

A Solar Moment



Republic Waste Services Inc.

By Mark Roberts, P.E., Ted Alexander, P.E., and Kanishka Perera, P.E.

Exposed
geomembrane
solar cap matches
renewable energy
with efficient landfill
closure design.

Having a light bulb moment is so last century. In the 21st century, it might be more appropriate to call an inspiration a “solar moment.” The transformation of a portion of an active landfill on the outskirts of San Antonio, TX, into a closed sideslope and renewable-energy facility is nothing less than a solar moment for the solid waste management community. A landfill closure system that protects the environment and actually generates revenue is without question a sustainable return on investment for the landfill owner.

When Republic Waste Services Inc. sought a way to modify the existing closure design for a portion of its Tessman Road municipal solid waste landfill that had reached permitted final grades, the result was the first installation of a solar energy cover using exposed geomem-

brane solar cap (EGSC) technology. The solar energy cover installed at the Tessman Road Landfill over a two-month period in early 2009 is now generating about 120 kW of renewable solar power.

The Landfill Triple Play

Like many new ideas, the idea to transform a landfill closure system into a renewable-energy park emerged not from a long-term study, but from a simple tossing around of ideas between client and consultant, not unlike jotting down notes on a napkin. Located in an arid, windy area with bad soil that makes it difficult to grow grass, the Omaha, NB-based HDR Inc. designed something other than a traditional grass-covered composite final-cover system—a landfill EGSC that would provide environmental protection and generate revenue.

The Tessman Road Landfill Solar Energy Cover allows Republic Waste Services to generate electricity that can be sold to the local power company or used for onsite energy needs. Or both.

The idea to affix flexible solar panels directly to the surface of an exposed geomembrane cap seemed feasible, and the solar power could be tied directly into the existing landfill-gas-to-energy system. So, instead of installing an expensive-to-maintain grassy cap or an effective but underutilized geomembrane cap, the Tessman Road Landfill Solar Energy Cover allows Republic Waste Services to generate electricity that can be sold to the local power company or used for onsite energy needs. Or both.

More than just a win-win situation, the Tessman Road Landfill Solar Energy Cover is a win-win-win. It provides a triple play of benefits: generating renewable energy, creating a revenue stream, and reducing maintenance requirements by eliminating the need to mow and maintain a grass-covered landfill cap (also reducing carbon-dioxide emissions).

