge of sub-surface migration of gases, such as methane, radon, and VOCs can benefit from site redevelopment incorporating a new plastic-dome matrix technology (Cupolex) as an effective, efficient, and “green” engineering control method for those gases. Specific attributes of the plastic-dome matrix technology for mitigation of sub-surface methane and other gases include: ease of system assembly, sustainable component manufacture from recycled thermoplastic, increased aeration efficiency over traditional gravel sub-slab systems, cost-effective construction, reduced long-term operating costs, simpler construction inspections, and simpler operational testing methods. In addition, with the plastic-dome matrix system, the sub-slab aeration space can, in appropriate settings, serve as a reservoir for stormwater management.

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Disclaimer:
The authors and their organization have no affiliation with neither the technology supplier company Pontarolo Engineering nor the Cupolex product.
Waste Management
A Key Player for Improving Sustainability of the Food–Energy–Water Nexus

The Food–Energy–Water (FEW) nexus refers to the inextricable linkage that exists among the food, energy, and water sectors. Improvement in one sector (e.g., reducing the use of synthetic fertilizers for crop growth) may lead to positive sustainability influences on the other two sectors (e.g., reduced energy consumption for fertilizer manufacturing and reduced water consumption for energy production). The rising interest in resource recovery from waste streams has created an opportunity for waste management to play an important role in improving the sustainability of the FEW nexus. This article spotlights important research progress, as well as commercial cases that demonstrate how a positive synergism can take place between the recovery/re-use of waste materials and the FEW nexus.
Understanding the FEW Nexus

Food, energy, and water are indispensable for sustaining human activities. Historically, the issues that emerged in these three sectors were treated separately; however, the interdependence among the sectors has called for a nexus approach to understand the potential synergies and trade-offs in order to make informed decisions. Figure 1 shows an illustrative causal-loop diagram of the FEW nexus. The component “food production” here is defined collectively as the production of both agricultural products (e.g., crops and livestock) and the processed food products (e.g., grocery and restaurant food) from these agricultural products. The increase in food consumption is met by the rise in food production, through increased application of fertilizers. Both food production and food consumption also generate food waste. The water scarcity is driven by both increased water withdrawal and water quality deterioration associated with the rise in water use. Similarly, fossil resource extraction for energy production increases with the demand on energy from the food and water sectors.

In addition to interactions within individual FEW sectors, feedback loops also exist between FEW sectors. For example, the increase in fertilizer production (from the rising demand in food consumption) affects both energy use and fossil resource extraction directly, which, in turn, leads to more water use (e.g., cooling water for electricity production) and water contamination. Consequently, the water scarcity situation may be exacerbated, which may negatively impact the potential for food production, reducing the nexus’s capacity to satisfy the increasing demand in food consumption in the future. These internal and external sector interactions constitute the dynamics of the FEW nexus, indicating both challenges and opportunities for improving the sustainability of the nexus.

The major challenge is to ensure that the synergies from technology change (e.g., a large-scale deployment of a new technology) will outweigh the trade-offs among FEW sectors. For instance, encouraging crop-based biofuel production may lead to synergistic benefits for both food production and energy supply; however, increased demand on irrigation water may impose stress on water availability. On the other hand, opportunities reside in resource recovery to upcycle wastewater from waste streams and to offset the demand on fossil resource for the production of energy and products. Figure 2 shows a scheme where the production of fertilizers

Figure 1. A causal-loop diagram for the FEW nexus.

Note: The “+” sign indicates an enhancing relationship, while the “−” sign indicates the opposite.
and energy from fossil resources can be offset by introducing the waste-to-energy and waste-to-products components into the FEW nexus.

Role of Waste Management

There is an ample body of research on converting food waste to energy through anaerobic digestion (AD), a process during which microorganisms break down organic waste in the absence of oxygen. The biogas generated from AD typically contains a concentration of methane that can be used as a fuel for electricity and heat generation. In addition to electricity and heat, organic wastes such as fat, oil, and grease (FOG) could also be converted into transportation fuel (e.g., biodiesel) to replace petroleum-based diesel.

