Remediation of a former quarry and permanent containment of buried toxic materials

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ABSTRACT

The site of the former Landreville quarry, owned by Les Carrières Rive-Sud Inc. (CRS), was used for stone extraction, and crushing operations until 1992 and was the scene of illegal dumping of toxic waste. A remediation plan for the quarry was approved by the Ministry of the Environment of Quebec in 2015, and work began in the spring of 2018. The remediation work consists of containing the toxic materials buried in a portion of the quarry and backfilling a part of the flooded area of the CRS site to secure the wall of the former dump. This required approximately 2.5 million cubic meters (3,300,000 yd^3) of clean soil and coarse materials (concrete, brick, and rock) to be imported to the site. The final cover system includes a geomembrane, a drainage geocomposite for rainwater drainage and mechanical protection, and a drainage geocomposite for gas collection. The CRS site remediation plan also includes gas treatment and groundwater quality monitoring. This paper presents the various technical requirements for the site remediation and explains how the different geosynthetics selected and implemented were able to meet the project expectations.

PROJECT BACKGROUND

The rehabilitation project of the former Landreville quarry is part of a process initiated in 2004 to definitively solve the problem that the current site represents for the health and safety of the public as well as for the environment. The project is located in Boucherville, QC, Canada (Figure 1).

Figure 1. Project location (source: Plan de réhabilitation, Juillet 2012)

The objectives of the project are as follows:

- Secure the site for the purpose of protecting public health and safety.
- Establish a mechanism to control emissions that degrade the environmental conditions of the surrounding area.
- Substantial reduction of meteoric water infiltration on the top of the old dump.
- Containment and capture of biogas to prevent its migration out of the former quarry.
- If required, the capture and treatment of groundwater contaminated by the former landfill.

The materials present at the decommissioned disposal site consist of a matrix of fill (clayey silt and clay) and residual materials (demolition materials, foundry residues and other debris). Lenses of decomposing putrescible material have been observed. The height of the material can reach 20 m (66 ft). The following mitigation measures are in place to meet the project objectives:

- Backfilling and reprofiling of the former landfill waste with a 16 m (52 ft) maximum thick layer of low contaminated material.
- Installation of a liner/drainage system over the landfill area to capture and discharge biogas produced under this new liner and to limit water infiltration from the surface.
- Installation of a biogas collection trench around the perimeter of the landfill.
- Installation of a groundwater pumping well in the area of the landfill and treatment of the pumped water before discharge (if required).
- Construction of a mound on top of the geosynthetic cover to a maximum height of 25 m (82 ft).

The mount to be built on top of the final cover is part of a large landscape project that will convert the site into a public municipal park. It will be built gradually for 7 years. It will occupy the entire area of the former quarry, including the dump area. Its maximum projected elevation is 54 m (177 ft) for a total volume of approximately 2,200,000 m^3 (2,877,000 yd^3). The soil imported to the site contains low levels of contamination. The disposal of this soil allows the project to be financed as the generators of the imported soil pay to disposal fees to the regulated site. The installation of the geosynthetic cover at the early stages allowed the implementation of mitigation measures for the biogas generated by the site to be accelerated.

The surface area of the geosynthetic liner/drainage cover is 85,000 m2 (915,000 sf). The mount involves loads of soil deposited on the geosynthetics that are much higher than most final geosynthetic covers. A typical facility has up to 1m (3ft) of soil. This increased height has impacted the design and the choice of the geosynthetics material used.

FINAL COVER REQUIEREMENTS

The final cover of the site was designed to limit the entry of surface water into the waste. This prevents additional water from leaching into the waste and allows for collection of biogas produced by the waste. These factors will prevent any risk to the health of the public since the site will be rehabilitated into a public municipal park, including a 45,000 m^3 (59,000 yd^3) lake filled with underground and runoff water.

The design of the final cover of the site had to meet several technical constraints to ensure its long-term watertightness and to meet the expectation of a renowned municipal park. These include:

- Final soil covers sustainable for mature vegetation and recreational activity.
- A northern slope length up to 160 m (525 ft) facing the lake with 3 separated steps to enjoy the scenery (Montreal's skyline from south shore).
- Water quality in the lake sustainable for aquatic activity, excluding swimming.
- Strong measures to prevent growth of invasive species on the newly rehabilitated site.

