October 2023

EvoGuard Erosion Control Environmental Benefits vs. Traditional Silt Fences

Jeffrey A. Adams, PhD, PE (ENGEO Incorporated)
Ben Croze (ENGEO Incorporated)
Josef Tootle, GE (ENGEO Incorporated)

INTRODUCTION

We have prepared this alternatives analysis document to assess the environmental benefits that may result from the installation of the EvoGuard (FKA: SOXfence®) Erosion Control product. The product, which is used for erosion control (Exhibit 1), has been successfully deployed to prevent soil erosion. The purpose of this assessment is to determine how its use in a hypothetical application compares with other alternatives with respect to efficacy and derived primary and secondary environmental benefits. For the purposes of this analysis, we have compared an EvoGuard installation with a silt fence alternative (Exhibit 2) as well as a "do-nothing" alternative. For simplicity, costs are reported in current (Year 0) dollars.

EXHIBIT 1: Typical EvoGuard (FKA: SOXfence®) Installation (Source: SOX Erosion Solutions)

CONCEPTUAL PROJECT DESCRIPTION

To assess the efficacy of EvoGuard, we have developed a hypothetical stabilization application. We have assumed the stabilization of a slope face that is 50 feet long for a project duration of 5 years. To further compare alternatives, we will assume that at the base of the hill there is a body of water, a trail, and residences; impacts on each of these will be considered. We also assume the current hillside is relatively barren either from construction activity, fire, erosion, or previously uncontrolled runoff. We assume that the total shipping distance to deliver each alternative to site is 50 miles per installation. Our calculations assume a medium sized gas-powered car for shipping. For comparison, we will examine the performance of EvoGuard (Alternative 3), a traditional silt fence (Alternative 2), and a "do-nothing" option (Alternative 1) for this application. We assume a fence height of 3 feet. For the silt fence alternative, we selected the "Contractor Grade Assembled Silt Temporary Fencing" which is available at Home Depot. The "do-nothing" case assumes no construction or other stabilization effort and would result in hillside erosion and/or debris flows. The alternatives include the following.

*"Over the course of the 5-year project timeline the silt fence alternative will have to be installed **10 times**."*

Alternative 1 – No Improvements Installed

Alternative 2 – Contractor Grade Assembled Silt Temporary Fencing (Including Wood Posts)

We assume a silt fence lifespan of 6 months. This is based on a review of various county, city, and state reports across the U.S. Over the course of the 5-year project timeline the silt fence alternative will have to be installed 10 times.

Alternative 3 – EvoGuard Mesh Type 2 with fire-retardant

We assume that the EvoGuard will only have to be installed once during the 5-year project timeline.

Materials:

- Unit cost: **$24**; $24 per 3-foot x 50-foot roll including wooden stakes per installation.

Labor:

- Assume labor is **$300** for one installation, including staking, trenching, and required machinery (3 hours of labor).

Shipping:

- Unit cost: **$5.92**; 30 miles per gallon (average mid-size car), **$3.55** per gallon (2023 average), 50 miles per installation.

Unit weight:

- 13 pounds per installation on a 50-foot-long slope.
  - 4 pounds for 3-foot x 50-foot fabric roll (150 square feet).
  - 9 pounds for attached wooden stakes.

TOTAL COST: $3,299.20

Materials:

- **$234.50** per 3-foot x 50-foot roll (based on pricing of $4.69 per linear foot).
- **$5** per T-post (1 T-posts per 5.5 feet) = $45 per installation.

Labor:

- Assume labor is **$20** for installation, including staking (no trenching, 30 minutes of labor).

Shipping:

- Unit cost: **$5.92**; 30 miles per gallon (average mid-size car), **$3.55** per gallon (2023 average), 50 miles per installation.

Unit weight:

- 3.82 pounds per 3-foot x 50-foot roll (150 square foot).
- 33.75 pounds for 9 metal T-posts (3.75 pounds per T-post).

