

The management system of

GSE Lining Technology Co., Ltd.

Head office: 555 Rasa Tower 26 th Floor, Phaholyothin Rd., Soi 19,
Chatuchak, Bangkok 10900, Thailand
Factory: 111/5 Moo 2, Nikompattana, Amphur Nikompattana,
Rayong 21180, Thailand

has been assessed and certified as meeting the requirements of

ISO 9001:2008

For the following activities

The manufacture of polyethylene geomembrane sheets

Further clarifications regarding the scope of this certificate and the applicability of
ISO 9001:2008 requirements may be obtained by consulting the organisation

This certificate is valid from 10 November 2012 until 10 November 2015 and
remains valid subject to satisfactory surveillance audits.
Re certification audit due before 10 October 2015
Issue 4. Certified since 23 June 1998



Authorised by

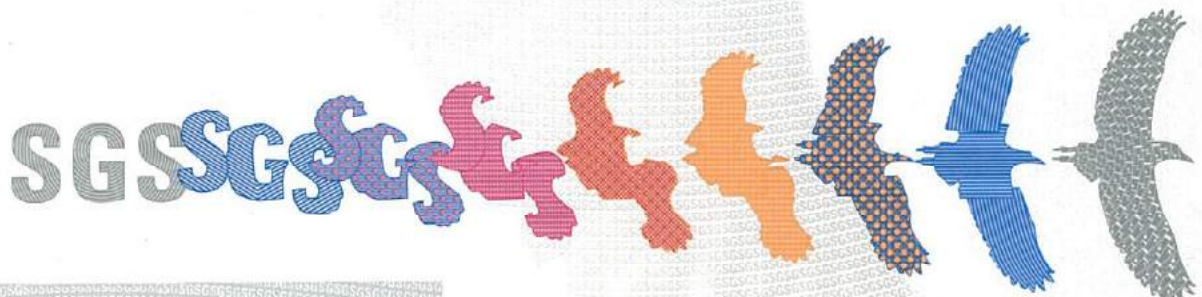
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The management system of

GSE Lining Technology Co., Ltd.

111/5 Moo 2, T. Nikompattana, A. Nikompattana
Rayong 21180, Thailand



has been assessed and certified as meeting the requirements of

ISO 14001:2004

For the following activities

The manufacture of polyethylene geomembrane sheets

This certificate is valid from 14 November 2011 until 14 December 2014 and remains valid subject to satisfactory surveillance audits.
Re certification audit due before 14 November 2014
Issue 6. Certified since 14 December 1999

Authorised by

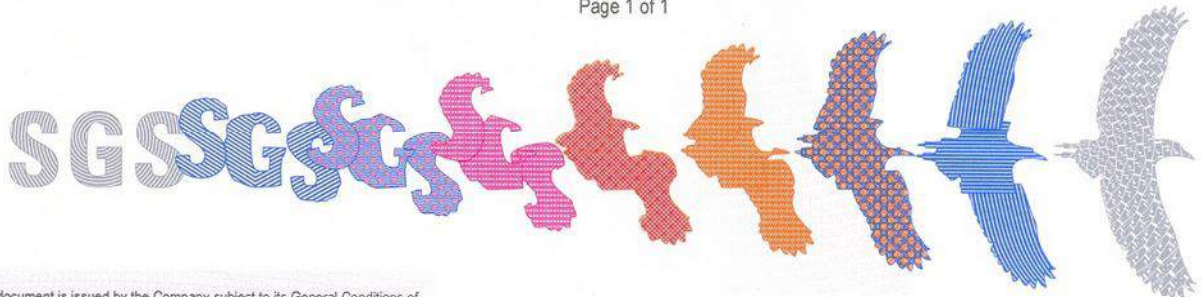
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POLYETHYLENE GEOMEMBRANE SPECIALIST

For environmental lining solutions the world comes to **GSE**



ISO 9001: 2000 & ISO 14001: 2004 Certified



RECREATIONAL LAKE



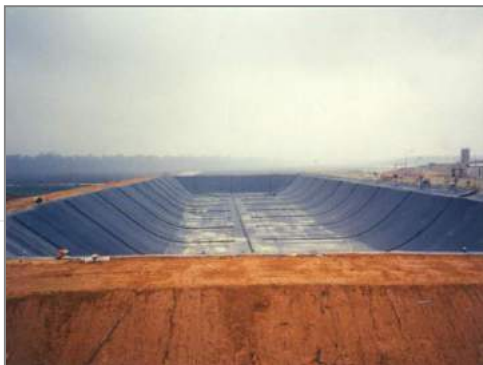
WATER RESERVOIR



CANAL LINING



WASTE WATER POND



FLOATING COVER



LANDFILL WASTE PIT



AQUACULTUR PONDS



ASH POND



LINER DEPLOYMENT

Our Commitments – Highest Quality Products and Services



GSE LINING TECHNOLOGY COMPANY LIMITED

555 Rasa Tower 26th Floor, Phaholyothin Road,
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www.GSEworld.com



GSE HD is a smooth, high quality, high density polyethylene (HDPE) geomembrane produced from specially formulated, virgin polyethylene resin. This polyethylene resin is designed specifically for flexible geomembrane applications. It contains approximately 97.5% polyethylene, 2.5% carbon black and trace amounts of antioxidants and heat stabilizers; no other additives, fillers or extenders are used. GSE HD has outstanding chemical resistance, mechanical properties, environmental stress crack resistance, dimensional stability and thermal aging characteristics. GSE HD has excellent resistance to UV radiation and is suitable for exposed conditions. *These product specifications meet or exceed GRI GM13.*

