Preliminary Investigation (PI-0322)

Caltrans Division of Research, Innovation and System Information

Performance of Compost-Based Best Management Practices in Water Quality Protection

Requested by
Scott Blair, Division of Design

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Executive Summary

Background

In recent years, California water bodies have been severely impaired as a result of activities that degrade the soil and release contaminants in stormwater runoff. Erosion control best management practices (BMPs) have been used to help prevent the contamination of water resources.

The California Department of Transportation (Caltrans) has identified the need for more practices and products that can be utilized to protect California's water resources. Compost-based BMPs, such as compost filter socks, compost berms and compost blankets, may assist in Caltrans' efforts to prevent further contamination of water resources by filtering runoff to capture various contaminants.

To assist Caltrans with its review, CTC & Associates conducted a national survey of state departments of transportation (DOTs) to inquire about the use of compost-based BMPs and assessment of their performance in filtering contaminants to protect water quality. Results of a literature search and consultations with selected experts supplemented survey findings.

Summary of Findings

Survey of Practice

A national survey of state DOTs solicited feedback from the members of three Transportation Research Board (TRB) standing committees and members of the American Association of State Highway and Transportation Officials (AASHTO) Committee on Maintenance. The survey sought information about respondents' use of compost-based BMPs and possible efforts to assess the performance of these materials in protecting water quality by controlling the export of specific contaminants.

The survey received 11 responses from 10 state transportation agencies. Only four responding agencies use compost-based BMPs. Of these, only one agency—Washington State DOT—conducts performance assessments of compost-based BMPs. The six remaining responding agencies are not currently using compost for erosion control. These respondents reported concerns regarding nitrogen and phosphorus in the effluent and challenges in procuring compost for the blankets used in erosion control.

Survey findings are highlighted below in two topic areas:

- Practices and applications.
- Performance assessment.

Practices and Applications

Arizona, **Washington State** and **West Virginia** DOTs and **Idaho** Transportation Department use the three types of compost-based BMPs of interest to Caltrans: berms, blankets and filter socks. All four agencies use compost filter socks.

In Arizona, compost-based BMPs are used for stabilization and to encourage vegetative growth where appropriate. Compost is used with tackifier for sloped areas. The compost blankets used by Idaho Transportation Department are "blown on."

Respondents are most likely to use compost-based measures on construction sites; only Idaho Transportation Department uses compost on lands abutting agricultural uses. For these applications, compost is used for the promotion of quick seed establishment and not as an immediate means to filter stormwater or runoff.

Washington State DOT uses compost-based BMPs on mitigation sites as a soil amendment. The respondent noted, "BMPs with compost are more likely to provide enhanced treatment versus basic treatment." The agency defines *enhanced water quality treatment (versus basic water quality treatment)* as "[t]he use of runoff treatment BMPs designed to capture dissolved metals at a higher rate than basic treatment BMPs."

Other respondents offered additional details of compost-based BMP use and impacts:

- In Arizona, compost is used only in appropriate biomes to avoid unwanted nonnative growth.
- Idaho Transportation Department uses compost berms with seed near wetlands and on fish passage bridge and culvert projects.
- For a time, West Virginia DOT considered replacing silt fence applications with compost filter socks. Citing durability challenges and water flows under the compost filter sock, the respondent reported that the agency is "moving the other direction."

Performance Assessment

Agency practices of Washington State DOT, the only responding agency assessing the performance of compost-based BMPs in protecting water quality, are highlighted in a brief case study. After addressing a state program that evaluates stormwater treatment BMPs and presenting the survey respondent's feedback, the case study concludes with a compilation of related resources, including Washington State DOT manuals describing agency practices for the use of compost-based BMPs.

Monitoring the Effectiveness of Best Management Practices

The state of Washington evaluates treatment BMPs using Technology Assessment Protocol—Ecology (TAPE), a Washington State Department of Ecology program that "provides a peer-reviewed regulatory verification and certification process for emerging stormwater treatment technologies." The TAPE program establishes monitoring procedures and methods and performance goals for the following treatments:

- Pretreatment.
- Oil treatment.
- Basic treatment.
- Metals treatment.
- Phosphorus treatment.
- Construction treatment.

Two recently published technical evaluation reports prepared for or by Washington State DOT related to the TAPE certification process provided these recommendations:

Vegetated Filter Strip and Modified Vegetated Filter Strip Effectiveness Evaluation
The report's conclusions offer recommendations for use:

> VFS [vegetated filter strips] are preferred highway BMPs that infiltrate and treat stormwater, reducing overall pollutant loads. These BMPs are among the simplest and most cost-effective means of controlling the effects of stormwater runoff from roads and highways.
>
> A VFS modified with a compost blanket amendment provides additional pollutant removal abilities, including dissolved metals sorption, and potentially increased infiltration and improved vegetation establishment as compared to a standard VFS. The MVFS [modified vegetated filter strip] BMP is a standard VFS with a 3-inch compost blanket. The MVFS presents a practical and affordable method to retrofit a standard VFS with compost amendment capabilities.

The report's executive summary described test results in terms of hydrologic performance:

> All BMPs studied exhibited an overall volume reduction of approximately 75 percent of runoff. The MVFS had approximately [3] percent greater reduction as compared to the VFS. This reduction in volume is the primary reason for the reduction in pollutants.

The report's conclusions chapter provides more detailed project results:

> Both the VFS and MVFS 2-meter and 4-meter BMPs met Technology Assessment Protocol—Ecology criteria for [b]asic and [e]nhanced treatment. Specifically, each of these four BMPs demonstrated:
>
> - >80 percent total suspended solids pollutant removal efficiency.
> - >30 percent dissolved copper pollutant removal efficiency.
> - >60 percent dissolved zinc pollutant removal efficiency.

Evaluation of Biofiltration Swale Media Mixes for Maximizing Phosphorus Removal
Researchers evaluated the performance of 40 materials that could be used in a media mix with compost and fine sand to identify those most likely to enhance phosphorus removal from stormwater. From the 40 original materials, researchers identified 12 materials for qualitative assessment using four testing tasks (jar test, adsorption isotherms, column test and swale test) and offered the following recommendation:

> The alum-based WTR [water treatment residual] was the best performer in all the four testing tasks in this study. In addition, WTRs are a waste material so it is essentially a free material. Transport and processing of the WTR into a suitably graded material, like a fine sand, will require some logistics and cost. Alum-based WTR is more plentiful tha[n] other WTRs because alum is less expensive to treat water, but it creates more sludge per volume of water treated.
>
> The recommendation for WSDOT [Washington State DOT] in this report is to use the alum-based WTR as part of [the] media mix with medium-grade compost and topsoil in a biofiltration swale for a second-phase project that will evaluate the proposed media mix in a field trial with real-world surface runoff and water quality.

Washington State DOT's follow-up on these findings indicated the presence of arsenic in some WTR samples. The agency has set aside the WTR-based work and current compost bioswales research does not include any WTR. The agency may revisit this material in the future as time and resources permit, but at present is seeking "better options." The agency's current bioswale study is not considering a compost-amended material.

An older technical report seeking approval through the TAPE protocol, published in September 2011, sought to "demonstrate satisfactory performance of the compost-amended biofiltration swale for issuance of a GULD [general use level designation] for basic, enhanced (dissolved metals removal) and oil treatment."

Compost Performance in Controlling the Export of Contaminants

When asked about compost-based BMPs' performance in controlling the export of certain contaminants, the respondent stated, "Nutrient export is understood to be an impact of compost. WSDOT addresses this concern in various manuals for both construction and design, particularly regarding whether to use compost-based BMPs in TMDL [total maximum daily load] areas or areas near 303(d)-listed water bodies." The Washington State Department of Ecology describes areas on the 303(d) list as "water bodies in the polluted water category."

The table below summarizes the respondent's feedback on the performance of compost-based BMPs with regard to each contaminant considered in the survey. The respondent identified several contaminants as a "net nutrient exporter."

Contaminant	Compost-Based BMP Performance
Nitrate, oxidized nitrogen, potassium, soluble phosphorus, total phosphorus, total nitrogen	Compost BMPs are a net nutrient exporter; some mitigation via enhanced infiltration/load removal.

Contaminant	Compost-Based BMP Performance
Heavy metals	Treatment, as far as known, via "locking up" of metals due to cation exchange/sorption processes, as well as the following: • Enhanced infiltration/load removal through the compost increasing surface roughness. (The respondent noted that this may be specific to the agency's compost blanket applications.) • Greater soil infiltration ability and hydraulic conductivity. • Enhanced vegetation establishment, which promotes better biofiltration processes and phytoremediation/rhizosphere remediation.
Oil	Removal via sorption; allows for some breakdown or volatilization in BMP.
Total dissolved solids	Removal via enhanced infiltration/load removal.
Total suspended solids	Removal via enhanced infiltration/load removal and biofiltration processes.

Consultation with Experts

CTC contacted five experts known to have experience with the impacts of compost-based BMPs on water quality:

Consulting Firms

- Ron Alexander, R. Alexander Associates, Inc.
- Britt Faucette, vice president, Research and Development/Regulatory/Technical Services, MKB Company/Filtrexx International LLC.

Transportation Agencies

- Teresa Stephens, research engineer, Oklahoma Department of Transportation.

University Researchers

- Sally Brown, research professor, University of Washington.
- David Crohn, associate professor emeritus, University of California, Riverside Extension.

Publications provided by or associated with these experts are summarized in the table beginning on page 9. The table provides the publication or project title, the year of publication if research is completed and a brief description of the resource. Significantly more detail about each resource can be found in the **Detailed Findings** section of this report.

Related Research and Resources

A literature search of publicly available domestic in-progress and published research identified a representative sampling of publications that are organized into the following topic areas:

- National research and guidance.
- State research.
- Related resources.

Tables summarizing these publications are presented by topic area beginning on page 11. Each table provides the publication or project title, the year of publication if research is completed, and a brief description of the resource. Significantly more detail about each resource can be found in the **Detailed Findings** section of this report.

Gaps in Findings

The survey received a relatively limited response. Of the 10 responding agencies, only four use the compost-based BMPs of interest to Caltrans, and only one agency has experience with determining the effectiveness of compost-based erosion control measures in filtering the contaminants contained in stormwater runoff. Reaching out directly to agencies not participating in the survey could uncover useful information about other agencies' experience. Finally, while a literature search identified more than two dozen publications addressing this topic, relatively few were published within the past five years.

Next Steps

Moving forward, Caltrans could consider:

- Examining in detail selected publications cited in this Preliminary Investigation to learn more about the results of completed research and identify how it can inform a path forward for continued examination of compost-based BMPs' efficacy in filtering contaminants in stormwater runoff.
- Contacting Washington State DOT to learn more about current agency practices for the use of compost-based BMPs and their impacts on water quality. This outreach might include:
    - An in-depth review of the TAPE program.
    - An assessment of how the TAPE program has impacted current and anticipated agency use of compost-based erosion control measures.
    - Discussion of recent findings associated with the performance of compost-amended materials and plans for future research.
- Reaching out to selected agencies not participating in the survey to determine if other agencies are actively engaged in assessing the performance of compost-based BMPs in protecting water quality.

Consultation with Experts

Publication or Project (Year)	Expert/Agency	Excerpts from Abstract or Description of Resource
Library of Articles (2024)	Ron Alexander	Provides a selection of Alexander's articles and publications on compost specifications and erosion control.
Filtrexx Research Library (2022)	Britt Faucette	Contains research, both published and unpublished, on the performance of compost filter sock for sediment and erosion control and diverse environmental applications.
Compost Filter Socks for Storm Water and Erosion Control in Construction (Research in Progress)	Oklahoma Department of Transportation	Expects to review and evaluate the use of compost filter socks for stormwater and erosion control in construction. Researchers "will develop and refine a simplified laboratory method for determining leaching potential of compost filter socks at Oklahoma construction sites. This new standard will then be utilized to test various compost filter sock compositions for leaching of contaminants."
ODOT SPR 2286: Compost Filter Socks for Stormwater and Erosion Control in Construction (2020)	Oklahoma Department of Transportation	Presents "very preliminary results" that address total suspended solids in the outflow versus added sediment and describes the tasks at three field sites being monitored for nutrients, metals, sediment and flow.
Evaluation of Compost Blankets for Erosion Control and Runoff Water Quality on a Constructed Hillslope in Southern California (2014)	University of California, Riverside Extension	Evaluates greenwaste and biosolids fine (<9.5 mm) compost blankets for their effectiveness in curbing soil erosion and maintaining runoff water quality following three consecutive natural rainstorms on a 3:1 constructed hillslope in southern California. Greenwaste compost released the smallest amounts of suspended metals. Fine-textured greenwaste and biosolids composts are effective for erosion control under semiarid conditions.
Composts as Post-Fire Erosion Control Treatments and Their Effect on Runoff Water Quality (2013)	University of California, Riverside Extension	Considers three types of compost used as mulches following the controlled burn of coastal sage scrub vegetation. Compared to untreated controls, compost use effectively controlled runoff, sediment, nutrient and metal exports after fire removed the vegetation from the slope.