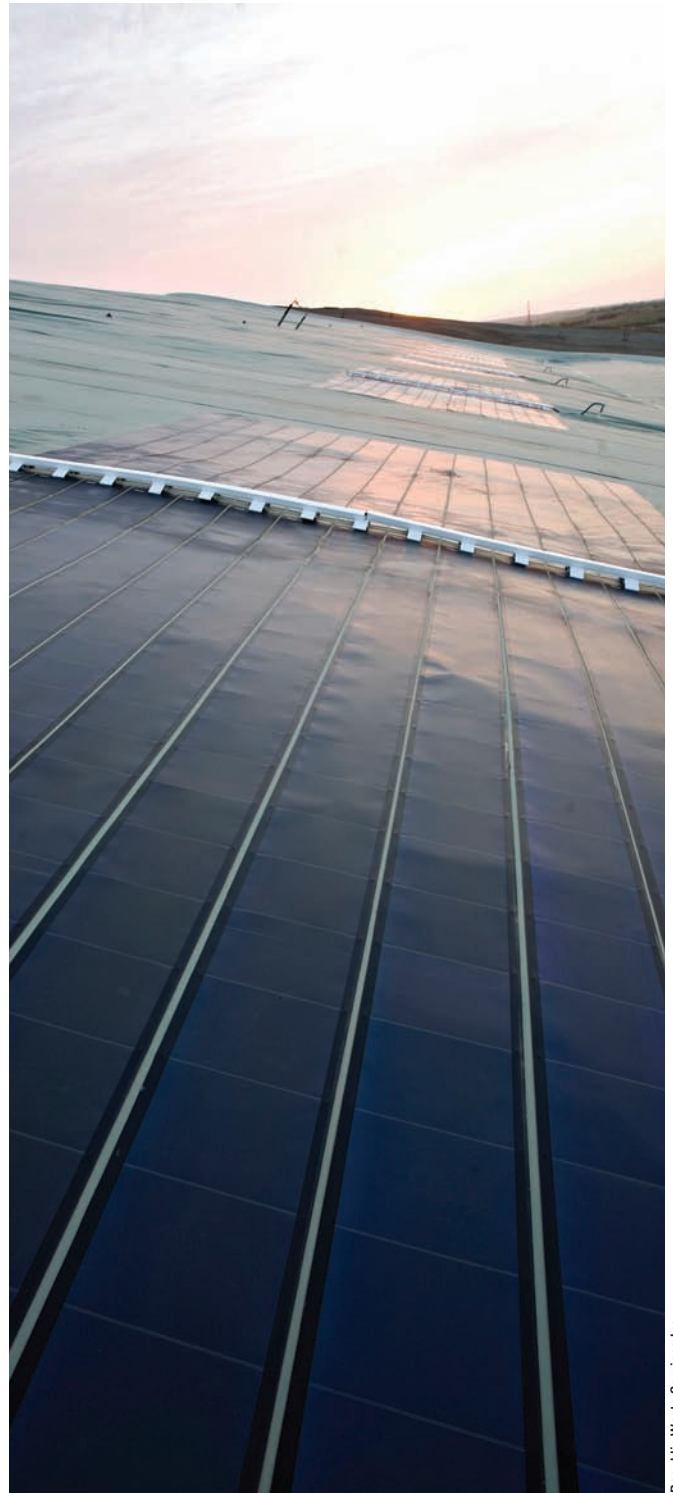
EGSC Versus Traditional Landfill Cover

The project began when Republic Waste Services approached HDR Engineering Inc. to redesign the existing closure system to incorporate an innovative geomembrane cover system to serve as both a superior closure system and a stable mounting platform for flexible solar panels. The project permit allowed for a full build-out area of more than 50 acres, but Republic Services chose to launch this innovative process by installing a limited solar cover over a 5.6-acre section of the landfill sideslope.

The initial phase of the solar cover opened in early April on the southern side of Phase 3 of the Tessman Road Landfill. This first-ever EGSC features 1,050 flexible laminate solar panels mounted on a 60-mil reinforced thermoplastic polyolefin (TPO) geomembrane cover.

The EGSC design for the Tessman Road Landfill Solar Energy Cover is significantly different from a traditional final cover design. While the absence of traditional vegetative support and topsoil cover layers can give the impression something is missing, the streamlined EGSC design actually provides greater environmental protection than a traditional landfill cap.

A key difference is that a typical Subtitle D closure simply drapes a geomembrane over the intermediate cover, relying on soil and drainage layers above for ballast, whereas an EGSC is anchored directly into the landfill at prescribed distances. The anchors are positioned based on the strength of the membrane material and an analysis of the natural forces (e.g., wind and weather) that may work against it.



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Materials like that used for the Tessman Road Landfill cover often have 20- to 30-year manufacturer warranties.

The EGSC includes a bedding layer of at least 12 inches of intermediate cover and a final layer to achieve prescribed final grades. This bedding layer is compacted and graded to achieve a smooth surface with desired slopes and transitions to support the geomembrane anchored above. The geomembrane engineered into the landfill slopes becomes an ideal stable platform for flexible solar panels. The EGSC design allows the landfill cover system to be built based on local weather conditions and desired or warranted length

of service. Materials can easily be replaced, and continued beneficial reuse of the area can be achieved indefinitely.

Reducing Costs

To a casual observer, it might seem that a traditional Subtitle D–prescribed final closure cover system would provide greater environmental protection than the streamlined appearance of the EGSC design, but that is not the case. An EGSC system represents a more effective design with advantages in multiple areas, as described in the following paragraphs.

Greater cover stability—Traditional landfill cover systems use soil as ballast for the underlying geomembrane and to support an overlying vegetative growth layer. Many landfills with this type of closure design find it challenging and expensive to maintain the vegetative cover layer. An EGSC eliminates the need to mow a grass-topped cover and related problems with erosion and loss of topsoil.

The EGSC takes advantage of the strength and flexibility of the geomembrane material to provide a final cover engineered to encapsulate the waste mass and survive long-term outdoor exposure. Anchored directly into the landfill, an EGSC provides a stronger cover able to withstand stresses and strains from severe weather, including wind.