Although waste cooking oil has been extensively studied and has become a regular feedstock for commercial biodiesel production, other types of waste FOG are less utilized. Grease trap waste from restaurants and other food establishments, for example, has the potential to complement the U.S. biodiesel market with up to 390 million gallons in 2016. Besides fuel supply, reduced greenhouse gas (GHG) emission is an additional benefit of converting grease trap waste to biodiesel.

The major challenge constraining the large-scale utilization of grease trap waste is its highly heterogeneous composition, which necessitates the development of cost-effective pretreatment technologies.

Similarly, the residual coffee oil in spent coffee grounds is another potentially considerable feedstock for biodiesel; however, logistics are the major challenge for utilizing spent coffee grounds. The logistics of collecting and storing spent coffee grounds to enable their reuse in fuel production are not economically viable at present.

Another example of how waste management can improve...
the sustainability of the FEW nexus is in the area of wastewater management. The elevated concentrations of nitrogen (N) and phosphorus (P) in contaminated wastewater represent an opportunity for resource recovery and reuse to offset both energy generation and product manufacturing from fossil resources.\textsuperscript{9} One highly relevant research topic is the cultivation of microalgae in nutrient-rich (i.e., N and P) wastewater for bioenergy and bioproduct production.\textsuperscript{10} Microalgae consume the nutrients as well as organic carbon from the wastewater while accumulating lipids (fats), carbohydrates, proteins, pigments, and other valuable substances that can potentially displace fossil-based counterparts.\textsuperscript{11} The algal lipids can be converted to biodiesel and the defatted algae can be used as an animal feed additive or digested for biogas (and hence energy) generation.

**Commercial Application of Waste Management Technologies**

With the increasingly stringent regulations on food waste disposal in many cities and states, anaerobic digestion has become one of the preferred options for food waste treatment, with the resulting biogas then used for energy generation. There are an estimated 216 Water Resource Recovery Facilities (WRRFs) in the United States that accept food waste for co-digestion with sewage sludge. From the WRRFs that responded to a U.S. Environmental Protection Agency (EPA) survey on “food waste-to-energy,” it was concluded that although there are challenges associated with co-digestion, the benefits of energy generation and cost savings outweigh the difficulties.\textsuperscript{12}

The grease trap waste from slaughterhouses may be a viable feedstock for biodiesel production because it has a relatively consistent and high grease concentration. For example, Natural Fiber Technologies (http://www.natural.center) has started the preparation of a pilot-scale grease-recovery and on-site biodiesel production facility at a slaughterhouse in New Zealand. The pilot facility is expected to process about 315 million liters of grease trap waste and the annual biodiesel production will be approximately 1 million kilograms (~1.1 million liters).

A screening-level life cycle assessment shows that biodiesel produced from this system can have a low global warming potential (0.51–0.77 kg CO\textsubscript{2}-eq/kg biodiesel) and a high “energy return on energy invested” factor (EROI=2.7–3.9). There are 650 federally inspected cattle slaughterhouses in the United States, plus poultry and pork slaughterhouses, which represents a significant source of grease trap waste for biodiesel production in the United States.\textsuperscript{13}

Besides fuel production, technologies for recovering agricultural nutrients such as phosphorus and nitrogen (as ammonia) from waste have also been implemented at commercial scale. The Durham Advanced Wastewater Treatment Facility, operated by Clean Water Services (CWS) (http://cleanwaterservices.org/) in suburban Portland, OR, treats on average 26 million gallons per day of wastewater and has a phosphorus discharge limit of 0.11 mg/L total phosphorus based on a monthly median value. To meet the stringent effluent phosphorus limit, Durham relies on biological phosphorus removal (BPR) and tertiary chemical phosphorus removal.