Publication or Project (Year)	Expert/Agency	Excerpts from Abstract or Description of Resource
Impact of Compost Application on Soil Erosion and Water Quality (2011)	University of California, Riverside Extension	Presents findings from four research objectives: • Considers the use of compost for remediating fire-damaged soils. • Reviews compost blankets as a means of restoring soils damaged by construction activity. • Investigates a potential BMP for minimizing water pollution from compost operations, including a calculator developed to estimate a compost pile's potential water holding capacity. • Presents results of a literature review conducted on several topics related to the beneficial use of compost.
Tools to Quantify the Potential for Phosphorus Loss from Bioretention Soil Mixtures (2021)	University of Washington	Tests a broad range of composts and biosolids in combination with three water treatment residuals as components of bioretention systems in batch incubation studies. Results suggest both extracts are appropriate tools for predicting phosphorus (P) release from bioretention mixes and that their predictability can be significantly improved by considering the reactivity term.
Connections: Recycled Organics and Fire-Ravaged Soils (2020)	University of Washington	Includes these recommendations for additional research: • Will adding a nutrient-rich material to these sites result in too much growth of understory vegetation? In a fire situation, that could translate into more fuel. That could be tested by comparing growth post-fire on sites with high nutrient composts and lower nutrient composts. • How much will the increased water holding capacity that comes when using recycled organics help to reduce fires and fire intensity?
Nutrient, Metal and Organics Removal from Stormwater Using a Range of Bioretention Soil Mixtures (2019)	University of Washington	Uses a column study to test the ability of bioretention soil mixtures (BSMs) to remove nutrients, metals and polyaromatic hydrocarbons from stormwater collected from an urban highway. Results indicate that the BSMs tested were a source of nutrients but were generally effective at removing metals and polyaromatic hydrocarbons from stormwater.
Predictors of Phosphorus Leaching from Bioretention Soil Media (2017)	University of Washington	Tests the phosphorus saturation index (PSI) and P saturation ratio (PSR) across a wide range of bioretention soil mixtures (BSMs) for their relationship to total and dissolved P in column leachate. The PSR was found to be a good predictor of P leaching from all BSMs; the PSI was a poor predictor. The PSR also predicted total P in leachate for individual events more effectively than the PSI. Total P in the BSMs had no relationship to P in the leachate.

Publication or Project (Year)	Expert/Agency	Excerpts from Abstract or Description of Resource
Stormwater Bioretention Systems: Testing the Phosphorus Saturation Index and Compost Feedstocks as Predictive Tools for System Performance (2016)	University of Washington	Conducts a replicated column trial to evaluate the potential for the PSI to predict P movement in bioretention soil mixtures (BSMs). Results indicate that the PSI may be an effective tool for predicting P movement in bioretention systems. Compost feedstock does not indicate the ability of composts to filter contaminants filtration, with all composts tested showing high contaminant removal.

National Research and Guidance

Publication or Project (Year)	Excerpts from Abstract or Description of Resource
NCHRP Research Report 1040: Achieving Highway Runoff Volume and Pollutant Reduction Using Vegetated Compost Blankets: A Guide (2023)	Presents a state-of-the-art investigation into vegetated compost blankets used for stormwater control and their resulting impacts on vegetative establishment, stormwater volume reduction and water quality improvement. The research was based on a comprehensive analytical, field and laboratory assessment.
Compost Filter Berms (2021)	Addresses the potential for nutrient discharges and pollutant retention when using compost filter berms.
Compost Filter Socks (2021)	Considers the effectiveness of this erosion control treatment with regard to pollutant filtration.
Compost Blankets (2012)	Notes that applying a compost blanket also works well as a stormwater BMP because it removes pollutants such as heavy metals, nitrogen, phosphorus, fuels, grease and oil from stormwater runoff, thus improving downstream water quality (USEPA 1998).

State Research

Publication or Project (Year)	State	Excerpts from Abstract or Description of Resource
Straw Wattle and Compost Filter Sock Performance for Retaining Stormwater Contaminants Following the 2018 Camp Fire (Draft Report: June 2024)	California	Compares the performance of two sediment retention products—straw wattles (SW) and compost filter socks (CFS)—for use to retain stormwater contaminants following an urban fire. Results indicate that "[c]ompost filter socks (CFS) were found to retain metals to a greater extent than straw wattles (SW). Six of the seven trace metals analyzed were retained at significantly higher concentrations in CFS compared to SW deployed after the Camp Fire."

Publication or Project (Year)	State	Excerpts from Abstract or Description of Resource
Effectiveness of Compost Blankets (Research in Progress)	Ohio	Expected to consider the effectiveness of compost-based BMPs at road construction sites, including a field evaluation of the existing compost blankets to examine the effects of the compost amendment rate on runoff water quantity and quality, water infiltration and nearby vegetation.
Water Quality Characteristics and Performance of Compost Filter Berms (2006)	Texas	Examines the water quality impacts of compost leachate constituents and structural integrity of unseeded compost filter berms, seeded compost filter berms and compost/mulch filter socks.

Related Resources

Publication or Project (Year)	Excerpts from Abstract or Description of Resource
Phosphorus in Compost and Risks to Water Quality (2017)	Examines how compost can be used with the risk of P contamination of water, with presenters noting that leaching is highly dependent on soil chemistry and measurements of water-extractable P and PSI and should be used to evaluate risk (not total P in compost).
Effects of Compost Age on the Release of Nutrients (2016)	Conducts detailed rainfall simulation studies of one compost type at three different ages to determine the effect of compost age on the extent and rates of nitrogen release. Rain simulations (storms) performed on each of the three compost ages show that nitrogen release declined each day of the repeated daily storms.
Performance of Compost Filtration Practice for Green Infrastructure Stormwater Applications (2013)	Determines the multiple-event removal efficiency and capacity of compost filter socks and filter socks with natural sorbents to remove soluble P, ammonium-nitrogen, nitrate-nitrogen, *E. coli*, *Enterococcus* and oil from urban stormwater runoff.
Hydrologic and Water Quality Aspects of Using a Compost/Mulch Blend for Erosion Control (2010)	Compares the stabilization performance of two types of compost wood mulch blend top dressing (low and high organic matter), a wood-based hydromulch and seeded bare soil to determine the amount of sediment and nutrients exported from each type of treatment.
Storm Water Pollutant Removal Performance of Compost Filter Socks (2009)	Determines whether compost filter socks with or without the addition of a flocculation agent can significantly remove suspended clay and silt particulates; ammonium nitrogen (NH_4–N) and nitrate-nitrite nitrogen (NO_3–N); fecal bacteria; heavy metals; and petroleum hydrocarbons from stormwater runoff.

Publication or Project (Year)	Excerpts from Abstract or Description of Resource
Performance of Compost Filter Socks and Conventional Sediment Control Barriers Used for Perimeter Control on Construction Sites (2009)	Compares the sediment removal efficiency, peak flow rate and cost of straw bales, mulch filter berms, compost filter socks and compost filter socks plus polymer used as perimeter sediment control devices under high-intensity/duration single storm event conditions.
Sediment and Phosphorus Removal from Simulated Storm Runoff with Compost Filter Socks and Silt Fence (2008)	Compares the sediment removal efficiency of silt fence and compost filter socks; the impact of adding polymers to compost filter socks in sediment and P load reduction; and relationships between compost filter media particle size distribution and pollutant removal efficiency and hydraulic flow rate.
Using Compost Can Reduce Water Pollution (Fact Sheet) (2008)	Discusses the use of compost blankets, socks and berms during all phases of construction.
Erosion Control and Storm Water Quality from Straw with PAM, Mulch and Compost Blankets of Varying Particle Sizes (2007)	Determines how blending wood mulch with compost may affect its performance as an erosion control practice relative to a straw blanket with polyacrylamide (PAM). Also determines the effect of particle size distribution of the organic erosion control blanket on runoff, erosion and vegetation establishment.
Flow-Through Rates and Evaluation of Solids Separation of Compost Filter Socks vs. Silt Fence in Sediment Control Applications (2007)	Finds that flow-through rate changes with time, as does ponding depth due to the accumulation of solids on/in the sediment filters. Changes in depth with time were a linear function of flow rate after 10 minutes of flow, up to the time the sediment filter is overtopped. Findings inform development of a Microsoft Excel-based interactive design tool to assist engineers and erosion and sediment control planners on how to specify compost silt socks relative to silt fence in perimeter sediment control applications.
Organic BMPs Used for Storm Water Management (2006)	Evaluates compost filter media for sediment, nutrient and hydrocarbon removal from stormwater runoff on a 3:1 slope. Findings include: • Total solids and petroleum hydrocarbon reduction from filtration of storm runoff consistently over 95%. • Reduction in nitrate nitrogen and total P concentrations from storm runoff. • Increased reduction of total suspended solids and turbidity. • Consistently high removal percentages of petroleum hydrocarbons over three consecutive storm runoff events.
Evaluation of Stormwater from Compost and Conventional Erosion Control Practices in Construction Activities (2005)	Tests four types of compost blankets, hydroseed, silt fence and a bare soil (control) in field test plots.

Detailed Findings

Background

In recent years, California water quality has been severely impaired because of polluted stormwater runoff and degraded soils that are more prone to erosion due to wildfires, construction, agriculture, and other natural and human activities. Erosion control best management practices (BMPs) are used to help prevent the contamination of water resources.

A comprehensive review of relevant literature is needed to examine compost-based BMPs, such as compost filter socks, compost berms and compost blankets, and assess their performance and effectiveness in runoff filtration to capture various contaminants. The California Department of Transportation (Caltrans) has a particular interest in research studies that identify the effectiveness of compost-based BMPs in the protection of water resources and for post-fire remediation and soil bioremediation (biological system of microorganisms in a mature, cured compost to sequester or break down contaminants in water or soil).

To inform Caltrans' continued use of compost-based BMPs, this Preliminary Investigation gathered literature and reporting from state departments of transportation (DOTs) about the performance of these erosion control measures in protecting water quality. Consultations with selected experts supplemented survey findings and literature search results.

Survey of Practice

An online survey distributed to state DOT members of the following committees sought information about agency experience with compost-based BMPs:

- Transportation Research Board (TRB) committees:
    - Standing Committee on Hydrology, Hydraulics and Stormwater.
    - Standing Committee on Landscape and Environmental Design.
    - Standing Committee on Roadside Maintenance Operations.
- American Association of State Highway and Transportation Officials (AASHTO) Committee on Maintenance.

Together, the membership of these committees provided a national pool of potential respondents.

Respondents were asked to provide information about the types of compost-based BMPs their agencies use and the locations where they are installed. Agencies with experience assessing the performance of compost-based BMPs in protecting water quality described this performance in terms of controlling the export of specific contaminants. Survey questions are provided in Appendix A.

The survey received 11 responses from 10 state transportation agencies:

- Arizona DOT (two responses).
- Idaho Transportation Department.
- Indiana DOT.
- Nevada DOT.
- New York State DOT.
- Texas DOT.
- Vermont Agency of Transportation.
- Washington State DOT.
- West Virginia DOT.
- Wisconsin DOT.

Survey results are summarized below in two topic areas:

- *Users of compost-based best management practices*. Four responding agencies use compost-based BMPs. Presentation of these survey findings begins immediately below. One of these agencies—Washington State DOT—is highlighted in a brief case study (see page 17).
- *Nonusers of compost-based best management practices*. Six of the responding agencies are not currently using compost for erosion control. Respondents reported concerns regarding nitrogen and phosphorus in the effluent and challenges in procuring compost for blankets used in erosion control. Presentation of these survey findings begins on page 24.

Users of Compost-Based Best Management Practices

Practices and Applications

The survey queried respondents about the use of three types of compost-based BMPs: berms, blankets and filter socks. Table 1 identifies the use of these compost-based BMPs by four responding agencies: Arizona, Washington State and West Virginia DOTs and Idaho Transportation Department. The most frequently used application among respondents is the compost filter sock.

Table 1. Respondents' Use of Compost-Based BMPs

State	Compost Berms	Compost Blankets	Compost Filter Socks
Arizona[1]	X		X
Idaho	X	X[2]	X
Washington	X	X	X
West Virginia			X

1 In Arizona, compost-based BMPs are used for stabilization and to encourage vegetative growth where appropriate. Compost is used with tackifier for sloped areas.

2 The compost blankets used by Idaho Transportation Department are "blown on."

Table 2 summarizes respondents' use of compost-based erosion control measures in various locations. Respondents are most likely to use compost-based measures on construction sites; only one agency—Idaho Transportation Department—uses compost on lands abutting agricultural uses. For this agency, compost is used to promote quick seed establishment and not as an immediate means to filter stormwater or runoff.