The EGSC also provides greater stability by removing the potential for saturated cover soil that can lead to differential settlement, erosion, and clogging of the drainage layer of a traditional landfill cover. With no soil or geosynthetic layers that can slip, slide, or pull away from the liner, the EGSC allows water to sheet flow away from the liner into constructed drainage basins.

Erosion control and soil maintenance—Major storm events often leave behind ruts and channels in soil cover atop traditional landfill closures that sometimes expose the liner below. Because this overlying soil acts as ballast for the liner, eroded materials must be replaced and the affected area regrassed before another storm creates greater damage. In direct contrast, an EGSC design does not rely on soils and vegetation for cover or ballast so there are no maintenance or replacement costs in the closure monitoring and maintenance budget for these needs.

Rainwater intrusion—Heavy rainfall events can increase the head on the underlying geomembrane on a traditional landfill cap, with rainwater leaking through panel welds or defects in the membrane. Because an EGSC removes rainfall as stormwater, there is no time for it to pond or build pressure on the geomembrane surface. An EGSC is designed to sheet-flow rainwater directly into a perimeter drainage channel, leaving minimum head on the liner. To handle any increased flow off the geomembrane, perimeter drainage channels can be widened and pond storage volumes adjusted to avoid any increase in predevelopment discharges.

Inspection and Maintenance—The soil and geocomposite layers used as traditional landfill cover make inspection of the geomembrane below challenging. In the event of suspected damage to the liner, the overlying protective layers must first be removed, repairs made, and the cover layers replaced, all of which can make maintenance costly for a traditional liner. In contrast, an EGSC offers ease of visual inspection and surface repairs, if necessary.

Long-term outdoor performance—Exposed geomembranes have gained acceptance as engineered alternative landfill closure systems over the last decade. Despite this relatively short history, the geomembrane materials used in landfill applications have demonstrated successful long-term outdoor performance in related

industries. For example, these materials are used as exposed liners for water/wastewater ponds and roofing systems, with the ability to retain their physical properties over extended periods of outdoor exposure.

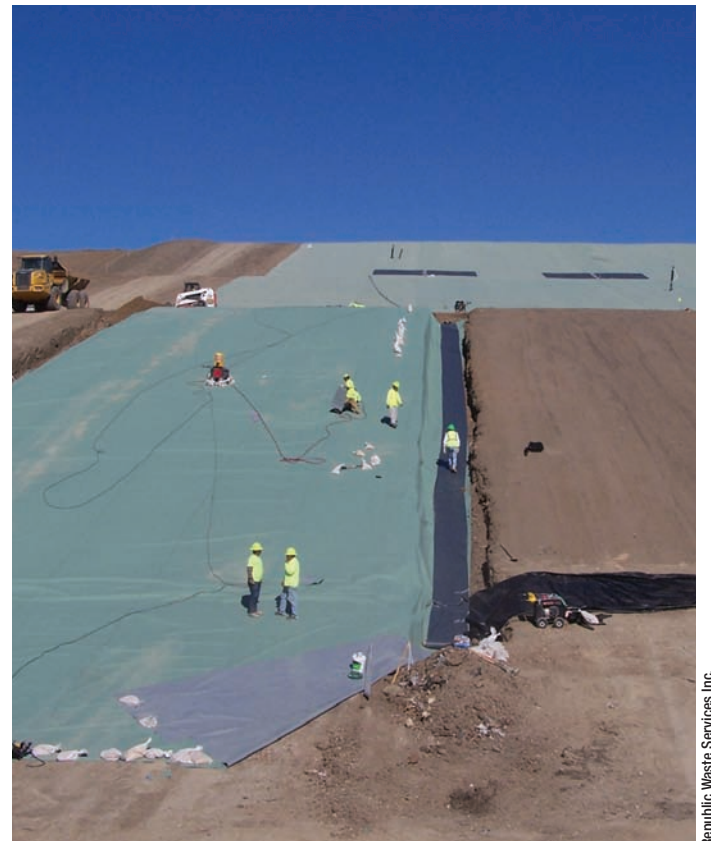
It is common for a geomembrane material like that used for the Tessman Road Landfill Solar Energy Cover to have at least a 20- or 30-year manufacturer warranty. The exposed geomembrane and the adhesive used to attach the flexible solar panels were tested and guaranteed to work together under long-term outdoor conditions. Nonetheless, because this is the first use of these materials in a landfill closure system, performance will be carefully monitored.

