Energy industries using HDPE liners for flowback water evaporation/recycling ponds

Case Studies (https://geosyntheticsmagazine.com/category/case-studies/), Feature (https://geosyntheticsmagazine.com/category/feature/) | October 1, 2021 | By: Neil C. Nowak

(https://geosyntheticsmagazine.com/wp-content/uploads/sites/26/2021/09/figure-1-weep-system.jpg)

FIGURE 1 To increase evaporation with low costs in mind, a "weep" system was added at Danish Flats to allow water to flow and fan out over the surface of the HDPE liner that is above the waterline.

The problem to be solved is the disposal and recycling of millions of gallons of production water (brine water) and flowback water annually generated from the oil and gas industry in an environmentally safe, less costly and efficient manner. A technology that is effective and safe is the evaporation or storage of the water in lined containment ponds after separation and removal of the hydrocarbon component from the water. This article features three case studies, located near Wright, Wyo., Cisco, Utah, and Midland, Texas. They were designed to evaporate or recycle water in geomembrane-lined ponds. The purpose of this article is to demonstrate that black high-density polyethylene (HDPE) liners increase evaporation over the use of clay or unlined ponds, and the use of a white liner reduces evaporation relative to a black liner.

The projects are complete and have been operational for several years, and they continue to be expanded per their permits. The production and flowback water from oil and gas wells at each site is trucked or piped to the sites for disposal or recycling. The water is evaporated in ponds lined with black HDPE geomembranes as the top layer by using a combination of factors that are favorable to the evaporative process, including the natural characteristics of the site and arid climate. HDPE liner was chosen to protect the surface and groundwaters of the area and to assist with the evaporation of the water. The top layer liner was white at XRI Blue Buchanan Pond in Midland, Texas, for the storage and to reduce the evaporation relative to the black liner.

The projects are interesting in that each facility provides oil and gas production companies in the area with a large commercial alternative to production water and flowback disposal versus numerous small ponds or disposal via injection wells.

Case study basic conditions Bluegrass Water, Wright, Wyo.

The project is in a semiarid region of northeastern Wyoming in Campbell County, which is at 4,888 feet (1,490 m) above mean sea level. According to the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) map, the average annual precipitation is 17.1 inches (43.5 cm). The National Weather Service developed the free water surface evaporation rate, the annual amount expected to evaporate from the disposal ponds, which is 45 inches (114.3 cm) per year. This evaporation data is based on a water containment that is not lined with white or black HDPE geomembranes.

Danish Flats, Cisco, Utah

The project is in an arid region of eastern Utah in the area known as Danish Flats, which is at 4,610 feet (1,405 m) above mean sea level.

The site is in the Mancos Shale Formation lowland area including the Greater Cisco area. The Mancos Shale Formation is the predominant outcrop in this area (Hunt 1996).

According to the USDA NRCS map, the average annual precipitation is 6 inches (15.2 cm). As in Wyoming, the National Weather Service developed the free water surface evaporation rate, which is 50 inches (127 cm) per year. This evaporation data is based on a water containment that is not lined with white or black HDPE geomembranes.

XRI Blue Buchanan Pond, Midland, Texas

The project is in an arid region of west Texas in the area known as the Permian Basin, which is at 2,690 feet (820 m) above mean sea level. The site is in Midland County 9.9 miles (16 km) south of Midland.
According to the USDA NRCS map, the average annual precipitation ranges between 12 and 15 inches (30.5 and 38.1 cm). The free water surface evaporation rate is 58 inches (147.3 cm) per year. This evaporation data is based on a water containment that is not lined with white or black HDPE geomembranes.

Project details Purpose

The main purpose of the projects is to evaporate the production water and flowback water as quickly as possible, or to store and recycle the water while maintaining environmental controls and containment.

Several water-disposal options exist, including reinjection wells, fracking injection, treatment for surface discharge, recycling for reuse in the development of oil/gas and evaporation. The evaporation technology was chosen for some of these projects due to the ideal site conditions for evaporation, including low precipitation, windy conditions, high ambient temperatures and plenty of sun. Other projects are designed to store the water for reuse and, therefore, use white color liners.