Table 2. Respondents' Use of Compost-Based BMPs by Location

State	Wildfire-Impacted Lands	Lands Abutting Agricultural Uses	Construction Sites	Mitigation Sites
Arizona	Compost stabilization with tackifier	N/A	• Sediment control on slopes • Disturbance perimeter • Compost stabilization with tackifier	N/A
Idaho	Compost filter socks used in conjunction with seed to reduce runoff velocity in channels and on slopes	Compost used in conjunction with seed to promote quick seed establishment on roadsides	Compost blankets, compost berms and compost filter socks used in conjunction with seeding activities	N/A
Washington	N/A	N/A	Respondent referred to agency manuals that address compost use on construction sites	Compost used as soil amendment in mitigation sites in accordance with the agency's Standard Specifications, Division 8-02 (See **Related Resources** on page 23 for this citation.)
West Virginia	N/A	N/A	Perimeter control in place of silt fence, water bars and other diversions	N/A

N/A Not applicable

As Table 2 indicates, Washington State DOT uses compost as a soil amendment on mitigation sites. The respondent noted that "BMPs with compost are more likely to provide enhanced treatment versus basic treatment." The agency distinguishes these water treatment types in the glossary included in its April 2019 Highway Runoff Manual (see **Related Resources** on page 23 for this citation):

> **basic (water quality) treatment** (versus enhanced water quality treatment) The Washington State Department of Ecology's performance goal is to achieve 80% removal of total suspended solids for influent concentrations that are greater than 100mg/l, but less than 200mg/l. For influent concentrations greater than 200mg/l, a higher treatment goal may be appropriate. For influent concentrations less than 100mg/l, the facilities are intended to achieve an effluent goal of 20mg/l total suspended solids.

enhanced runoff treatment, enhanced water quality treatment (versus basic water quality treatment) The use of runoff treatment BMPs designed to capture dissolved metals at a higher rate than basic treatment BMPs.

Other respondents offered additional details of compost-based BMP use and impacts:

- In Arizona, compost is used only in appropriate biomes to avoid unwanted nonnative growth.
- Idaho Transportation Department uses compost berms with seed near wetlands and on fish passage bridge and culvert projects.
- For a time, West Virginia DOT considered replacing silt fence applications with compost filter socks. Citing durability challenges and water flows under the compost filter sock, the respondent reported that the agency is "moving the other direction."

Performance Assessment

Agency practices of Washington State DOT, the only responding agency assessing the performance of compost-based BMPs in protecting water quality, are highlighted in the brief case study below.

Washington State Department of Transportation

The state of Washington evaluates treatment BMPs using Technology Assessment Protocol—Ecology (TAPE), a Washington State Department of Ecology program. Results included in two recent technical reports submitted by Washington State DOT in connection with the TAPE program are discussed below. The case study also summarizes the respondent's survey responses related to the performance of compost BMPs in controlling the export of contaminants and concludes with a compilation of related resources.

Monitoring the Effectiveness of Best Management Practices

Washington State DOT conducts "effectiveness monitoring of treatment BMPs" as part of its National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permit requirements. Previous monitoring produced studies of modified vegetated filter strips and compost-amended biofiltration swales, discussed below. Future monitoring may include other compost-based BMPs.

Technology Assessment Protocol—Ecology (TAPE)

The TAPE program reviews and certifies emerging stormwater treatment technologies. This evaluation of permanent stormwater treatment systems considers:

- Specific sampling criteria.
- Site and technology information.
- Quality assurance and quality control measures.
- Target pollutants.
- Evaluation report content.

The TAPE program establishes monitoring procedures and methods and performance goals for the following treatments:

- Pretreatment.
- Oil treatment.
- Basic treatment.
- Metals treatment.
- Phosphorus treatment.
- Construction treatment.

Washington State DOT submits reports to the Department of Ecology through the TAPE protocol to request approval of BMPs that use compost. The respondent provided two technical evaluation reports related to the TAPE certification process that are described below.

Vegetated Filter Strip and Modified Vegetated Filter Strip Effectiveness Evaluation: Technical Evaluation Report, Stormwater Branch, Environmental Services Office, Washington State Department of Transportation, January 2023.

(This report has been provided to Caltrans separately.)

The goal of this study was to determine "how well VFS [vegetated filter strips] and MVFS [modified vegetated filter strips] work at different widths (perpendicular to the roadway centerline) and calculated residence times." An MVFS is described as "an experimental filter strip BMP that adds a [3]-inch compost blanket to the surface of the soil to enhance filtration, increase surface roughness, and improve plant growth and cover."

The report's conclusions offer recommendations for use:

> VFS are preferred highway BMPs that infiltrate and treat stormwater, reducing overall pollutant loads. These BMPs are among the simplest and most cost-effective means of controlling the effects of stormwater runoff from roads and highways.
>
> A VFS modified with a compost blanket amendment provides additional pollutant removal abilities, including dissolved metals sorption, and potentially increased infiltration and improved vegetation establishment as compared to a standard VFS. The MVFS BMP is a standard VFS with a 3-inch compost blanket. The MVFS presents a practical and affordable method to retrofit a standard VFS with compost amendment capabilities.

Sampling Procedures

Two monitoring study sites were used to evaluate performance following the TAPE monitoring procedures and methods. Influent and effluent samples were collected from 131 separate storm events from 2012 through 2018. Lab analyses of the "collected flow-weighted composite samples" included:

- Total suspended solids (TSS).
- Total and dissolved copper.
- Total and dissolved zinc.
- Hardness as $CaCO_3$.

- pH.
- Total phosphorus (TP).
- Orthophosphate.
- Total Kjeldahl nitrogen.
- Nitrate-nitrite.
- Particle size distribution (PSD).

Evaluation Results

The report's executive summary described test results in terms of hydrologic performance:

> All BMPs studied exhibited an overall volume reduction of approximately 75 percent of runoff. The MVFS had approximately [3] percent greater reduction as compared to the VFS. This reduction in volume is the primary reason for the reduction in pollutants.

The report's conclusions chapter, which begins on page 66 of the report (page 74 of the PDF), provides more detailed project results:

> Both the VFS and MVFS 2-meter and 4-meter BMPs met Technology Assessment Protocol—Ecology criteria for [b]asic and [e]nhanced treatment. Specifically, each of these four BMPs demonstrated:
>
> - >80 percent TSS pollutant removal efficiency.
> - >30 percent dissolved copper pollutant removal efficiency.
> - >60 percent dissolved zinc pollutant removal efficiency.
>
> The MVFS 2-meter and 4-meter BMPs statistically demonstrated TSS, dissolved copper and dissolved zinc reductions. WSDOT attributed the MVFS BMPs' ability to remove the dissolved phase metals to the compost blanket amendment, presumably via sorption. Influent flow rates were homogenous, with extremely low coefficients of variance. Influent flow rates did not demonstrate any impact on pollutant removal efficiencies. Stormwater residence time in the BMPs, despite being different between the different widths, did not demonstrate any influence on pollutant removal efficiencies.

Evaluation of Biofiltration Swale Media Mixes for Maximizing Phosphorus Removal: Technical Report, Nigel Pickering and Md. Arafat Ali, Washington State Department of Transportation, March 2022.

(This report has been provided to Caltrans separately.)

As the authors note in the executive summary, "[t]he goal of this research work is to identify a new media mix that will improve P [phosphorus] removal efficiency from stormwater. This study is a [systematic] evaluation of 40 materials that could be used in a media mix with compost and fine sand for enhanced P removal from stormwater."

Using the dissolved P removal performance demonstrated by the original 40 materials, researchers identified 12 materials for qualitative assessment (low to high)

using four testing tasks (jar test, adsorption isotherms, column test and swale test) and offered this primary conclusion and recommendation:

> The alum-based WTR [water treatment residual] was the best performer in all the four testing tasks in this study. In addition, WTRs are a waste material so it is essentially a free material. Transport and processing of the WTR into a suitably graded material, like a fine sand, will require some logistics and cost. Alum-based WTR is more plentiful tha[n] other WTRs because alum is less expensive to treat water, but it creates more sludge per volume of water treated.
>
> The recommendation for WSDOT [Washington State DOT] in this report is to use the alum-based WTR as part of [the] media mix with medium-grade compost and topsoil in a biofiltration swale for a second-phase project that will evaluate the proposed media mix in a field trial with real-world surface runoff and water quality.

Note: Washington State DOT's follow-up on the findings of this technical report identified high levels of arsenic in the WTR material. (The agency noted that researchers had not tested the WTR sample for this naturally occurring element.) After a WTR sample from a different water treatment plant was tested and found not to have arsenic, the agency concluded that the presence of arsenic appears to be site-specific. Given this ambiguity, Washington State DOT has set aside the WTR-based work, and current compost bioswales research does not include any WTR. The agency may revisit this material in the future as time and resources permit, but at present is seeking "better options."

The agency's current bioswale study is not considering a compost-amended material.

An older technical report seeking approval through the TAPE protocol, **Compost-Amended Biofiltration Swale Evaluation,** published in September 2011, sought to "demonstrate satisfactory performance of the compost-amended biofiltration swale for issuance of a GULD [general use level designation] for basic, enhanced (dissolved metals removal) and oil treatment." Among the project's eight major findings are the two provided below:

- The compost-amended biofiltration swale achieved superior treatment performance to the control biofiltration swale for all of the following parameters: TSS, dissolved and total zinc, dissolved and total copper, and TPH [total petroleum hydrocarbons].
- The compost-amended biofiltration swale generally exported TP whereas the control biofiltration swale did not. Both the compost-amended biofiltration swale and control biofiltration swale exported SRP [soluble reactive phosphorus]; however, SRP export from the compost-amended biofiltration swale was much higher.

A citation for this September 2011 report appears on page 24.

Compost Performance in Controlling the Export of Contaminants

When asked about compost-based BMPs' performance in controlling the export of certain contaminants, the respondent stated, "Nutrient export is understood to be an impact of compost. WSDOT addresses this concern in various manuals for both construction and design, particularly regarding whether to use compost-based BMPs in TMDL [total maximum daily load] areas or areas near 303(d)-listed water bodies." The Washington State Department of Ecology describes areas on the 303(d) list as "water bodies in the polluted water category."

Table 3 summarizes the respondent's feedback on the performance of compost-based BMPs with regard to each contaminant considered in the survey. As previously noted, the respondent identified several contaminants as a "net nutrient exporter."

Table 3. Performance of Compost-Based BMPs in Controlling Export of Selected Contaminants (Washington State DOT)

Contaminant	Compost-Based BMP Performance
Nitrate, oxidized nitrogen, potassium, soluble phosphorus, total phosphorus, total nitrogen	Compost BMPs are a net nutrient exporter; some mitigation via enhanced infiltration/load removal.
Heavy metals	Treatment, as far as known, via "locking up" of metals due to cation exchange/sorption processes, as well as the following: • Enhanced infiltration/load removal through the compost increasing surface roughness. (The respondent noted that this may be specific to the agency's compost blanket applications.) • Greater soil infiltration ability and hydraulic conductivity. • Enhanced vegetation establishment, which promotes better biofiltration processes and phytoremediation/rhizosphere remediation.
Oil	Removal via sorption; allows for some breakdown or volatilization in BMP.
Total dissolved solids	Removal via enhanced infiltration/load removal.
Total suspended solids	Removal via enhanced infiltration/load removal and biofiltration processes.

The additional pollutants below are also evaluated under the state's TAPE program:

- *Hardness*: No observed impact based on the agency's recent studies.
- *Particle size distribution*: No observed pattern in the agency's recent studies.

Related Resources

Technology Assessment Protocol—Ecology (TAPE): Process Overview, Washington State Department of Ecology, September 2018.
https://apps.ecology.wa.gov/publications/documents/1810039.pdf
From the overview of TAPE:

The TAPE program provides a peer-reviewed regulatory verification and certification process for emerging stormwater treatment technologies. The TAPE program is administered by the Washington State Department of Ecology (Ecology), with assistance from staff at the Washington Stormwater Center (www.wastormwatercenter.org/), which provides stormwater management assistance, including guidance on certification of emerging treatment technologies. ….

Proponents must demonstrate performance by testing their stormwater treatment technology at field sites in the Pacific Northwest or at pre-approved testing sites located in other parts of the United States. The testing protocol is specifically designed to evaluate flow-through best management practices (BMPs) with relatively short detention times, and may not be suitable for all stormwater treatment technologies. Ecology has developed an alternative monitoring protocol that applies to long-detention BMPs (e.g., wet ponds) (Ecology 2018b). This document is included as an [a]ppendix in the Technical Guidance Manual for Evaluating Emerging Stormwater Treatment Technologies.

See Table 1, TAPE Performance Goals, on page 5 of the manual (page 11 of the PDF).

Related Resource:

Emerging Stormwater Treatment Technologies (TAPE), Washington State Department of Ecology, undated.
https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies
This website offers a general description of the TAPE program, including highlights of the changes reflected in the 2018 update of guidance documents, facilities that have been preapproved for evaluation and performance goals for these treatments:

- Pretreatment.
- Oil treatment.
- Basic treatment.
- Metals treatment.
- Phosphorus treatment.
- Construction treatment.

The website also provides these use level designations:

- *General use level designation (GULD)*: GULD technologies may be used in Washington and are subject to Use Level Designation conditions. We will only accept written comments on technologies that have received GULD.
- *Conditional use level designation (CULD)*: CULD allows continued use of the technology for a specified period of time. The vendor and/or developer must conduct field testing during the permitted time for most CULD technologies. These technologies are considered likely to attain a General Use Level.
- *Pilot use level designation (PULD)*: PULD allows limited use of the technology to allow field testing to be conducted. PULD technologies may be installed

provided that the vendor and/or developer agree to conduct field testing based on the TAPE at all installations.

