



**MBHE ENVIRONMENTAL PTY (LTD)**  
**MIDDELWATER LANDFILL DEVELOPMENT**

**PROPOSED MIDDELWATER CLASS B  
WASTE FACILITY**

**ADDENDUM TO DESIGN REPORT**

**REVISION 2**

**Ref. No.755-2022  
January 2026**

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## PROPOSED MIDDELWATER CLASS B - LANDFILL DEVELOPMENT

### ADDENDUM TO DESIGN REPORT REVISION 2

#### EXECUTIVE SUMMARY

Envitech Solutions (Pty) Ltd was appointed in February 2022 to assist with the necessary site investigations and technical design for a waste license application, for a landfill development at the Middelwater Resource Facility (previously known as “Multisand”), in terms of the National Environmental Management: Waste Act (Act No.59 of 2008).

The Applicant, MBHE Group (Pty) Ltd, was previously granted a Mining Right with references ML 14/2001 and DMR Reference GP30/5/1/2/2 (245) MR. The mining of sand, aggregate and silica quartzite is taking place on the site. A waste license was later granted, in September 2016, by the Gauteng Department of Agriculture and Rural Development (GDARD) with license number **12/9/11/L1442/3**. This license authorized the Re-use, Recycling, Treatment and Recovery of Hazardous Waste. The License did not include Disposal activities.

In 2022 Envitech prepared a Design Report in support of a Waste Management License Application for General Waste Disposal. The design was submitted in September 2022 to GDARD. A response was received, with reference number Gaut 002/23-24/W0028, dated 28/11/2025, requiring additional information before the Amendment could be considered for approval. This report Addendum dated January 2026 is being submitted in response to the aforementioned letter. The Addendum includes updated Engineering Design Drawings and calculations for stormwater management, and slope stability calculations for landfill cells and dams. Further, a Table of Responses has been included to address the queries individually.

The original project Design Engineer was Mr. Kris Matulovich, Professional Engineer with ECSA Registration number 20190729. The project is currently under the Design Engineer Mr. Brendon Jewaskiewitz, Professional Engineer with ECSA Registration number 20170189.

### **Site Description**

The Middelwater site is located approximately 24 kms west of Pretoria, 10km west of Rosslyn and Ga-Rankuwa is approximately 6km to the north of the mining area. The mine is situated within the Tshwane Metropolitan area. The site occupies the farm Middelwater 593 JQ and Portion 33 of Vissershoek 435 JQ and Portion 125 of Wildebeesthoek 310 JR, De Wildt, Gauteng. The area of the land under application is **97.9452 hectares**.

The geology follows the Rustenburg layered suite of the Bushveld Igneous Complex, which is part of the Pretoria Group. There are various intrusions of partly magmatized Hybrid rock, undifferentiated Quartzites, limestone and volcanic rocks occur on the west/ east line through the area. Shales and quartzites of the Pretoria Group of the Transvaal Supergroup, also contribute. The site is not underlain by dolomite.

The area corresponds to the catchment of the Crocodile River upstream of the confluence of the Elands River, in Water Management Area 3, and lies within two quaternary catchment areas, namely A21J and A23K. The Crocodile Western Bankenveld ecological unit the surface water quality is generally classified as POOR

The groundwater is generally of a high quality and in terms of its chemical composition, all water samples comply with the SA National Drinking Water Standards Groundwater and are to be monitored routinely at monitoring boreholes. The groundwater level is approximately 25m below ground level.

### **Site Classification**

#### **Waste Class**

In view of the wastes to be accepted on site, as described above, and in accordance with the proposed new *National Norms and Standards for Disposal of Waste to Landfill (R636 of August 2013)*, the landfill will be designed to receive “**Type 2**” wastes. The landfill therefore requires a “**Class B**” containment barrier system.

Climatic data clearly shows a negative water balance. The landfill therefore classifies as a **G:L:B**.

The waste stream will be general waste including construction and demolition waste. There will be no hazardous waste nor sewage sludge disposed of on the landfill. There

will be no leachate re-circulation and no liquid co-disposal. A **Class B** barrier system is therefore required in the disposal areas.

**The proposed landfill barrier system is as follows, from the top:**

- 210g/m<sup>2</sup> woven geotextile
- 38mm stone drainage layer, 300mm thick (150mm on slopes)
- 1200 g/m<sup>2</sup> non-woven geotextile
- 1,5mm HDPE geomembrane
- Geosynthetic Clay liner 3,7 kg/m<sup>2</sup>
- Base preparation layer 150mm ripped and re-compacted with finger drains at 25m centres for subsoil/ leakage collection drainage.

**The proposed leachate dam barrier system is as follows, from the top:**

- 100mm thick geocells filled with 5 MPa concrete
- 1000 g/m<sup>2</sup> non-woven geotextile
- 2mm smooth geomembrane
- 3,7 kg/m<sup>2</sup> geosynthetic clay liner
- Composite cusped sheet, cusps facing upwards
- 1,5mm HDPE smooth geomembrane
- Base preparation layer 150mm ripped and re-compacted with finger drain sub-soil collectors

**The proposed contaminated water dam barrier system is as follows, from the top:**

- 100mm thick geocells filled with 5 MPa concrete
- 1000 g/m<sup>2</sup> non-woven geotextile
- 1,5mm smooth geomembrane
- 3,7 kg/m<sup>2</sup> geosynthetic clay liner
- Base preparation layer 150mm ripped and re-compacted with finger drain sub-soil collectors

### **Surface Water Management**

The design separates clean and contaminated water. Clean upslope runoff is to be intercepted and diverted around the operational areas in unlined trapezoidal drains and by diversion berms. Drains are sized to convey the peak flows from a 1:50 year 24 hour storm.

Contaminated water is collected off roadways and landfill edge-berms' outer side slopes, in lined drains and directed to the contaminated water dam, for evaporation, re-use or discharge, should water-quality testing prove that the water is suitable for release. The contaminated water dam has been sized to accommodate a 1:50 year, 24-hour storm runoff, with 800 mm freeboard. The drains have been sized to accommodate peak flows from a 1:50 year, 24-hour storm, with 500 mm freeboard.

Rainfall over the landfill cells will percolate through the waste together with leachate produced from organics within the waste. The resulting leachate will be conveyed in HDPE pipes to the leachate dam. In the operations of the proposed landfill site, it is noted that evaporation from the leachate dam will exceed inflow from the landfill cells. The dam has been sized to accommodate a 1:50 year, 24-hour storm runoff from two operating cells with 800mm freeboard.

Stormwater calculations have been included in Appendix C. These include catchment analyses, also shown on drawing 755-2022-018 sheet 1. Drain capacities were calculated for trapezoidal drains- both clean and contaminated- and for a concrete pipe main. Rational formula calculations and drain capacity calculations spreadsheets are included in Appendix C. Drain cross sections are shown on drawing 755-2022-018 sheet 2.