The exposed geomembrane installation for the Tessman Road Landfill Solar Energy Cover incorporated special procedures to facilitate this monitoring, including welding 30 small (1-foot-by-2-foot) test geomembrane panels onto the geomembrane. Each year, one test panel will be removed and tested for strength and flexibility compared with original parameters.

The Details: Geomembrane

Required performance characteristics of a geomembrane used for a landfill closure application include resistance to ultraviolet light, seam strength, seam durability, chemical resistance, puncture resistance, stress-strain strength, and interface friction. For the Tessman Road Landfill Solar Energy Cover application, studies that evaluated geomembrane materials were used to make the selection.

The material selected for the Tessman Road Landfill Solar Energy Cover is a green, 60-mil, fiber-reinforced, flexible polypropylene-based thermoplastic polyolefin (TPO) product manufactured by Firestone Specialty Products. The primary differences between



The 5.6-acre project area caps three tiers of south-facing landfill sideslope, with flat areas separating the tiers.

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this TPO product and those in similar landfill applications are in its strength, flexibility, and thickness, as well as a relatively low expansion-contraction coefficient in high and low temperatures. The material selected for Tessman Road meets the design criteria for exposed geomembrane caps set forth by Gleason, Houlihan, and Giroud (1998), including the ability to resist damage from exposure to sunlight, temperature extremes, tensile strain resulting from downslope creep, punctures caused by hailstones, and strong wind.

Double-track fusion seams were used to seam the panels. Leister seams were used in some areas to accommodate construction sequencing and solar panel deployment.

The Details: Anchor Trench Design

A key differentiator between an exposed geomembrane landfill cap and a traditional grass-topped cover is that the exposed geomembrane is securely anchored rather than held in place with soil ballast. This is especially important when a closed landfill is in an area that may experience strong winds, which is the case in San Antonio, where the Tessman Road Landfill is located.

The high-tensile-stress properties of the Tessman Road Landfill geomembrane led to a decision to space vertical anchor trenches up the slope of the landfill at specific positions and intervals to protect the cover from the design wind uplift. Horizontal anchors were used as secondary anchors to support grade breaks and exterior berms. The anchor trenches were positioned to address stress-and-strain requirements of the geomembrane and tied directly into the landfill.

The material for the project is a green, 60-mil, fiber-reinforced, flexible-polypropylene-based product notable for its strength, flexibility, and thickness as well as for a relatively low coefficient of expansion and contraction.

The Details: Solar Panels

The Tessman Road Landfill Solar Energy Cover geomembrane provides a stable surface on which to mount the array of flexible solar laminate panels to generate renewable power that can be sold to the local power company through the existing grid tie-in of the landfill gas-to-energy system. The flexible solar panels were manufactured by United Solar and adhered directly to the geomembrane for long-term use and stability. They are less than 1 quarter-inch thick and



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On the Tessman Road Landfill Solar Energy Cover, 1,050 panels were adhered to the exposed geomembrane.

15.5 inches wide by 216 inches long. Each panel is about 23 square feet and each rectangular sub-array includes 30 panels. The 35 sub-arrays fill about six-tenths of an acre, a small portion of the total EGSC project area, leaving room to expand the solar generation capacity over time.

On the Tessman Road Landfill Solar Energy Cover, 1,050 panels were adhered to the exposed geomembrane. The 5.6-acre project area caps three tiers of south-facing landfill sideslope, with flat areas (benches) separating the tiers. The panels are positioned parallel to final-grade contours with sideslopes angled about 15 degrees to the horizontal.

Each subarray is attached to an above-surface raceway that groups the panel wires before they are connected to combiner boxes at the toe of the slope via conduit located inside the lined vertical anchor trenches. Conduit is also laced in a continuous geomembrane sleeve in the anchor trench to prevent infiltration of landfill gas. The solar panels are connected in strings to reach the system voltage, with strings connected in parallel to increase total amperage.