Approved and functionally equivalent technologies are also provided.

Water Quality Assessment and 303(d) List, Washington State Department of Ecology, undated.
https://ecology.wa.gov/water-shorelines/water-quality/water-improvement/assessment-of-state-waters-303d
This website describes Washington State's water quality assessment practices.

Division 8, Miscellaneous Construction, Standard Specifications for Road, Bridge and Municipal Construction, Washington State Department of Transportation, 2024.
https://www.wsdot.wa.gov/publications/manuals/fulltext/M41-10/SS.pdf
Division 8-01, Erosion Control and Water Pollution Control, begins on page 8-1 of the manual (page 751 of the PDF). Relevant portions of this section include:

- 8-01.3(4), Placing Compost Blanket.
- 8-01.3(9)B, Gravel Filter, Wood Chip or Compost Berm.
- 8-01.3(12), Compost Sock.

Division 8-02, Roadside Restoration, begins on page 8-18 of the manual (page 768 of the PDF). Relevant portions of this section include 8-02.3(6)A, Compost.

Chapter 5, Stormwater Best Management Practices, Highway Runoff Manual, Washington State Department of Transportation, April 2019.
https://wsdot.wa.gov/publications/manuals/fulltext/M31-16/highwayrunoff.pdf
The respondent noted that this publication provides guidance for the agency's permanent BMPs, including the following:

Vegetated Filter Strip Geometry

The following are applicable for basic vegetated filter strips in eastern and western Washington and CAVFS [compost-amended vegetated filter strips] in eastern Washington.

- Ensure vegetated filter strips provide a minimum residence time of 9 minutes for full water quality treatment in eastern Washington. In western Washington, provide a flow rate adjustment (described below) to use the 9-minute criterion.

….

- In areas where enhanced treatment is required, consider using a CAVFS or a media filter drain (see BMP RT.07). The media filter drain will usually require less treatment area to achieve the water quality treatment objectives. [See page 5-36 of the manual, page 240 of the PDF.]

Chapter 5, TESC Best Management Practices, Temporary Erosion and Sediment Control Manual (TESCM), Washington State Department of Transportation, May 2019.
https://www.wsdot.wa.gov/publications/manuals/fulltext/M3109/TESCM.pdf
References to standard specifications are supplemented by a description of the function and design, installation and maintenance of the following BMPs:

- 5-1.1.4, Compost Socks. (See page 5-8 of the manual, page 74 of the PDF.)
- 5-1.1.14 Filter Berms (Gravel Filter, Wood Chips or Compost Berm). (See page 5-22 of the manual, page 88 of the PDF.)

Table 5-4, Mulch Standard Specifications and Guidelines (page 5-37 of the manual, page 103 of the PDF), provides the application rate for compost blankets: 2-inch minimum thickness; approximately 100 tons per acre (750 pounds per cubic yard).

Compost-Amended Biofiltration Swale Evaluation, John Lenth and Rebecca Dugapolski, Washington State Department of Transportation Design Office, September 2011. https://www.wsdot.wa.gov/research/reports/fullreports/793.1.pdf
The excerpt below from the report's conclusions (beginning on page 85 of the report, page 105 of the PDF) presents two of the project's eight major findings:

> Currently, WSDOT has very limited options for meeting end-of-pipe enhanced treatment for stormwater runoff. Constructed wetlands, the primary available stormwater technology, require a large area and ongoing maintenance, both of which are expensive in urban areas. Biofiltration swales require much less area and can easily fit in medians or right-of-way; however, they are currently approved for basic treatment, not for enhanced treatment.
>
> This report presents performance data collected to support the issuance of a GULD for the compost-amended biofiltration swale. Hydrologic and water quality monitoring was conducted in a standard biofiltration swale (control) and a compost-amended biofiltration swale from May 2009 through June 2010. During this monitoring period, a total of 23 separate storm events were sampled, resulting in a total of 15 grab samples and 16 composite samples from each swale (15 of which were paired events with successful sampling at both the compost-amended and control biofiltration swales). The major conclusions for this monitoring are summarized below:
>
> - The compost-amended biofiltration swale achieved superior treatment performance to the control biofiltration swale for all of the following parameters: TSS, dissolved and total zinc, dissolved and total copper, and TPH.
> - The compost-amended biofiltration swale generally exported TP whereas the control biofiltration swale did not. Both the compost-amended biofiltration swale and control biofiltration swale exported SRP; however, SRP export from the compost-amended biofiltration swale was much higher.
>
> ….

Nonusers of Compost-Based Best Management Practices

Six responding agencies are not using compost-based BMPs:

- Indiana DOT.
- Nevada DOT.
- New York State DOT.
- Texas DOT.

- Vermont Agency of Transportation.
- Wisconsin DOT.

Three respondents offered details of their agencies' experiences with these BMPs:

- **Contents of effluent**. Compost is used in planting but not in the agency's stormwater practices because "[c]ompost causes the effluent to have more nitrogen and phosphorus than the influent" (*New York State DOT*).
- **Investigation underway**. A current investigation of new BMPs may include compost-based measures (*Indiana DOT*).
- **Limited availability**. The type of compost required for use in blankets that are employed for erosion control is not readily available in Vermont, and the state transportation agency has been reluctant to specify the use of a material that could be challenging to procure. The respondent speculated that suppliers are not producing the material because a sufficient local market is lacking. The agency uses compost as a component of other items such as landscape backfill (*Vermont Agency of Transportation*).

Consultation with Experts

We contacted five experts known to have experience with the impacts of compost-based BMPs on water quality:

Consulting Firms

- Ron Alexander, R. Alexander Associates, Inc.
- Britt Faucette, vice president, Research and Development/Regulatory/Technical Services, MKB Company/Filtrexx International LLC.

Transportation Agencies

- Teresa Stephens, research engineer, Oklahoma Department of Transportation.

University Researchers

- Sally Brown, research professor, University of Washington.
- David Crohn, associate professor emeritus, University of California, Riverside Extension.

Consulting Firms

R. Alexander Associates, Inc.

In a response to an email inquiry, Ron Alexander noted that a significant amount of data exists on this topic and suggested we contact Dr. Britt Faucette (MKB Company/Filtrexx International LLC) and Dr. David Crohn (University of California, Riverside Extension).

Provided in *Related Resources* below is a link to Alexander's library of articles related to compost. Links to the three articles below provide a small sampling of Alexander's publications. These articles, which address how compost can bind phosphorus, were published by Alexander in a digital-only publication:

- Recycled Organics Products and Phosphorus Claims, *BioCycle*, August 2021.
- Recycled Organic Products and Phosphorus, *BioCycle*, May 2021.
- Phosphorus and Compost Use Dynamics, *BioCycle*, December 2016.

Contact: Ron Alexander, R. Alexander Associates, Inc., 919-349-0460, ron@alexassoc.net.

Related Resources:

Library of Articles, R. Alexander Associates, Inc., 2024.
https://www.alexassoc.net/library-of-articles
A selection of Alexander's articles and publications on compost specifications and erosion control are available on this web page.

MKB Company/Filtrexx International LLC

Britt Faucette has conducted research examining compost filtration and impacts to water quality. Dr. Faucette recommended a review of the website, cited as a *Related Resource* below, for a comprehensive list of peer-reviewed and technical white papers. A sampling of these publications is presented in the **Related Research and Resources** section of this Preliminary Investigation (see page 34).

Contact: Britt Faucette, vice president, Research and Development/Regulatory/Technical Services, MKB Company/Filtrexx International LLC, 404-687-8393, britt.faucette@filtrexx.com.

Related Resource:

Filtrexx Research Library, MKB Company/Filtrexx International LLC, 2022.
https://filtrexx.com/en/resources/research-library
From the website: Filtrexx Research Library contains research, both published and unpublished, on the performance of compost filter sock for sediment and erosion control and diverse environmental applications.

Transportation Agencies

Oklahoma Department of Transportation

A research project that is reviewing and evaluating the use of compost filter socks for stormwater and erosion control in construction is expected to be completed in September 2024. A summary of the project appears in *Related Resources* below. Following that summary is a citation that describes a 2020 presentation given by the project's principal investigator of "very preliminary results" from the project. An Oklahoma DOT contact was unavailable to provide a response to an inquiry about the project's current status,

Related Resources:

Research in Progress: Compost Filter Socks for Storm Water and Erosion Control in Construction, Oklahoma Department of Transportation, start date: October 2019; expected completion date: September 2024.
Project description at https://trid.trb.org/view/1667133
From the project description: An update to the Standards Specifications for Highway Construction of erosion and sediment control measures through the Storm Water Action Team is ongoing. Part of this update includes reviewing and evaluating new erosion control products like compost filter socks. It is not known if compost filter socks can function effectively as an erosion control product without leaching contaminants to the environment. Research in conjunction with laboratory and data analysis are needed to determine if compost filter socks do leach contaminants under conditions identified at transportation construction sites in Oklahoma. This project will develop and refine a simplified laboratory method for determining leaching potential of compost filter socks at Oklahoma construction sites. This new standard will then be utilized to test various compost filter sock compositions for leaching of contaminants. A cost–benefit analysis will be performed to compare the use of compost filter socks to current practices. Results from field monitoring of filter sock implementation will be used to inform the ODOT Storm Water Action Team for development of a standard and specification to use on ODOT construction sites.

ODOT SPR 2286: Compost Filter Socks for Stormwater and Erosion Control in Construction, Jason Vogel, Jessica Shepard, Christina Gildea, Grant Graves and Keith Strevett, Oklahoma Water Survey, University of Oklahoma, 2020.
https://static1.squarespace.com/static/526c7a98e4b023d8f09390ed/t/5f9c8394cec7c33d46db51fa/1604092830339/Vogel_OTRD_2020.pdf
This presentation provides an overview of the current research project in progress, including research objectives, testing methodologies, and product and installation specifications. Slide 13 presents "very preliminary results," citing total suspended solids in the outflow versus added sediment. Slide 20 highlights the tasks at three field sites being monitored for nutrients, metals, sediment and flow.

University Researchers

University of California, Riverside Extension

Several of David Crohn's publications are included in *Related Resources* below, including a 2014 article that evaluates runoff water quality in regions where compost blankets are used for erosion control, a 2013 article that examines compost as a post-fire erosion control practice and a 2011 report that looks at the impact of compost on soil erosion and water quality. Dr. Crohn was unable to respond to our email inquiry.

Contact: David Crohn, associate professor emeritus, University of California, Riverside Extension, 951-827-3333, david.crohn@ucr.edu.

Related Resources:

"Evaluation of Compost Blankets for Erosion Control and Runoff Water Quality on a Constructed Hillslope in Southern California," Vijayasatya N. Chaganti and David M. Crohn, *Transactions of the American Society of Agricultural and Biological Engineers*, Vol. 57, Issue 2, pages 403-416, May 2014.
https://www.researchgate.net/publication/265511659_Evaluation_of_compost_blankets_for_erosion_control_and_runoff_water_quality_on_a_constructed_hillslope_in_Southern_California
From the abstract: Compost blankets are useful for reducing sediment exports from soils cleared and compacted by construction activity, but their effectiveness as a water quality measure has not been evaluated for semiarid conditions. This field study evaluated greenwaste and biosolids fine (<9.5 mm) compost blankets for their effectiveness in curbing soil erosion and maintaining runoff water quality following three consecutive natural rainstorms on a 3:1 constructed hillslope in southern California. Both runoff concentration and mass losses for sediments, total dissolved solids (TDS), total suspended solids (TSS), turbidity, nutrient exports and metal exports through runoff were evaluated for each of the three storms. Cumulative totals across all three storms were also calculated. A nonparametric Kaplan-Meier approach was adapted to deal with nondetects observed in trace metal analysis in order to calculate the cumulative metal losses. Composts significantly reduced runoff and associated sediment loads compared to untreated controls. Mean runoff was 77% and 92% less for greenwaste and biosolids compost, respectively, relative to the control. Respective TSS exports were 88.5% and 97% less. TDS losses were 81% less from biosolids, but greenwaste did not differ significantly from the control. Biosolids contributed more NH_4^+-N and suspended P but less dissolved P than the other treatments. Dissolved trace metals were seldom detected in runoff, except for Cu and Zn, but detected losses were greatest from the controls. Greenwaste compost released the smallest amounts of suspended metals. Fine-textured greenwaste and biosolids composts are effective for erosion control under semiarid conditions.