Comments from GDARD emphasized the continuity of containment of contaminated water. Penetration details of riser pipes through geomembranes on the crests of cell and dam berms were shown previously. The case of pipe inlets into the leachate dam and pipe outlet from one cell into another (one case) through the berm have been shown. Concrete anchor blocks seal the "top hat" welded pipe/geomembrane seals.

### **Slope Stability Analysis**

Global stability analysis was recorded in the design report, with a FoS of **1.77 (Morgenstern-Price Method)** and **1.73 (Sarma Method)**. Veneer stability of the dam slopes has been requested, in addition to verification of the landfill cells' veneer stability. This has been addressed. The Factors of Safety were calculated, and confirmed to exceed 1,5, as required.

### **CQA**

A full construction quality assurance (CQA) document was included in the Design Report. Only one addition has been made to the CQA report, which was a geomembrane wrinkle height limit, and therefore only an excerpt has been included from the revised document. Pipe specifications, with respect to jointing and specification of drainage stone were also previously addressed on the CQA report. References to these queries have been included in the Table of Responses.

### **Table of Responses**

A table of responses has been included in **Section 8**, where the clarifications sought by GDARD have been addressed individually. Items for the attention of the Environmental Assessment Practitioner are noted "for EAP" and not addressed further. Only items related to the Engineering Design are addressed in this Addendum. The EAP will provide clarifications on environmental studies and any clarifications from the site Owner.

### **Appendices**

The GDARD request for information letter is attached as Appendix A. The relevant Addendum drawings are attached in Appendix B. Calculations are attached in Appendix C.

**PROPOSED MIDDELWATER CLASS B - LANDFILL DEVELOPMENT**

**ADDENDUM TO DESIGN REPORT REVISION 2**

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**APPENDIX B:** ADDENDUM DRAWINGS

**APPENDIX C:** CALCULATIONS

## PROPOSED MIDDELWATER CLASS B LANDFILL DEVELOPMENT

### ADDENDUM TO DESIGN REPORT

#### 1. TERMS OF REFERENCE

Envitech Solutions (Pty) Ltd was appointed in February 2022 by Mr. Werner van Wyk of MBHE Environmental (Pty) Ltd to assist with the necessary site investigations and technical design for a waste license application, for a landfill development at the Middelwater Resource Facility, in terms of the National Environmental Management: Waste Act (Act No.59 of 2008).

The Applicant, MBHE Group (Pty) Ltd, was previously granted a Mining Right with references ML 14/2001 and DMR Reference GP30/5/1/2/2 (245) MR. The mining of sand, aggregate and silica quartzite is taking place on the site. A waste license was later granted, in September 2016, by the Gauteng Department of Agriculture and Rural Development (GDARD) with license number **12/9/11/L1442/3**. This license authorized the Re-use, Recycling, Treatment and Recovery of Hazardous Waste. The License did not include Disposal activities.

The submission of the design report was in September 2024 and comments from the Regulatory Authorities (Gauteng Department of Environment) were received on the 28 November 2025. This report seeks to address the comments received from the Authorities.

The Addendum includes updated engineering design drawings and stormwater management and slope stability calculations for landfill cells and dams. Further, a Table of Responses has been included to address the queries individually.

#### 2. BACKGROUND INFORMATION

##### 2.1 Regional Context and Objectives

With the development and growth of the urban areas, particularly in the northern part of Johannesburg and Tshwane areas, there is a need to develop new waste disposal facilities. Any new facilities should meet the requirements of the National

Environmental Management: Waste Act No.59 of 2008 and the more recent National Waste Management Strategy (NWMS).

In accordance with the National Waste Management Strategy and the waste management hierarchy, the proposed disposal facility will include the following:

- Materials recycling facility (MRF),
- Engineered landfill (Classification Class B) developed in a series of cells,
- Related infrastructure such as administration buildings, weighbridge, workshops.

The Design Report included Design Drawings and the Construction Quality Assurance (CQA) Plan, which outlined quality assurance protocols during construction.

This addendum will provide summarized background information from the Design Report to provide context, as applicable.

## **2.2 Design Engineer, Peer Review**

The original project Design Engineer was Mr. Kris Matulovich, Professional Engineer with ECSA Registration number 20190729. The project Design Engineer is Mr. Brendon Jewaskiewitz, Professional Engineer with ECSA Registration number 20170189.

Contact Details: 011 425-2810,

Email: [brendon@envitech.co.za](mailto:brendon@envitech.co.za)

## **2.3 The Developer's Representative**

The Developer's Representative will be Mr. Gert van Rensberg of Middelwater Landfill (Pty) Ltd.

Contact Details: Cell: 083 227 2291  
Tel: 012-504-2002/5

Email: [gert@multisand.co.za](mailto:gert@multisand.co.za)

## 2.4 Description of the Waste Stream for Disposal

The waste stream will be general waste including construction and demolition waste. There will be no hazardous waste nor sewage sludge disposed of on the landfill. There will be no leachate re-circulation and no liquid co-disposal.

## 3. SITE DESCRIPTION

### 3.1 Location and access

The Middelwater mining site is located approximately 24 kms west of Pretoria, 10km west of Rosslyn and to the south of the R566 Pretoria-Brits Road. Ga-Rankuwa is approximately 6km to the north of the mining area, opposite the R566 road.

The mine is situated within the Tshwane Metropolitan area and is served by the Tshwane Metropolitan Council. The location of the site is indicated in Figure 1 below.

The site occupies the farm Middelwater 593 JQ and Portion 33 of Vissershoeck 435 JQ and Portion 125 of Wildebeesthoek 310 JR, De Wildt, Gauteng. The area of the land under application is **97.9452 hectares**.

Large sections of the mining area have been irreversibly transformed, primarily by sand mining activities. Fallow agricultural lands dominate the southern section of the mining area. The northern and eastern borders, however, still retain the original savanna habitat of the area and remain in relatively pristine condition with regards to the vegetation still present within these zones. From Figure 1 below, only the area north of the red line is envisaged for the Waste Management Facility.

