# GCLs CONTROL SEEPAGE IN EARTHEN CANALS

The Ochoco Irrigation District in Prineville, Oregon installed approximately 50,000 $ft^2$ of geosynthetic clay liner (GCL) in an irrigation canal as part of its Canal Lining Demonstration project in 1999. Roughly 1,245 linear feet of canal was lined using a GCL to reduce seepage into downgradient property and also into an adjacent basement of a single family dwelling.

The US Bureau of Reclamation also wished to investigate the long term hydraulic performance and durability of the GCL. To accomplish this, four distinct test sections of the canal were lined with the GCL installed in differing configurations to evaluate performance. Section 1 contained Bentomat® DN which was left uncovered. Section 2 was installed with an enhanced GCL also left uncovered. Section 3 was constructed with Bentomat DN and covered with 6 inches of soil. Finally section 4 was installed with the enhanced GCL and covered with 6 inches of soil.

Results of the project have been very favorable based on observations of the adjacent property drying up and also no leakage into the downgradient basement.

In another project, Bentomat CL, a needlepunched GCL laminated with a geomembrane, was installed into a portion of the Westside Main Canal in Brawley, California in 1999. Over 180,000 $ft^2$ of GCL was installed within 3 days on this project.

Water levels in downgradient piezometers decreased significantly when after the GCL was installed. The Imperial Irrigation District (IID), estimates that at least 53,000 gallons of water are being conserved each day as a result of installing the GCL in this canal lining project.

With their ease of installation, cost effectiveness, hydraulic performance and resilience to many physical and climatic issues, GCLs will continue to be specified for canal lining projects in the an effort to conserve valuable water in the arid west.



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# GCLs Control Seepage in Earthen Canals

*by Brad Miller and Jim Olsta*

**Introduction**

A geosynthetic clay liner (GCL) is a manufactured hydraulic barrier consisting of high-swelling sodium bentonite clay bonded to geotextiles or geomembranes. GCLs have been manufactured since the early-1980's, initially used in ponds and tank farms. The structure of interlayer sodium cations makes sodium bentonite hydrophilic (water attracting). The sodium cation clay structure swells as it attracts water molecules so that little free-water space is available in the clay voids, hence, maximum water permeabilities of 5 x 10-9 cm/sec are readily obtained using GCLs.

There are unreinforced and reinforced GCLs available for use. Unreinforced products are manufactured using either adhesives and/or pressure. These products incorporate the use of a geotextile or flexible geomembrane to carry the bentonite layer. The unreinforced GCL is used on slopes gentler than 10:1, such as on the flat areas of canals, reservoirs, lagoons, and landfills. Reinforced GCLs are manufactured by needlepunching the top and bottom geotextiles together to encapsulate the sodium bentonite layer. Physical bonding of the geotextiles enhances the GCLs internal resistance to shearing and creep. Reinforced GCLs can be used in many applications that have sideslopes steeper than 10:1.

**Construction Issues**

GCL is typically manufactured in rolls 13.8 to 15.5 feet (4.2 to 4.7 meters) wide and 150 feet (45.7 meters) long, and weigh upwards of 2,800 pounds (1,200 kilograms), so applicable offloading and installing equipment should be used that can withstand the heavy roll loads. Panels are overlapped typically 6 to 12 inches (150 to 300 mm), depending upon the application. If the GCL is not self-seaming (i.e., needlepunched products), then a thin layer of granular sodium bentonite is applied in the overlap seam at a typical rate of 0.25 pounds (375 grams) per lineal foot of seam. Self-seaming GCLs do not require additional sodium bentonite.

GCLs are traditionally covered with a minimum of 12 inches (300 mm) of soil to protect the liner and provide confinement to the sodium bentonite layer. The 12-inch minimum soil cover is deployed onto the GCL in a single lift using standard earthwork equipment. An ongoing research project is being done to evaluate whether less cover can be allowed in canals where leakage rate requirements aren't as stringent as other applications (e.g., ponds and landfills)..

**CASE STUDIES**

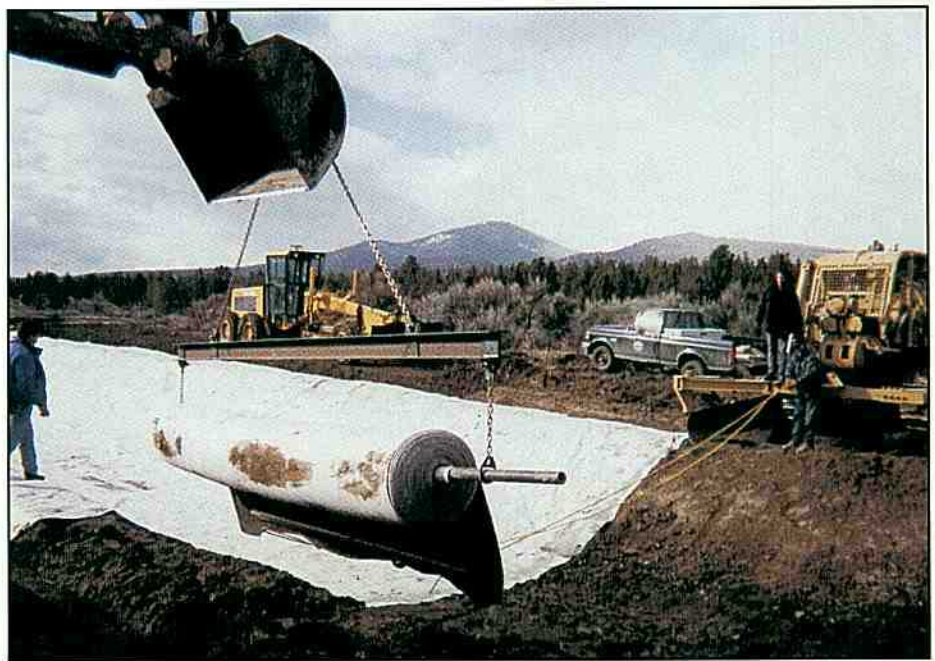
The following are two recent projects where GCLs were utilized in controlling seepage through earthen canals.