"Composts as Post-Fire Erosion Control Treatments and Their Effect on Runoff Water Quality," D. M. Crohn, V. N. Chaganti and N. Reddy, *Transactions of the American Society of Agricultural and Biological Engineers*, Vol. 56, Issue 2, pages 423-435, 2013.
https://www.hcd.ca.gov/community-development/disaster-recovery-programs/ndrc-application-documents/docs/crohn_et_al._2013_trans_asabe.pdf
From the abstract: Erosion from fire-damaged wildlands poses a significant water quality concern. Deprived of vegetation, runoff intensifies, which escalates exports of sediments and other pollutants. Used as mulches, composts shield the soil surface and reduce runoff by absorbing water and promoting infiltration. This field study considered three types of compost used as mulches following the controlled burn of coastal sage scrub vegetation. Nine treatments considered a coarse greenwaste compost (>9.5 mm), a fine greenwaste compost (<9.5 mm) and a biosolids co-compost, each of which was surface-applied to 2.5 and 5 cm mulch depths, along with a final treatment of incorporation of 5 cm of material into 8 cm of soil. Results were aggregated from four sequential natural storm events on 2.5:1 steepness replicated plots, with the runoff sampled for sediment, nutrients and metals. A novel non-parametric Kaplan-Meier approach was adapted to sum metal samples falling below detection limits. Compared to untreated controls, compost use effectively

controlled runoff, sediment, nutrient and metal exports after fire removed the vegetation from the slope. Runoff, total dissolved solids (TDS), total suspended solids (TSS) and total solids (TS) were reduced by averages of 86%, 88%, 80% and 97%, respectively. Suspended metals were typically reduced by 93% to 95%. Compost use also reduced turbidity and, in most cases, nutrient exports. Mulching and soil incorporation were, in general, equally effective. Applying 5 cm mulches offered no performance advantage over 2.5 cm mulches, and in the case of biosolids compost 5 cm performed less well, contributing more dissolved solids, ammonium-N and dissolved metals (Cd, Cr, Cu and Mo) than the 2.5 cm treatment. Greenwaste compost particle size did not significantly affect runoff, and results for the coarse and fine greenwaste composts were similar. Compost mulches appear to be an effective means of reducing pollution from soils following wildfires.

Impact of Compost Application on Soil Erosion and Water Quality (formerly titled **Compost Best Management Practices and Benefits**), David Crohn, California Department of Resources Recycling and Recovery, May 2011.
Citation at https://www2.calrecycle.ca.gov/Publications/Details/1377
From the executive summary: This report presents the results of a research project that evaluated ways to conserve water and protect water quality as related to compost production and application. The project has four related objectives. The first objective considers the use of compost for remediating fire-damaged soils; the second looks at compost blankets as a means of restoring soils damaged by construction activity; the third investigates a potential [b]est [m]anagement [p]ractice (BMP) for minimizing water pollution from compost operations, including a calculator developed to estimate a compost pile's potential water holding capacity; and the fourth is a literature review conducted on several topics related to the beneficial use of compost.

Related Resource:

Compost Best Practices and Benefits, David Crohn, California Department of Resources Recycling and Recovery, March 2011.
https://spvsoils.com/wp-content/uploads/2020/08/CalRecycle-compost-use-on-fire-soils-Crohn-2011013.pdf
This report is the earlier published version of the previous citation.

David Crohn, Associate Professor Emeritus of Environmental Sciences, Extension Resource Conservation Specialist, Environmental Sciences Department, University of California, Riverside, 2018.
https://profiles.ucr.edu/app/home/profile/crohn
Dr. Crohn's profile includes a selected list of publications in areas of interest, including organic mulches, produced from 2003 to 2009.

University of Washington

Sally Brown, research professor at the University of Washington, has performed lab column studies with different types of composts, including biosolids composts. Dr. Brown reported that based on the results of her work, the mixes that were tested absorbed metals "exceptionally well." Brown provided four published articles, which are

presented in *Related Resources* below along with a September 2020 online article by Brown.

Contact: Sally Brown, research professor, University of Washington, 206-755-1396, slb@uw.edu.

Related Resources:

"Tools to Quantify the Potential for Phosphorus Loss from Bioretention Soil Mixtures," Norah Kates, David Butman, Fritz Grothkopp and Sally Brown, *Journal of Sustainable Water in the Built Environment*, Vol. 7, Issue 4, November 2021.
Citation at https://ascelibrary.org/doi/abs/10.1061/JSWBAY.0000959
From the abstract: This study was conducted to determine if soil indices for phosphorus availability can be applied to bioretention systems. We tested a broad range of composts and biosolids in combination with three water treatment residuals (WTRs) as components of bioretention systems in batch incubation studies. Combinations of organics and WTRs were tested and observed P release was compared to expected release predicted by the phosphorus saturation ratio (PSR) and phosphorus saturation index (PSI). Phosphorus release ranged from 326 mg $P \cdot kg^{-1}$ in a food/yard compost to 7,227 ± 1,277 mg $P \cdot kg^{-1}$ in anaerobically digested biosolids. Adsorption capacity of the WTRs ranged from 56[%] to 94% of P added. Specific surface area and carbon content of the WTRs had minimal predictive ability. Across a wide range of PSI (0.046 to 1.4) and PSR (0.13 to 6.5) values, these ratios were highly significant in predicting P release with an R^2 value of 0.68 and 0.55, respectively. The adjusted R^2 when a reactivity term was included was 0.78 and 0.68 for PSI- and PSR-extractable measures, respectively. Our work suggests both extracts are appropriate tools for predicting P release from bioretention mixes and that their predictability can be significantly improved by considering the reactivity term.

"Connections: Recycled Organics and Fire-Ravaged Soils," Sally Brown, *BioCycle*, September 29, 2020.
https://www.biocycle.net/connections-recycled-organics-and-fire-ravaged-soils/
This online article, the second of two parts, begins with this statement: *The few research trials to date indicate that compost, biosolids and mulch are effective at holding soils burned by wildfires in place.* The article closes with a description of roadway rehabilitation in the Sierra Nevada and the following:

Further Research Questions

Our knowledge of how compost helps soils and how fire hurts soils is enough to know that compost will be an effective tool to eliminate erosion of soils post-fire. The limited studies have confirmed this. The information that is out there (largely from [two to three] studies) says that surface application is fine and that the particle size of the compost is not critical. That doesn't mean that we know enough to know how to best use this resource. The most detailed study by Crohn et al. [see "Composts as Post-Fire Erosion Control Treatments and Their Effect on Runoff Water Quality," page 26] showed that adding more of the biosolids compost actually was worse than adding less. More nutrients were in the runoff with the higher rates of application.

Additional research is needed to answer such questions as:

- Will adding a nutrient-rich material to these sites result in too much growth of understory vegetation? In a fire situation, that could translate into more fuel. That could be tested by comparing growth post-fire on sites with high nutrient composts and lower nutrient composts.
- How much will the increased water holding capacity that comes when using recycled organics help to reduce fires and fire intensity? Another thing worth testing.

With these questions comes the important fact. Composts and organics can be a critical tool to keep burnt soils in place post-fires. Understanding nuances of an approach is a very different thing from understanding the basics. Not knowing the best way is no excuse for not using this tool now.

"Nutrient, Metal and Organics Removal from Stormwater Using a Range of Bioretention Soil Mixtures," Julia G. Jay, Megan Tyler-Plog, Sally L. Brown and Fritz Grothkopp, *Journal of Environmental Quality*, Vol. 48, Issue 2, pages 493-501, March-April 2019.
Citation at https://acsess.onlinelibrary.wiley.com/doi/10.2134/jeq2018.07.0283
From the abstract: A column study was conducted to test the ability of bioretention soil mixtures (BSMs) to remove nutrients, metals and polyaromatic hydrocarbons (PAHs) from stormwater collected from an urban highway. Infiltration rate, plant growth response and turbidity of the effluent were also measured. The BSMs were made from a range of types and rates of composts and additional materials such as water treatment residuals, sawdust, and oyster shells. Sand was used as a control. Total N [nitrogen] and P in stormwater measured 1.8 ± 1 and 0.08 ± 0.03 mg L^{-1}. All treatments were a source of these nutrients. Metal concentrations in the stormwater were low, with mean Cu and Zn concentrations of 39.8 ± 19.1 and 173 ± 113 µg L^{-1}, and Cd and Pb close to detection limits. All treatments absorbed Cu and Zn from stormwater with varying levels of removal efficiency. The three treatments tested removed 84[%] to 100% of the PAHs from the stormwater. In general, contaminant removal (N, P and Zn) efficiency was not related to infiltration rate, with a slight decrease in Cu removal efficiency observed with increased infiltration rate (R^2 = 0.32). These results indicate that the BSMs tested were a source of nutrients but were generally effective at removing metals and PAHs from stormwater.

Core Ideas

- A wide range of bioretention soil mixtures were tested for their ability to remove contaminants from stormwater.
- No single bioretention soil mixture outperformed others across all categories.
- Retention time was generally not related to contaminant removal efficiency.

"Predictors of Phosphorus Leaching from Bioretention Soil Media," Julia G. Jay, Sally L. Brown, Kate Kurtz and Fritz Grothkopp, *Journal of Environmental Quality*, Vol. 46, Issue 5, pages 1098-1105, September-October 2017.
Citation at https://acsess.onlinelibrary.wiley.com/doi/abs/10.2134/jeq2017.06.0232
From the abstract: The phosphorus saturation index (PSI) and P saturation ratio (PSR) were tested across a wide range of bioretention soil mixtures (BSMs) for their relationship to total and dissolved P in column leachate. The BSMs tested were made using different feedstocks including sand alone, food and yard waste compost, biosolids and yard compost, and high Fe biosolids. The PSI of the mixtures ranged from 0.23 ± 0.03 (biosolids and yard waste compost 15%, oyster shells 5%) to 1.26 ± 0.02 (biosolids and yard waste compost 80%). The PSR of the mixtures ranged from 0.05 ± 0 (100% sand) to 3.12 ± 0.12 (biosolids and yard waste compost 80%). A total of 12 storm events were staged using both synthetic rainwater (total P = 1.71 ± 0.3 mg L^{-1}) and actual stormwater (total P = 0.08 ± 0.03 mg L^{-1}). Excluding the sand-only mixture, all treatments were a source of P for the duration of the study. However both total and dissolved P concentrations decreased over time. Effluent concentrations of total P in the first event ranged from 0.59 to 75.55 mg L^{-1} but decreased by the final event to between 0.15 and 10.73 mg L^{-1}. The PSR was found to be a good predictor of P leaching from all BSMs with an R^2 of 0.73 for total mass of P leached across all leaching events. The PSI was a poor predictor (R^2 < 0.3). The PSR also predicted total P in leachate for individual events more effectively than the PSI. Total P in the BSMs had no relationship to P in the leachate.

Core Ideas

- Applying tools developed for agronomic soils to urban systems.
- The phosphorus saturation [ratio] can predict behavior of phosphorus in stormwater systems.
- Water treatment residuals limit P movement in green stormwater infrastructure.

"Stormwater Bioretention Systems: Testing the Phosphorus Saturation Index and Compost Feedstocks as Predictive Tools for System Performance," Sally Brown, Amber Corfman, Katrina Mendrey, Kate Kurtz and Fritz Grothkopp, *Journal of Environmental Quality*, Vol. 45, Issue 1, pages 98-106, January-February 2016.
https://www.researchgate.net/publication/281942689_Stormwater_Bioretention_Systems_Testing_the_Phosphorus_Saturation_Index_and_Compost_Feedstocks_as_Predictive_Tools_for_System_Performance
From the abstract: A replicated column trial was conducted to evaluate the potential for the phosphorus saturation index (PSI) to predict P movement in bioretention soil mixtures (BSMs). The impact of compost feedstock on BSM performance was also evaluated. Three composts (biosolids/yard, yard/food waste and manure/sawdust) were each brought to PSI values of 0.1, 0.5 and 1.0 through the addition of Fe-based water treatment residuals (WTRs) to lower the PSI and P salts to increase the PSI. A synthetic stormwater solution was used for 12 leaching events. The PSI predicted total and dissolved P concentrations in column leachate. All composts removed P at PSI 0.1. All composts were a source of P for the higher PSI values tested, with P concentrations in the leachate decreasing over time. Ammonia and nitrate from all treatments decreased over time, with all treatments

showing effective N removal. Copper removal (total and dissolved) was >90% for all treatments, with the highest removal observed at PSI 0.1 for all composts. Zinc removal (total) was also greatest in the 0.1 PSI for all composts. At PSI 0.5 and 1.0, the biosolids/yard compost was less effective than the other materials at removing Zn, with a removal efficiency of approximately 50%. Infiltration rates were similar across all treatments and ranged from 0.44 ± 0.1 cm min^{-1} in the manure/sawdust at PSI 0.1 to 3.8 ± 2.8 cm min^{-1} in the food/yard at PSI 1.0. Plant growth in the manure/sawdust compost was reduced in comparison to the other composts tested across all PSI levels. The results of this study indicate that the PSI may be an effective tool for predicting P movement in bioretention systems. Compost feedstock does not indicate the ability of composts to filter contaminants filtration, with all composts tested showing high contaminant removal.

Dr. Sally Brown, Research Associate Professor, University of Washington, undated.
http://faculty.washington.edu/slb/
This summary profile of Dr. Brown includes links to research projects and selected publications.

Related Research and Resources

Results of a literature search of in-progress and published research are presented below in the following categories:

- National research and guidance.
- State research.
- Related resources.