TOTAL COST: $305.42

TABLE 1: ALTERNATIVE COST COMPARISON

01 ALTERNATIVE 1: DO NOTHING

TOTAL COST	MATERIAL (per installation)	LABOR (per installation)	SHIPPING (per installation)	#OF INSTALLS (per installation)
N/A	N/A	N/A	N/A	N/A

02 ALTERNATIVE 2: SILT FENCE

TOTAL COST	MATERIAL (per installation)	LABOR (per installation)	SHIPPING (per installation)	#OF INSTALLS (per installation)
$3,299.20	$24	$300	$5.92	10

03 ALTERNATIVE 2: EvoGuard®

TOTAL COST	MATERIAL (per installation)	LABOR (per installation)	SHIPPING (per installation)	#OF INSTALLS (per installation)
$305.42	$279.50	$20	$5.92	1

EVOGUARD FOR SLOPE FACES

EvoGuard is protective fencing that slows water encroachment, retains sediments, and serves as a containment barrier. EvoGuard uses a reinforced, heavy-duty knitted polyethylene mesh available in 1-, 2-, and 3-foot panel heights. Metal T-posts or untreated wooden stakes are typically used to anchor the technical mesh along the desired area. EvoGuard is manufactured with 4-inch diameter sleeves to expedite post attachment. Posts are fed through the sleeve and then further attached using zip-ties between the posts and grommets in the mesh. EvoGuard can be installed by trenching and anchoring the mesh below ground or by a non-trenched approach where the mesh is laid on the existing grade and anchored using toe pins to create an integrated containment toe. The product is manufactured with an ASTM rated fire-retardant, rendering it a self-extinguishing non-accelerant. The material is also UV stabilized, protecting it from long-term exposure. Product specifications are listed in Table 2 below.

PARAMETER	SPECIFICATION
Course Count	11SPI
Shade Factor	88.5%
Weight	3.67 oz./square yard
Break Strength	63 lbs. warp and 84 lbs. fill
Break Elongation	36.6% warp and 51.3% fill
Tear Strength	150 pounds per square inch (psi)
Air Permeability	441 cubic ft./minute square foot
Length	50-foot or 100-foot rolls
Color	Tan or green
Fire Retardent	ASTM rated

ALTERNATIVES ANALYSIS

To perform an alternatives analysis, we have assumed the dimensions as indicated above in the conceptual project description section, and we have assumed a 5-year design life for the EvoGuard and a 6-month design life for the silt fence. We have assumed identical delivery routes for materials in each constructed scenario. We assume that differences in manufacturing fence material types are negligible. We have selected a no-trench installation alternative for the EvoGuard and the required trenching installation for the silt fence. The carbon emissions, labor, shipping, and equipment are factored into calculations below.

PREVENTION OF SOIL EROSION/ RUNOFF FLOW VELOCITY

The purpose of the project contemplated by this alternatives analysis is to control sediment and divert water while containing accumulated organic matter or debris. Of primary importance is the ability of the project alternatives to function as a containment barrier and to arrest sediment transport and mitigate erosion.

Under a do-nothing alternative (Alternative 1), no improvements would be made to the slope. As a result, no additional protection would be provided to the slope or surrounding areas and wasting processes from erosion would occur. As a result, the slope would be susceptible to landslides and water flow on the slope that would mobilize debris and organic material. High-turbidity runoff could have detrimental effect on surrounding water bodies, and general erosion could damage any trails or infrastructure at the base of the hill. As a do-nothing alternative, Alternative 1 offers no additional protection with respect to soil erosion or sediment control.

Both the silt fence (Alternative 2) and EvoGuard (Alternative 3) provide sufficient erosion protection. Initially after installation, both fence types can slow water velocity, trap debris and organics, and ultimately reduce erosion. However, the design and material composition of EvoGuard would result in superior performance during large runoff flows and high volumes of debris accumulation as compared to silt fencing. While traditional silt fences will confer similar benefits, a weaker design and material makeup make this alternative more vulnerable in high-flow situations. As a result, while both Alternative 2 and 3 provide a similar degree of erosion protection, Alternative 3 (EvoGuard) should be considered a better alternative for reducing surface flow velocity and reducing the potential for related deleterious effects in a broader set of circumstances.