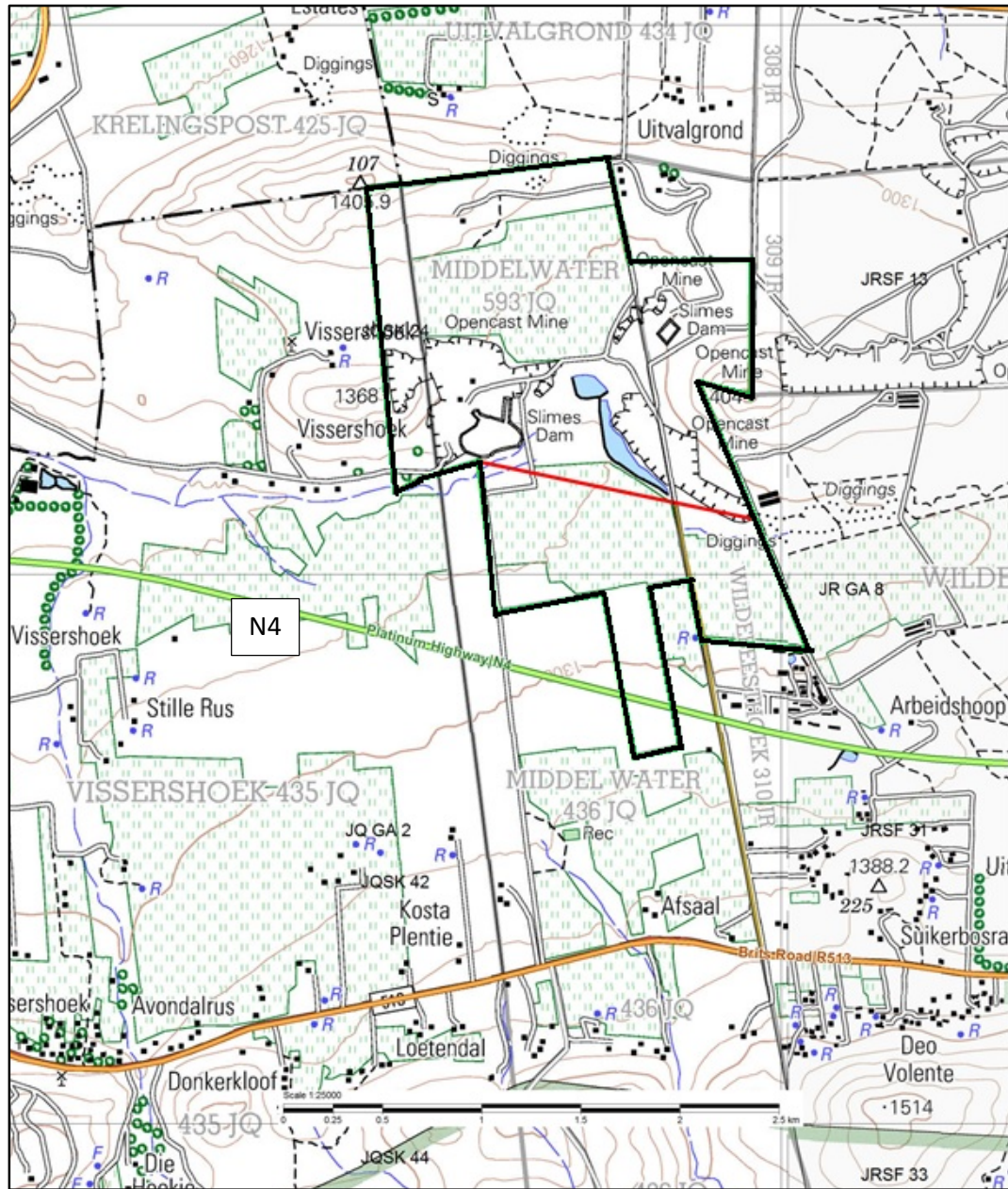
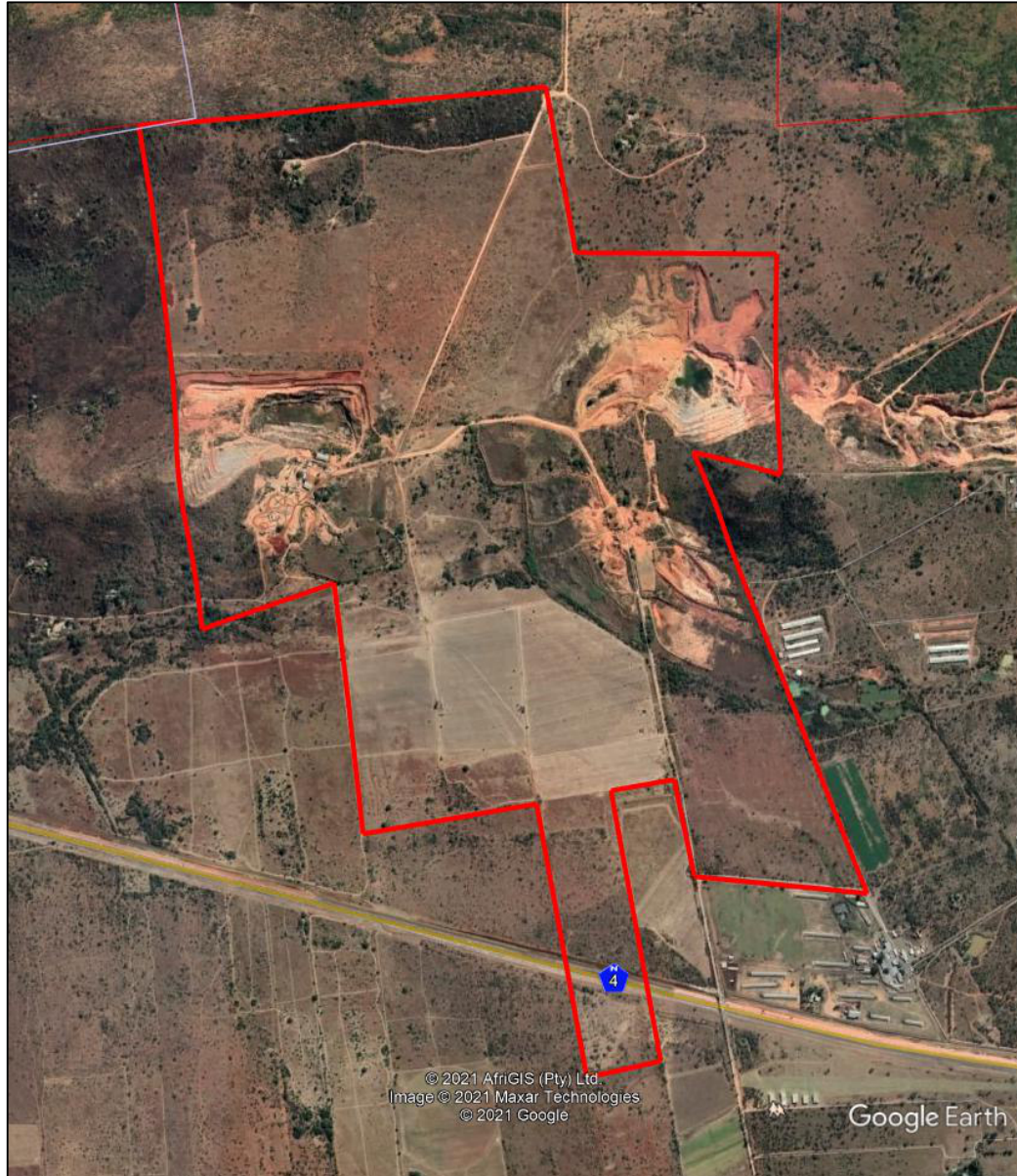


Figure 1: Locality Plan of the Middelwater Resource Facility, 1:50,000



**Figure 2: Middelwater Mine Layout in 2021**

**Table 1: Site Co-ordinates**

POINT	LATITUDE	LONGITUDE
Centre of site	25,639871 deg South	27,988822 deg East
Access road	25,623009 deg South	27,995728 deg East

## 4. REGIONAL CLIMATE

The mining area is situated within the Highveld climate zone that generally has relatively warm to hot summers and mild winters.