Product Specifications

TESTED PROPERTY		TEST METHOD	FREQUENCY		MINIMUM VALUE					
Product Code			HDS 030 A00T	HDS 050 A00T	HDS 075 A00T	HDS 100 A00T	HDS 150 A00T	HDS 200 A00T	HDS 250 A00T	HDS 300 A00T
Thickness, mm (mils)	ASTM D 5199	every roll	0.27 (10.8)	0.45 (18)	0.68 (27)	0.9 (36)	1.35 (54)	1.8 (72)	2.25 (90)	2.7 (108)
Density, g/cm	ASTM D 1505	every 5th roll	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Tensile Properties (each direction)	ASTM D 6693, Type IV Dumbbell, 2 ipm	every 5th roll	8 (46)	14 (80)	21 (122)	28 (162)	43 (243)	57 (324)	71 (405)	85 (486)
Strength at Break, N/mm-width (lb/in)			5 (29)	8 (46)	11 (63)	15 (84)	23 (130)	30 (173)	38 (216)	45 (257)
Strength at Yield, N/mm-width (lb/in)			600	700	700	700	700	700	700	700
Elongation at Break, %	G.L. 51 mm (2.0 in)		13	13	13	13	13	13	13	13
Elongation at Yield, %	G.L. 33 mm (1.3 in)									
Tear Resistance, N (lb)	ASTM D 1004	every 5th roll	40 (9)	65 (15)	93 (21)	125 (28)	187 (42)	249 (56)	311 (70)	373 (84)
Puncture Resistance, N (lb)	ASTM D 4833	every 5th roll	105 (24)	176 (40)	263 (59)	352 (79)	530 (119)	703 (158)	881 (198)	1,059 (238)
Carbon Black Content, %	ASTM D 1603	every 5th roll	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Carbon Black Dispersion	ASTM D 5596	every 5th roll	+Note 1	+Note 1	+Note 1	+Note 1	+Note 1	+Note 1	+Note 1	+Note 1
Notched Constant Tensile Load, hrs	ASTM D 5397, Appendix	90,000 kg	400	400	400	400	400	400	400	400
REFERENCE PROPERTY		TEST METHOD	FREQUENCY		NOMINAL VALUE					
Thickness, mm (mils)	ASTM D 5199	every roll	0.3 (12)	0.5 (20)	0.75 (30)	1.0 (40)	1.5 (60)	2.0 (80)	2.5 (100)	3.0 (120)
Oxidative Induction Time, minutes	ASTM D 3895, 200° C; O ₂ , 1 atm	90,000 kg	>100	>100	>100	>100	>100	>100	>100	>100
Roll Length (approximate), m (ft)			200 (656)	420 (1,738)	280 (918)	210 (689)	140 (459)	105 (344)	85 (279)	70 (230)
Roll Width, m (ft)			7.1 (23.3)	7.1 (23.3)	7.0 (23)	7.0 (23)	7.0 (23)	7.0 (23)	7.0 (23)	7.0 (23)
Roll Area, m ² (ft ²)			1,420 (15,284)	2,982 (40,495)	1,960 (21,114)	1,470 (15,847)	980 (10,557)	735 (7,912)	595 (6,417)	490 (5,290)
40' Container, roll			35	16	16	16	16	16	16	16
Tensile Properties (each direction)	ASTM D 6693, Type IV Dumbbell, 2 ipm	every 5th roll	11 (63)	18 (103)	26 (149)	35 (200)	53 (303)	70 (400)	88 (503)	105 (600)
Strength at Break, N/mm-width (lb/in)			7 (40)	10 (57)	14 (80)	19 (109)	29 (166)	38 (217)	48 (274)	57 (326)
Strength at Yield, N/mm-width (lb/in)			750	800	800	800	800	800	800	800
Elongation at Break, %	G.L. 51 mm (2.0 in)		17	17	17	17	17	17	17	17
Elongation at Yield, %	G.L. 33 mm (1.3 in)									
Tear Resistance, N (lb)	ASTM D 1004	every 5th roll	45 (10)	75 (17)	113 (25)	150 (34)	225 (51)	300 (68)	375 (84)	450 (101)
Puncture Resistance, N (lb)	ASTM D 4833	every 5th roll	144 (32)	240 (54)	360 (81)	480 (108)	680 (153)	840 (189)	950 (214)	1,200 (270)
Melt Index	ASTM D 1238, Cond. E	20,000 kg	<=1.0	<=1.0	<=1.0	<=1.0	<=1.0	<=1.0	<=1.0	<=1.0

NOTES:

- +Note 1: Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- GSE HD provided in thicknesses of 0.5 mm to 3.0 mm has an approximate weight of 1,430 kg (3,152 lb). GSE HD 0.3 mm material is provided in rolls weighing approximately 413 kg (910 lb) each.
- All GSE geomembranes have dimensional stability of ±2% when tested with ASTM D 1204 and ITB of <77° C when tested with ASTM D 746.

DS005 TH R03/10/03

This information is provided for reference purposes only and is not intended as a warranty or guarantee. GSE assumes no liability in connection with the use of this information. Please check with GSE for current, standard minimum quality assurance procedures and specifications.

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Europe/Middle East/Africa	GSE Lining Technology GmbH	Hamburg, Germany		49-40-767420	Fax: 49-40-7674233
Asia/Pacific	GSE Lining Technology Company Ltd.	Bangkok, Thailand		66-2-937-0091	Fax: 66-2-937-0097

Asia Pacific Operations

Gundle/SLT Environmental, Inc. (GSE) is the global leader in providing geosynthetic lining solutions, products and services to the waste containment, mining, water, wastewater treatment, aquaculture, agriculture, power and other industrial industries.



GSE's world headquarters is located in Houston, Texas, USA with manufacturing facilities in the United States, Thailand, Germany, Chile and Egypt. GSE products and services are available around the world to help you complete your project on schedule and within budget. GSE offers the largest selection of geosynthetic products in the industry. These products include geomembranes, geotextiles, geonets, geocomposites, geosynthetic clay liners, vertical barrier systems, and concrete protection liners.