INSTALLATION OPTIONS

EvoGuard offers a no-trench option for installation, which can allow for faster installation and reductions in monetary and environmental costs. In this installation approach, the technical mesh on the bottom of the EvoGuard is placed on the existing grade and staked into the ground to create an integrated containment toe. This design allows for sediments to collect, adding mass and weight to the system and increasing its function while it works. Furthermore, without the need to mobilize equipment or labor for trenching installation, EvoGuard can be installed more quickly and with greater simplicity as compared to traditional silt fences. This saves on installation costs and reduces environmental costs associated with mobilizing and operating machinery for trenching. This also reduces reliance on heavy equipment which increases safety onsite. Any dangers associated with operating machinery for installation are eliminated. In addition, EvoGaurd can be installed in spaces where heavy equipment cannot access for silt fence trenching. While EvoGuard is also compatible with traditional trenching installations, the option to choose between installation type is a clear advantage of EvoGuard over traditional silt fences, which always require trenching.

As a do-nothing alternative, Alternative 1 has no associated installation.

DURABILITY AND MAINTENANCE

A main difference between Alternatives 2 and 3 is durability and subsequent maintenance costs. Silt fences are made of a single sheet of woven polypropylene which leaves them vulnerable to damage and increases the risk of system failure even if only one area is affected. EvoGuard is made with a structural rope channel, running along the top and bottom of the technical mesh, and post sleeves that fully integrate the stakes into the system and maximize structural integrity. This design creates individual structural zones between each post that increase overall durability and prevent system failure if one zone is damaged. EvoGuard is also constructed with rip-stop technology that allows for impact penetration without resulting in unraveling. Unlike silt fences, the system can withstand the impact of an isolated event, without weakening the integrity of the remaining panels. Furthermore, EvoGuard Mesh Type II is fire-retardant, which expands its application to fire prone areas. EvoGuard's ASTM fire-retardant material will not provide fuel for flames unlike traditional silt fences which may combust and accelerate a fire. Additionally, the technical mesh is UV stabilized, protecting it from long-term exposure. The more durable material of EvoGuard not only allows for better functionality, as discussed above, but reduced maintenance and replacement costs. This also confers multiple environmental benefits. Since EvoGuard degrades less over time, less EvoGuard material is needed over a project lifetime as compared to traditional silt fences, which become weathered and require frequent replacement and disposal. Multiple installations result in increased carbon emissions because of having to produce, transport, and install new silt fences. This is particularly noteworthy if posts are damaged during operation and re-trenching must occur to reinstall an entire fence. Not only is a single silt fence installation more costly than an EvoGuard installation due to trenching, but traditional silt fences typically require more frequent replacement. In the long term, both environmental and monetary costs associated with silt fence operation are higher.

As a do-nothing alternative, Alternative 1 has no associated maintenance costs.

REDUCTION IN SURFACE FLOW DEBRIS AND TURBIDITY

In addition to affecting the runoff velocity, Alternatives 2 and 3 affect the water quality of runoff. Surface runoff can be contaminated with a variety of pollutants. Flows emanating from agricultural, residential, or recreational areas (e.g., parks or golf courses), may be impacted with herbicides, pesticides, fertilizers, or sediments from bare-earthen areas. In urban settings, surface runoff may be impacted with petroleum hydrocarbons, volatile organic compounds (VOCs), or heavy metals.

In the do-nothing approach, the natural soils of the slope would allow for surface flow infiltration, which could lead to a reduction of select waterborne contaminants. However, the exposed soils of the slope would be subjected to the erosive effects of surface flow, which could mobilize soil and negatively affect the flow and the quality of receiving waters. Large debris flow or landslides would not be contained under this alternative. Ultimately, water could flow unmanaged and lead to unstable slope conditions resulting in slope failure.

Considering Alternative 2 and 3, these fences act as barriers which contain debris flows and sediment. Both fence types would encourage growth of native vegetation by preventing topsoil washout and allowing vegetation to root and propagate. Over time this would add to slope stability downhill of the fence as native flora establishes. This process would also aid in reducing turbidity in runoff and help minimize waterborne contaminants. EvoGuard has the added benefit of a larger apparent opening size (AOS), which allows vegetation to establish on the barrier itself. Root systems can grow directly through the technical mesh, further encouraging plant growth and retention of sediment/contaminants.