The area has summer rainfall, and dry winters. The area receives between 500 and 600mm of precipitation per annum. Rain falls predominantly during summer in the form of showers and thunderstorms, which generally are of short duration (30 - 60 minutes). However, at times the storms can last between 3 to 4 hours.

Maximum temperature in summer (January) can reach an average of 30°C while the average minimum temperature in winter (June) is -2°C (Mucina and Rutherford, 2006). Frost does occur occasionally.

Regional evaporation far exceeds precipitation, at between 1700 and 1800mm per annum.

## 5. SITE GEOLOGY & HYDROGEOLOGY

### 5.1 Geology

The mining area lies in the Rustenburg layered suite of the Bushveld Complex, which is part of the Pretoria Group. The formation strikes due west and dips at an angle of approximately 25 degrees to the north. There are various intrusions of partly magnetised Hybrid rock, undifferentiated Quartzites, limestone and volcanic rocks occur on the west/ east line through the area, according to the Geological Maps of the area.

The geology of the Marikana Thornveld (SVcb 6), one of the vegetation units found on-site, consists mainly of mafic intrusive rocks of the Rustenburg Layered Suite of the Bushveld Igneous Complex. Shales and quartzites of the Pretoria Group of the Transvaal Supergroup, also contribute.

Geologically, the Gold Reef Mountain Bushveld (SVcb 9), another of the on-site vegetation types, consists predominantly of quartzites, conglomerates and some shale horizons of the Magaliesberg, Daspoort and Silverton Formations (Vaalian Pretoria Group) and the Hospital Hill, Turffontein and Government Subgroups (Randian Witwatersrand Supergroup).

No Structural features such as faults or dyke intrusions are indicated on available geological maps or have been intersected during the quartzite mining operations. However, the geophysical studies conducted as part of the geotechnical and geohydrological investigation revealed the presence of some structural features.

Two ground magnetic survey along profiles indicated the presence of a prominent negative magnetic anomaly along a NW-SE direction in the north-western corner of the study area representing a dyke intrusion. The reversely magnetised rocks giving rise to this negative anomaly pattern, together with the strike direction of the dyke, is an indication that this dyke is part of the Pilansberg dyke swarm with an intrusion age of approximately 1 310 Ma.

## **5.2 Surface Water Catchment Areas**

The area falls within the Crocodile (West) Marico Water Management Area (WMA 3), one of 6 water management areas that make up the Limpopo River Basin Catchment Area. The area corresponds to the catchment of the Crocodile River upstream of the confluence of the Elands River, which includes the major tributaries of the Sterkstroom, Magalies, Bloubankspruit, Jukskei, and Hennops rivers.

### **Quaternary Catchment**

The property lies within two quaternary catchment areas, namely A21J and A23K, which are part of the Crocodile West and Marico Catchment Management Area.

All the water that runs off the mine property is in the form of sheet water and it runs in an south-easterly direction towards the watercourse located east of the property. The average rainfall is 600mm per annum. This results in drainage calculated at approximately 8% and evaporation at 5%.

There is no significant change expected in the flow of water emanating from the mine. Therefore, the watercourse is not affected by the mining activities. No flood peaks affect the mining area. The low-lying drainage runoff area is approximately 80m away. There are no rivers or streams through the mining area.

## **5.3 Surface Water Quality**

The mining area is located within the Crocodile Western Bankenveld ecological unit.

Generally, the Water Quality is classified as POOR - flows have high levels of nutrients and water quality problems but are free from significant organic pollution. This is primarily the result of urban runoff and industrial discharges. The water quality on-site is not significantly affected by the mining activities. Most water runs off the area, except for limited quantities retained in the two pit areas, and the water in the settling dams.

#### **5.4 Ground Water Quality**

The current mining activities are not negatively impacting the groundwater resources. During the washing and screening process no harmful chemicals are used. If any seepage occurs, the borehole water quality monitoring would reflect this.

All the mining activities take place above the water table and the underlying non-porous quartzite does not allow for much drainage or seepage. The depth of the proposed landfill cells and dams would not exceed 10 m below natural ground level. No negative impact is expected on the groundwater resources in the area.

The water is generally of a high quality and in terms of its chemical composition. Only one borehole, MS-BH24 (to the south of the proposed landfill site) has a nitrate concentration above that specified in the National Standard. In all other respects, the water from this borehole is of high quality and complies with the SA Drinking Water Standards.

#### **5.5 Ground Water Levels**

The water table on-site is approximately 25m below ground level, and the boreholes on-site verify this. Periodically, during very dry periods, the water table has been known to fall to 28mbgl, but it is generally reported to be constant.

#### **5.6 Perched Water Level**

Seepage was only encountered in three of the test pits and is interpreted to be a localised perched water level associated with the ephemeral drainage line.

The degree of fracturing associated with dyke intrusions often controls the ground water conditions associated with such intrusions. This was tested by drilling three boreholes across the dyke intrusion indicated by the detailed ground magnetic survey in the north western part of the study area. The drilling results indicated that (i) only very limited fracturing is associated with this specific dyke, (ii) no groundwater was intersected during the drilling and all three boreholes were dry at completion, (iii) the

static water level that was established at a depth of 43 m to 44 m a few days after completion of drilling the boreholes, is also much deeper than that measured at other boreholes to the north of the quartzite ridge, and (iv) the contact zone between the dyke and the host rock cannot be considered as a potential ground water yielding structure of any significance. The lack of groundwater associated with such structures is a favourable indication for the development of landfill sites.

### 5.7 Aquifer Classification

It was concluded that the overall aquifer classification for the area is one of generally low to medium potential sustainable yield, good water quality, with the aquifers regarded as minor aquifers.

## 6. CONCEPTUAL DESIGN

*This section only focuses on the design information relevant to the queries and comments received from GDE. A full description of the design is found in the Design Report.*

### 6.1 Site Classification

#### Waste Class

The proposed Middelwater landfill facility is intended to accept general wastes comprising general- domestic, commercial, garden, builder's rubble and general dry industrial waste for disposal. In view of the wastes to be accepted on site, as described above, and in accordance with the proposed new *National Norms and Standards for Disposal of Waste to Landfill (R636 of August 2013)*, the landfill will be designed to receive "**Type 2**" wastes. The landfill therefore requires a "**Class B**" containment barrier system.

#### Size of Landfill Operation

The site is intended to be a commercial waste disposal facility and as such it is intended that more than 670 tons/day of waste will be received.

