DEVELOPMENT OF THE NYAMASOGA HAZARDOUS WASTE LANDFILL, UGANDA

S. C. A. Louw. Jones & Wagener (Pty) Ltd, Johannesburg, South Africa. silke@jaws.co.za
J. R. Shamrock. Jones & Wagener (Pty) Ltd, Johannesburg, South Africa. shamrock@jaws.co.za

ABSTRACT
EnviroServ Uganda (ESU) has established a hazardous waste landfill on a 44 hectare plot of land of land located in the Nyamasoga village in Hoima district, Uganda. The site was strategically chosen to be close to the exploratory oil drilling blocks on Lake Albert and to be in close proximity to a future proposed oil refinery site. The expected waste stream will initially be stabilised drilling mud cuttings, drilling fluids and other stabilised hazardous waste. The site may in the future receive other industrial waste and waste from the proposed oil refinery. Jones & Wagener (J&W) were appointed to conduct the conceptual design of the landfill site and thereafter the detailed design of the landfill, site office area with weighbridge, access roads, leachate collection and storage system, contaminated stormwater dam and other associated stormwater management systems.

As there was no local legislation regarding the standards for disposal of hazardous waste to landfills in Uganda the barrier system was specified according to the latest South Africa regulations. In terms of the National Norms and Standards for Disposal of Waste to Landfill (Notice 636 of 2013) the waste classified as a Type 1 hazardous waste which may only be disposed of at a Class A landfill designed in accordance with section 3(1) and (2) of these Norms and Standards.

Issues experienced with the construction of a multi composite barrier in Uganda will be discussed, from availability of materials required for landfill construction, importation of materials, geosynthetic alternatives to standard design elements of the barrier system, interface with the contractor and geosynthetic installer and on site design changes required to simplify construction and ensure the site was delivered on time.

The construction was successfully completed and the site officially inaugurated on the 23rd April 2015.

1. BACKGROUND

EnviroServ Uganda (ESU) has established a hazardous waste landfill on a 44 hectare plot of land of land located in the Nyamasoga village in Hoima district, Uganda. The site, which was officially inaugurated on the 23rd of April 2015, was strategically chosen to be close to the exploratory oil drilling blocks on Lake Albert and to be in close proximity to a future proposed oil refinery site. The expected waste stream will initially be stabilised drilling mud cuttings, drilling fluids and other stabilised hazardous waste. The site may in the future receive other industrial waste and waste from the proposed oil refinery.

2. AIMS & OBJECTIVES

Jones & Wagener (J&W) were appointed to conduct the conceptual design of the landfill site and thereafter the detailed design of the landfill site, office area with weighbridge, access roads, leachate collection and storage system, contaminated stormwater dam and other associated stormwater management systems. It was requested by ESU that the landfill have a modular cell development plan to cater for clients who required designated cells for their wastes.

3. PROJECT DESCRIPTION

3.1 Geology

The geology of the area is of the Cambrian age and consists of the Basement Complex system rocks. The rocks are described as granites and gneisses including amphibolites and quartzites. In most areas the hard rock is overlain by an overburden with a relative clayey consistency, related to the natural residue of gneisses. Often hard, lateritic clay is found near surface.

Field tests in the form of seven boreholes and eight test pits were located across the site. The dominant soil at the proposed landfill site is sandy clays occasionally with some gravel. These sandy clays are underlain by deep formation of highly to completely weathered granite gneiss producing dense sandy formation. The weathered rock is encountered at depths varying from 2.5 m to 4.5 m hence, the maximum depth of the cells and contaminated stormwater dam was set at 5m to limit hard rock excavation and possible perched groundwater interception.

3.2 Site Layout

Upon receiving the survey of the acquired land, the location of the facilities across the site had to be planned. Due to the presence of steep topography in the form of a small hill in the eastern corner of the property, it rendered this area as unsuitable for any development use. Entrance onto the site is dictated by the Hoima-Kaiso-Tonya highway which is located along the southern border of the property therefore the site office was placed in the south close to the entrance. The site office is located in the side of small hill with the terrace platform designed such that the volume of cut to fill balances.