In 2009, CWS worked with Ostara Nutrient Recovery Technologies (http://www.ostara.com) to install North America’s first commercial nutrient recovery facility. Opened in 2009, the facility simplifies the treatment process by directly removing and recovering phosphorus and ammonia from wastewater that would otherwise have to be retreated. In 2011, the “Waste Activated Sludge Stripping to Remove Internal Phosphorus” (WASSTRIP) process was invented by CWS and implemented full scale. The WASSTRIP process causes biological phosphorus release prior to organic solids (biosolids) digestion, which increases recoverable phosphorus and also improves operation of the treatment plant by reducing struvite (mineral crystal) formation in the digesters and downstream solids handling processes, and by enhancing biosolids dewaterability. The simultaneous improvement of the wastewater treatment process and nutrient recovery will improve water quality, while reducing the energy use and carbon emission from the levels that would ordinarily be experienced with the standard production of fertilizer from fossil resources.

**Opportunities reside in resource recovery to upcycle wastewater from waste streams and to offset the demand on fossil resource for the production of energy and products.**
Summary
The FEW nexus refers to the inextricable linkage that exists among the food, energy, and water sectors. An improvement in one sector may lead to positive sustainability influences on the other two sectors. Waste management can play an important role in the development and sustainability of the FEW nexus, when the recovery/re-use of waste materials is strategically integrated within the nexus. In particular, the recovery of energy and products from a number of waste types has been demonstrated to have positive synergies throughout the FEW nexus. With continuing research and development efforts and the engagement of industrial sectors, a triple bottom line improvement is expected for key stakeholders of the FEW nexus.

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A team of EPA researchers recently traveled to the Flint Hills region of Kansas to take air measurements during prescribed burns of prairie land that will be used to better determine the impact of smoke in nearby communities.

Central Kansas is home to the largest remaining tallgrass prairie in North America with five million acres in Kansas and portions of Nebraska and Oklahoma. Fires were once a natural occurrence, but now they are intentionally set during prescribed burns, primarily in the spring. The fires burn the invasive plants and rejuvenate the soil, which encourages growth of native grasses. This, in turn, benefits farmers and ranchers who graze cattle and bison on the land. However, the downside is that smoke plumes can contribute significantly to air pollution in nearby communities and farther downwind, sometimes as far as the East Coast, particularly when burning is concentrated during the short spring season.

U.S. Environmental Protection Agency (EPA) researchers are supporting best smoke management practices for prescribed burns of prairies to reduce the impact of smoke in nearby communities and those much farther away. Last November, the research team traveled to the rolling prairies of Flint Hills, KS, to take air measurements during the planned fires using a novel air sampling system developed in the laboratory. Researchers had previously visited the area in March 2017 during the traditional peak burn season to take air samples. They will use the two data sets to see if there are any differences in smoke plume emissions from spring and fall.
“This effort used the latest advances in open fire emissions sampling technology to assist the state’s agricultural and environmental interests,” says Brian Gullett, lead scientist for the study.

Smoke from prescribed burning contains air pollutants—notably particles—that can impact health. During burns, air pollution levels can sometimes exceed federal limits. People who are most vulnerable to these pollutants, such as those with lung and heart problems, are at greater health risk. The smoke can also cause the general population to experience irritation of the eyes, nose, and throat and cause visibility problems.

The Flint Hills study is providing air emissions data needed to better predict the best times, locations, and conditions to burn. To get measurements in the smoke plume, researchers use both ground-based and aerial sampling systems to measure levels of particulate matter (PM), black and brown carbon, and volatile organic chemicals (VOCs), as well as impacted background ozone levels.

These data will provide information specific to the Flint Hills region for prescribed grassland burning that can be used in models to better predict where smoke plumes will go and how much pollution may disperse downwind and impact communities. Better forecasts of smoke impacts will allow for better selection of days to do burning and better modeling tools will allow for more sophisticated understanding of regional pollution impacts from these types of burns.