#### Potential for Significant Leachate Generation

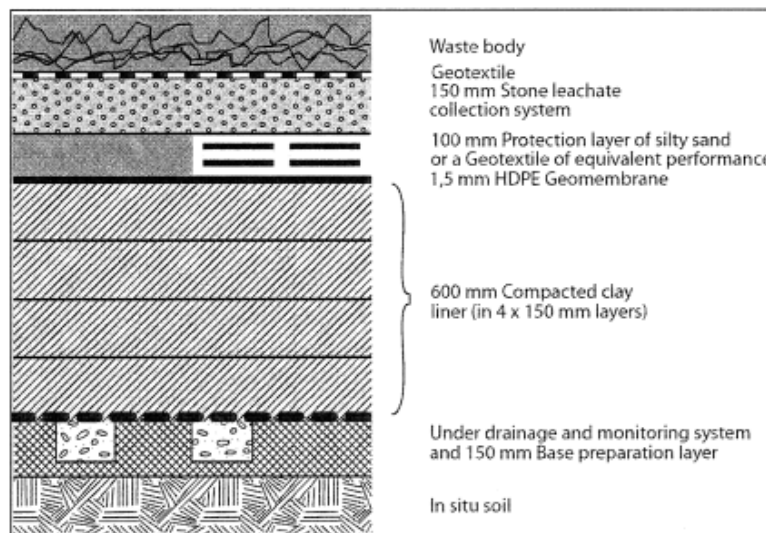
The climatic water balance for the Middelwater Landfill site was calculated and found to be **Negative**.

No significant volumes of high moisture content wastes are expected to be received at the site. Provided that upslope surface water drainage systems are installed to prevent the ingress of stormwater runoff onto the waste body, the site water balance should not be affected and significant leachate generation should not be expected.

The landfill therefore classifies as a **G:L:B-**. However, in terms of the Norms and Standards for Disposal of Waste to Landfill (R636 of August 2013), issued under the Waste Act, it is proposed to install a Class B barrier system which includes for leachate drainage and collection.

## 6.2 Landfill liner system

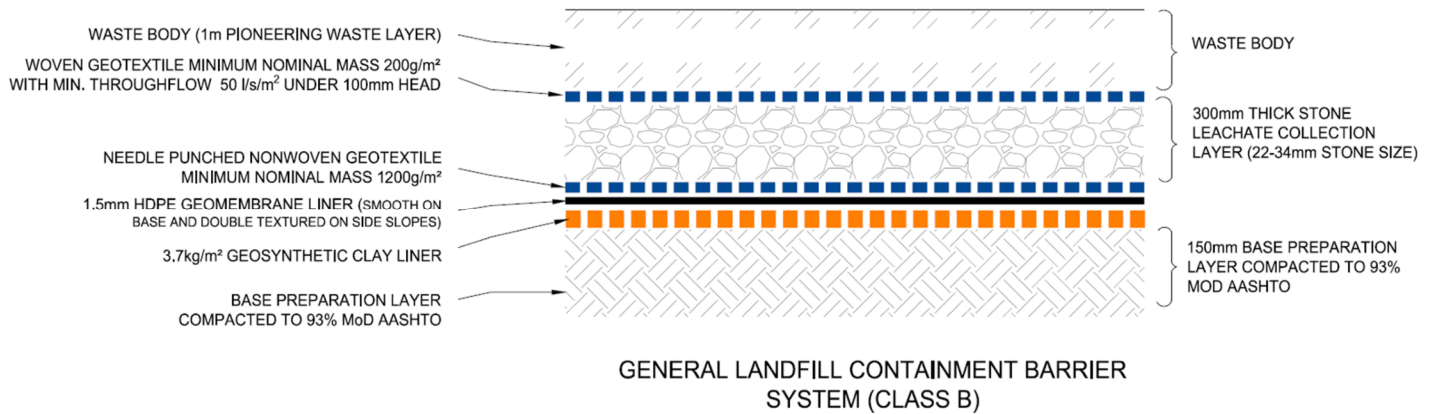
The landfill liner system will be in accordance with Class B of the 2013 *National Norms and Standards for Disposal of Waste to Landfill (R636)* as shown in **Figure 3** below.



**Figure 3: Norms and Standards (R636) Class B Barrier**

**Figure 3** above indicates the required Class B Barrier from the *Norms and Standards for Disposal of Waste to Landfill* for Type 2 waste, in terms of the *National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008)*, *R636 and R634*.

The proposed barrier containment system for Middelwater is shown in **Figure 4** below. The proposed landfill liner system and details are shown in drawing number 722-2022-009 in the Book of Design Drawings.



**Figure 4: Schematic of Barrier System, and layers legend (below)**

It can be seen when comparing the proposed liner system to the standard, that the proposed barrier system replaces 600mm compacted clay layers and the silty sand layer above the geomembrane, with a geosynthetic clay layer (GCL) and a protection geotextile over the geomembrane respectively.

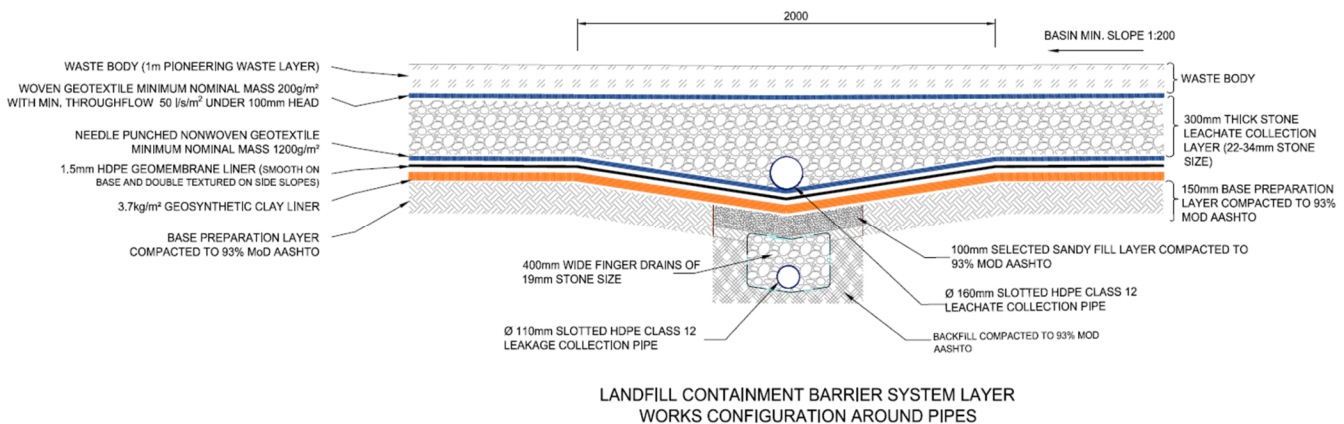
The motivation and specification of the alternative materials are discussed in Section 12.14 in the Design Report.

The proposed barrier containment system in **Figure 4** above is as follows:

1. 1.0m Selected Waste (pioneer layer).
2. Geotextile Separation Layer – Woven geotextile of nominal mass 210g/m<sup>2</sup>, with a minimum through flow of minimum 50 litres/second/m<sup>2</sup> under a 100mm head.
3. Stone Leachate Drainage Layer – 300mm thick on the cell base and 150mm thick on slopes of 22-34mm washed stone aggregate. The leachate drainage layer (LCS) is exposed to atmospheric pressure both with the drainage layer exposed along the cell periphery and leachate collection pipes discharging into manholes and ultimately daylighting into the leachate dam.
4. Geotextile Protection Layer – needle punched non-woven geotextile layer of nominal mass 1200g/m<sup>2</sup>, GRI–GT12(a). Cylinder load testing utilising the proposed stone aggregate, protection geotextile and

HDPE geomembrane will be carried out on the liner materials to be used for construction to verify the materials specifications and resulting GMB strains.