**Ochoco Irrigation District Canal Lining**

The Ochoco Irrigation District installed approximately 50,000 square feet of GCL in one of its canals in Prineville, Oregon in March of 1999. The project was partially funded by the U.S. Bureau of Reclamation (USBR) as part of its Canal Lining Demonstration Project (Swihart and Haynes, 1999).

Approximately 1,245 linear feet of canal was lined using GCL in an effort to reduce canal seepage into downgradient property, including seepage into a basement of an adjacent single family dwelling. The second objective of the project was to provide the USBR with an opportunity to investigate the long term durability and hydraulic performance of the GCL.

**Approximately 1,245 linear feet of canal was lined using GCL in an effort to reduce canal seepage into downgradient property, including seepage into a basement of an adjacent single family dwelling.**



**A second machine was utilized - a front end loader with a winch system to pull the material up into the opposite canal berm and anchor trench.**

Construction involved placing different GCLs in four distinct test sections along the canal. Section 1 contained Bentomat DN® that was left uncovered, and Section 3 was covered with 6 inches of soil. Section 2 contained an enhanced version of the GCL left uncovered, and Section 4 was covered with 6 inches of soil. The polymembrane laminate was placed on the subgrade. The rationale between the four test sections was so the USBR could investigate the long term durability and hydraulic performance of the two materials in a covered and uncovered state.

The Ochoco Irrigation District installed the GCL using a tracked excavator with a spreader bar attached to the excavator bucket. The material was initially deployed from one edge of the canal berm using manual labor (3-4 persons) to pull the roll across to the opposite side. Midway through the project it was decided to utilize a second machine - a front end loader with a winch system to pull the material up into the opposite canal berm and anchor trench. The district was able to deploy the 50,000 sf of GCL in two 10-hour shifts (Swihart and Haynes, 1999).

The canal was located in an area containing fractured basalt. Initially, #3 rebar, bent into angles, was used to pin the GCL in the uncovered sections. The rebar was difficult to hammer into the subgrade. Midway through, they switched to 3/8-inch thick nails with washers that proved much easier to hammer in place.

The estimated construction cost for the project ranged from $0.76 per square foot (sf) for the uncovered sections to $0.87 per sf for the covered sections.

The results of the lining project have been favorable based on the observations of the USBR and District personnel. They have observed no more leakage into the downgradient basement, and the adjacent property has also begun to dry up as the canal seepage has been reduced. The canal was drained in November of 1999, and noticeable sedimentation has been observed in the uncovered section.

**Imperial Irrigation District Westside Main Canal Lining**

The Imperial Irrigation District (IID) lined a portion of its Westside Main Canal in February of 1999 using the enhanced Bentomat CL® product. The Westside Main is located in Brawley, California and is one of three main lateral canals that moves water from the All American Canal into the vast and rich agricultural lands of the Imperial Valley in Southern California.

The canal was emergency lined because the IID detected water seepage less than 100 meters downgradient of the canal at the base of a bluff overlooking the New River floodplain. The IID considered concrete lining the canal, however, it would have taken at least two weeks to complete. They determined that the canal could be taken offline only five days if lined with GCL. This downtime was acceptable for the downstream users of the water.

Construction began on February 22, 1999 with the IID using all available excavators to "muck out" the bottom and sides of the canal so the GCL could be placed on an acceptable subgrade. Preparations for the liner took two days, and lining began February 24, 1999 (Giller, 1999). Over 180,000 sf of GCL was deployed within 3 days with a split shift of crews working from early morning to midnight. The GCL was deployed from a front end loader equipped with a stinger pole. The GCL panels were carried down through the first canal slope using at least four laborers and pulled up the other sideslope using the end of the excavator bucket. The GCL was covered with a minimum of 12 inches of equipment compacted soil/sludge. IID estimated the total construction cost to be less than $200,000 (Giller, 1999).

One challenge encountered during the installation was the wet, uneven, and yielding subgrade prepared for the GCL. The GCL panels were overlapped a minimum of 18 inches to account for the yielding subgrade.

The installation of the GCL has been a success for the IID as it has eliminated the seepage in the toe of the bluff. IID has also measured reduced water levels in piezometers located downgradient of the canal berm. Table 1 (above) summarizes the decreased water levels in the three piezometers after 50 days of GCL installation.

| PIEZOMETER | DISTANCE FROM CANAL (ft) | WATER LEVEL DECREASE (ft) |
|---|---|---|
| Well B-1 | 20 | 3.5 |
| Well B-2 | 50 | 6.5 |
| Well B-3 | 100 | 9.0 |

**The canal was drained in November of 1999 and noticeable sedimentation has been observed in the uncovered section.**

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IID estimates they are conserving at least 60 acre-feet of water each year (e.g. 53,000 gallons each day) by using the GCL. This amount is a small step towards helping IID to comply with the California 4.4 Plan, an agreement between California and the Department of the Interior that limits California to its annual entitlement of 4.4 million acre-feet of Colorado River water.

**Final Comments**

The previously summarized case studies indicate that GCLs can be successfully utilized to control seepage in canals. The GCLs are relatively easy to install, cost effective, minimize canal seepage, and are resistant to many physical and climatic issues that may effect the performance of compacted soil or clay liners.

The use of GCLs for lining canals should continue to increase as more political, economic, and regulatory demands will drive water conservation in the arid west. **L&W**

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