Selection of technology

While several lining technologies exist and are allowed by the regulatory agencies, the HDPE liner was chosen for the top layer for several reasons, including durability, resistance to ultraviolet (UV) degradation, chemical resistance, black color and ease of construction.

The addition of the proper amount of high-quality carbon black to the geomembrane during manufacturing is universally accepted as being resistant to significant deterioration caused by weathering. In addition to high-quality carbon black, highly effective chemical UV stabilizers further extend the life of the liner. These additives absorb incident radiation and terminate free radical production, thus protecting the HDPE geomembrane against thermal degradation and possible chemical reactions with surrounding materials. Other factors that affect the potential UV resistance of a material include average density, density range or dispersion, chemical stabilizer system, catalyst type and amount of residue, copolymer type, combined chemical exposures, and failure criteria (GSE 2003).

Implementation

Production water and flowback water are delivered to the sites via tanker trucks and via pipelines from well sites located within the geographic area local to each site; the delivery method used depends on transportation costs and disposal fees when compared to other alternatives for water disposal in the area. The water is off-loaded and sent through a treatment process, such as separation equipment, gun-barrel tanks or other state-of-the art equipment.

The operation units include gun-barrel tanks, a sludge pond and a series of 5.2-acre (2.1-ha) evaporation ponds. All the structures are connected via gravity or force-main fed via an underground piping system. The Bluegrass Water facility process is similar to the Danish Flats layout.

To increase evaporation with low costs in mind, a “weep” system was added at Danish Flats to allow water to flow and fan out over the surface of the HDPE liner that is above the waterline. This system utilizes the exposed HDPE liner to increase evaporation by using the heat generated from the exposed HDPE liner in combination with the increased surface area of the water fanning out over the liner (**Figure 1**).

The incoming water at the Danish Flats and Bluegrass Water sites flows through the gun-barrel tank systems and the sludge pond before entering the evaporation ponds. The pretreatment facilities and the evaporation ponds have been designed to follow the topography, allowing for gravity flow throughout the system.

Volatile organic compound (VOC) emissions from the separation equipment and ancillary tankage are controlled to maintain air quality.

The sludge ponds and storage/evaporation ponds have an interior slope of 3 horizontal to 1 vertical, or 3:1, and a maximum exterior slope of 2 to 1. The HDPE geomembrane chosen has a textured surface, which will increase the safety characteristics of the facility by making it easier to walk on, especially on the interior slopes.

Surface water will not be allowed to enter the ponds because the constructed berms are several feet higher than the surrounding ground surface, and diversion and control ditches are used to direct the run-on and runoff for minimizing the impact of stormwater.