The EvoGuard technical mesh also allows for water to diffuse through the barrier, unlike silt fences which can trap water and lead to pooling. Standing water provides a breeding ground for mosquitoes, bacteria, or parasites, and presents health concerns for humans and animals. Pooling also inhibits plant growth, which, as discussed above, helps to stabilize the slope and filter out waterborne pollutants. These issues can be avoided by installing EvoGuard instead of silt fences and thus allow water to diffuse through the containment barrier.

Another benefit of using either Alternative 2 or 3 is that vegetation can establish downhill and act as a vegetative filter strip (VFS), a useful best management practice (BMP) commonly implemented for stormwater runoff treatment. A VFS is an area of vegetation that removes sediment and other pollutants from surface water runoff through filtration, deposition, infiltration, adsorption, decomposition, and volatilization (Smyth et al., 2018). The United States Environmental Protection Agency (EPA) encourages use of engineered VFSs to reduce nonpoint source (NPS) pollution (USEPA, 2002).

Three distinct layers are present within a VFS – the surface vegetation, the root zone, and the subsoil horizon (Grismer and O'Geen, 2006). The vegetation and its ability to slow surface flow velocity increases the residence time over the turf surface, allowing sediments and contaminants to settle. Additionally, the permeable surface and presence of organic matter allows surface flow to infiltrate into the root zone. Within the root zone, some of the water flow continues to infiltrate into the underlying soil horizon, while some continues as lateral "interflow" within the root zone (Grismer and O'Geen, 2006). For nutrients, the most important VFS capture mechanism is infiltration. Nitrogen is primarily removed via uptake by the vegetation or resident microbial activity, while phosphorus and heavy metals are captured via adsorption to soil particles (Grismer and O'Geen, 2006).

As a result, surface water quality is improved due to the removal of sediments, contaminants, and nutrients from the flow, resulting in a beneficial effect on the quality of the receiving water. Recent research has indicated that vegetation is effective in reducing sediment, contaminant, and nutrient loads in surface runoff, including total suspended solids (TSS), select nutrients, and select heavy metals (Water Research Foundation, 2020). Although the degree of contaminant removal is highly dependent on vegetation type, soil conditions, VFS dimensions, slope angle, and climate conditions, pseudo-VFS systems such as those that may develop in Alternative 2 or 3 can be highly efficient at contaminant removal. Field studies indicate that VFSs can successfully remove more than 90 percent of sediments, 50 to 80 percent of nutrients (Smyth et al., 2018), and over 60 percent of certain pathogens (Grismer and O'Geen, 2006). Empirical studies of prairie filter strip use adjacent to agricultural fields have demonstrated reduced nitrate-nitrogen (NO3-N), total nitrogen (TN), and total phosphorus (TP) concentrations by 35 percent, 73 percent, and 82 percent, respectively (Zhou et al., 2014).

Contaminant and nutrient removal continue over the life span of the VFS feature, provided basic maintenance activities are performed. To maintain optimal pollutant removal efficiency, permanent vegetative plants should be harvested properly to encourage dense growth and removal of sediment, nutrients, and other pollutants trapped in the plant tissue (Smyth et al., 2018). Other straightforward maintenance practices include activities at the surface to maintain uniform sheet flow across the vegetation, removal of excessive sediment accumulation, repair of bare spots or distressed vegetation, and limitations of foot or vehicular traffic across the vegetated surface (Grismer and O'Geen, 2006).

The difference between Alternatives 2 and 3 is their strength and durability in mitigating flow from large storm events and repeated flows over time. EvoGuard would be more resistant to weathering over many seasons since it has a higher material strength, which allows it to withstand higher stormwater flows and retain a greater volume of debris for a given storm event. This durability increases the likelihood that vegetation will establish on the hillside (VFS formation) and mitigate erosion and pollutant runoff. EvoGuard would also be at a lower risk of tearing or falling over during high-flow periods, which is critical to ensure hillside stability. A severely damaged fence (torn, fallen, ripped, etc.), even for a brief time, could result in hillside failure and damage to any trails, infrastructure, or receiving water. The importance of avoiding such failures informs the use of a stronger fence, such as EvoGuard, to reduce risks.