“It takes broad partnerships, from ranchers and researchers to downwind-communities and regulators, to understand the benefits and challenges associated with the complex practice of the management of five million acres of tallgrass prairie in our nation’s heartland,” says Josh Tapp, Deputy Director for the Environmental Sciences and Technology Division in EPA’s Region 7 Office in Kansas City. “It is through these Flint Hills partnerships that common-sense practices can be refined and implemented to ensure the protection of public health while promoting sustainable agriculture and protecting an endangered ecosystem.”

Open Burn Research Program
The Flint Hills project is one of several open burn studies conducted in the field and at EPAs laboratories over the past 15 years by EPAs Office of Research and Development. Not only has the research expanded knowledge of emissions from prescribed forest burns and agricultural field burns, it has assisted in characterizing emissions from other sources of...
Researchers used the technology to provide air quality data during the Deepwater Horizon oil spill in the Gulf of Mexico in 2010. Another project involved sampling emissions from simulated overseas military burn pits for the U.S. Air Force, and others were conducted to characterize emissions from open burning and open detonation during demilitarization operations for the U.S. Department of Defense.

There are a number of challenges researchers must overcome in order to efficiently and safely sample smoke plumes to characterize emissions. These include: getting into the plume, having the correct equipment to measure every pollutant of interest, ensuring sample quality, and minimizing the proximity hazards for people and equipment especially when dealing with fires.

**The Flyer**

To overcome these obstacles, EPA researchers have designed a variety of air emission samplers and modified commercially bought sensors to fit specialized needs in burn emission sampling. One of these is the aerial sampling system called the Flyer, which was used in the Flint Hills study. This system, developed by Dr. Gullett and his team, enables researchers to safely sample the chemical composition of smoke plumes. The instrument platform, attached to a 16-foot-diameter, helium-filled balloon (aerostat), includes interchangeable sampling instruments that allow for continuous and batch measurement of particles, light carbon gases, metals, volatile and semi-volatile organics, temperature, global positioning, and others. An on-board computer system allows for wireless control of the samplers and data transfer to the ground.

**Kolibri**

Another sampler used in the study is the Kolibri, a lightweight air sampler that weighs up to eight pounds and can be used on an unmanned aerial system (UAS, or drone) to measure emissions. EPA has placed its Kolibri system on UASs owned and operated by other agencies to provide data for the U.S. Department of Defense and others. Its advantage over the Flyer is in its freedom of positioning in a manner and speed not possible with the tethered aerostats. The Kolibri is controlled by a microcontroller, which can record and transfer data in real time through a radio module. The Kolibri can also measure and sample a broad variety of compounds. Due to its dynamic sensor response, the Kolibri system can be applied to various challenging open area scenarios such as fires, lagoons, flares, and landfills as well as forest and agricultural burns.

Results from these studies using this innovative technology have been published in leading scientific journals and are being used to improve the science of open burning characterization. The findings are also being used by EPA and states in burning plans in an effort to minimize potential health impacts.

**More Information**

A list of EPA journal articles is available on the Wildland Fire Research (https://www.epa.gov/air-research/epa-wildland-fire-research-publications-2010-2016) page.

Learn more about EPA’s Wildland Fire Research (https://www.epa.gov/air-research/wildland-fire-research-protect-health-and-environment).

For more information on the research discussed in this column, contact Ann Brown, U.S. Environmental Protection Agency (EPA), Office of Research and Development, Research Triangle Park, NC; phone: 1-919-541-7818; e-mail: brown.ann@epa.gov.
As environment, health, and safety (EH&S) project managers, we work in a world of changing priorities and schedules as regulations evolve, business objectives change, and stakeholder requirements play out as projects proceed. To address changing priorities and schedules, we’re tempted to “multitask,” believing that we can accomplish multiple objectives simultaneously. Although some may claim they are effective at multitasking, most managers will agree that challenging tasks are best accomplished by a focused effort. On the other hand, the completion of multiple tasks in parallel by multiple individuals or teams can be an effective way to meet project objectives. In fact, project scheduling approaches that incorporate Gantt charts and critical path methodology typically reflect the parallel completion of tasks (see Keeping on Schedule, Part 1 (http://pubs.awma.org/flip/EM-Jan-2009/pmfile.pdf), EM January 2009; and Keeping on Schedule, Part 2 (http://pubs.awma.org/flip/EM-Mar-2009/pmfile.pdf), EM March 2009). These scheduling tools illustrate the importance of order and sequence when executing project tasks.