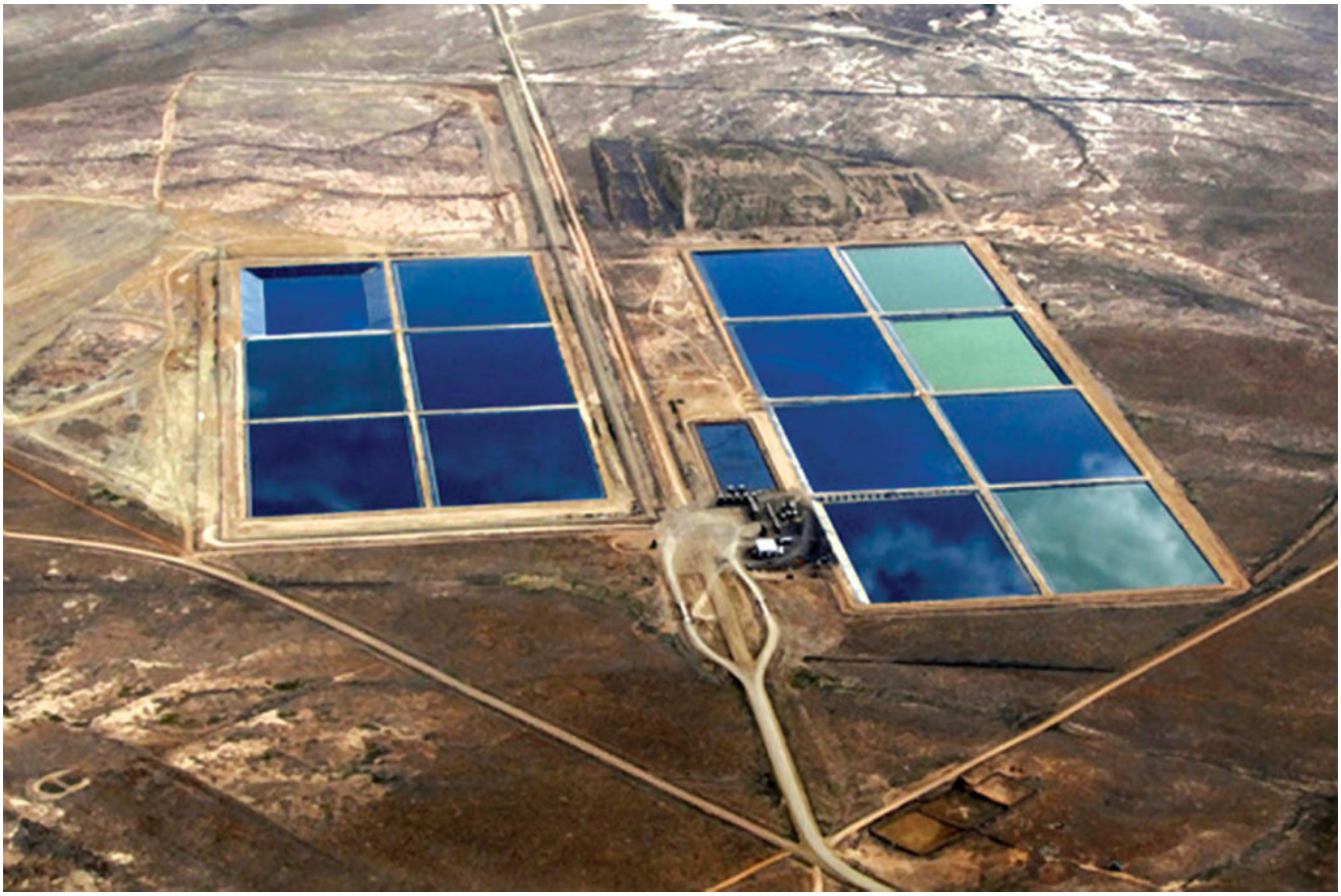
The leak detection system is between the primary and secondary liners, and it is inspected, and data is recorded, as required. A summary of the inspections is reported to the regulatory agencies as needed. Liquid from the sump can be pumped back into the pond. If the volume of the leak exceeds certain thresholds, specific protocols for repairing the liner are required.

The entire facility area at each site has been fenced and gated to help prevent cattle or other animals from entering. Since the sludge ponds could have oily material on the surface, netting has been used to deter the entry of birds or other wildlife at the Danish Flats and Bluegrass Water sites.

The volume of water able to be stored for evaporation or storage in the ponds is as follows:

- Bluegrass Water: Ponds 1–8 are 25 feet (7.62 m) water-holding depth and nearly 1 million barrels (at 42 gallons [159 L] per barrel) each, for a total capacity of 8 million barrels. Enhanced evaporation with sprayers were used to improve evaporation.
- Danish Flats: Ponds 1–8 are 12 feet (3.66 m) of water-holding depth and nearly 240,000 barrels each, for a total capacity of 2 million barrels. Ponds 9–13 are 22 feet (6.71 m) of water-holding depth and nearly 632,000 barrels each, for a total capacity of 3,160,000 barrels.
- XRI Buchanan: Pond 1 is 12 feet (3.66 m) of water-holding depth for a capacity of nearly 500,000 barrels.

The project at Danish Flats was photographed from the air on June 29, 2009 (**Figure 2**), when it was partially completed and partially operational. The water was distributed from the sludge pond to the operational ponds. Currently, more than 13 evaporation ponds are operational at Danish Flats.