Figure 2 shows a plan view of the cover prior to the installation of the liner/drainage system. The dome has slopes of 5 to 10% and the sides have slopes of 33 and 66%. The stability of the cover on the 66% slopes is not a long-term concern because this area has been designed as a 2 m (6-1/2 ft) deep perimeter drainage trench that will be completely filled.

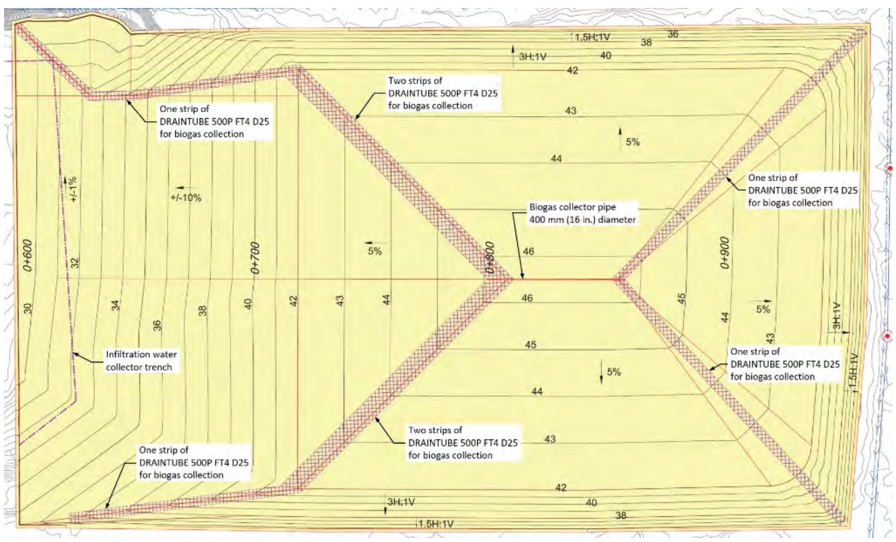

Figure 2. Plan view of the cover prior to the installation of the liner/drainage system (source: Demande de modification de l'approbation du plan de réhabilitation, 2020)

Figure 3 shows a cross section of the southern part of the final cover. The final elevation of the site at the end of the project can be seen.

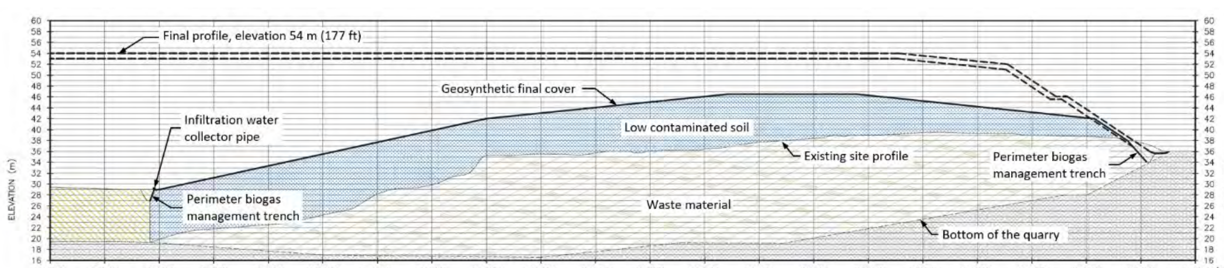

Figure 3. Cross section of the final cover (source: Demande de modification de l'approbation du plan de réhabilitation, 2020)

The typical cross-section designed for the final geosynthetic cover is shown in Figure 4 and is comprised from bottom to top with:

- A multi-linear drainage geocomposite for biogas collection.
- An LDPE waterproofing geomembrane that is 1.5 mm thick.
- A multi-linear drainage geocomposite for rainwater collection and protection of the geomembrane.