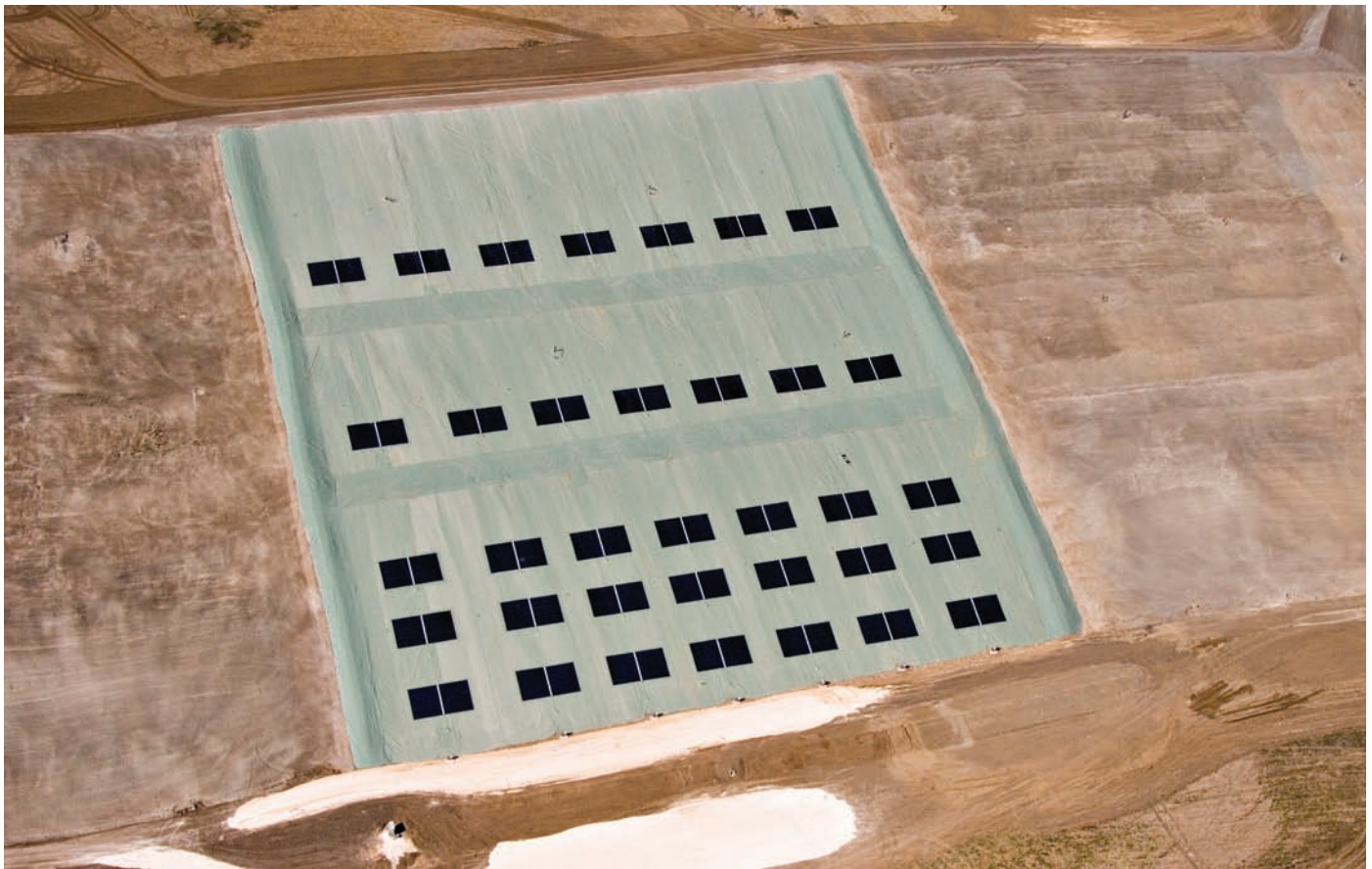
The panels are adhered to the geomembrane with SikaLastomer-68 adhesive (an ethylene propylene copolymer), designed for use on both the solar panels and the geomembrane surface with excellent long-term weathering properties. This adhesive was selected based on a long history of success in photovoltaic roofing systems. The panels can withstand high and low temperature extremes and can generate electricity in high or low light. They are guaranteed for 20 years and can be replaced with relative ease.