5. Primary Liner
  - Landfill cell base – 1,5mm thick smooth HDPE geomembrane liner (GRI - GM13).
  - Landfill cell slopes – 1,5mm thick double textured HDPE geomembrane liner (GRI - GM13) – rougher textured side laid downwards.
6. Geosynthetic Clay Liner (GCL), reinforced, with a minimum unit mass of 3 700g/m<sup>2</sup>.
8. Base Preparation Layer – Rip and recompact 150mm thick layer of in-situ material to 95% MOD AASHTO with sub-soil / leakage detection finger drains as per **Figure 5** below.



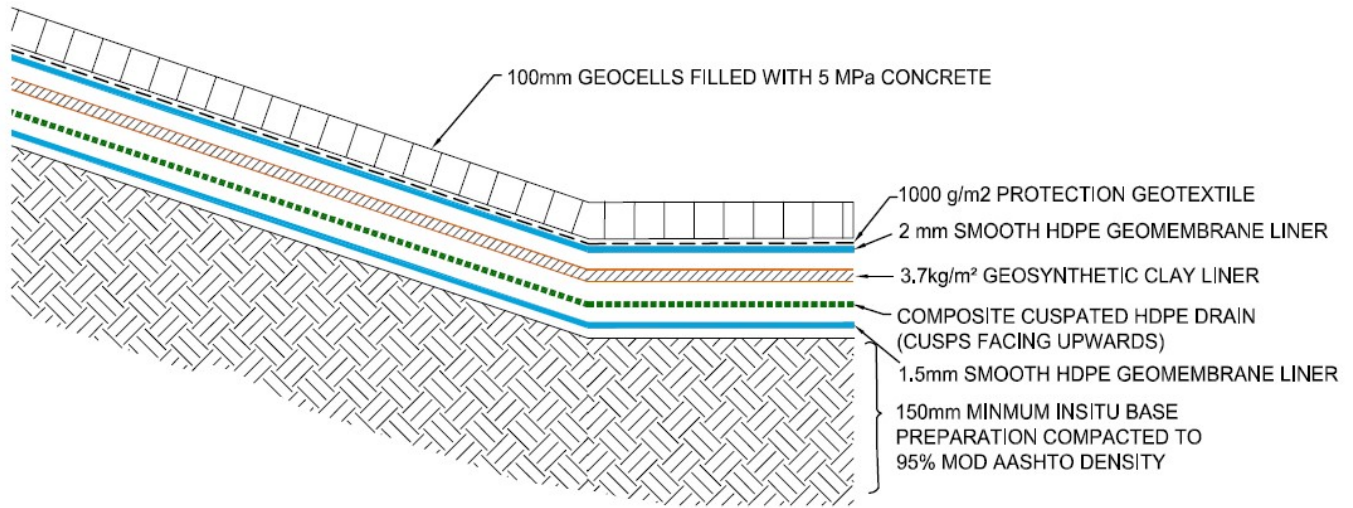
**Figure 5 - Liner system with sub-soil leakage detection finger drain**

The liner system makes provision for the collection and drainage of leachate above the primary liner and for leakage detection and collection between the primary liner and compacted in-situ material.

### 6.3 Leachate Dam Liner System

The leachate dam has been sized to contain the runoff from 2 waste cells for the 1 in 50-year recurrence interval 24-hour duration storm. The leachate pond has been sized at 23 000 m<sup>3</sup> plus an 800mm freeboard, with a geocells-lined (filled

with concrete) emergency spillway to control overflow water during extreme rainfall events.



**Figure 12: Proposed barrier containment system – Leachate Dam**

The liner design for the leachate pond is as shown in **Figure 12** above, and the details are shown on drawing number 755-2022-017. The leakage detection between the primary and secondary geomembranes is shown on the drawing as well, with sump details. Refer also to Section 6.8. The proposed leachate dam barrier system is as follows, from the top:

- 100mm thick geocells filled with 5 MPa concrete
- 1000 g/m<sup>2</sup> non-woven geotextile
- 2mm smooth geomembrane
- 3,7 kg/m<sup>2</sup> geosynthetic clay liner
- Composite cuspated sheet, cusps facing upwards
- 1,5mm HDPE smooth geomembrane
- Base preparation layer 150mm ripped and re-compacted with finger drain sub-soil collectors

#### 6.4 Contaminated Dam Liner System

The proposed contaminated water dam barrier system is as follows, from the top:

- 100mm thick geocells filled with 5 MPa concrete
- 1000 g/m<sup>2</sup> non-woven geotextile
- 1,5mm smooth geomembrane
- 3,7 kg/m<sup>2</sup> geosynthetic clay liner
- Base preparation layer 150mm ripped and re-compacted with finger drain sub-soil collectors

## 6.5 Slope Stability Analysis

Once the waste body height is higher than the perimeter berm, edge berms of waste must be formed to control the outer side slope angle to a 1:3 slope. The edge berms would typically be 1, 5m to 2m high and waste deposition would take place behind this berm until the waste is level with top of the berm. With the next lift, a new edge berm would be formed prior to waste deposition. The volumes of wastes being landfilled and operational slopes achieved will be monitored on a regular basis to ensure compliance with design parameters. This is achieved by regular surveys in combination with auditing.

As strict CQA monitoring will take place during construction and stability berms will be constructed on the perimeter during waste body lifts, as well as a stability bench at 10m lift height, long term stability issues are not anticipated. Refer to drawing number 755-2022-012 for the proposed Final Landform. The height limit of the proposed fill model landform is 20m above natural ground level.

Global slope stability analysis has been undertaken and the calculations are included in Appendix C. Materials input parameters were based on recent laboratory test results and experience on similar projects. These parameters will need to be verified at time of construction to ensure correct selection of geosynthetic materials for the liner system.

In terms of interface friction, the critical interface appeared to be that of the smooth HDPE geomembrane / protection geotextile on the landfill base.

Stability analyses were carried out using GEO5 2019, a slope stability program which computes the stability of slopes and embankments with circular or polygonal slip surfaces. In terms of polygonal or non-circular slip surfaces, the programme can

perform the Sarma, Spencer, Janbu or Morgenstern-Price, Shahunyants and ITF methods. The Sarma and Morgenstern-Price methods were used for this analysis.

The Sarma (1979) method falls within a category of general sliced methods of limit states. It is based on fulfilling the force and moment equilibrium conditions on individual blocks. The blocks are created by dividing the region above the potential slip surface by planes, which in general have a different inclination.

Morgenstern-Price (1967) is a general method of slices developed on the basis of limit equilibrium. It requires satisfying equilibrium of forces and moments acting on individual blocks. The blocks are created by dividing the soil above the slip surface by vertical dividing planes.