**Order and Sequencing**

by David Elam

Structured project activity sequencing and planning supports project execution flexibility.
The Project Management Institute’s Project Management Body of Knowledge (PMBOK Guide; Sixth Edition, 2017) speaks to the importance of order when planning projects. For example, the cost estimating and project budgeting tasks come after the sequential completion of the following tasks:

1. **Define Project Activities.** Identify and describe the activities required to complete the project scope of work.

2. **Sequence Project Activities.** Order the project activities to satisfy the scope of work. Note that the order of activities required to satisfy the scope of work may be different from the most efficient sequence.

3. **Estimate Resource Requirements for Activities.** Determine the personnel and equipment resources needed to complete each project activity and where those resources must be stationed to support the project activity.

4. **Estimate Duration for Activities.** Determine how long the personnel and equipment will be required for each project activity.

5. **Develop the Project Schedule.** Establish the project schedule once the scope, sequence, resource requirements, and duration for each activity are defined.

This sequential approach to developing the project cost estimate and budget forms the basis for project planning. This doesn’t mean that priorities and schedules cannot change during the execution of the project. In fact, this project planning approach guides informed decisions when project priorities and schedules must change to meet evolving business objectives. For example, if we built the project budget and schedule based on completion of a task by a mid-level engineer working 40 hours and discover that the candidate mid-level engineer has been delayed on other project work, we can evaluate the impact on budget and schedule if staffing changes are required. The change in personnel may require more calendar days to complete the project or necessitate paying overtime to keep the project on schedule; as a result, the cost for this task may be higher than originally planned. We have a baseline for comparison, we can present the information to the project owner, and the project owner can then decide if the change is consistent with business needs.

I was recently reminded of the importance of activity sequencing during the completion of a training program project. We developed the project budget using the sequential approach described above. Shortly after the project was authorized, the training program manager compressed the project schedule by one month, changed the training location, and required an onsite review meeting instead of a web-based review meeting. There was no question that the addition of the onsite review meeting resulted in additional costs; however, the training manager did not understand why the change in schedule and training location would affect project costs. After all, he reasoned, the preparation work would be the same and the training team was going to have to travel somewhere anyway. How could these changes have a significant effect on the project costs?

Fortunately, our structured approach to project budget development and scheduling allowed us to show how the compressed schedule would require additional staff and oversight to complete content development by the new date. While we would be able to complete the work by relying on parallel preparation efforts, those efforts would require direction, oversight, and review that had not been anticipated in the initial planning stages. Although the travel costs for personnel at the new venue were essentially identical to the original plan, there were significant differences in transporting the equipment required for the training program exercises. Again, our structured and disciplined approach enabled us to show how we had developed the original budget and how that budget was impacted by the mobilization of support equipment to the new location.

In short, the sequencing of project activities is essential to the development of accurate and defensible project budgets and schedules. Further, the sequence of tasks developed during the budgeting and planning stages must be carried through to the project execution stage to achieve the project’s technical and financial objectives. Perhaps most important, the discipline of project activity sequencing during project planning does not limit our options during the execution stage. Instead, the discipline of project activity sequencing allows us to inform decisions when changes in project objectives or schedules are requested.