It is ideal that all contaminated water flows under gravity to an area where it can be collected thus the contaminated stormwater dam was located in the lowest area on site which is in the north. The landfill was placed in the northern portion of the site in a C-formation around the contaminated stormwater dam. This location was ideal as the natural fall of the ground was very close to the minimum slope required at the base of cells of 1 in 20 or 5 % and the drainage distance of the contaminated water was kept to a minimum. The size of the landfill was restricted on the south east and south west edges by the steepness and direction in which the natural ground slopes respectively. Roads were designed along the entire perimeter of the landfill to enable access to all working areas on site and there is an access road joining the landfill to the site office and the entrance. Due to the presence of a water shed in the south, no infrastructure could be planned in this area as it drains to a different catchment. The general site layout is illustrated in Figure 1.

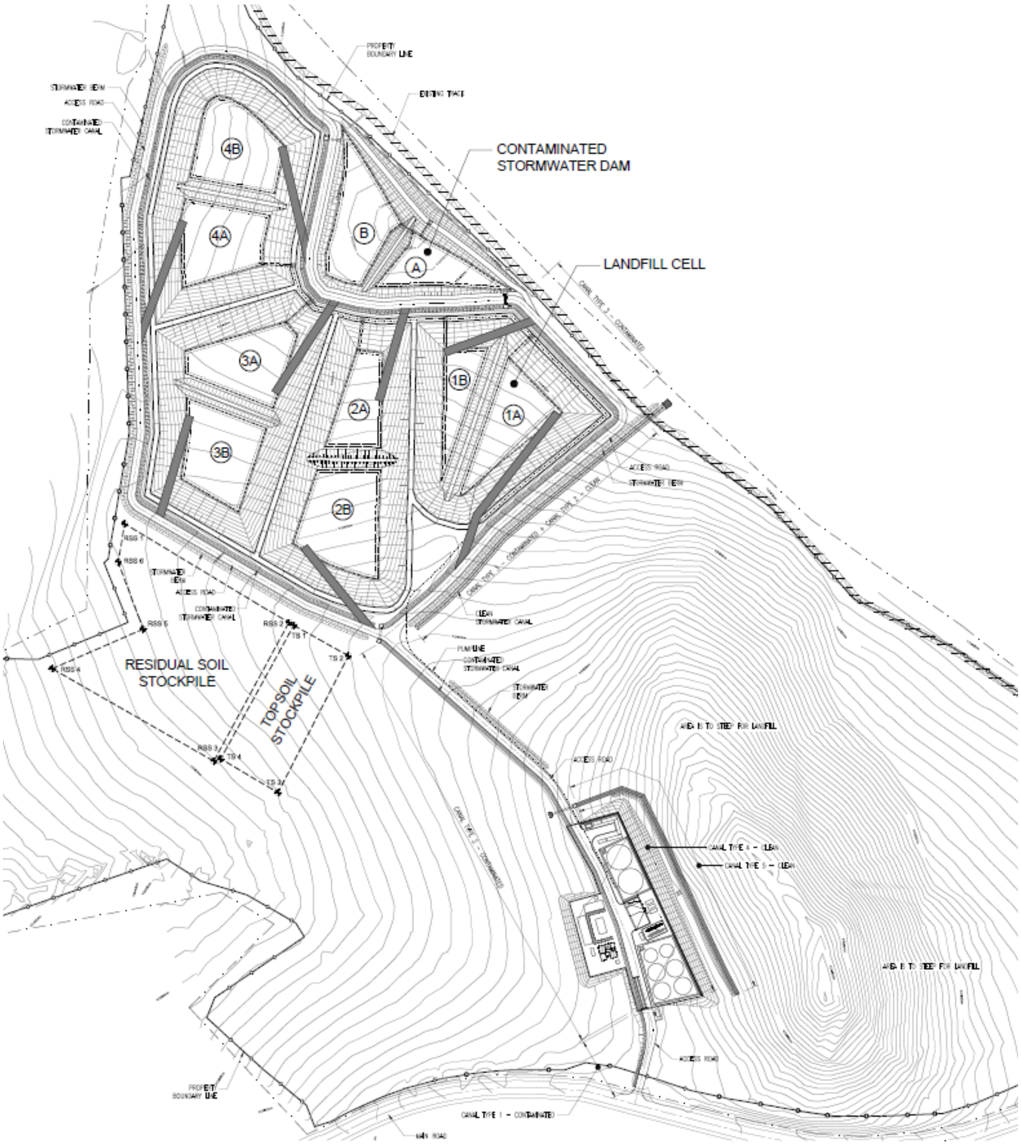

Figure 1. Site layout.

The landfill was designed to comprise four cells. As mentioned above, it was requested that the cells have a modular layout and consequently each cell was further split into two. Filling of the landfill will occur in phases commencing with Cell 1A and move progressively northward towards Cell 4B.