Input parameters used in the stability analyses are shown in Table 2 below.

**Table 2: Stability analysis input parameters**

<b>Material</b>	<b>Density</b> $\gamma_{\text{bulk}}$ (kN/m <sup>3</sup> )	<b>Friction Angle</b> $\phi'$ (°)	<b>Cohesion</b> $c'$ (kPa)
Waste <sup>(1)</sup>	15	15	25
Geotextile/Geomembrane Interface <sup>(2)</sup>		8,7	0

(1) The waste parameters adopted are those recommended in the *Minimum Requirements for Waste Disposal by Landfill* (Department of Water Affairs and Forestry (1998).

(2) The geotextile/geomembrane interface values were those determined in recent testing on similar projects.

A leachate pressure head of 0,3m was used in the stability analyses.

### Stability Analyses Results

The results of the stability analyses are given in the table below.

**Table 3: Stability Analyses Results**

<b>Software</b>	<b>Waste Density</b> $\gamma_{\text{bulk}}$ (kN/m <sup>3</sup> )	<b>Leachate Depth</b> (m)	<b>FoS</b>	<b>Method</b>
GEO5 2019	15	0,3	1,77	Morgenstern-Price
	15	0,3	1,73	Sarma

The results of the analyses are included in **Appendix C**.

The critical failure surface is shown in **Figure 13** below.



**Figure 13: GEO5 2019: Critical Slope Failure Surface**

From the above it can be seen that the minimum FoS of 1.5 for a 1v: 3h slope is readily achievable.

## 6.6 Veneer Stability Analysis

A veneer stability analysis was carried out on the leachate dam, contaminated stormwater dam and the landfill cell slope liner system in accordance with the methodology of Soong and Koerner (2005). This methodology is described in *“Designing with Geosynthetics, 6th Edition”*, by Robert M. Koerner.

a. The following input parameters were used in the calculations (**Landfill Cell:**

### **1.5mm Textured HDPE vs GCL):**

- Thickness of cover soil (stone drainage layer) : 0,15m
- Slope angle (1v:3h) : 18,43°
- Length of slope : 33.73m
- Unit weight of stone layer : 18,6kN/m<sup>3</sup>
- Unit weight of operating equipment (skid steer) : 50kN/m<sup>3</sup>
- Friction angle of cover (stone) : 35°
- Cohesion of cover (stone) : 0 kN/m<sup>2</sup>
- Critical interface friction angle (GCL/geomembrane) : 29°
- Critical interface adhesion (GCL/geomembrane) : 17kN/m<sup>2</sup>

A Factor of Safety of **2.68** was obtained from the analyses. The veneer stability calculations are included in **Appendix C**.

b. The following input parameters were used in the calculations (**Landfill Cell: 1.5mm Textured HDPE vs 1200g/m<sup>2</sup> Geotextile**):

- Thickness of cover soil (stone drainage layer) : 0,15m
- Slope angle (1v:3h) : 18,43°
- Length of slope : 33.73m
- Unit weight of stone layer : 18,6kN/m<sup>3</sup>
- Unit weight of operating equipment (skid steer) : 50kN/m<sup>3</sup>
- Friction angle of cover (stone) : 35°
- Cohesion of cover (stone) : 0kN/m<sup>2</sup>
- Critical interface friction angle (GTX/geomembrane) : 23,5°
- Critical interface adhesion (GTX/geomembrane) : 11kN/m<sup>2</sup>

A Factor of Safety of **2.01** was obtained from the analyses. The veneer stability calculations are included in **Appendix C**.

The most critical interface will be between geomembrane and the geotextile with a factor of safety of **2.01** for the landfill cell which is greater than 1.5

c. The following input parameters were used in the calculations (**Contaminated Stormwater Dam: 1.5mm Smooth HDPE vs 1000g/m<sup>2</sup> Geotextile**):

- Thickness of cover soil (stone drainage layer) : 0,1m
- Slope angle (1v:3h) : 18,43°
- Length of slope : 23.09m
- Unit weight of stone layer : 24kN/m<sup>3</sup>
- Unit weight of operating equipment (N/A) : 0kN/m<sup>3</sup>
- Friction angle of cover (stone) : 30°
- Cohesion of cover (stone) : 0kN/m<sup>2</sup>
- Critical interface friction angle (GTX/geomembrane) : 15.5°
- Critical interface adhesion (GTX/geomembrane) : 5.5kN/m<sup>2</sup>

A Factor of Safety of **1.71** was obtained from the analyses. The veneer stability calculations are included in **Appendix C**.

d. The following input parameters were used in the calculations (**Contaminated Stormwater Dam: 1.5mm Smooth HDPE vs GCL**):

- Thickness of cover soil (stone drainage layer) : 0,1m
- Slope angle (1v:3h) : 18,43°
- Length of slope : 23.09m
- Unit weight of stone layer : 24kN/m<sup>3</sup>
- Unit weight of operating equipment (N/A) : 0kN/m<sup>3</sup>
- Friction angle of cover (stone) : 30°
- Cohesion of cover (stone) : 0kN/m<sup>2</sup>
- Critical interface friction angle (GCL/geomembrane) : 24°
- Critical interface adhesion (GCL/geomembrane) : 14 kN/m<sup>2</sup>

A Factor of Safety of **3.42** was obtained from the analyses.

It should be noted that no constructional/ vehicle loading was considered for the dam as the concrete will be pumped into place. The veneer stability calculations are included in **Appendix C**.

The most critical interface will be between geomembrane and the geotextile with a factor of safety of **1.71** for the contaminated stormwater dam which is greater than 1.5.

e. The following input parameters were used in the calculations (**Leachate Dam: 2.0mm Smooth HDPE vs GCL**):

- Thickness of cover soil (stone drainage layer) : 0,1m
- Slope angle (1v:3h) : 18,43°
- Length of slope : 16.44m
- Unit weight of stone layer : 24kN/m<sup>3</sup>
- Unit weight of operating equipment (N/A) : 0kN/m<sup>3</sup>
- Friction angle of cover (stone) : 30°
- Cohesion of cover (stone) : 0kN/m<sup>2</sup>
- Critical interface friction angle (GCL/geomembrane) : 25°
- Critical interface adhesion (GCL/geomembrane) : 15kN/m<sup>2</sup>

A Factor of Safety of **3.65** was obtained from the analyses. The veneer stability calculations are included in **Appendix C**.

f. The following input parameters were used in the calculations (**Leachate Dam: 2.0mm Smooth HDPE vs 1000g/m<sup>2</sup> Geotextile**):

- Thickness of cover soil (stone drainage layer) : 0,1m
- Slope angle (1v:3h) : 18,43°
- Length of slope : 16.44m
- Unit weight of stone layer : 24kN/m<sup>3</sup>
- Unit weight of operating equipment (N/A) : 0kN/m<sup>3</sup>
- Friction angle of cover (stone) : 30°
- Cohesion of cover (stone) : 0kN/m<sup>2</sup>
- Critical interface friction angle (GTX/geomembrane) : 15.8°
- Critical interface adhesion (GTX/geomembrane) : 7kN/m<sup>2</sup>