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In November 2017, the U.S. Environmental Protection Agency (EPA) announced a proposal to repeal Obama-era regulations, which took effect in January 2018 pertaining to greenhouse gas (GHG) emissions and fuel efficiency standards for heavy-duty glider vehicles, glider engines, and glider kits. The term “glider” refers to a special subset of the heavy-duty on-road trucks (e.g., tractor semi-trailer vehicles) that are ubiquitous on highways across the United States. Specifically, gliders are trucks with new body parts (including such things as the truck frame and cab) that are mated with “used” powertrain components (including the engine, transmission, and oftentimes the rear axle).
Glider trucks are sought out by trucking companies of all sizes due to their significantly lower prices (as compared to similar “new” trucks). Glider trucks are also favored due to the relative ease of servicing their older engines, which often have fewer complicated electronic components subject to failure. Additionally, older gliders are frequently exempted from new vehicle safety regulations that can increase operating costs. In December 2017, for example, the Federal Motor Carrier Safety Administration began requiring the use of electronic logging devices to automatically log hours driven and miles traveled (to combat driver fatigue). Trucks manufactured before the 2000 model-year—including many gliders—are exempted from compliance with these new electronic logging device regulations.

To potentially compound their perceived environmental problems, gliders are increasing rather than decreasing in popularity. Gliders avoided regulation by EPA until late in the Obama Administration in large part due to their relatively small share of the heavy-duty truck market. Gliders saw a tenfold uptick in sales in the past decade, however. Sales of glider kits grew from approximately 1,000 trucks in 2007 to about 10,000 trucks sold in 2015.

The air impact of 10,000 glider trucks could be much more than meets the eye. EPA under the Obama Administration estimated that 10,000 pre-2010 glider trucks emit GHGs at a rate 20 times greater than more environmentally friendly model-year 2010 engines. By that same measure, gliders emit 10 times more NOx than model-year 2010 engines. All of this comes at a time when air emissions from mobile sources have become a greater concern, as mobile source emissions have surpassed stationary source emissions from electric utilities as the single greatest contributor to air pollution in the United States according to the Energy Information Administration.

While some view EPA’s plans to repeal new glider regulations as a continuation of the Trump Administration’s attack on perceived Obama-era regulatory overreach, EPA’s basis for the proposed repeal of the glider rules appears to be rooted in a sound and defensible legal argument. Simply stated, EPA is now taking the position that it lacks authority under the Clean Air Act to regulate gliders because gliders are not “new motor vehicles”, and gliders are not powered by “new motor vehicle engines”.

The agency’s argument is that, under Section 202 of the Clean Air Act (42 U.S.C. §7521), EPA was granted the authority to prescribe emission standards for “new motor vehicles” and/or “new motor vehicle engines”. Section 216 of the Clean Air Act (42 U.S.C. §7550) defines “new motor vehicle” and “new motor vehicle engine” to mean vehicles and/or engines that have never had their titles transferred to an ultimate purchaser. Because glider powertrains (engines, transmissions, and rear axles) have all been part of previously titled vehicles, EPA now asserts that gliders are not “new motor vehicles” subject to agency regulation under Section 202 of the Clean Air Act.

The public comment period for EPA’s proposed action ended on January 5, 2018. At this writing, it was unclear when EPA would seek to finalize its repeal of the glider regulations. Like many other EPA actions since President Trump took office in January 2017, expect the agency’s repeal to be met with legal challenges. Here, such challenges could come from environmental groups, various trucking industry groups, and new truck manufacturers. Intervenors on EPA’s behalf might include Detractors of gliders include environmentalists, the American Lung Association, and (perhaps not surprisingly) manufacturers of new trucks who stand to lose market share when gliders are purchased in lieu of newly manufactured trucks. Those who support stricter regulation of glider air emissions argue that older glider engines emit more air contaminants and/or are less fuel efficient than newer model-year engines. Glider-related air emissions concerns include not just GHGs like carbon dioxide (CO2), but also U.S. Clean Air Act criteria pollutants such as oxides of nitrogen (NOx) and particulate matter (PM).
small trucking businesses, small and large farms (who frequently use glider vehicles), and glider manufacturers themselves. For its part, EPA has already laid some of the groundwork for its eventual defense—preemptively citing case law in its proposed regulation in support of the agency’s “inherent authority to reconsider, revise, or repeal past decisions” provided such action is supported by “a reasoned explanation”.