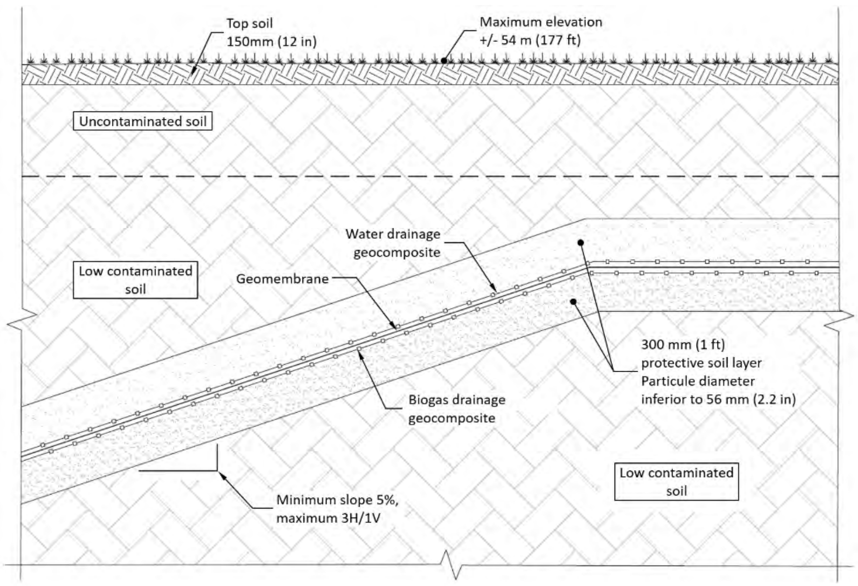

Figure 4. Detail of the final cover composition (source: Demande de modification de l'approbation du plan de réhabilitation, 2020)

GAS COLLECTION

The biogas generation rate was estimated to be 0.0086 $m^3/hr/m^2$ ($4.70x10^{-4}$ $scfm/ft^2$) using the model developed by the EPA. It was determined using a conservative approach, assuming that all of the stored material is putrescible, and that degradation of the waste began in 1979 (more than 10 years after placement). This low rate does not require an active biogas capture system.

The geocomposite for the gas collection is a multi-linear drainage geocomposite (as defined by ASTM D4439) Draintube type. It is composed of two needle-punched non-woven geotextile layers incorporating corrugated and perforated polypropylene mini-pipes of 25 mm (1 in) diameter. The mini-pipes are spaced 2 m (80 in) apart across the width of the product.

The product is connected at the end to a solid header pipe using mechanical connectors. This system allows each mini-pipe of the geocomposite to be connected directly to the main header, thus reducing pressure losses. The depression (negative pressure) in the geocomposite under the geomembrane and thus the collection of gas is optimized. The collection of the biogas is based on a passive system but has been designed and implemented to be connected to an active vacuum system in the event that the biogas migrates off-site after construction.

Figure 5 shows a typical cross section of the geocomposite/collector connection. This mechanical connection also limits the risk of movement of the geocomposite in relation to the collector, should settlement occur during the final refilling of the cover.

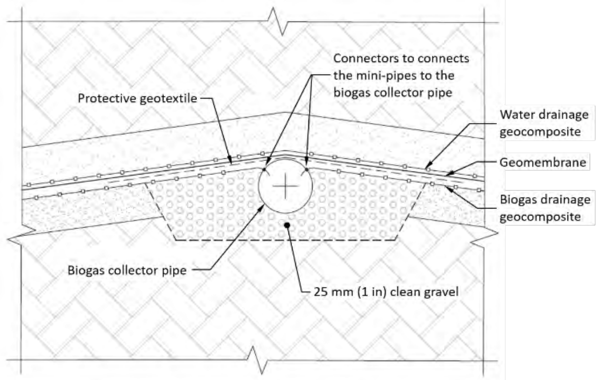

Figure 5. Connection detail of the multi-linear drainage geocomposite to the header pipe (source: Demande de modification de l'approbation du plan de réhabilitation, 2020)

The drainage geocomposite collects the biogas from the entire cover and drains it to the header pipe with a stable drainage capacity, even under high loads (after the construction of the mound on the geosynthetics cover). Indeed, whatever the hydraulic gradient, the geocomposite shows a stable transmissivity under loads up to 2,400 kPa (50,000 psf), when confined between a geomembrane and a sand layer.

In addition, the creep resistance of the geocomposite was also tested to ensure that, even under high load, the product will not exhibit a loss of drainage capacity over time. Figure 6 shows the transmissivity of the product measured for loads between 24 kPa (500 psf) and 2,400 kPa (50,000 psf) with several gradients, and presents the variation with time of the transmissivity of the geocomposite under 2,400 kPa (50,000 psf) for 1,000 hours.