3.3 Geometry

All cells are surrounded by a berm to aid in stormwater separation and slope stability. The berm on the downstream side has been constructed higher than the rest of the cell in order to improve the waste body stability. The crests of the berms are all 4m wide to allow space for geomembrane anchor trenches and the external sideslopes are to be constructed at a gradient of 1 (vertical) to 2 (horizontal). The internal sideslopes of the cells have been designed as 1 (vertical) to 3 (horizontal) as this is the maximum slope at which conventional layerworks can be placed on sideslopes and it is the expected limit of interface friction for the liner package. The basin has been designed to have a minimum cross fall of 5 % to ensure that all liquids drain effectively to the low point in the cell from where it can be removed. Each cell is split approximately in half by a separation berm which has a height of 3 m (measured from the bottom of the cell basin) and crest width of 2.5 m wide. Sumps for the collection of the subsoil water, as well as for the leakage detection and leachate collection systems are provided. Liquids collected in these sumps is then pumped up into storage tanks where they are treated in the Leachate Treatment Plant (LTP) as illustrated in Figure 2.

The LTP has been designed to treat both the contaminated runoff from the landfill and the leachate generated in the cells. The process consists of the following steps:

- pH correction;
- Pre filter;
- Ultra filtration (UF);
- Reverse osmosis (RO).

The permeate from the RO process is stabilised along with the other incoming wastes and disposed of in the landfill.

Figure 2. Bunded tank area on the site office platform.

3.4 Barrier System

No legislation was found regarding the disposal of hazardous water to landfills in Uganda and thus the barrier system has been specified according to the latest South Africa regulations. Compliance to the standards of the oil companies involved also had to be demonstrated. In terms of the National Norms and Standards for Disposal of Waste to Landfill (Notice 636 of 2013) the waste was assumed to classify as a Type 1 hazardous waste which may only be disposed of at a Class A landfill designed in accordance with section 3(1) and (2) of these Norms and Standards. This lining standard is shown in Figure 3. The same liner package was used in the contaminated stormwater dam with the only difference the replacement of the leachate drainage layer with a ballast and protection layer. The ballast and protection layers ensure the long term durability of the contaminated stormwater dam barrier by removing exposure to UV and heat from the sun, removing exposure to mechanical damage by plant or fire, and ensuring a composite effect is maintained in the primary barrier by surcharging the liner to prevent it floating as HDPE is slightly less dense that water.

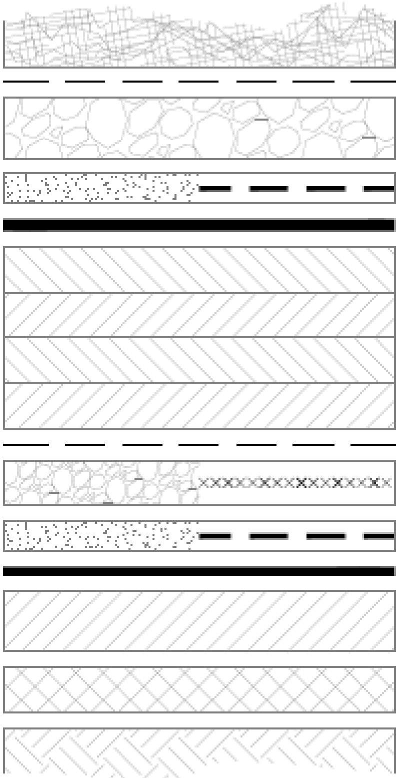

Figure 3. Class A Landfill Barrier (from the National Norms and Standards for Disposal of Waste to Landfill, Notice 636 of 2013).

The barrier system is referred to as a double composite liner system (a composite being a geomembrane and compacted clay liner in intimate contact); the primary composite liner is separated from the secondary composite liner by a leakage detection system. From the geotechnical investigation, the shallowest perched groundwater table level that was encountered in a borehole was at a depth of 5.2 m. The presence of subsoil water below the liner package when the cell basin is excavated could therefore be expected. Some seepage was encountered during excavation. As a result of this, a subsoil drainage layer was installed on the cell basin. Due to difficulty with sourcing natural filter materials a geocomposite drainage material was used for this layer. This was a general design theme in that geosynthetic alternatives were predominately used due to their availability and speed of deployment.