The Results are Electric!

The Solar Energy Cover and supporting infrastructure at the Tessman Road Landfill is designed to generate renewable solar energy throughout the year. This system may well produce renewable electricity throughout the 30-year post-closure long-term care period and beyond.

Grid-tied solar energy systems are designed to operate with the local electric utility grid. Tessman Road, like many large landfills, already has a connection to the grid through the existing landfill-gas-to-energy facility. The Tessman Road Landfill Solar Energy Cover feeds into this existing system tie-in, providing a single connection to the electric utility for the two alternative renewable energy sources generated at the landfill. In addition, the power generated

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by the solar array can be used to reduce the parasitic load on the gas-to-energy facility.

Even with the limited array of solar panels deployed at the Tessman Road Landfill Solar Energy Cover (covering just over one-tenth of available geomembrane space), using this as a model with an estimate of \$0.089 per kWh, a system the size of the Tessman Road Landfill Solar Energy Cover can generate about \$16,000 in energy revenue per year. This economic benefit can be expanded by either increasing the density of solar panels on the existing project area or by increasing the area of the EGSC as other areas reach final closure grades.

And...the Results Save Money, Too!

If generating renewable energy and creating a new revenue stream aren't convincing enough, the EGSC design brings cost savings in areas associated with a traditional Subtitle D landfill closure. Consider the example of a traditional closure system that requires funds to excavate, transport and place soil atop the geomembrane. These costs, along with associated geocomposite drainage material costs, disappear with an EGSC closure system—an estimated savings of at least \$50,000.

These savings can be used to purchase more solar panels, boosting renewable energy revenue.

An additional advantage is that the EGSC design requires less airspace than traditional covers. Using an estimated permitted airspace of \$30 per cubic yard and an average traditional soil component thickness of 2 feet, potential airspace savings are estimated at \$96,000 per acre.

The basic costs saved by fertilizing, controlling erosion, not mowing, and other cover maintenance typically add up to about \$1,000 per year per acre, a significant savings. The monitoring, geomembrane testing, and reporting costs, as well as repair costs of existing exposed geomembrane caps have proven significantly less than upkeep costs of a traditional Subtitle D closure cap. The solar panels require minimal upkeep beyond periodic dusting or rinsing if necessary.

A Sustainable Investment

There's more than one way to turn a closed landfill green. A grassy top may be green, but a cover producing commercial-scale renewable energy may be an even "greener" solution than one consuming valuable topsoil and emitting carbon dioxide into the atmosphere through maintenance mowing. A large landfill closure project could generate solar power on a utility-sized scale, offsetting a community's need for expensive infrastructure upgrades and expansions.

The Tessman Road Landfill Solar Energy Cover

project is an outstanding example of sustainable investment, with a high benefit-to-cost ratio, relatively low risk and great potential to increase energy efficiency and produce green jobs. Solar energy generated from a landfill can also serve as a prominent reminder to a community of a major beneficial reuse of a closed landfill, fostering energy resilience and reducing overall energy consumption.

MSW

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{ Add Firestone, Add Innovation }

Innovative projects require innovative products, like Firestone Geomembranes. When Republic Services, Inc. selected the Tessman Rd Landfill as the site for their first ever solar energy cover (SEC), they selected a Firestone Geomembrane System for the exposed cover. The landfill will house a 135kW solar ray rating system that will complement the onsite landfill gas-to-energy technology to increase the overall renewable energy output.

BENEFITS INCLUDE:

- LESS LEACHATE
- EROSION CONTROL MITIGATION
- CLEAN STORMWATER
- INCREASED AIR SPACE
- IMPROVED METHANE DRAWDOWN
- LESS MAINTENANCE
- EASY TO INSPECT
- EASY TO MAINTAIN
- METHANE & ELECTRIC CO-GENERATION APPLICATIONS
- GAINING REGULATORY ACCEPTANCE
- LESS CARBON FOOTPRINT

{ Proud to be part of the overall solution }



To learn more about geomembrane solutions from Firestone Specialty Products
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