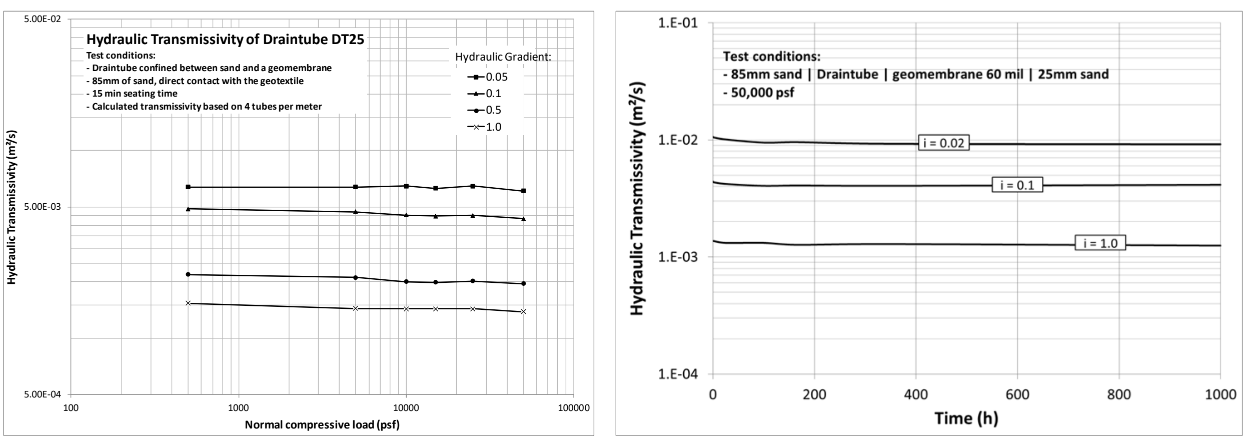

Figure 6. Hydraulic transmissivity of the multi-linear drainage geocomposite for several loads, and over of the time

The results presented above confirm that when confined, normal load does not have any significant effect on the transmissivity of the multi-linear geocomposite up to 2,400 kPa (50,000 psf). It also did not experience any change in transmissivity over the 1,000 hours under that load.

This resistance to creep in compression is specific to this multi-linear geocomposite. It is documented by Saunier et al. (2010) and in the ASTM D7931 Standard Guide for specifying drainage geocomposites.

WATERPROOFING

The waterproofing geomembrane installed over the gas drainage geocomposite is a textured low-density polyethylene (LDPE) geomembrane with a minimum thickness of 1.5 mm (60 mils) in compliance with GRI GM17.

The geomembrane has two main functions. It helps to limit water getting into the contaminated soils of the landfill (limiting the risk of waste leaching) and also prevents gas from diffusing into the topsoil, allowing for efficient collection by the multi-linear drainage geocomposite.

Substantial differential settlements are not anticipated in the geosynthetics, given the age of the waste. In addition, the large layer of uncontaminated soil on the old waste before the geosynthetics are installed limits the phenomenon of localized settlement that could have significantly stressed the geomembrane during reloading. Moreover, the LDPE geomembrane has a better behavior towards potential deformations than a HDPE membrane.

RAINFALL WATER DRAINAGE

The main functions of the drainage layer placed directly on the geomembrane are to drain the infiltrated rainwater and to mechanically protect the geomembrane against puncture by the upper soil layers.

The purpose of the drainage of infiltrated rainwater is to reduce the hydraulic head on the geomembrane and to stabilize the upper soil layer by preventing it from becoming saturated. The performance of the filtration and drainage system must be maintained over the long-term and under heavy loads, since the overlying soil will be up to 25 m (82 ft) thick in some places, which equates to a stress of 450 kPa (9,400 psf).

The rainwater drainage geocomposite is a multi-linear drainage geocomposite Draintube type. It is composed of two needle-punched non-woven geotextile layers incorporating 25 mm (1 in) diameter corrugated and perforated polypropylene mini-pipes. The mini-pipes are spaced 1 m (40 in) apart across the width of the product. The product is preferably installed with the mini-pipes in the direction of the slope. It is connected at the toe to a collection trench (Figure 7).