EMBODIED CARBON AND CARBON SEQUESTRATION

Another dimension considered in this alternatives analysis is the carbon footprint of the project alternatives. In considering the overall carbon footprint, we have considered both the construction carbon footprint as well as the operational carbon footprint.

The construction carbon footprint considers the net of carbon sources (emissions) and sinks associated with the manufacture, delivery, and installation of a project. The operational carbon footprint considers the net of carbon emissions or sequestration that occur during the presence, operation, and maintenance of the alternative. As discussed in Section 4, we have assumed that the fabrication of fence material for Alternatives 2 and 3 is the same. Carbon costs for stakes and T-posts are considered. Costs of installation may be higher for Alternative 2 due to trenching, but for carbon calculations we assume that trenching is done by hand. Installation of the traditional silt fence would take longer, however we are assuming that there is a negligible carbon impact from laborers digging the trench.

As a do-nothing alternative, Alternative 1 is assumed to be carbon neutral for this analysis, although it is likely that slope erosion or failure would release carbon sequestered in vegetation and soil and require future slope rebuilding or dredging. This would result in carbon emissions and eliminate the assumed carbon neutrality.

In considering operational carbon, we assume no sinks or sources of carbon emissions. Although routine operations and maintenance, such as cleaning and repair, may occur on a periodic basis, it is our opinion these will have a negligible contribution to this carbon calculation. As a result, as stated, no net carbon emissions or sequestration occurs during the operational phase of Alternative 2 or 3.

For Alternative 2 and 3 installation, carbon is generated during refining of petroleum-based raw materials and the manufacturing of the EvoGuard and silt fence. To determine these emissions, we classified the product as a HDPE-based geotextile. For our calculations, we estimated an embodied carbon unit value of 1.9 kg of CO_2 emissions per kg of polyethylene, or 2.35 pounds of CO_2 emissions per pound of HDPE (Hammond and Jones, 2011, Raja et al., 2015).

As noted, we have assumed a unit weight of 0.408 ounces (0.0255 pound) per square foot of EvoGuard and a unit weight of 0.427 ounces (0.0267 pound) per square foot of traditional silt fences.

Assuming a 50-foot-long and 3-foot-high fence, this results in an EvoGuard weight of 1.2 pounds per linear foot of slope. Applying the embodied carbon unit value for HDPE geotextile, we estimate 8.98 pounds of CO_2 emissions per fence. The same calculation for the traditional fence yields 9.40 pounds of CO_2 emissions per fence. As previously mentioned, due to a weaker construction we anticipate ten replacement silt fences will be needed during the 5-year long project. Thus, ten silt fences will be required, which yields 94 pounds of CO_2 emissions for Alternative 2 during the project lifetime.

The wooden stakes for Alternative 2 and T-posts for Alternative 3 also affect carbon emissions. For the silt fence, 9 pounds of wooden stakes are required for each installation. The 10 installations thus require 90 pounds of wood. Assuming wood has a 50% CO_2 sequestration rate, there will be 45 pounds of CO_2 sequestered in the wood stake production (Leys, 2022). For Alternative 3, 33.75 pounds of steel will be required for the 9 T-posts. For our calculations we estimate that 1 pound of steel produces 1.85 pounds of CO_2 (Hoffman, 2020). For the single Alternative 3 installation this yields 62.44 pounds of CO_2 released.

Shipping for Alternatives 2 and 3 both assumes a medium sized car travelling 50 miles per installation. Assuming an average of 0.682 pounds of CO_2 per mile yields 34.1 CO_2 per installation of either alternative (Hammond, 2011).

Thus, per the 5-year project lifetime, Alternative 3 releases 34.1 pounds of CO2 and Alternative 2 releases 341 pounds of CO2 (accounting for 10 installations). Any impact that the weight of either Alternative would have on the car's carbon emissions is considered negligible.

Installation may also result in carbon emissions. EvoGuard will be installed by a non-trenching method and does not require machinery. Driving posts into the ground may require some fossil fuel powered equipment, however this is a requirement for both Alternatives 2 and 3 and will thus be ignored for the present comparison. The traditional silt fence may have to be installed using machinery capable of trenching. Furthermore, as previously discussed we are assuming ten silt fence installations over the 5-year-long project.