GSE ASIA PACIFIC OPERATIONS

GSE Lining Technology Co., Ltd. manages the Asia Pacific operations from Bangkok, Thailand, with sales offices in Australia, China, India and Vietnam. It provides its customers in the Asia Pacific region with a global network of carefully selected independent installers. GSE's Asian manufacturing facility is located in the Rayong Industry Zone near the major deepwater port of Laem Chabang, Thailand. At this facility, there are round die co-extrusion and flat cast geomembrane production lines.

Each production line is equipped with an advanced computerized control monitoring system and an online spark testing device to continually check the liner integrity. The facility is equipped with a state-of-the-art laboratory for product testing.



Round die co-extrusion



[Manufacturing facility]

GSE PRODUCTS

GSE manufactures high density polyethylene (HDPE) and linear low density polyethylene (LLDPE) geomembrane liners to suit your specific applications. These geomembranes are manufactured in seamless widths of 7.0 m and thicknesses ranging from 0.3 mm to 3.0 mm. They are available in smooth or textured surfaces with black, white, or green surface colors.

GSE HD is a premium grade smooth HDPE geomembrane liner that exhibits outstanding chemical resistance, exceptional ultraviolet light resistance and excellent tensile properties. It is suited for applications requiring superior chemical resistance in exposed or covered applications.

GSE UltraFlex is a premium grade, smooth LLDPE geomembrane liner with outstanding elongation and flexibility. Its high elongation properties make it ideal for applications where differential settlement may occur.

GSE HD Textured & GSE UltraFlex Textured are premium textured HDPE and LLDPE geomembrane liners that increase the frictional resistance between geosynthetic and/or soil layers against the liners. This means the air space can be increased by the angle of the side slopes in landfill applications.



[GSE FrictionFlex Geomembrane]

GSE HD FrictionFlex & GSE UltraFlex FrictionFlex are the spray-on textured version of GSE HD and GSE UltraFlex. GSE FrictionFlex products are manufactured by using high quality HDPE and LLDPE geomembranes which are textured using GSE's secondary texturing process. This process is the only one that produces a textured material without significant reduction of any physical properties. The products provide not only an enhanced interfacial frictional resistance; they also provide outstanding tensile properties and can accommodate potentially larger settlement and differential settlement conditions. A smooth edge is provided during the texturing process of each geomembrane panel which is a value added to the field seaming process.



[GSE Leak Location Spark Testing]

GSE Leak Location liner is a spark-testable HDPE geomembrane that can be easily tested for post-installation damage using equipment capable of performing spark testing in the field per ASTM D 7240.

GSE White is a premium, co-extruded, light reflective HDPE or LLDPE geomembrane liner with a smooth or textured surface. The white surface reduces liner temperature by reflecting solar energy, which reduces wrinkling caused by expansion and contraction during installation.

GSE Green is a HDPE geomembrane liner that has a U.V. stabilized and

green upper surface to improve the aesthetics surrounding.

GSE QUALITY ASSURANCE PROGRAM

GSE's Quality Assurance Program begins with careful specification of resins and extends through our manufacturing process. Prior to acceptance, GSE tests all raw materials upon delivery to ensure they meet all requirements for its geosynthetic products. GSE geomembranes are monitored both during and after the manufacturing process by trained, experienced technicians. GSE's laboratory is fully equipped with the latest material testing technology available in the industry and is accredited by the GAI-LAP. All GSE geomembrane liners must pass through numerous industry standard ASTM tests before delivery to the job site. Certification is provided for each roll of the product to demonstrate it meets contract specifications.

GSE TECHNICAL SUPPORT

No matter what the size or scope of your project, the GSE Technical Sales Group is available to help you select the right products for your project requirements. Through your GSE Sales Representative an experienced GSE Technical Manager can provide you with technical support to help develop and provide specifications for different applications, and recommend those GSE products best suited to meet your project needs.

GSE is a leading manufacturer and marketer of geosynthetic lining products and services. We've built a reputation of reliability through our dedication to providing consistency of product, price and protection to our global customers.

Our commitment to innovation, our focus on quality and our industry expertise allow us the flexibility to collaborate with our clients to develop a custom, purpose-fit solution.

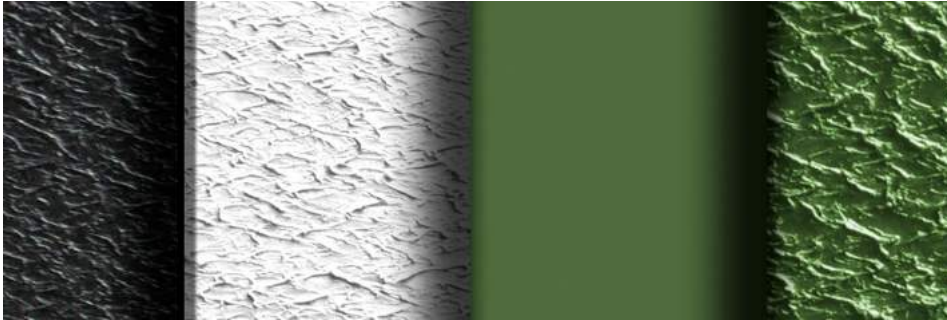
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Aquaculture

The aquaculture farming production process can be greatly improved by utilizing GSE polyethylene geomembrane lining systems. GSE geomembranes offer significant operation and cost benefits over soil, clay, concrete and steel in aquaculture applications.

GSE is the world's largest manufacturer and installer of geomembrane lining systems and has extensive experience supplying liners for aquaculture facilities.



[GSE Geomembrane Products]

WATER CONTAINMENT

As clean water becomes more expensive to acquire and the cost to pump water increases, the need for secure water containment grows. Efficient operation of any aquaculture facility requires consistent water volumes, high water quality, and low operating costs. Additionally, location of aquaculture facilities, like other food producing facilities, has become more difficult as concerns about clean surface water and groundwater resources grows.