National Research and Guidance

A 2023 National Cooperative Highway Research Program (NCHRP) report examines various factors that influence the performance of compost blankets in runoff filtration. Guidance documents published by the U.S. Environmental Protection Agency describe the water quality impacts of compost filter berms, filter socks and blankets.

NCHRP Research Report 1040: Achieving Highway Runoff Volume and Pollutant Reduction Using Vegetated Compost Blankets: A Guide, Allen P. Davis, Ahmet Aydilek, Gary K. Felton and Erica R. Forgione, 2023.
Publication available at https://www.trb.org/Publications/Blurbs/182948.aspx
From the foreword: *NCHRP Research Report 1040: Achieving Highway Runoff Volume and Pollutant Reduction Using Vegetated Compost Blankets: A Guide* presents a state-of-the-art investigation into vegetated compost blankets (VCBs) used for stormwater control and their resulting impacts on vegetative establishment, stormwater volume reduction and water quality improvement. The research was based on a comprehensive analytical, field and laboratory assessment. This report will be of immediate interest to design and maintenance engineers.
….

In order to provide state DOTs with an effective and economical BMP to assist them with effective uses of VCBs in highway projects, research was needed to evaluate the hydrologic and water quality benefits of VCBs as used in a wide variety of roadway settings. This involved determining pollutant removal capability and capacity; assessing VCBs' ability to detain and retain runoff; and gauging the effect of climate, soils, compost composition, compost blanket thickness and other parameters on VCB performance.

Compost Filter Berms, *National Pollutant Discharge Elimination System Stormwater Best Management Practice*, U.S. Environmental Protection Agency, December 2021.
https://www.epa.gov/system/files/documents/2021-11/bmp-compost-filter-berms.pdf
This guidance document addresses the potential for nutrient discharges and pollutant retention when using compost filter berms:

- *From page 3 of the document*: Studies examining the use of erosion and sediment control practices utilizing compost in bioretention systems, compost blankets and as soil amendments have shown both reductions in organic nutrients and releases of nutrients (N and P) in leachate and infiltrate.

  The potential for nutrient discharges from erosion and sediment control practices that utilize compost should be considered to determine whether compost use is

appropriate especially in cases where there are receiving waterbodies that are sensitive to or are currently impaired by nutrients. Site conditions, compost type and composition, compost berm placement and management of the compost system also will affect potential nutrient loadings or reductions and pollutant loadings to receiving waters. The use of this practice should be considered when weighing the overall efficacy of the system in terms [of] initial nutrient loadings, mid-life nutrient trapping capacity and the potential for end-of-life nutrient discharges where nutrients are of concern.

- *From page 4 of the document*: In addition to retaining sediment, compost can retain pollutants—such as heavy metals, nitrogen, phosphorus, oil and grease, fuel, herbicides, pesticides, and other potentially hazardous substances—due to the better chemical adsorption and physical filtration capacity of the compost media (Faucette & Tyler, 2006; Faucette et al., 2008; Faucette et al., 2009). [All three publications are cited in **Related Resources** beginning on page 35.]

Compost Filter Socks, *National Pollutant Discharge Elimination System Stormwater Best Management Practice*, U.S. Environmental Protection Agency, December 2021. https://www.epa.gov/system/files/documents/2021-11/bmp-compost-filter-socks.pdf
The effectiveness of this erosion control treatment with regard to pollutant filtration is addressed on pages 3 and 4 of this guidance document:

> A number of studies have shown that compost filter socks are at least as effective as traditional erosion controls at removing settleable solids, total suspended solids and a variety of other pollutants from stormwater. An Ohio State University study found that compost filter socks have a 50 percent higher flow-through rate than silt fences without a reduction in sediment removal efficiencies (Keener et al., 2007). A U.S. Department of Agriculture study found that compost filter socks reduced clay and silt particulates (the major contributors to suspended solids and turbidity) by 65 percent, outperforming straw bales and mulch berms. The same study saw a reduction in bacteria of 75 percent, reduction in heavy metals of 37 [percent] to 71 percent and reduction in petroleum hydrocarbons of 43 [percent] to 84 percent (Faucette et al., 2009). In a similar study, compost filter socks reduced phosphorus concentrations by about 60 percent compared to removal rates of around 20 percent by silt fences (Faucette et al., 2008).

Compost Blankets, *National Pollutant Discharge Elimination System Stormwater Best Management Practice*, U.S. Environmental Protection Agency, March 2012. https://www.epa.gov/sites/default/files/2015-11/documents/compostblankets.pdf
This somewhat dated guidance document addresses water quality on page 1:

> Controlling erosion protects water quality in surface waters, such as streams, rivers, ponds, lakes and estuaries; and increasing stormwater infiltration replenishes groundwater aquifers. Applying a compost blanket also works well as a stormwater best management practice (BMP) because it:
>
> - Retains a large volume of water, which aids in establishing vegetation growth within the blanket,
> - Acts as a cushion to absorb the impact energy of rainfall, which reduces erosion,

- Stimulates microbial activity that increases the decomposition of organic matter, which increases nutrient availability and improves the soil structure,
- Provides a suitable microclimate with the available nutrients for seed germination and plant growth, and
- Removes pollutants such as heavy metals, nitrogen, phosphorus, fuels, grease and oil from stormwater runoff, thus improving downstream water quality (USEPA 1998).

State Research

Two projects—one that recently concluded and one in process—are highlighted below:

- A research project recently concluded in California evaluated the performance of compost filter socks and straw wattles "to retain contaminants from stormwater runoff after the 2018 Camp Fire."
- An Ohio DOT project in progress is considering the effectiveness of compost-based BMPs at road construction sites. This project was expected to be completed in July 2024.

Although the 2006 Texas DOT research project cited below is somewhat dated, the study's examination of "the water quality impacts of compost leachate constituents and structural integrity of unseeded compost filter berms, seeded compost filter berms and compost/mulch filter socks" appears to be relevant to Caltrans' interests.

California

Draft Contractor's Report: Straw Wattle and Compost Filter Sock Performance for Retaining Stormwater Contaminants Following the 2018 Camp Fire, California Department of Recycling and Recovery, June 2024.

(This draft report has been provided to Caltrans separately.)

From the executive summary:

> This study compares the performance of two sediment retention products, straw wattles (SW) and compost filter socks (CFS), collectively referred to in this report as "products." These products are used as best management practices (BMPs) for stormwater protection and erosion control following wildfires. The goal of the study is to compare the performance of SW and CFS to retain contaminants from stormwater runoff after the 2018 Camp Fire. The SW and CFS samples studied in this research were deployed during the 2018 Camp Fire throughout the town of Paradise where they remained throughout the rainy season until sample collection in 2019. Sediment samples near these products were also collected and analyzed for contaminant concentrations to compare with the concentrations found in deployed products. This study characterized trace metals, per- and polyfluoroalkyl substances (PFAS), and polychlorinated dibenzo-p-dioxins and furans (PCDD/F) of these SW, CFS and sediment samples.

Below are excerpts from the project's conclusions:

> The present study has detailed the results of a field-sampling and laboratory-based assessment of contaminant uptake in straw and compost sediment control devices following an urban wildfire. The study has revealed that both inorganic and organic contaminants are present in stormwater systems, persist following fire and can be retained via sediment controls.
>
> Compost filter socks (CFS) were found to retain metals to a greater extent than straw wattles (SW). Six of the seven trace metals analyzed were retained at significantly higher concentrations in CFS compared to SW deployed after the Camp Fire.
>
> To the author's knowledge, this is the first study to measure PFAS and PCDD/F in stormwater sediments following urban burnings. While the total number of samples was small, the frequent detections coupled with some relatively high concentrations suggest that persistent organic chemicals should be considered for watershed management and protections when responding to urban disasters.
> ….
>
> The study also reveals that installing sediment controls quickly, correctly and with sufficient capacity is likely to be effective in reducing contaminant loading into local watersheds. The presence of chemicals in sediments behind products clearly shows that chemicals can be prevented from entering the environment. It should also be noted that the teams frequently observed failing sediment controls during sampling as many of the retention structures were not maintained, were overtopped, and insufficient quantities of controls were in place by the end of the winter season.
> ….
>
> The increased contaminant retention by CFS in laboratory experiments clearly shows that there is a difference in surface reactivity between the two materials, thus contaminant uptake is not only related to particle capture. The side-by-side sorption tests show increased PFOA [perfluorooctanoic acid] sorption by CFS, while there was almost no PFOA sorption by SW. These experiments were not dependent on flow through as they were batch sorption tests conducted in controlled settings under identical conditions. Therefore, the compost materials do seem to be a better sorbent, at least for PFOA.

Ohio

Research in Progress: Effectiveness of Compost Blankets, Ohio Department of Transportation, start date: January 2023; expected completion date: July 2024.
Project description at
https://www.dot.state.oh.us/Divisions/Planning/SPR/Research/reportsandplans/Lists/Final%20Reports%20All/AllItems.aspx?View=%7b7D4D0273-6FC5-48A5-AD17-9CC3A7E83DA0%7d&FilterField1=State%5fx0020%5fJob%5fx0020%5f%5fx0023%5f&FilterValue1=136694
From the project description: Soils disturbed by roadway construction often exhibit reduced soil porosity, lower precipitation storage capacity and lower infiltration rates, thereby yielding increased surface runoff. … This project is designed to investigate the

effectiveness of compost blankets for roadside vegetation establishment and stormwater management in Ohio. The goal of this research dovetails with ODOT's [Ohio DOT's] mission by developing and conducting tests to determine the performance of various compost blanket treatments on the improvement of erosion control, reduction of stormwater runoff, improvement of infiltration rates and support of long-term sustainable vegetation. The outcome of this project will result in specifications, standard details and a decision matrix that provides guidance on the use, limitations, design and implementation of vegetated compost blankets on existing roadway embankments for the conditions prevalent in Ohio. This outcome can assist with ODOT's mission to increase capacity by minimizing the risk of having roadways taken out of service by stormwater flooding or erosion. The objectives of this project are to complete a series of complementary activities: (1) A literature review on the performance of compost blankets; (2) survey questionnaires and follow-up interviews on the current state-of-the-art at ODOT, (3) laboratory assessment of the effects of compost amendment rate on the hydraulic properties and erosion of soil; (4) field evaluation of the existing compost blankets to examine the effects of the compost amendment rate on runoff water quantity and quality, water infiltration and nearby vegetation; and (5) field testing of optimized compost blankets.

Texas

Water Quality Characteristics and Performance of Compost Filter Berms, Beverly B. Storey, Aditya B. Raut Desai, Ming-Han Li, Harlow C. Landphair and Timothy Kramer, Texas Department of Transportation, April 2006.
https://static.tti.tamu.edu/tti.tamu.edu/documents/0-4572-1.pdf
Researchers examined the water quality impacts of compost leachate constituents and structural integrity of unseeded compost filter berms, seeded compost filter berms and compost/mulch filter socks. *From the abstract*:

> The Texas Department of Transportation, in conjunction with the Texas Commission on Environmental Quality and the Environmental Protection Agency, commissioned a study to examine the water quality impacts of compost leachate constituents and structural integrity of unseeded compost filter berms, seeded compost filter berms and compost/mulch filter socks. Wood mulch filter berms, straw bales and silt fence were tested comparatively. Three compost types were tested: dairy manure, biosolids and yard waste. The berms and filter sock material used a mixture of 50 percent compost and 50 percent wood chips. Studies were conducted with low velocity flows. Each of the alternatives was tested for two rounds consisting of three repetitions each round on both sand and clay soils. Results showed that the yard waste compost outperformed the dairy manure compost and biosolid compost in water quality characteristics and structural durability in performance.

Related Resource:

> **Summary Report: Water Quality Characteristics and Performance of Compost Filter Berms**, Beverly B. Storey, Aditya B. Raut Desai, Ming-Han Li and Harlow C. Landphair, Texas Transportation Institute, April 2006.
> https://static.tti.tamu.edu/tti.tamu.edu/documents/0-4572-S.pdf
> This technical brief summarizes the activities of the research project described above.

Related Resources

The publications cited below examine compost in connection with a range of issues, including the risk of phosphorus contamination of water, the multiple-event removal efficiency and capacity of compost filter socks, and the capacity of compost filter media for sediment, nutrient and hydrocarbon removal from stormwater runoff.

"Phosphorus in Compost and Risks to Water Quality," Geoffrey Kuter, Mike Carignan and Dave Harding, *Managing Residuals in a Complex World: The Northeast Residuals and Biosolids Conference*, October 2017.
https://www.newea.org/wp-content/uploads/2017/11/Kuter-PhosphorusComposts-NEBiosolidsConference-27Oct2017.pdf
This conference presentation addressed the following question: How can we use compost without risk to phosphorus contamination of water? Noting that "[s]tudies with composts are limited," the presenters offered the following guidance:

- Compost amendments are effective in improving soil properties, which reduce runoff, loss of soil and phosphorus in runoff.
- Compost should be used to raise levels of soil organic matter.
- Composts will increase levels of phosphorus in soil and thus the potential for leaching of phosphorus, particularly in sandy soils.
- Leaching is highly dependent on soil chemistry and measurements of water-extractable phosphorus and phosphorus saturation index, and should be used to evaluate risk (not total phosphorus in compost).
- Repeated applications of compost to provide nutrients may not be justified where phosphorus losses are of concern.