The vegetation that can establish on a stabilized slope provides a means to sequester carbon (Qian and Follett, 2002). During photosynthesis, plants take in carbon as carbon dioxide and fix the carbon into their structural (leaves, stems, roots, etc.) and non structural (sugars and other metabolites) components (Putnam, 2016). In perennial grass ecosystems, a substantial portion of that carbon ends up in the soil organic matter because of their large fibrous root systems (Putnam, 2016). Further, as roots die, they decompose into soil organic matter, fixing carbon in the soil, allowing vegetated areas to act as a carbon sink for greenhouse gases (Leslie, 2021). Natural grasslands play a major role in carbon sequestration, and in many scenarios trap carbon more securely in the soil compared to forests (Dass, 2018). Grasses bank carbon in the subsurface more effectively than forests where large amounts of carbon is stored in the tree bodies above ground. Furthermore, carbon sequestration in grasslands is more resistant to release during droughts and fires. Thus, encouraging vegetation by using EvoGuard or a silt fence would have a net positive carbon impact.

Of course, ongoing maintenance activities and the use of power equipment can result in generation of carbon emissions. Further, a limit may be reached as to the carbon sequestering capacity of grasses, such that over a long period of time, ongoing carbon emitting activities can go from a net carbon sink (sequestration) to a net carbon source. But this is dependent on how the grass area is maintained. A natural grassland hill does not require high-intensity maintenance. We are assuming that the hillside was barren at the project outset due to construction activity, fire, erosion, or runoff, and that installation of Alternative 2 or 3 would allow for the reestablishment of native flora. We assume the grasses that grow can be modelled and represented by a sequestration rate of 100 grams of carbon per square meter per year, or 0.0205 pounds of carbon per square foot per year. This is at the lower end of a range estimate of 25.4 to 204.3 grams of carbon per square meter per year to account for maintenance emissions generation and lower growth rates (and CO2 utilization) that may occur in colder or drier climates (Zirkle et al., 2011).

The area of hillside that a 50-foot-long fence can adequately protect is highly variable. For this analysis we analyzed net carbon emissions for various amounts of protected areas. For example, if the silt fence is placed 30 feet up from the base of the hill, this yields a protected area of approximately 1,500 feet (30 feet of slope face measuring 50 feet in hillside length) and a 5-year long carbon sequestration of 154 pounds of CO2. This analysis approach was repeated for various protected areas to identify a carbon breakeven point. These calculations found that for an EvoGuard of 50 feet long, you must ensure the fence protects an area of 1030 square feet, or 20.6 feet of slope face, to have a net neutral carbon impact. Protecting an area of more than 1030 square feet results in a carbon sink scenario, while less than this area results in some net carbon emissions. For the traditional silt fence, you must ensure the fence protects an area of 29,796 square feet, or 596 feet of slope face, to have a net neutral carbon impact. A summary of the analysis is presented graphically in Figure 1.

The difference in the carbon breakeven areas is primarily due to the higher emissions that are required to install and reinstall the traditional silt fence over the project timeline. The overall carbon emissions for Alternative 2 are much higher because the silt fence must be replaced every 6 months.