(https://geosyntheticsmagazine.com/wp-content/uploads/sites/26/2021/09/figure-2-danish-flat.jpg)

FIGURE 2 Danish Flats facility plan view

Operational data

At Danish Flats, operators have experienced various quantities of water deliveries, ranging from 10,000 barrels to 35,000 barrels per day. The water is moved from the off-loading area through the sludge pond and to the evaporation ponds by gravity or via force main for distribution to Phase 2. Each pond at Danish Flats has a freeboard requirement of 2 feet (0.61 m), and each pond at Bluegrass Water has a freeboard requirement of 3 feet (0.91 m).

In Cisco, Utah, in July and August the ambient air temperatures often exceeds 100˚F (37.8˚C), and it is generally windy. The evaporation encountered during the months of July and August 2008 at the site was measured to be 15–18 inches (38.1–45.7 cm) per month, respectively. The Danish Flats operators observed very favorable evaporation of the water and measured the total evaporation for the year 2008 above the estimate of 50 inches (127 cm) for six months of operation.

In 2009, the Danish Flats facility was measured to have 60 inches (152.4 cm) of evaporation, which took place mostly between April 1 and October 31, and again in 2010 the evaporation total exceeded 60 inches (152.4 cm) over the entire water surface of the ponds. The deeper ponds at Danish Flats experienced a 30% lower evaporation rate due to the deeper water depth; therefore, the entire depth of water was not able to achieve warmer temperatures as did the shallower ponds.

At XRI Buchanan, the top liner used was a white color 60 mil (1.5 mm) thick HDPE to reduce the evaporation relative to the black liner, due to the facility wanting to retain the water for reuse in the fracking operations (**Figure 3**).