3.4.1 Compacted clay liner

Findings from the geotechnical investigation showed that the majority of the site is underlain by sandy clays and silty sand. Samples of the material on site were taken and tested to determine whether their permeability would comply with the required specification of 1×10^{-9} m/s. Results showed that the material did not meet the specification and would have to be enhanced with bentonite. Results from various tests of the sandy clay mixed with different concentrations of benonite lead to the conclusion that an addition of 6 % (by mass) bentonite is required to achieve the specified permeability. The proposed liner package is shown in Figure 4. The secondary composite was made up of a Geocomposite Clay Liner (GCL) in contact with a 1.5 mm double textured High Density Polyethylene (HDPE), the primary composite of four 150 mm thick Bentonite Enhanced Soil (BES) layers in intimate contact with a 2 mm monotextured HDPE. The texturing of the HDPE is to ensure overall barrier stability, the thicker primary composite liner to make the barrier package less vulnerable to mechanical damage. A geocomposite drainage layer was used between the primary and secondary composite liners. The bulk of the geosynthetics were supplied and installed by Gundle Geosynthetics who are a South Africa geosynthetic installation company.

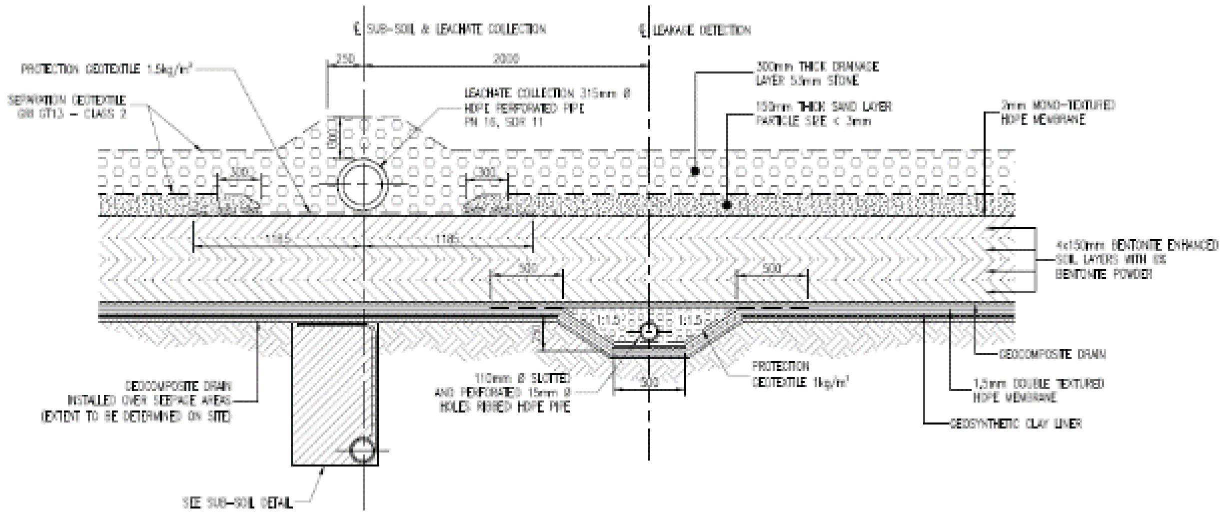

Figure 4. Proposed lining details.

Figure 5 to Figure 7 are some photos during construction of the key elements of the landfill while Figure 8 shows the installation of the ballast layer of the contaminated stormwater dam.