"Effects of Compost Age on the Release of Nutrients," Bilal B. Al-Bataina, Thomas M. Young and Ezio Ranieri, *International Soil and Water Conservation Research*, Vol. 4, Issue 3, pages 230-236, September 2016.
Citation at https://doi.org/10.1016/j.iswcr.2016.07.003
From the abstract: Composted organic materials are applied to help restore disturbed soils, speed revegetation and control erosion; these changes are generally beneficial for stormwater quality. Ensuring that nutrient release from compost is adequate for plant needs without degrading stormwater quality is important since composts release nitrogen at variable rates (1 [to] 3% of total N/yr) and the leaching process can extend for many years. The aim of this work was to understand the effect of compost age on the extent and rates of nitrogen release by conducting detailed rainfall simulation studies of one compost type at three different ages. Models describing temporal changes in nitrogen release to runoff during a single storm and across multiple storms were developed and applied to the runoff data. Nitrogen content (%) and bulk density of compost increased with the increase in compost age and total nitrogen release decreased with increasing compost age. The three rain simulations (storms) performed on each of the three compost ages show that nitrogen release declined each day of the repeated daily storms. A first-order kinetic model was used to estimate the amount of nitrogen remaining on compost after several storms.

"Performance of Compost Filtration Practice for Green Infrastructure Stormwater Applications," Britt Faucette, Fatima Cardoso, Walter Mulbry and Pat Millner, *Water Environment Research*, Vol. 85, Issue 9, pages 806-814, September 2013.
Citation at
https://www.researchgate.net/publication/258212311_Performance_of_Compost_Filtration_Practice_for_Green_Infrastructure_Stormwater_Applications
From the abstract: Urban storm water runoff poses a substantial threat of pollution to receiving surface waters. Green infrastructure, low impact development, green building ordinances, National Pollutant Discharge Elimination System (NPDES) storm water permit compliance, and Total Maximum Daily Load (TMDL) implementation strategies have become national priorities; however, designers need more sustainable, low-cost solutions to meet these goals and guidelines. The objective of this study was to determine the multiple-event removal efficiency and capacity of compost filter socks (FS) and filter socks with natural sorbents (NS) to remove soluble phosphorus, ammonium-nitrogen, nitrate-nitrogen, *E. coli*, *Enterococcus* and oil from urban storm water runoff. Treatments were exposed to simulated storm water pollutant concentrations consistent with urban runoff originating from impervious surfaces, such as parking lots and roadways. Treatments were exposed to a maximum of 25 runoff events, or when removal efficiencies were <= 25%, whichever occurred first. Experiments were conducted in triplicate. The filter socks with natural sorbents removed significantly greater soluble phosphorus than the filter socks alone, removing a total of 237 mg/linear [meter] over eight runoff events, or an average of 34%. The filter socks with natural sorbents removed 54% of ammonium-nitrogen over 25 runoff events, or 533 mg/linear [meter], and only 11% of nitrate-nitrogen, or 228 mg/linear [meter]. The filter socks and filter socks with natural sorbents both removed 99% of oil over 25 runoff events, or a total load of 38,486 mg/linear [meter]. Over 25 runoff events the filter socks with natural sorbents removed *E. coli* and *Enteroccocus* at 85% and 65%, or a total load of 3.14 CFUs x 108 / linear m and 1.5 CFUs x 109 /linear [meter], respectively; both were significantly greater than treatment by filter socks alone. Based on these experiments, this technique can be used to reduce soluble pollutants from storm water over multiple runoff events.

"Hydrologic and Water Quality Aspects of Using a Compost/Mulch Blend for Erosion Control," Bradley Eck, Michael Barrett, Anne McFarland and Larry Hauck, *Journal of Irrigation and Drainage Engineering*, Vol. 136, Issue 9, pages 646-655, September 2010.
Citation at http://dx.doi.org/10.1061/(ASCE)IR.1943-4774.0000223
From the abstract: Construction projects often expose large amounts of soil to erosive forces of wind and rain. These areas must be stabilized and vegetated before a Notice of Termination can be submitted to regulators. The objectives of this project were to compare the stabilization performance of two types of compost wood mulch blend top dressing (low and high organic matter), a wood based hydromulch and seeded bare soil and to determine the amount of sediment and nutrients exported from each type of treatment. Ten test plots 12.2 × 2.4 m^2 were constructed at a quarry in Parker County, Texas, and outfitted with runoff capture systems. Runoff quality and quantity was evaluated for [two] years after installation. Sediment discharge was reduced by 98% on the compost/mulch blend plots and about 75% with hydromulch treatment compared to bare plots. Treatments reduced nutrient loads, although runoff concentrations of

nitrate and dissolved [phosphorus] from compost treated plots were often higher than from bare soil or hydromulch plots.

"Storm Water Pollutant Removal Performance of Compost Filter Socks," L. B. Faucette, F. A. Cardoso-Gendreau, E. Codling, A. M. Sadeghi, Y. A. Pachepsky and D. R. Shelton, *Journal of Environmental Quality*, Vol. 38, Issue 3, pages 1233-1239, May 2009. Citation at https://doi.org/10.2134/jeq2008.0306
From the abstract: In 2005, the U.S. Environmental Protection Agency (USEPA) National Menu of Best Management Practices (BMPs) listed compost filter socks (FS) as an approved BMP for controlling sediment in storm runoff on construction sites. The objectives of this study were to determine if FS with or without the addition of a flocculation agent to the FS system can significantly remove (i) suspended clay and silt particulates, (ii) ammonium nitrogen (NH_4–N) and nitrate-nitrite nitrogen (NO_3–N), (iii) fecal bacteria, (iv) heavy metals and (v) petroleum hydrocarbons from storm water runoff. Five separate (I–V) 30-min simulated rainfall-runoff events were applied to soil chambers packed with Hartboro silt loam (fine-loamy, mixed, active, nonacid, mesic fluvaquentic Endoaquepts) or a 6-mm concrete veneer on a 10% slope, and all runoff was collected and analyzed for hydraulic flow rate, volume, pollutant concentrations, pollutant loads and removal efficiencies. In corresponding experiments, runoff was analyzed for (i) size of sediment particles, (ii) NH_4–N and NO_3–N, (iii) total coliforms (TC) and *Escherichia coli*, (iv) Cd, Cr, Cu, Ni, Pb and Zn, and (v) gasoline, diesel and motor oil, respectively. Results showed that: (i) FS removed 65% and 66% of clay (<0.002 mm) and silt (0.002 [to] 0.05 mm), respectively; (ii) FS removed 17%, and 11% of NH_4–N and NO_3–N, respectively, and when NitroLoxx was added to the FS, removal of NH_4–N load increased to 27%; (iii) total coliform and *E. coli* removal efficiencies were 74[%] and 75%, respectively, however, when BactoLoxx was added, removal efficiency increased to 87[%] and 99% for TC and 89[%] and 99% for *E. coli*, respectively; (iv) FS removal efficiency for Cd, Cr, Cu, Ni, Pb and Zn ranged from 37[%] to 72%, and, when MetalLoxx was added, removal efficiency ranged from 47[%] to 74%; and (v) FS removal efficiency for the three petroleum hydrocarbons ranged from 43[%] to 99% and the addition of PetroLoxx increased motor oil and gasoline removal efficiency in the FS system.

"Performance of Compost Filter Socks and Conventional Sediment Control Barriers Used for Perimeter Control on Construction Sites," L. B. Faucette, J. Governo, R. Tyler, G. Gigley, C. F. Jordan and B. G. Lockaby, *Journal of Soil and Water Conservation*, Vol. 64, Issue 1, pages 81-88, January/February 2009.
https://filtrexx.com/application/files/4214/5927/8966/118-2009-JSWC-Compost-Filter-Sock-Mulch-Berms-and-Hay-Bale-Field-Performance.pdf
From the abstract: The objective of this study was to compare the sediment removal efficiency, peak flow rate and cost of straw bales, mulch filter berms, compost filter socks and compost filter socks + polymer used as perimeter sediment control devices under high intensity/duration single storm event conditions to assist environmental regulators and design professionals in choosing an appropriate best management practice for their construction site or storm water pollution prevention plan. A simulated rainfall intensity/duration was chosen in order to produce a direct runoff (Q) per linear unit length of treatment equivalent to that generated in 24-hour, [five]-year return for north Georgia (11.25 cm [4.5 inch]) using the maximum drainage area allowed for silt fence on a 10% slope. All sediment control treatments restricted peak runoff flow rates

relative to the bare soil (control). All treatments discharged significantly lower total solids (concentration and load) than the bare soil, while all compost sock treatments were significantly lower (concentration and load) than the mulch filter berm and straw bale. Removal efficiency for total solid load ranged from 63.5% to 88.2%. Single-event [phosphorus] factor (soil loss ratio) was determined for all treatments and ranged from 0.118 to 0.365. All treatments were significantly lower than the bare soil, and all compost filter socks were significantly lower than the mulch filter berm. All treatments discharged significantly lower total suspended solids (concentration and load) than the bare soil, and all compost sock treatments were significantly lower (concentration and load) than the mulch filter berm and straw bale. Removal efficiency for total suspended solid load ranged from 60.4% to 89.5%. All compost filter socks had significantly lower turbidity relative to bare soil, and the addition of the polymer to the compost filter sock treatments had significantly lower turbidity relative to the compost filter socks without the polymer. Percent turbidity reduction ranged from 8.1 to 49.1. Total cost of installation was estimated for each sediment control device based on product + freight from distributor + staking materials + labor to install. Total cost for sediment control devices ranged from $1.75 to $2.87 per linear 30 cm (1 [foot]).

"Sediment and Phosphorus Removal from Simulated Storm Runoff with Compost Filter Socks and Silt Fence," L. B. Faucette, K. A. Sefton, A. M. Sadeghi and R. A. Rowland, *Journal of Soil and Water Conservation*, Vol. 63, Issue 4, pages 257-264, July 2008. Citation at https://doi.org/10.2489/jswc.63.4.257
From the abstract: The objectives of this study were (1) to determine and compare the sediment removal efficiency of silt fence and compost filter socks, (2) to determine if the addition of polymers to compost filter socks could reduce sediment and phosphorus loads, [and] (3) to determine relationships between compost filter media particle size distribution and pollutant removal efficiency and hydraulic flow rate. Simulated rainfall was applied to soil chambers packed with Hatboro silt loam on a 10% slope. All runoff was collected and analyzed for hydraulic flow rate, volume, total suspended solids (TSS) concentration and load, turbidity and total and soluble [phosphorus] concentration and load. Based on 7.45 cm h^{-1} (2.9 [inches] hr^{-1}) of simulated rainfall-runoff for 30 minutes duration, bare soil (control) runoff TSS concentrations were between 48,820 and 70,400 mg L^{-1} (6.5 oz gal^{-1} and 9.4 oz gal^{-1}), and turbidity was between 19343 and 36688 Nephelometric Turbidity Units. Compost filter sock and silt fence removal efficiencies for TSS concentration (62% to 87% and 71% to 87%), TSS load (68% to 90% and 72% to 89%), and turbidity (53% to 78% and 54% to 76%) were nearly identical; however with the addition of polymers to the compost filter socks sediment removal efficiencies ranged from 91% to 99%. Single event support practice factors (P factor) for silt fence were between 0.11 and 0.29, for compost filter socks between 0.10 and 0.32, and for compost filter socks + polymer between 0.02 and 0.06. Total and soluble [phosphorus] concentration and load removal efficiencies were similar for compost filter socks (59% to 65% and 14% to 27%) and silt fence (63% and 23%). Although when polymers were added to the filter socks and installed on phosphorus fertilized soils, removal efficiencies increased to 92% to 99%. Compost filter socks restricted hydraulic flow rate between 2% and 22%, while the silt fence restricted between 5% and 29%. Significant correlations ($p < 0.05$) were found between middle range particle sizes of compost filter media used in the filter socks and reduction of turbidity in runoff; however, hydraulic flow rate was a better indicator (stronger correlation) of total pollutant removal efficiency performance

for compost filter socks and should be considered as a new parameter for federal and state standard specifications for this pollution prevention technology.

Using Compost Can Reduce Water Pollution, Fact Sheet, U.S. Composting Council, 2008. https://www.sandiego.gov/sites/default/files/legacy/environmental-services/pdf/miramar/CompostReducingWater.pdf
The use of compost blankets, filter socks and berms during all phases of construction are discussed briefly in this fact sheet. *From the fact sheet*:

> Since it is not always feasible to prevent erosion during construction, compost can be effectively used to filter storm water leaving a construction site. Typically construction sites use silt fence or hay bales to provide sediment control around the perimeter of the site. Using composted mulch, either in freestanding filter berms or contained in long tubes called "filter socks," has proved to be much more effective. While the typical practices act as temporary storm water detention devices, counting on gravity to settle out solids, the compost-based practices work both as a detention and a filter, removing suspended solids, settleable solids, along with soluble pollutants such as petroleum hydrocarbons and nutrients.