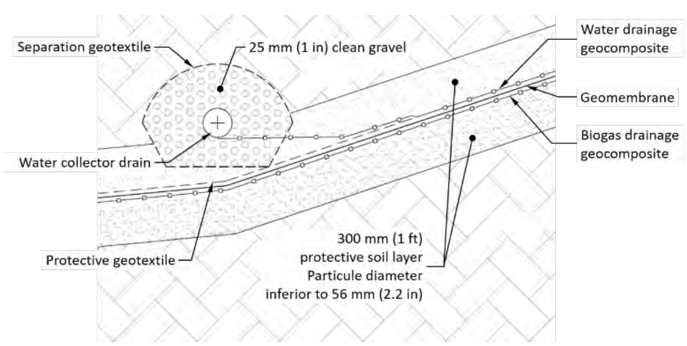

Figure 7. Connection detail of the drainage geocomposite to the collector trench (source: Demande de modification de l'approbation du plan de réhabilitation, 2020)

As explained in the previous paragraph, the multi-linear geocomposite is not sensitive to creep in compression when confined, which allows it to maintain its hydraulic characteristics under high loads. It has a transmissivity of $1x10^{-3}$ m^2/s, measured at a hydraulic gradient of 0.1, confined under 480 kPa (10,000 psf) between a geomembrane and a layer of sand, for 100 hours. The geocomposite was sized to drain a flow of $1x10^{-6}$ m/s ($1.45x10^{-3}$ gpm/ft^2).

The multi-linear geocomposite also protects the geomembrane against puncture by the overlying soil. Its CBR puncture strength is greater than 3,200 N (719 lb). The backfill in contact is a 300 mm (1 ft) layer of granular soil with particle diameters less than 56 mm (2.2 in).

CONSTRUCTION WORK

The installation of the geosynthetics was optimized and adapted in order to meet the constraints related to the earthwork and the treatment of specific points, in particular the decontamination of areas identified during the reprofiling of the cover, prior to the installation work as shown in Figure 8.

Figure 8. Soil surface conditions before the installation of the geosynthetics

Figure 9 shows the unrolling of the multi-linear geocomposite for gas collection. Once in place, it is longitudinally welded continuously with the hot wedge welder (the same one used to weld the geomembrane) to avoid any displacement during the installation of the geomembrane above it. Sand bags are also used at the edge of the rolls.

Figure 9. Installation of the multi-linear geocomposite for gas collection

The mechanical connection of the mini-pipes of the geocomposite to the main header is shown in Figure 10. The upper geotextile of the multi-linear geocomposite is then put back in place to protect the connections.

Figure 10. Mechanical connection of the geocomposite mini-pipes to the main header

The geomembrane is unrolled on the drainage geocomposite and welded using the double-welding method (Figure 11).

Figure 11. Installation of the geomembrane on the geocomposite

The drainage geocomposite for infiltrated rainwater removal is installed on the geomembrane (figure 12). It is also longitudinally welded continuously with the hot wedge welder to avoid any displacement during the backfilling process.

Figure 12. Infiltrated rainwater drainage geocomposite

It is backfilled as the work progresses, with the tracked construction equipment travelling on a thick layer of soil to prevent any damage to the geosynthetics (Figure 13).

Figure 13. Backfilling

Finally, a general view of the site during construction of the geosynthetic final cover is shown in Figure 14.

Figure 14. General view of the final cover construction

CONCLUSION

The construction of an impermeable final cover on the toxic waste is an essential part of the overall remediation project of the former quarry that will ultimately become a renowned municipal public park. The impermeable final cover that includes drainage layers for rainwater and gas collection prevents the rainwater to infiltrate the toxic material and the gas from dissipating on the site.

The use of geosynthetics materials has reduced the need for importing granular drainage media from outside of the site. More specifically the use of multi-linear drainage geocomposites maintained the required drainage capacity for gas collection and water drainage after the final cover was buried under a maximum of 26 m (85 ft) of soil material and increased the weathertight performance of the cover by protecting the geomembrane from mechanical puncture and controlling the hydraulic heads (water and gas) on its overall surface.

The large amount of earthwork on the site in conjunction with the construction of the final cover over an area of 85,000 m^2 (915,000 sf) required strong cooperation between the different stakeholders (general contractors, geosynthetics installers, engineering firms, etc.) which has been the case during the overall direction of the project.

REFERENCES

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