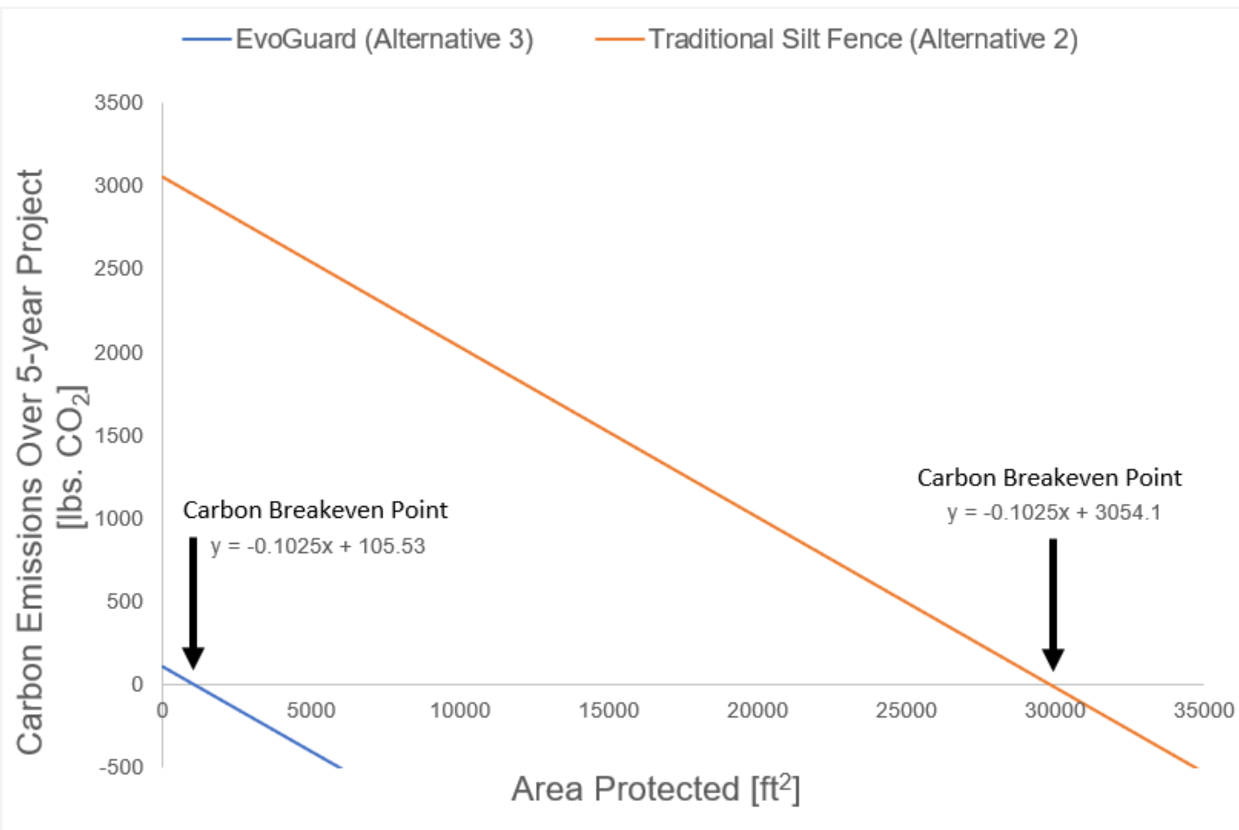
CONCLUSION

Across the assessed environmental dimensions, the EvoGuard product presents a superior alternative to the use of a traditional silt fence alternative, while both offer a range of advantages over a "do-nothing" alternative (Table 3). The following table provides a summary of the performance of the considered alternative across the assessed dimensions. Of course, the do-nothing alternative would likely result in project failure.

TABLE 3: SUMMARY OF ALTERNATIVE ANALYSIS

DIMENSION	ALTERNATIVE 1 DO NOTHING	ALTERNATIVE 2 SILT FENCE	ALTERNATIVE 2 EVOGUARD®
Reduction of Runoff Velocity/Erosion	−	+	+
Durability/Maintenance	−	−	+
Installation Options	−	−	+
Reduction of Contaminant Loading	−	+	+
Embodied Carbon/Sequestration	−	−	+

FIGURE 1: Carbon emission summary as a function of protected area for a 5-year project lifetime



Both traditional silt fences and EvoGuard can reduce hillside erosion, trap debris, reduce runoff velocity, and promote vegetation downhill. The main difference between the products is their durability and installation requirements. EvoGuard is better constructed and can withstand more weathering, which reduces the need for repairs, limits the risk of failure in large storm events, and promotes consistent vegetation growth. Also, EvoGuard offers two installation options (non-trench and trenched) so it can be installed in various circumstances, including areas where trenching machinery can't access. As a result, in addition to providing an easy-to-install, technically effective, and cost-effective alternative, EvoGuard offers an environmentally protective and sustainable erosion protection solution.