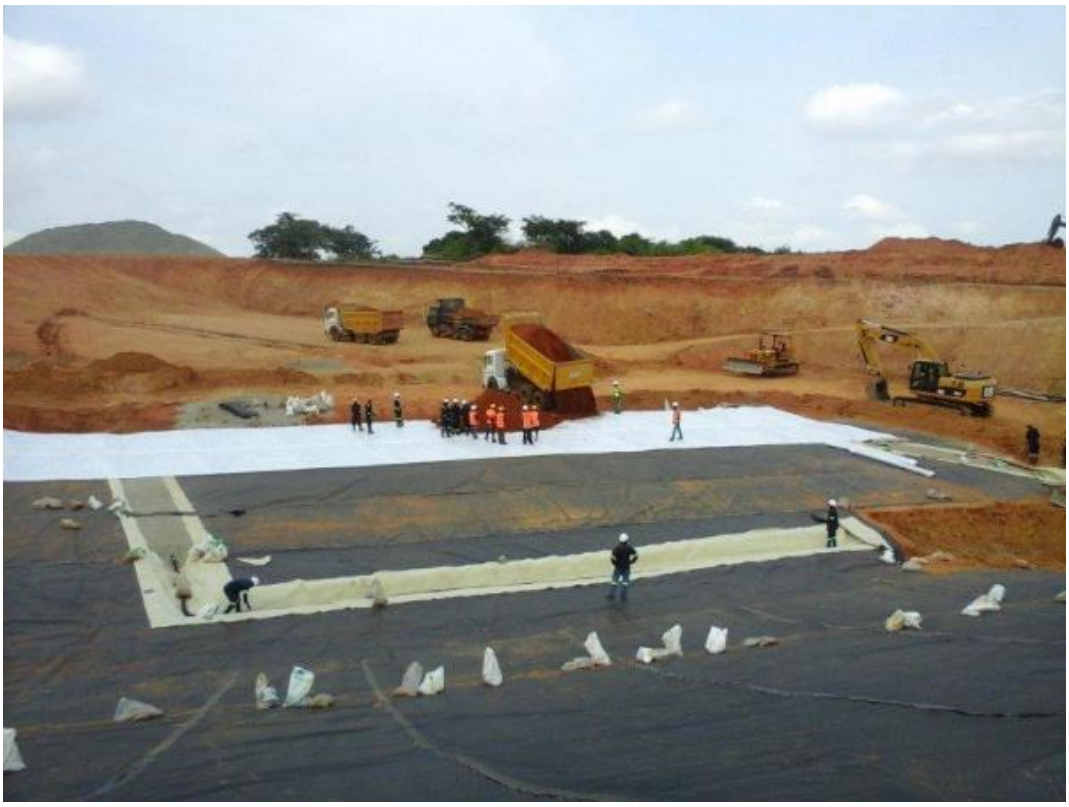

Figure 5. Construction of the secondary composite leachate detection system and placement of first soil layer of the primary composite.

Figure 6. Primary layer of Cell1Ai complete – top of 2 mm monotextured HDPE.

Figure 7. Installation of drainage (leachate collection) layer.

Figure 8. Contaminated stormwater dam.

4. PROBLEMS ENCOUNTERED & INNOVATIONS

Once earthworks commenced on site, sourcing of materials required for construction was a high priority. It was then discovered that besides the fact that bentonite would be particularly uneconomical for the quantities that were required, it could also not be sourced locally in bulk quantities. The design was thus changed to incorporate GCLs in the primary composite liner, but at the same time maintain the thickness of the primary composite. The advantage of a GCL in the primary liner would be an expected faster construction time due to less quality assurance required as opposed to the BES layer. In order for GCLs to be hydraulically equivalent to the BES liner, the flux through the liner should be equivalent. It was found that Naue's Bentofix NSP 4900 met the flux specification of the primary BES layer. Due to the unknown nature of expected and future waste streams that will be disposed of in the landfill, and their effect on the swelling potential of the bentonite in the GCL, ESU and J&W felt that a single GCL could not replace the four, 150 mm thick layers of BES. The decision was to continue with the construction of a 300 mm compacted soil layer onto which a GCL was placed, followed by another 300 mm compacted soil layer and another GCL on top of that as illustrated in Figure 9.

The shape of the leachate collection trench was also changed after a more practical design was developed on site in consultation with the contractor, a local Ugandan firm Epsilon Construction. The new methodology for installation of the leachate collection pipes on top of the primary HDPE was stipulated in bullet form on the drawings to better aid the contractor. This is due to the reality that the installation of the layer on top of the primary HDPE represents the biggest risk to the overall barrier performance due to the risk of puncture.