In contrast to some of its early 2017 efforts to repeal and/or delay Obama-era regulations, EPA’s glider-related efforts may have a greater chance of surviving legal challenges. Recall, for example, a legal defeat suffered by the agency in mid-2017 in connection with its efforts to delay implementation of Obama-era New Source Performance Standards pertaining to methane emissions from oil and gas facilities. There, the agency relied on a much shakier legal argument under the Clean Air Act in an effort to justify a stay of implementation (to allow for a more time consuming repeal effort). Several environmental groups appealed, and EPA lost in the U.S. Court of Appeals for the D.C. Circuit. Ultimately, the Court found EPA’s “broad discretion” to reconsider previously adopted rules to be much less broad than the agency first thought.

As EPA continues to look for opportunities to roll-back Obama-era regulations, the agency’s efforts to repeal increased regulation of glider trucks begs the question: What other mobile source standards might find themselves subject to a fresh look from EPA? Could we see a change in emission standards for locomotives, locomotive engines, and/or heavy equipment (especially in light of the Trump Administration’s stated goal of funding a major infrastructure initiative)? What about nonroad and small engines for lawn mowers, chainsaws, and generators (all of which are used by individuals and small businesses alike)? Finally, if regulatory changes are made, how worried do manufacturers and regulated entities need to be about the possibility of another complete reversal of environmental policy in 2020 or 2024?

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In Memoriam

Joseph E. Padgett (1926–2017)

Past-President Joseph (Joe) E. Padgett passed away on December 13, 2017, in Raleigh, NC. He was 91.

After serving in the U.S. Navy at the end of World War II (1944–1945), Padgett received a bachelor’s degree in mechanical engineering from Johns Hopkins University in 1948 and a master’s degree in mechanical engineering from Caltech in 1951. Upon graduating from Johns Hopkins University, he went to work for Westinghouse in Philadelphia, PA (1948–1954), designing jet engines, and while there, he met Teel Dunn of Swarthmore. They were married in 1953.


In 1971, Padgett joined the U.S. Environmental Protection Agency (EPA) in Durham, NC, as chief of systems analysis staff. The following year, he became director of the Strategies and Air Standards Division, where he and his division were heavily involved in development of the U.S. Clean Air Act.

He was a licensed professional engineer in Ohio, a diplomat of the American Academy of Environmental Engineers, and holder of several U.S. patents (including, ice detector, air motor actuator, and gas generator).


Following his retirement from EPA in 1995, Padgett was active in the National Association of Retired Federal Employees (NARFE), serving two terms as president of the Raleigh chapter. He is survived by his three children Jay, David, and Judy, and seven grandchildren.
Navigating the choppy waters of a career in the environmental industry. While certain aspects will be outside of your control, there are steps you can take to better manage your career.

I have been working as an environmental consultant for nearly 10 years. Sixteen months ago, I sold the President of a prominent CEMS company on the idea of starting an Air Permitting Group. From Day 1, well really Day -32, this project was my baby. I was responsible for every aspect of getting the division off of the ground. This involved designing the website and writing all of the content, doing all of the business development work, developing collaborations with other firms, hunting for promising request for proposals (RFPs), cold-calling until my fingers hurt, and completing all of the technical work that came in. I accomplished quite a bit in a relatively short period of time. I am quite proud of my work during this time, but sadly, now it is over. My bosses had to make a tough call and shift funding from my project to take care of a backlog in another division. I give you this background to emphasize the fact that sometimes certain aspects are outside of your control. It’s no one’s fault, it’s business, it happens. In fact, it wasn’t the first time that I’d gone through this.

My first job in this field was with a boutique consulting firm in New Jersey. The office was myself, an eager kid who knew little about environmental regulation, a scientist working from home, and my boss, an expert with over 45 years of consulting experience. I was lucky to learn from this man for eight years. I started out with simple tasks and eventually built up to be
point-person for a number of clients. Then came the plateau. I was hit by the vivid realization that I had reached as high as I could within that company. We all get there at some point. You want to advance, earn more, and challenge yourself, but that opportunity may not be with your current company. If you are following me so far and have felt the same sentiments, then it is likely time to move on. How do you do it?