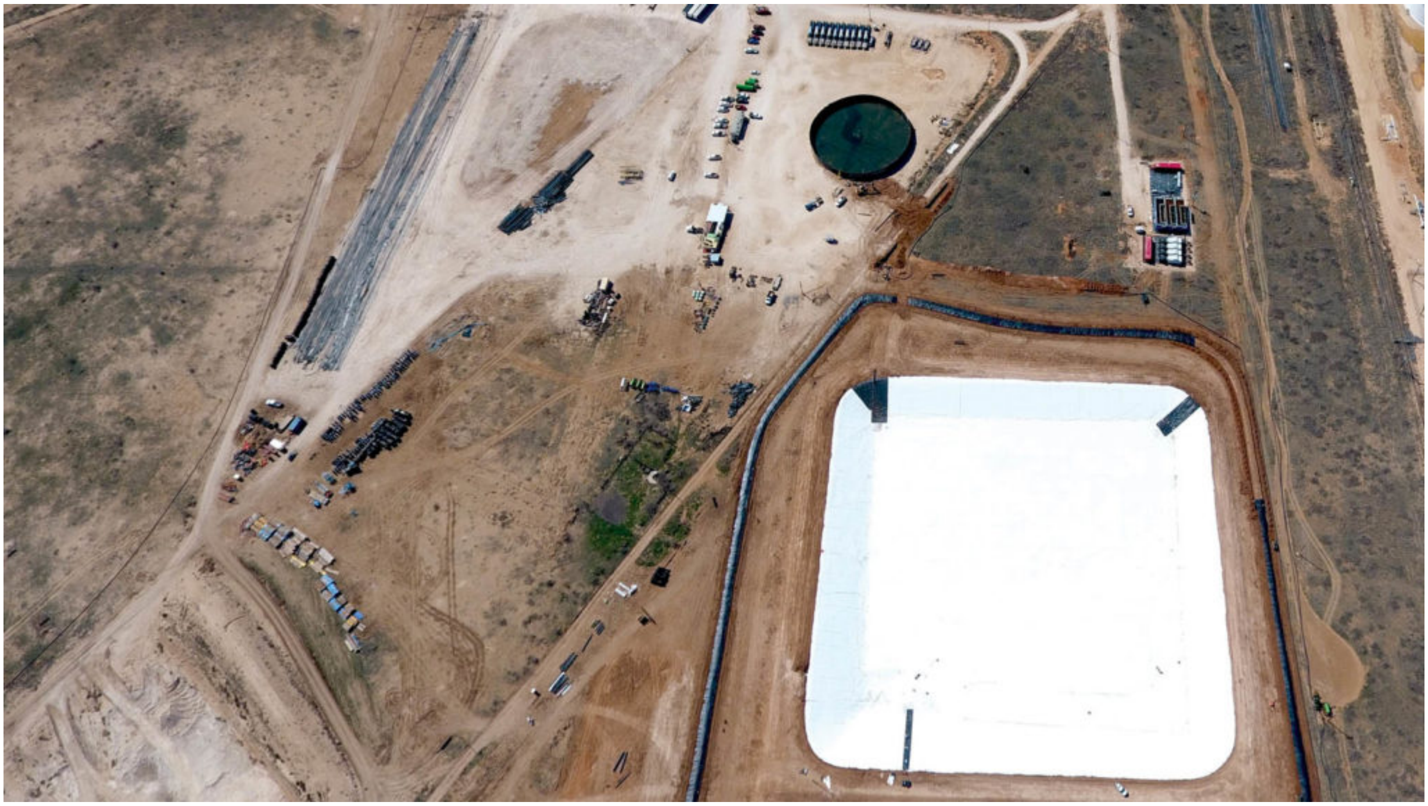


FIGURE 3 XRI Buchanan recycled water pond with white liner

Conclusions

The use of HDPE as the primary liner in the ponds appears to be enhancing the evaporation of the water. At Danish Flats, the estimate of 50 inches (127 cm) of evaporation per year was far exceeded, given the 33 inches (83.8 cm) of evaporation experienced in only July and August 2008; it totaled 70 inches (177.8 cm) for 2008. In years 2009 and 2010, the evaporation rate was more than 60 inches (152.4 cm). In 2012, the evaporation rate was 42 inches (106.7 cm) from May through August. The "weep" system was an enhancement to increase evaporation, which was not quantitatively measurable, but may have been a factor in the total evaporation. The deeper ponds at Danish Flats experienced approximately a 30% lower evaporation rate due to cooler water at depth. Similarly, the evaporation experienced at the Bluegrass Water project was also more than the pan evaporation estimate based on ponds without the HDPE liner effects, including the increase in evaporation from the estimate of 45 inches (114.3 cm) per year to nearly 55 inches (139.7 cm).

The evaporation rates at Bluegrass Water have been enhanced with the use of sprayers that assisted with the evaporation.

The durability and resistance to UV degradation due to the proper amount of carbon black in the geomembrane and other factors as discussed are the major reasons for the use of the HDPE geomembrane liner as the top layer. The increased evaporation rates due to the black color of the HDPE has been a great benefit and, in combination with the "weep" system, has realized an increase with the total evaporation at each facility.

The white liner at XRI Buchanan was used to reduce evaporation relative to the black liner. The surface temperature of the white liner as compared to a black liner can be 104˚F (40˚C) cooler (Solmax 2020) due to reflecting the sunlight, thus reducing the ability of the water to heat and, hence, reducing the water evaporation. The quantitative reduction in the amount of evaporation is not known.

Some of the liners were installed during the summer months, and, due to the expansion and contraction of the liner with ambient air temperature gradients, the anchor trenches were only filled during the coolest part of the day to reduce bridging.

An existing study was conducted on an HDPE liner installed at a site in Colorado after 20 years of service where the liner was not buried and exposed to weathering, UV light and cooling tower blowdown water. The material was tested for various properties and was found to have no significant reduction in the primary physical properties of the HDPE (Ivy 2002).

Acknowledgments

Thank you to Bluegrass Water and XRI Buchanan, as well as to Mustang Extreme and Raven/Colorado Lining Inc., which provided installation expertise and constructed the HDPE liners at the ponds in-field. All are performing exceptionally well and without leaks due to construction.

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All figures courtesy of the author.

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