Installing a GSE geomembrane is the solution. GSE geomembrane not only has extremely low permeability rates to help keep pond water volume consistent, they also keep waste product contained, and prevent the intrusion of groundwater borne pollutants from entering aquaculture ponds.

WATER QUALITY CONTROL

GSE HDPE geomembranes are certified by NSF61 for potable water containment. These high quality geomembrane liners contain no additives or chemicals which can leach out and impact water quality or harm animal life. GSE geomembranes can be repeatedly cleaned and disinfected with no decrease in the liner's performance. The result is improved water quality, allowing for higher crop densities, healthier crops due to greater dissolved oxygen levels and improved feed conversion ratios. This produces better tasting product and improves profit potential.



Indonesian Aquaculture Facility

BENEFITS:

- Secure water containment
- Enhanced water quality control
- Cleaning & disinfection capabilities
- Erosion protection
- Low turbidity
- Minimized pumping costs
- Consistent pond volume control
- Dissolved oxygen level control
- Smooth harvesting surface
- Rapid installation
- Low installation & maintenance cost
- Long life
- Easy repair

EROSION CONTROL

Effective erosion control is another significant advantage of a GSE lining system. The liner eliminates slope deterioration caused by surface rains, wave action and wind. The liner prevents eroded materials from filling the pond and reducing the volume. In addition, costly erosion repair and dredging are eliminated.



[GSE Aqua Tank]

DISEASE AND MICROBIOLOGICAL CONTROL

While diseases cannot be eliminated, lined ponds reduce their occurrence and impact. They also assure rapid and dependable recovery because the liner can be cleaned, disinfected and returned to service within days. GSE geomembranes are resistant to microbiological attack and growth. The surface cleans easily and thoroughly to give you a better control over your operations.

CROP QUALITY

With more consistent, better quality water, your aquaculture product grows more quickly, is healthier and tastes better. By using GSE geomembrane on your project, your overall operation is more efficient and produces a higher quality product.

THE LINER SYSTEM

Made from the highest quality resins, GSE geomembranes boast exceptional tensile strength, puncture resistance, durability and longevity. They have outstanding thermal and dimensional stability and are highly resistant to UV exposure, extreme temperatures and water absorption.

Each liner system installed by GSE uses state-of-the-art welding technology to ensure a long-term containment system for your aquaculture project.

A SAMPLE OF GSE AQUACULTURE PRODUCTS

GSE polyethylene products offer the widest range of thicknesses, and technologies designed to meet the most demanding aquaculture requirements:

- Polyethylene Liners
- Tanks
- Net Pens
- HDPE Drains
- Raceways
- Hatchery Trays
- Drainage Nets & Composite
- Liner Ponds
- Fry & Brood Tanks
- Buoys
- Custom Fabrications

GSE products are being used at aquaculture facilities around the world to help increase revenue, reduce risks, and control operating costs.



[GSE Raceway]

ENGINEERING SUPPORT

The GSE Engineering Support Staff is comprised of multidisciplinary product professionals to support you across a range of project requirements. This includes knowledge in geomembrane, geosynthetic clay liners, geonet, geocomposite, nonwoven geotextile and concrete protection products and application solutions. Rely on our technical staff to help you solve your project issues.

CUSTOM FABRICATION

The GSE Custom Fabrication Group builds products to your exact specifications. We have extensive experience in prefabricated polyethylene products and components. A few examples of our custom fabricated products are Aqua Tanks, Quick Containment, concrete protection liners, boots, sumps, pads, pipes, daily covers, temporary containment, containment boom and other products to fulfill your fabrication needs.

INSTALLER NETWORK

The GSE Installer Network leads the industry with the most experienced, large, and flexible crews available around the world to meet your installation requirements. Each installer is equipped with state-of-the-art welding and testing equipment to ensure a successful installation. Selecting a qualified installer with the right product knowledge is critical to your success. Let GSE connect you to the right installer to handle your installation project of any size from start to finish.

GSE is a leading manufacturer and marketer of geosynthetic lining products and services. We've built a reputation of reliability through our dedication to providing consistency of product, price and protection to our global customers.

Our commitment to innovation, our focus on quality and our industry expertise allow us the flexibility to collaborate with our clients to develop a custom, purpose-fit solution.

[DURABILITY RUNS DEEP] For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.



Canals

THE PROBLEM

As clean water becomes more expensive to acquire, the need for secure water containment and transport grows. Over time, concrete-lined canals may crack, resulting in a significant loss of water. Earthen canals are also subject to erosion and leakage problems.

THE SOLUTION

GSE polyethylene geomembrane provide an effective and economical solution to canal leakage and erosion problems.



[GSE Geomembranes are available in a smooth or textured surface]

COVERED OR EXPOSED

Geomembrane canal liners may be left exposed or may be protected with a covering of soil or concrete. GSE's UV-stabilized geomembranes can remain exposed for an extended length of time with no expected decline in their level of performance. However, most canal lining systems should be protected against damage from rocks, debris, equipment and vandalism. Some applications require a protective concrete covering over the geomembrane. The protective concrete layer may be cast-in-place with reinforcing steel, pumped into geotextile forms, precast in panels or spray applied.

GSE textured geomembranes can improve concrete stability during its placement on slopes by increasing the friction between the liner and the concrete and the liner and the subgrade.

HDPE & LLDPE GEOMEMBRANES

Polyethylene geomembranes are commercially available in a range of resin densities and quality. However, GSE uses only the best quality high density (HDPE) and linear low density polyethylene (LLDPE) resins. These resins exhibit exceptional flexibility, strength and durability, as well as excellent chemical resistance. HDPE geomembranes are best for high wear conditions such as exposed applications and LLDPE geomembranes offer extra flexibility.