No pressure. It’s a difficult part of anyone’s career, but not uncommon. As you can expect, the first emotions that run through your head at a time like this are a combination of fear and uncertainty. You know that you have strong experience and good contacts, but sometimes that just is not enough. There are times when you need to make things happen. You need to decide how much of a “reach” you’ll try for with your next position. The perfect fit job is nearly impossible to find when you need it. The company may not need new hires at that level at that time. Do some homework, and make a list of a half-dozen companies you’d love to work for, then send a resume to their head of HR. If they see talent, often they will open up a slot for you.

When looking to make a change, my philosophy has always been to try and challenge myself a bit, to grow from my comfort zone. If you are doing this properly, looking back on your career, you should be able to tell yourself that each job, each step in life, was for a purpose, and that without each step you could not have attained the end result. Perform an objective review of your skills and expertise. You should be looking to take a bit of a risk with your next move. Perhaps that means taking on more of a leadership role or a specialist in a skill that you know well. Here are a few basic guidelines to help you along the way.

First, you never want to burn bridges. Your boss will likely be a valuable resource for you going forward as a reference and potential future contact. Always give at least two weeks’ notice and finish any open work before moving on. If you are unsure of how to proceed, and are on good terms with your employer, you may want to speak with them. If you have been a good worker for them they will likely be honest with you about potential opportunities with the company and ways forward for you elsewhere. Your next job opportunity may be with a former client or through their recommendation.

It’s a bit cliché, but good help is really hard to find. If you have proven yourself to be an eager, diligent worker, looking to learn more, someone will find you. Do good work, always introduce yourself to new industry contacts, and be open to opportunities. Above all, do not be afraid to take a risk, trust yourself, and always try and push a bit out of your comfort zone. Good luck.
Getting to Know

A&WMA’s Organizational Members

On this page you will find the company profiles of a randomly selected grouping of Organizational Members. A&WMA thanks you—and all of our current Organization Members—for your continued support of this Association.

Bay Area Air Quality Management District
(http://www.baaqmd.gov) is a proud member of A&WMA. Since 1955, the Air District has been the public agency responsible for protecting air quality in the nine counties that surround San Francisco Bay: Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, southwestern Solano, and southern Sonoma counties.

Air District programs monitor air emissions sources, promote climate protection, provide clean air grants, draft rules, and regulate stationary air pollution sources. The Air District’s mission is to protect and improve public health, air quality, and the global climate. The Air District encourages the public to reduce their polluting behavior through the Spare the Air program.

Communities are fundamental; whether around the corner or across the globe, communities provide a foundation, a sense of place and of belonging. That’s why at Stantec (http://www.stantec.com/en/services/atmospheric-science) we always design with community in mind. We care about the communities we serve—because they’re our communities too. This allows us to assess what’s needed and connect our expertise, to appreciate nuances and, to envision what’s never been considered, and bring together diverse perspectives, so we can collaborate toward a shared success. The Stantec community unites approximately 22,000 employees working in over 400 locations across 6 continents.

Our atmospheric science professionals have a proven record of delivering services for all of your project needs. Educated in natural sciences and experts in the latest regulatory and permitting compliance, our engineers, scientists, and data analysts go beyond the common approach to develop results for you. We have experience in air quality, acoustics, noise, vibration, climate change, greenhouse gases, odor, and lighting. As you develop your plans for growth, we’ll work with you to merge strategies for environmental risk management into your project.

Send Us Your Information
If you are a current Organizational Member and would like your company profile to be included in a future issue of EM, please contact Lisa Bucher, Managing Editor at lbucher@awma.org.

Consider Upgrading to Organizational Membership
Organizational Membership is the perfect solution for companies and organizations with six or more environmental professionals on staff who want to reduce membership costs and increase their participation in A&WMA. For more information, go to www.awma.org/join.

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