"Erosion Control and Storm Water Quality from Straw with PAM, Mulch and Compost Blankets of Varying Particle Sizes," L. B. Faucette, J. Governo, C. F. Jordan, B. G. Lockaby, H. F. Carino and R. Governo, *Journal of Soil and Water Conservation*, Vol. 62, Issue 6, pages 404-413, 2007.
https://www.filtrexx.com/application/files/7514/5928/0138/115-2007-JSWC-Performance-of-CECB-Straw-Pam-and-Various-CECB-Parfticle-Size-Specs.pdf
From the abstract: Compost and mulch blankets have been widely used for slope stabilization and erosion control at construction sites; however, the majority of research on these erosion control blankets has failed to meet state or federal specifications for particle size distribution. The primary objective of this study was to determine how blending wood mulch with compost may affect its performance as an erosion control practice relative to a straw blanket with polyacrylamide (PAM). The secondary objective of this study was to determine if particle size distribution of the organic erosion control blanket affects runoff, erosion and vegetation establishment. Researchers concluded that the greater percent of compost used in an erosion control blanket, the lower the total runoff and the slower the runoff rate. Compost erosion control blankets retained 80% of the simulated rainfall applied and reduced cumulative storm runoff by 60%, while the wood mulch blankets reduced runoff by 34% and straw with PAM by 27%. Conversely, the greater the percent of mulch used in the erosion control blanket, the lower the sediment and suspended sediment load. However, any combination of compost and mulch reduced runoff volume, runoff rate and soil loss relative to a straw blanket with [PAM]. The average cover management factor (C factor) for the straw with PAM was 0.189, the compost blanket was 0.065, and the mulch blanket was 0.013. Researchers also concluded that particle size distribution of the compost and mulch blankets was the leading parameter that reduced soil loss and runoff. If particle size distribution specifications are not followed, total soil loss can be four times greater, suspended solids can be five times greater, and turbidity can be eight times greater, relative to blankets that meet particle size distribution specifications. Nitrogen and phosphorus loading from mineral fertilizer used with conventional straw blankets may lead to increased nutrient loading of receiving surface water relative to the compost

and mulch blankets. The straw blanket with fertilizer increased total Kjeldahl nitrogen loading by more than 8,000%, the compost blanket increased total Kjeldahl nitrogen by 340%, and the mulch blanket by 18% relative to the control. Although the bare soil and mulch blanket treatments did not contribute any soluble phosphorus (P) to runoff, relative to the compost blanket, the soluble P load from the straw blanket with PAM was 3,800% greater. Results from this study may be used to revise particle size specifications for compost erosion control blankets and to help regulators and design professionals determine which type of erosion control best management practice is best for their particular application.

"Flow-Through Rates and Evaluation of Solids Separation of Compost Filter Socks Versus Silt Fence in Sediment Control Applications," Harold M. Keener, Britt Faucette and Michael H. Klingman, *Journal of Environmental Quality*, Vol. 36, Issue 3, pages 742-752, May/June 2007.
Citation at https://pubmed.ncbi.nlm.nih.gov/17412909/
From the abstract: Soil loss rates from construction sites can be 1000 times the average of natural soil erosion rates and 20 times that from agricultural lands. Silt fence (SF) is the current industry standard used to control sediment originating from construction activities. Silt fences are designed to act as miniature detention ponds. Research has indicated that SF sediment filtering efficiency is related to its ability to detain and pond water, not necessarily the filtration ability of the fabric. Design capacity and spacing [are] based on flow-through rate and design height. In addition, increased detention of runoff and pressure from ponding may increase the likelihood of overtopping or failure of SF in field application. Testing was conducted on compost silt socks (SS) and SF to determine sediment filtering efficiency, flow-through rate, ponding depth, overtopping point, design height and design capacity. Results indicate flow-through rate changes with time, as does ponding depth, due to the accumulation of solids on/in the sediment filters. Changes in depth with time were a linear function of flow rate after 10 min[utes] of flow, up to the time the sediment filter is overtopped. Predicting the capacity of SF and SS to handle runoff without the filter being overtopped requires consideration of both runoff rate and length of runoff time. Data show SS half the heights of SF were less likely to overtop than SF when sediment-laden runoff water flow rates are less than 1.03 L(-1) s(-1) m(-1) (5 gpm/ft, gal per minute per lineal foot). Ponded depth behind a 61.0-cm (24-in[ch]) SF increased more rapidly than behind a 30.5-cm diam. (12-in[ch]) SS, and at the end of the [30] minutes, the depth behind the SF was 75% greater than that behind the SS. Removal of solids by the SF and the SS were not shown to be statistically different. Results were used to create a Microsoft Excel-based interactive design tool to assist engineers and erosion and sediment control planners on how to specify compost SS relative to SF in perimeter sediment control applications.

"Organic BMPs Used for Storm Water Management," L. Britt Faucette and Rod Tyler, *International Erosion Control Association Annual Conference Proceedings*, 2006.
https://filtrexx.com/application/files/6314/5927/9546/108-2006-IECA-Conference-Proceedings-Filter-Soxx-Performance.pdf
From the abstract: Recent university research has shown that a compost system can reduce storm runoff, sediment and nutrient loss, and increase vegetation and soil quality parameters relative to industry standard best management practices. State departments of transportation and construction companies have reported positive

results in using compost as a filter media within filter socks. … Independent laboratory testing evaluated compost filter media for sediment, nutrient and hydrocarbon removal from storm water runoff on a 3:1 slope. Total solids and petroleum hydrocarbon reduction from filtration of storm runoff were consistently over 95%. Reduction in nitrate nitrogen and total phosphorus concentrations from storm runoff were observed. Additionally, increased reduction of total suspended solids and turbidity, in addition to consistently high removal percentages of petroleum hydrocarbons over three consecutive storm runoff events, were also reported.

"Evaluation of Stormwater from Compost and Conventional Erosion Control Practices in Construction Activities," L. B. Faucette, C. F. Jordan, L. M. Risse, M. Cabrera, D. C. Coleman and L. T. West, *Journal of Soil and Water Conservation*, Vol. 60, Issue 6, pages 288-297, 2005.
Citation at https://www.jswconline.org/content/60/6/288
From the abstract: Four types of compost blankets, hydroseed, silt fence and a bare soil (control) were applied in field test plots. Treatments were seeded with common bermuda grass. A rainfall simulator applied rainfall at an average rate equivalent to a 50 yr hr^{-1} storm event (7.75 cm hr^{-1}). Three simulated rain events were conducted: immediately after treatment application, at three months when vegetation was established and at one year when the vegetation was mature. After three months, the compost generated five times less runoff than hydroseed with silt fence, and after one year, generated 24[%] less runoff. All treatments proved better than the control at reducing solids loss. Total solid loads were as much as 3.5 times greater from hydroseed and silt fence compared to the composts during the first storm, and as much as 16 times greater during the second storm. Materials high in inorganic nitrogen (N) released greater amounts of nitrogen in storm runoff; however, these materials showed reduced N loss over time. Hydroseeding generated significantly higher total phosphorus (P) and dissolved reactive P loads compared to compost in storm runoff during the first storm event.

Contacts

CTC contacted the people below to gather information for this investigation.

Private Sector Firms

R. Alexander Associates, Inc.
Ron Alexander
919-349-0460, ron@alexassoc.net

MKB Company/Filtrexx International LLC
Britt Faucette
Vice President, Research and Development/Regulatory/Technical Services
404-687-8393, britt.faucette@filtrexx.com

State Agencies

Arizona

Eileen Dunn
Water Resources Manager, Infrastructure Delivery and Operations Division
Arizona Department of Transportation
602-245-0725, edunn@azdot.gov

Matthew J. Holcombe
Environmental Coordinator, Southeast District
Arizona Department of Transportation
480-498-9668, mholcombe@azdot.gov

Idaho

Cathy Ford
Roadside Program Manager
Idaho Transportation Department
208-334-8416, cathy.ford@itd.idaho.gov

Indiana

Reed Hathaway
Environmental Services
Indiana Department of Transportation
317-503-7897, rhathaway@indot.in.gov

Nevada

Nathan Morian
Maintenance and Asset Management Division
Nevada Department of Transportation
775-888-7854, nmorian@dot.nv.gov

New York

Christine Colley
Landscape Architect, Landscape Architecture Bureau
New York State Department of Transportation
518-485-9313, christine.colley@dot.ny.gov

Oklahoma

Teresa Stephens
Research Engineer
Oklahoma Department of Transportation
tstephens@odot.org

Texas

Tracey Janus
Environmental Program Manager
Texas Department of Transportation
737-701-8726, tracey.janus@txdot.gov

Vermont

Heather Voisin
Green Infrastructure Engineer, Highways Project Environmental Section
Vermont Agency of Transportation
802-498-5787, heather.voisin@vermont.gov

Washington

Elsa Pond
Total Maximum Daily Load Lead, Environmental Services Office
Washington State Department of Transportation
360-481-8989, elsa.pond@wsdot.wa.gov

West Virginia

Douglas Kirk
Chief Engineer of Environmental Compliance
West Virginia Department of Transportation
304-414-6957, douglas.w.kirk@wv.gov

Wisconsin

Jeremy Ashauer
Erosion and Sediment Control Engineer
Wisconsin Department of Transportation
920-412-6381, jeremy.ashauer@dot.wi.gov

University Researchers

California

David Crohn
Associate Professor Emeritus
University of California, Riverside Extension
951-827-3333, david.crohn@ucr.edu

Washington

Sally Brown
Research Professor
University of Washington
206-755-1396, slb@uw.edu

Appendix A: Survey Questions

An online survey was distributed to state transportation agency members of three Transportation Research Board (TRB) committees:

- Standing Committee on Hydrology, Hydraulics and Stormwater.
- Standing Committee on Landscape and Environmental Design.
- Standing Committee on Roadside Maintenance Operations.

To provide for a national pool of potential respondents, when necessary the distribution list also included a member of the American Association of State Highway and Transportation Officials (AASHTO) Committee on Maintenance.

Caltrans Survey on the Use of Compost-Based BMPs in Water Quality Protection

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Note: The response to the question below determined how a respondent was directed through the survey.

(Required) Does your agency use compost-based BMPs, such as compost filter socks, compost berms and compost blankets, to control erosion and protect water quality?

- No (Skipped the respondent to **Agencies Not Currently Using Compost-Based BMPs**.)
- Yes (Skipped the respondent to **Agencies Currently Using Compost-Based BMPs**.)

Agencies Not Currently Using Compost-Based BMPs

1. Does your agency have any previous experience with compost-based BMPs?
    - No
    - Yes (Please describe.)
2. (Required) Has your agency conducted an informal or more formalized assessment of the performance of compost-based BMPs in protecting water quality?
    - No (Skipped the respondent to **Wrap-Up**.)
    - No, but we plan to. (Skipped the respondent to **Agencies Planning to Assess the Performance of Compost-Based BMPs** and **Wrap-Up**.)
    - Yes (Skipped the respondent to **Assessing the Performance of Compost-Based BMPs** and **Wrap-Up**.)

Agencies Currently Using Compost-Based BMPs

1. What types of compost-based BMPs does your agency use? Please select all that apply.
    - Compost berms
    - Compost blankets
    - Compost filter socks
    - Other compost-based BMPs (Please describe.)

2. Please briefly describe how your agency uses compost-based BMPs to manage stormwater and/or runoff in the following applications.
    - Wildfire-impacted lands
    - Lands abutting agricultural uses
    - Construction sites
    - Mitigation sites
    - Other applications
3. (Required) Has your agency conducted an informal or more formalized assessment of the performance of compost-based BMPs in protecting water quality?
    - No (Skipped the respondent to **Wrap-Up**.)
    - No, but we plan to. (Skipped the respondent to **Agencies Planning to Assess the Performance of Compost-Based BMPs** and **Wrap-Up**.)
    - Yes (Skipped the respondent to **Assessing the Performance of Compost-Based BMPs** and **Wrap-Up**.)

Agencies Planning to Assess the Performance of Compost-Based BMPs

1. Please describe how your agency plans to assess the performance of compost-based BMPs in protecting water quality.
2. When do you anticipate beginning this assessment?
3. Who will be responsible for conducting this assessment?
4. Please provide any additional information you'd like to share about this planned investigation.

Assessing the Performance of Compost-Based BMPs

1. Please briefly describe how compost-based BMPs perform in controlling export of the following contaminants.
    - Heavy metals
    - Nitrate
    - Oil
    - Oxidized nitrogen
    - Potassium
    - Soluble phosphorus
    - Total dissolved solids
    - Total nitrogen
    - Total suspended solids
    - Other contaminants (Please list and describe.)
2. Please describe any other impacts your agency has identified when using compost-based BMPs.
3. Please provide links to documents associated with your agency's use of compost-based BMPs and their performance in protecting water quality. Send any files not available online to chris.kline@ctcandassociates.com.

Wrap-Up

Please use this space to provide any comments or additional information about your previous responses.