GSE lined canal with incorporated flow control system

GSE HDPE GEOMEMBRANES EXHIBIT:

- Long-Term Durability
- Flexibility
- Puncture Resistance
- Optional Textured Surfaces
- Large Roll Widths & Lengths
- UV Stability
- Low Temperature Flexibility
- Thermally Welded Seams
- Flow Improvement
- Reduced Maintenance

REPAIR OF EXISTING CANALS

GSE geomembranes are suitable for lining over cracked concrete canal linings. Sections of the canal can be repaired at different times if the budget does not allow for a complete relining at one time.

CASE HISTORIES - RELINE USING TEXTURED GEOMEMBRANE & SHOTCRETE

For 30 years, the Putah South Canal in Vacaville, CA supplied irrigation water for the Solano Irrigation District¹. Seepage was a continuing problem which was partially mitigated by lowering the surface height of the canal water by 24 in (61 cm). A decision was finally made and funds allocated to reline the worst section of the canal - about 4,000 ft (1,500 m). Various methods were considered.

The material chosen was a polyethylene geomembrane with a textured surface manufactured and installed by GSE. Installation began at the lowest point of the canal and proceeded upwards. The geomembrane panels were installed transverse to the canal and the panels were fusion welded together. They were then mechanically attached to the existing concrete liner at the top of the canal slopes.

Shotcrete with reinforcing fibers was then spray-applied to a 2 in (5 cm) thickness. The textured membrane allowed for applying the complete shotcrete thickness at one time instead of in three applications as would have been necessary using a smooth-surfaced geomembrane. Expansion and contraction joints were added at 12 ft (3.5 m) centers. One section was completed in 1989; a second section using the same method, was completed in 1993. The lining

eliminated water loss.

NEW CANAL WITH GEOMEMBRANE AND CAST-IN-PLACE CONCRETE

The Pasto Grande Umarzo Canal Project in the mountains of Peru involved constructing 59,000 feet (18 km) of concrete-lined canal in an arid region. The canal supplies drinking and irrigation water for an agricultural community. The canal lining consists of a geotextile cushion and the textured HDPE waterproofing geomembrane. A steel-reinforced, cast-in-place concrete protective covering was later installed to minimize the cost of the surface preparation and to protect the HDPE.

Several sections of the canal, which winds down the mountains, utilized a



[GSE lined canals help prevent water loss]

concrete-lined canal. The cast-in-place concrete was poured directly on top of the geomembrane. Forms were utilized on the steep side slopes.

GSE textured geomembrane was an excellent choice for this difficult and demanding canal lining installation and was able to withstand the traffic and activity necessary to install the protective concrete layer.

ENGINEERING SUPPORT

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¹Refer to the Concrete Placement over Geomembranes, Alice I. Comer, Bureau of Reclamation paper, USA.

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[DURABILITY RUNS DEEP] For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.



Coal

As the population grows, so does the demand for more electrical power capacity. This increase in demand has spurred the need for the new generating stations and innovative methods for improving efficiency at existing power plants. Geosynthetic materials provide solutions to various concerns associated with coal power generations such as groundwater protection, process water containment and ash impoundment.



[Coal Ash Impoundment]

Today's coal-fired power plants require optimal performance from containment lining systems. GSE manufactures the highest quality, most durable, longest lasting geosynthetics for use in Coal Combustions Product (CCP), cooling water and evaporation ponds.

With millions of square feet of geosynthetic products supplied and installed at coal power plants across the U.S.; GSE has the right geosynthetic products to meet your project requirements.

A SPARK-TESTABLE GEOMEMBRANE

Impoundments at coal power plants are typically exposed to the elements and are in constant use. If a post-installation leak test is required or deemed beneficial, consider GSE's spark-testable Leak Location liner system. A large impoundment installation can be tested for pinholes and other construction related damage to insure 100% containment without the added expense of the flooding the floor or the inability to test slopes and all the uncertainties present with other post-installation testing methods. GSE Leak Location liner can be regularly tested year after year to insure continued containment.



Leak Detection Liner



[Spark Testable Leak Location Liner]

PURPOSE:

An HDPE geomembrane used for groundwater protection, process water containment, and coal ash impoundment.

Many impoundments require a leak detection system to ensure the integrity of the primary liner system on a continuous basis. This system consists of a secondary HDPE geomembrane below the primary liner which is overlaid with either a geonet or a geocomposite net. If the leak detection system is placed directly below the primary liner, a geonet is used. If an intermediate soil layer or primary clay layer is used, then a geocomposite liner is utilized.

CASE HISTORIES

GSE installed the liner system at the Springerville Power Plant in Northeast Arizona and operated by Tri-State Generation and Transmission Association. The Bechtel Group designed the 1,500 MW plant, as well as the evaporation ponds comprised of over 2.5 million SF of geosynthetics. The lining system installation was performed by GSE Installation Services. The installation was completed ahead of schedule and under budget.



[Leak Location Geomembranes]

The Power Generating Station located in the Mojave Desert consists of two 790 MW generating units that supply power to 1.5 million homes. The power plant is fueled by a low-sulfur coal. The plant operates under a zero discharge permit. The total project size was over 1.8 million SF of geosynthetic materials. To insure complete

containment of all contaminants which enter the pond, GSE Leak Location White liner was selected for the quickest and most cost-effective leak detection inspection method available. The project was completed on schedule with a quick installation and economical leak detection of the installed geomembrane

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[Evaporation Pond]

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[Cooling Water Pond Storage]

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Landfills

GEOMEMBRANE QUALITY, CONSISTENCY SERVICE

Geomembrane quality begins with base resin selection. GSE's resins are blended with premium carbon black, antioxidant additives and UV stabilizers to ensure long life even in exposed conditions.