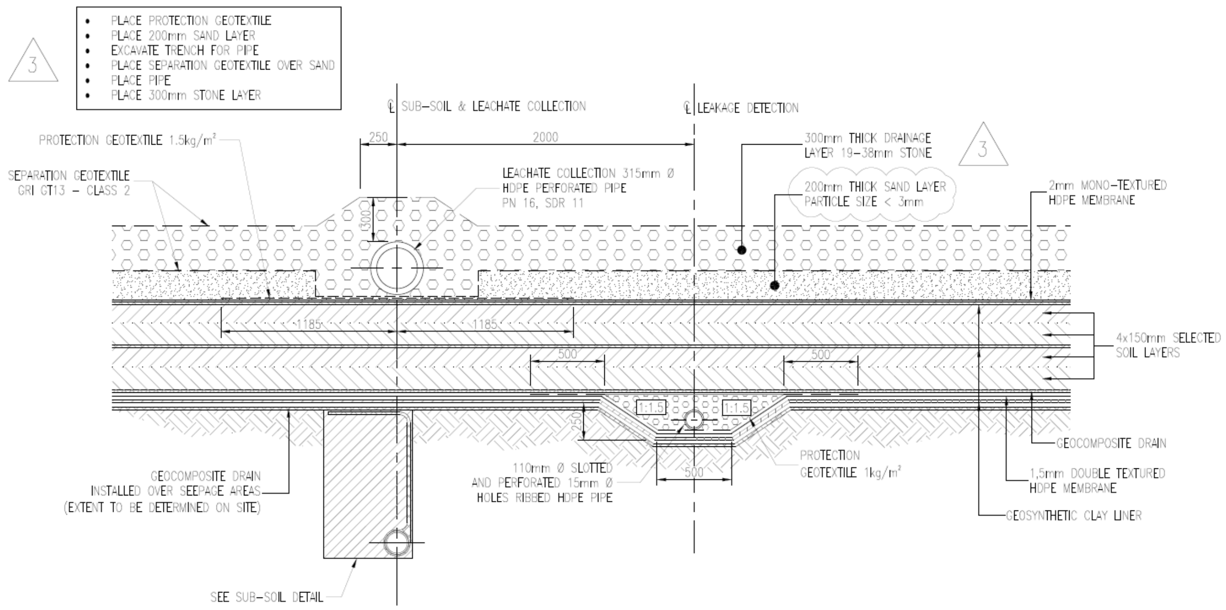

Figure 9. Final lining details.

After the design change from BES layers to the use of GCLs, more GCLs had to be ordered and shipped to site. The lead time on this product was about six weeks and construction could not be halted. To resolve the dilemma, the remaining quantity of GCL was carefully audited and this quantity was then utilised to estimate the extent to which the entire liner package could be constructed in Cell1A. Hence, Cell1A was split again by aid of building a separation berm as detailed in Figure 10 below. The drainage aspect of splitting Cell1A caused some complications – there would still only be one sump for each the subsoil and leachate detection systems for both cells in Cell1A. Therefore, the subsoil and leachate detection piping was continued through under the separation berm and the leachate collection pipe has been designed to go through the berm as detailed in Figure 10, allowing separate leachate collection from the two halves of the cell. The mean annual precipitation in the area around Hoima is just under 1.2 m per year thus splitting the cells also reduces the amount of leachate and contaminated stormwater generated during the commissioning phase of the landfill.

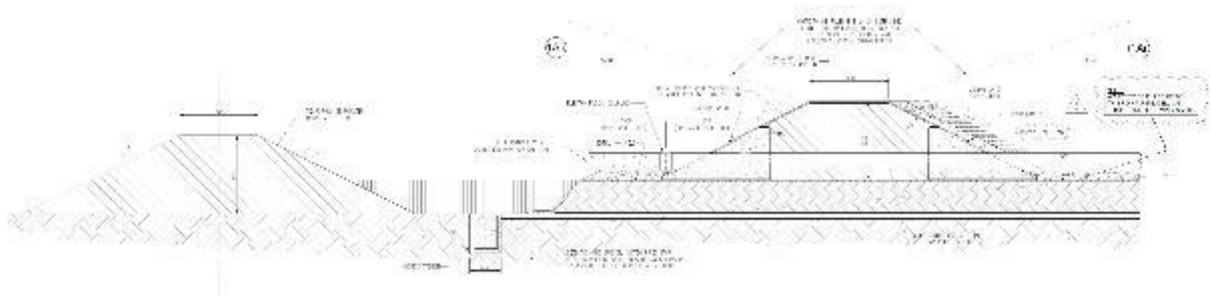

Figure 10. Separation berm detail between Cell1Ai and Cell1Aii.

5. PROJECT STATUS

The construction of Cell1Ai and Cell 1Aii is complete as well as the contaminated stormwater dam Phase 1. The treatment plant has been commissioned and the majority of Cell 1Ai has been filled with stabilised waste, which can be seen in Figure 11, after the permit to proceed was received from the Ugandan environmental authorities.

Figure 11. Filling with stabilised waste in Cell 1Ai.

6. REFERENCES

Department of Environment Affairs (DEA) b, 23rd August 2013, National Norms and Standards for Disposal of Waste to Landfill, Notice No. R. 636, Government Gazette No. 36784.