REFERENCES

Dass, P., Houlton, B., Wang, Y., Warlind, D. (2018). Grasslands may be more reliable carbon sinks than forests in California. Environmental Research Letters. 13(7):074027

Department of Public Works Storm Water Service Division. City of Springfield, Missouri (2008). Silt Fence. Retrieved from: https://www.springfieldmo.gov/DocumentCenter/View/3449/Silt-Fence-PDF?bidId=#:~:text=The%20maximum%20life%20expectancy%20for,10%2Dyear%20peak%20storm%20event.

Garofalo, M. (2021) Silt Fence Best Practices for Stormwater Management. Retrieved from: https://eastcoastsitework.com/silt-fence-best-practices-for-stormwater-management/

Grismer, M. E., and O'Geen, A. T. (2006). Vegetative filter strips for nonpoint source pollution control in agriculture. University of California, Division of Agriculture and Natural Resources, Publication 8195.

Hammond, G. P. and Jones, C. I. (2011). Inventory of (embodied) carbon & energy (ICE) v2.0. Department of Mechanical Engineering, University of Bath, Bath, UK.

Hoffman, C., Van Hoey, M., Zeumer, B. (2020). Decarbonization Challenge for Steel. McKinsey and Company. Retrieved from: https://www.mckinsey.com/industries/metals-and-mining/our-insights/decarbonization-challenge-for-steel

HomeDepot.com (2023). Contractor Grade Assembled 3 ft. x 100 ft. Silt Temporary Fencing. Retrieved From: https://www.homedepot.com/p/HDX-Contractor-Grade-Assembled-3-ft-x-100-ft-Silt-Temporary-Fencing-14987-0-3610/202521468

Leslie, M. (2021). The potential of turfgrass to sequester carbon and offset greenhouse gas emissions, University of Minnesota Turf Science. Retrieved from: https://turf.umn.edu/news/potential-turfgrass-sequester-carbon-and-offset-greenhouse-gas-emissions

Leys, A.P. (2022). How is carbon stored in trees and wood products? Forest and Wood Products Australia. Retrieved from: https://forestlearning.edu.au/images/resources/How%20carbon% 20is%20stored%20in%20trees%20and%20wood%20products.pdf

Putnam, S. (2016). Turfgrass scientist aims to use lawns for carbon sequestration. University of Connecticut, College of Agriculture, Health, and Natural Resources. Retrieved from: https://naturally.uconn.edu/2016/10/11/turfgrass-scientist-aims-to-use-lawns-for-carbon-sequestration/#

Qian, Y., and Follett, R. F. (2002). Assessing soil carbon sequestration in turfgrass systems using long-term soil testing data. Agronomy Journal, 94(4), 930–935.

Raja, J., Dixon, N., Fowmes, G., Frost, M., and Assinder, P. (2015). Obtaining reliable embodied carbon values for geosynthetics. Geosynthetics International, 22(5): 1–9.

Smyth, A., Wu, L., Muñoz-Carpena, R., and Li, Y. (2018). Vegetative filter strips – a best management practice for controlling nonpoint source pollution. Department of Soil and Water Sciences, University of Florida/IFAS Extension. Publication SL432.

Tahoe Regional Planning Agency BMP Handbook. (2014) Chapter 4 BMP Toolkit 4.5-r Silt Fence. Retrieved from: https://www.tahoebmp.org/Documents/BMPHandbook/Chapter%204/4.5/r_S iltFenc.pdf

USEPA (2002). Considerations in the design of treatment best management practices (BMPs) to improve water quality. Retrieved from: http://nepis.epa.gov/Adobe/PDF/2000D1JS.PDF.

Water Research Foundation (2020). International stormwater BMP database – 2020 summary statistics.

Zhou, X., Helmers, M. J., Asbjornsen, H., Kolka, R., Tomer, M. D., and Cruse, R. M. (2014). Nutrient removal by prairie filter strips in agricultural landscapes. Journal of Soil and Water Conservation, 69(1): 54–64.

Zirkle, G., Lal, R., and Augustin, B. (2011). Modeling carbon sequestration in home lawns. HortScience, 46(5): 808–814.

Read the full report at SOX Erosion—Environmental Benefits Across Several Dimensions.