GSE's manufacturing facilities include state-of-the-art production lines. GSE utilizes two unique geomembrane extrusion systems. With flat cast and round die extrusion capabilities, GSE can meet stringent tolerance requirements as well as produce patented, coextruded products.



[Landfill Application, Hawaii]

GSE geomembrane materials must pass a battery of quality control checks before being shipped and installed. From the base resin checks to 100% spark-tested product to laboratory quality assurance testing, all GSE geomembranes are thoroughly inspected. Installations require extensive planning to ensure on-time delivery and coordination with the earthmoving contractors.

LANDFILL CELL LINERS

Today's state-of-the-art landfill utilizes a range of geosynthetic products to maximize design efficiency, integrity and performance while minimizing overall cost. For environmental protection, the essential landfill component is the primary geomembrane liner.

The primary liner contains dangerous leachates and protects valuable groundwater resources. However, for a landfill liner system to function optimally, it needs to incorporate more than a smooth surfaced geomembrane.

Steep side slopes have become standard in landfills as a means to increase capacity and revenue. Steep slopes present problems for smooth liners because cover soil may not stay in place and, with overburden, the liner itself can slip down the slope and increase stress on seams and the sheet itself. To solve this problem, GSE offers co-extruded textured geomembranes.



GSE Textured Geomembranes



GSE Geonets

LEACHATE CONTAINMENT

A combination of geocomposites and geonets manufactured for use in soil separation, filtration, protection and drainage applications.



[Landfill Application, Germany]

The geomembrane liner provides containment for landfill leachates. For leachate collection, geocomposite nets provide high in-plane flow. The geocomposite is composed of GSE HyperNet HDPE geonet with geotextile bonded to one or both sides to keep cover soil from clogging the geonet. GSE FabriNet geocomposite is placed directly on top of the primary liner. The geotextile clings to textured geomembrane to lock the composites in place, especially on slopes.

Many regulations require a leak detection system to ensure the integrity of the primary liner on a continuous basis. This system consists of a secondary HDPE geomembrane below the primary liner which is overlaid with either a geonet or a geocomposite net. If the leak detection system is placed directly below the primary liner, a geonet is used. If an intermediate soil layer or clay layer is used, then a geocomposite net is utilized. Landfill cell liners are massive and critical projects. The geosynthetic liner system represents a small fraction of the overall cost but virtually 100% of the protection. Don't settle for mediocre quality. GSE provides



[Provides Excellent Longevity]

everything you need for the highest quality installation and the largest selection.

LANDFILL COVERS

A major long-term concern when employing a landfill cover is differential

settlement caused by decaying and shifting waste. The geomembrane cover must facilitate deformation caused by differential settlement without failure of the containment. To meet this requirement, GSE UltraFlex is made from a unique, linear low density polyethylene resin (LLDPE). Its utility and durability has been proven in over 50 million square feet (5 million square meters) of landfill cover applications.

LEACHATE PONDS

Leachate is collected from landfill cells and typically stored in lined ponds for treatment or evaporation. The liners in these ponds are generally exposed to the elements. HDPE lining systems exhibit the highest degree of durability under extreme environmental conditions including sunlight, freezing temperatures and abrasion.

HIGH-END ENGINEERING

To achieve true state-of-the-art landfill design, incorporate GSE's co-extruded geomembrane capabilities. GSE White is a co-extruded HDPE geomembrane, which provides significant benefits for the landfill owner, engineer and contractor.

The white surface has two primary functions. First, it reflects sunlight which minimizes radiant heat absorption and heat buildup to effectively minimize liner temperature. This results in less expansion of the liner. With less expansion, wrinkles are minimized. Another benefit of lower liner temperature is decreased moisture evaporation from underlying clay layers.

The second benefit of a white surface is improved visual inspection. If the thin white surface is damaged, the black portion of the sheet shows clearly. Post-installation damage is much more likely to be observed

and repaired. See the GSE White application sheet for more information.

If a post-installation leak test is required, consider the benefits of GSE's spark-testable GSE Leak Location. A large landfill installation can be tested for pinholes or other construction-related damage to 100% satisfaction without the added expense of flooding or the uncertainties of other leak testing methods. Specialized areas such as sumps and pipe penetrations require special products and installation techniques. To ensure complete containment protection, use GSE Leak Location since it can be electrically spark-tested at any time to find even the smallest punctures resulting from pipe laying or other incidental damage.

ENGINEERING SUPPORT

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[DURABILITY RUNS DEEP] For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.



Power

BACKGROUND

As the population grows, so does the demand for more electric power capacity. This increase in demand has spurred the need for new generating stations and innovative methods of generating electricity and operating existing power plants. Geosynthetic materials provide solutions to various concerns associated with these types of applications such as groundwater contamination. Geosynthetics have long been used in evaporation, cooling and brine ponds, but are also being used to line pumped storage ponds.



[GSE HDPE Geomembranes used as pond liners for Power Plants]

CASE HISTORIES

GSE has been lining ponds in power plant applications for over 30 years. One of GSE's earlier projects was for a Steam Electric Generating Station in Colorado. This installation consisted of 8 containment ponds ranging in size from less than an acre to over 20 acres. The containment ponds are used to store intermediate quality water, for fly ash recovery and as brine ponds. The ponds are still being used to this day.

The customer removed some small portions of the geomembrane and asked us to test them to see how well it was holding up after years of outdoor exposure. The ensuing forensic investigation showed that the material still retained much of the physical properties that it had at the time it was manufactured¹.

A more recent site where GSE geosynthetic materials have been used successfully in a power plant application is the Casa Grande Site in Arizona. This particular installation was a double lined system utilizing GSE 60 mil HDPE geomembrane, GSE HyperNet drainage net and a geosynthetic clay liner. The material was used in each of three 28 acre evaporation ponds for a total footprint of over 84 acres. The GSE HyperNet was installed between the primary and secondary geomembranes for a leak detection layer. GSE HDPE was chosen because of its high chemical resistance and its proven track record in exposed applications.



GSE HDPE Geomembranes



GSE White Textured Geomembrane

POWER PLANT APPLICATION

Man-made reservoirs are required for Power Plants to store water during periods of low energy consumption. This stored water can be used during peak energy demand cycles and does not require the use of natural water sources to provide power.

PUMPED STORAGE POND

Building new power plants is costly. As an alternative to building new power plants, some energy companies are looking to innovative methods to better utilize the full capacity of existing ones. While many generating stations operate at or near capacity during the day when demand is greatest, the same plants have excess generating capacity at night.



[Pumped Storage Ponds]

Power generators are using pumped storage ponds to store the excess nighttime capacity so that it may be used during the day when demand is greater. The pumped storage pond idea has been around for over 30 years, but relied on an available water source such as a dammed river or natural reservoir. Damming of rivers is increasingly coming under scrutiny due to environmental concerns associated with flooding naturally existing vegetation. By utilizing geosynthetics in constructing manmade reservoirs, they can be constructed in areas that lessen the impact on the environment.

To accomplish this task two large ponds are constructed; one at a higher elevation relative to the first. During the night, water is pumped from the lower elevation pond to the higher elevation pond. During the day, the water from the higher elevation pond flows back to the lower elevation pond through a turbine creating hydroelectric energy. Both of these

ponds are typically double lined with HDPE geomembrane. A geonet layer is installed between the two geomembrane layers to provide a leak detection system.

SOLUTIONS

GSE is the world leader in manufacturing geosynthetic materials that are used in a variety of applications from landfills to leach pads to storage ponds. GSE's product line consists of HDPE and LLDPE geomembranes, geonets, geocomposites, geotextiles and geosynthetic clay liners (GCL). GSE polyethylene geomembranes are available with smooth or textured surface on either or both sides.



[Hydro Power Plant Application]

GSE INNOVATIVE PRODUCTS PROVIDES SUPERIOR PROTECTION

For superior protection and leak detection, GSE Leak Location is utilized for either the secondary liner or for both layers of geomembrane. GSE Leak Location allows for the entire surface area to be spark-tested after installation including side slopes. Spark testing provides an extra measure of security against material leaching to the surrounding earth and ground water supply assuring that no environmental contamination can occur. For assured long-term containment and environmental protection, the surface can be spark-tested again either annually or at some

other predetermined interval to assure the installation remains leak-free².

In addition to black surfaced geomembrane; white surfaced geomembrane is also available. GSE White surfaced geomembrane speeds installation by reducing the amount of heat gain and therefore wrinkling of the geomembrane during installation³. Laboratory UV testing indicates this material can have a service life of up to 50 years depending on environmental factors such as elevation and latitude.

ENGINEERING SUPPORT

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¹Refer to the GSE Forensic Study Case History for more information.

²Refer to the application sheet for GSE White Surfaced Geomembranes for more information.

⁴Refer to the application sheet for GSE Leak Location Geomembranes for more information.

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Water & Wastewater Treatment

GSE PROVIDES A COMPLETE RANGE OF PRODUCTS AND SERVICES TO MEET YOUR WATER CONTAINMENT NEEDS

Water is the most precious and protected natural resource on earth. To meet containment and water treatment regulations, on-site water storage and treatment reservoirs are recognized as key in treatment facilities. GSE HDPE (High Density Polyethylene) and LLDPE (Linear Low Density Polyethylene) geomembranes and drainage products are proven to provide a cost-effective and efficient method of waterproofing earthen, concrete, and steel lined containment structures and reservoirs.

We offer a complete line of products and installation services to meet your specific water containment and treatment needs.

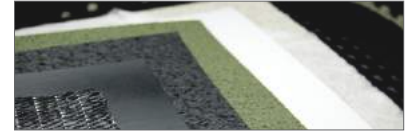


[GSE White Pond Evaporation]

WATER AND WASTEWATER CONTAINMENT APPLICATIONS

Thousands of industrial and municipal water and wastewater treatment facilities have relied on GSE materials, technology, and installation services in lining system applications. Many of the applications include:

- Water storage and treatment lagoons
- Sedimentation basins
- Grit chamber liners and flow control vertical baffles
- Floating covers for anaerobic digestion and odor control
- Geomembrane liners for corrosion protection of concrete structures
- Geomembrane liners to remediate leaking containment structures
- Factory-controlled prefabricated sumps, liners, piping systems, and pipe penetration connection liners



GSE Geosynthetic Products



[GSE Liner in wastewater treatment aerobic digester]

GSE GEOMEMBRANES ARE:

- Rugged and durable
- Resistant to hazardous and harsh liquids
- Certified for potable water containment
- UV-resistant for exposed liner applications
- Flexible for ease of installation
- Installed quickly when compared to clay and concrete



[StudLiner Sumps]

GSE QUALITY HDPE AND LLDPE GEOMEMBRANES

Polyethylene geomembranes are commercially available in a range of resin densities. GSE uses only high quality polyethylene resins specially formulated to exhibit excellent chemical resistance, UV-resistance, strength, durability, and resistance to stress cracking. These properties are critical to containment in most water and wastewater containment applications. GSE HDPE geomembranes are best suited for high wear, exposure to harsh liquid conditions and exposed applications. GSE LLDPE geomembranes offer higher flexibility to withstand large differential settlement conditions.

GSE geomembranes are used extensively in these applications due to their proven performance as a cost efficient replacement to conventional clay and concrete lining systems. And compared to other geomembranes, such as flexible PVC, GSE geomembranes contain no plasticizers or fillers that may cause premature geomembrane cracking and reduced service life.

GSE GEOSYNTHETIC CLAY LINERS PROVIDE AN ECONOMICAL ALTERNATIVE TO CONVENTIONAL COMPACTED CLAY LINERS

For water and wastewater containment lining applications that require compacted clay liners (CCLs), in addition to geomembranes, GSE also offers two types of Geosynthetic Clay Liners (GCLs), GSE BentoLiner Fabric Encased GCLs and GSE GundSeal Geomembrane Supported GCLs. GCLs are commonly used in water and wastewater containment applications, to replace conventional compacted clay

layers and geomembrane/compacted clay composite liners.

GSE BentoLiner is ideally suited as a replacement for thick layers of compacted clay by simply rolling out a fabric encased bentonite layer on flat or sloping areas. The GSE GundSeal is used as a replacement for a composite liner, replacing both a low permeability clay layer along with an impermeable and chemically resistant geomembrane. Its one product installation saves installation time as well as improves composite liner hydraulic performance.

Whether the choice is GSE BentoLiner or GSE GundSeal to provide an economical alternative to your compacted clay water containment requirements, GSE provides the widest range, most versatile, and highest quality GCLs in the world.



[GSE GundSeal in a food processing Sludge Lagoon]

REPAIR OF EXISTING LAGOONS AND LINED STRUCTURES

GSE geomembranes are suitable for lining of existing structures or to retrofit leaking liner systems, such as lagoon clay liners, cracked and weathered concrete liners, or corroded steel containment liners. The liners are simply installed over a prepared surface above the leaking liner.

PREFABRICATED LINING SYSTEMS

For smaller projects, such as collection sumps, small containment basins, grit

chambers, and vertical flow control baffles, GSE provides prefabricated geomembrane panels for the client's own installation. GSE Custom Fabrication is available to fabricate specialized size and dimensions to custom fit your containment structure.



[Bootless Pipe Penetration]

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INSTALLER NETWORK

The GSE Installer Network leads the industry with the most experienced, large, and flexible crews available around the world to meet your installation requirements. Each installer is equipped with state-of-the-art welding and testing equipment to ensure a successful installation. Selecting a qualified installer with the right product knowledge is critical to your success. Let GSE connect you to the right installer to handle your installation project of any size from start to finish.

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Mining

LINING SYSTEMS

Today's mining practices require optimal performance from containment lining systems. GSE manufactures and installs the highest quality, most durable, long-lasting geomembrane lining systems for specialized mining needs. GSE's wide range of geotechnical products are manufactured from polyethylene resin for use in demanding geotechnical applications. GSE's unique, linear low density (LLDPE)



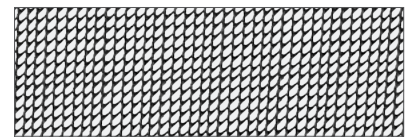
[GSE Mining Drainage Application]

geomembrane, called GSE UltraFlex was developed to meet the explicit needs of the mining industry by providing outstanding puncture and chemical resistance in addition to multiaxial performance.

GSE HDPE and LLDPE geomembranes are available in thicknesses from 40 mils (1.0 mm) to 120 mils (3.0 mm) and seamless widths of 22.5 feet (6.9 meters) to 34.5 feet (10.5 meters). Such wide-width panels mean fewer field seams, faster, more efficient installations and less opportunity for leakage. With millions of square feet installed at mining operations around the world, you can be assured that GSE's geomembranes will meet your needs. For applications requiring liner placement on slopes, GSE offers a unique method for texturing sheet to optimize the frictional characteristics of the liner called coextruded textured process. GSE textured geomembranes provide enhanced friction between both the protective cover and liner, and between the liner and soil below the liner.



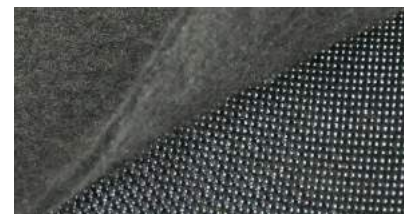
GSE BioDrain Geocomposite



GSE HyperNet Geonet

GSE MINING SYSTEMS

GSE's unique, linear low density (LLDPE) geomembrane, called GSE UltraFlex was developed to meet the explicit needs of the mining industry by providing outstanding puncture and chemical resistance in addition to multiaxial performance.



[GSE Drainage Geocomposite]

SOLUTION PONDS

Pond liners are typically exposed to the elements and constant use. Annual leak testing is not uncommon to minimize solution loss. To minimize leak testing costs and maximize assurance, use GSE Leak Location, a patented field spark-testable geomembrane which can be economically tested in place, when clean, dry and exposed, year after year. Add a second geomembrane layer along with a GSE geonet or GSE geocomposite net to create a leak detection system under the pond liner and ensure complete capture of valuable solutions.



[Mine Drain Application, Mexico]

CORROSION PROTECTION

GSE offers unique products for lining settling tanks and other structures that utilize scraper arms. For lining concrete tanks, consider GSE's StudLiner HDPE sheet which is embedded into new poured concrete or adhered to existing concrete with injected mortar to provide a smooth, wrinkle-free, rigid membrane surface for complete containment as well as abrasion protection. Used extensively in Europe for many years, GSE StudLiner is available in the U.S. and other countries worldwide. GSE StudLiner is available in a range of thicknesses and configurations to meet specific needs.

Another effective means for lining concrete structures is with GSE's standard geomembranes which can

be attached to concrete tanks using PolyLock HDPE attachment strips. These strips are positioned in the concrete forms used for pouring the tanks. The geomembrane can then be fitted and extrusion welded directly to the embedded HDPE strip to provide continuous attachment. For existing concrete tanks, the geomembrane can be secured by using metal batten strips and bolts.

GSE geomembranes are used to line settlement tanks, sumps, trenches, salt bins, etc., to prevent weathering and corrosion. GSE liners, used for corrosion protection for concrete structures are a very economical replacement for stainless steel tanks.

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[Mine Drainage Operation]

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