A Factor of Safety of **1.94** was obtained from the analyses. The veneer stability calculations are included in **Appendix C**.

g. The following input parameters were used in the calculations (**Leachate Dam: 1.5mm Smooth HDPE vs Cuspated Sheet**):

- Thickness of cover soil (stone drainage layer) : 0,1m
- Slope angle (1v:3h) : 18,43°
- Length of slope : 16.44m
- Unit weight of stone layer : 24kN/m<sup>3</sup>
- Unit weight of operating equipment (N/A) : 0kN/m<sup>3</sup>
- Friction angle of cover (stone) : 30°
- Cohesion of cover (stone) : 0kN/m<sup>2</sup>
- Critical interface friction angle (cuspa/geomembrane) : 20°
- Critical interface adhesion (cuspatated/geomembrane) : 6kN/m<sup>2</sup>

A Factor of Safety of **2.06** was obtained from the analyses. The veneer stability calculations are included in **Appendix C**.

h. The following input parameters were used in the calculations (**Leachate Dam: GCL vs Cuspated Sheet**):

- Thickness of cover soil (stone drainage layer) : 0,1m
- Slope angle (1v:3h) : 18,43°
- Length of slope : 16.44m
- Unit weight of stone layer : 24kN/m<sup>3</sup>

- Unit weight of operating equipment (N/A) : 0kN/m<sup>3</sup>
- Friction angle of cover (stone) : 30°
- Cohesion of cover (stone) : 0kN/m<sup>2</sup>
- Critical interface friction angle (GCL/cuspated sheet) : 23°
- Critical interface adhesion (GCL/cuspated sheet) : 13 kN/m<sup>2</sup>

A Factor of Safety of **3.23** was obtained from the analyses. The veneer stability calculations are included in **Appendix C**.

It should be noted that no constructional/ vehicle loading was considered for the leachate dam as the concrete will be pumped into place. The most critical interface will be between 2.00mm smooth geomembrane and the geotextile with a factor of safety of **1.94** for the leachate dam which is greater than 1.5.

### 6.7 Leachate management

Highly contaminated leachate should not enter the natural water regime without prior treatment or purification. It is intended that leachate will be monitored to assess leachate generation rates to ensure adequate storage and treatment arrangements are provided. The collected leachate will be stored in a leachate dam located south of the landfill.

The two main components of a leachate management system include the following:

- the liner system beneath the landfill to prevent infiltration into the ground water.
- The drainage/collection system to transfer leachate to the treatment/storage system.

Any leachate emanating from the waste in the landfill would appear in the granular leachate collection layer overlying the composite liner and would flow downslope at the base of the landfill towards the leachate collector pipes and sump. The base of each cell is to slope at a minimum of 2% towards the sump. These pipe drains consist of 160 mm diameter perforated HDPE pipes placed within a zone of 22-34 mm aggregate layer, 300mm thick. The pipes are placed in a herringbone formation, at approximately 25m centres.

It is envisaged that the generation of leachate will diminish with time in the completed landfill cells thereby reducing any potential risk of leachate being stored or trapped on the liner system. The leachate head above liner will be monitored and pumped out when necessary. Leachate must not be allowed to accumulate to a depth exceeding 300mm above the geomembrane liner.

During operations the leachate collection drains are operating at **atmospheric pressure** due to the stone drainage layer being exposed to the atmosphere. The leakage detection system is also under atmospheric pressure due to the fact that the sump riser pipe will daylight in a vented manhole at the crest of the landfill. The riser pipe is open-ended and also under atmospheric pressure.

### **Leakage Detection**

Beneath the landfill barrier, a leakage detection system of 110mm diameter perforated HDPE pipes mirrors the leachate collection system above. The pipes are contained in 400mm wide drain trenches, surrounded by 19mm stone, 200mm thick, wrapped in separation geotextile, forming leakage detection “finger drains”.

### **Pipe Specifications- leakage detection and leachate collection**

The drainage pipes will be perforated, double-wall HDPE pipes manufactured according to SANS ISO 4427 and confirmed to withstand the external loading. The load bearing capacity of the double walled HDPE pipes should have at least a factor of safety of 1,3.

### **Sumps**

Each cell has two sumps at the lowest point of the base. The leachate collection sump collects leachate from the drainage layer above the HDPE geomembrane liner. The second sump lies beneath the HDPE geomembrane liner and GCL, collecting any leakage that might seep through the barrier system. Both sumps are serviced by a 250mm riser pipe sleeve, that rises from the sump to the top of the outer berm crest.

The sleeves allow for a borehole pump to be lowered down to the sump and any leachate/ leakage pumped out and measured. Manholes are to be provided at

the top of the riser pipe, on the crest. The manholes drain by gravity into the leachate collector pipe which drain by gravity to the leachate dam.

Note that in one case, in Phase 2, the north-western cell will drain into the cell to the south. The conveyance of the extra volume through the lower cell is via a solid pipe and will not overwhelm the lower cell drainage system. The pipe penetration detail is shown on drawing 755-2022-014.

## **6.8 Leachate Dam**

The leachate dam has been sized to contain the runoff from half of the waste body for the 1 in 50-year recurrence interval 24-hour duration storm. The leachate pond has been sized at 23 000 m<sup>3</sup> plus an 800mm freeboard, with a geocells (filled with concrete) lined emergency spillway to control overflow water during extreme rainfall events.

The liner design for the leachate dam is as shown in **Figure 12** above, and the details are shown on drawing number 755-2022-017.

There are two sumps at the dam, to be drained by pumping to a manhole on the berm crest through a 250mm dia. HDPE pipe sleeve. Any leakage between the geomembranes is drained to the Leakage Detection sump. Any sub-soil water would drain to the sub-soil sump, which would effectively act as a secondary leak detection system.

## **6.9 Contaminated Water Dam**

The design separates clean and contaminated water. Clean upslope runoff is to be intercepted and diverted around the operational areas in unlined trapezoidal drains and by diversion berms. Contaminated water is collected, off roadways and landfill edge berms' outer side slopes, in lined drains and directed to the contaminated water dam, for re-use or discharge, should water-quality testing prove that the water is suitable for release. The contaminated water dam has been sized to accommodate a 1:50 year, 24-hour storm runoff, with 800 mm freeboard. The drains have been sized to accommodate peak flows from a 1:50 year, 24-hour storm, with 500 mm freeboard.

The contaminated water dam is sized at 66700m<sup>3</sup> and the sizing calculation is shown in Appendix C.

## 7. QUALITY ASSURANCE PLAN

The landfill liner construction quality assurance is vital to the performance of any proposed lining system. In addition to the Design Report this plan further details the construction quality assurance required for the proposed landfill development.

The detailed requirements for a construction quality assurance plan and specifications for the manufacture, supply and installation and testing of the liner materials, are provided in the project specifications.

The purpose of the Construction Quality Assurance (CQA) Plan is to present the principles and practices of construction quality assurance to be implemented during the installation of the above specified liner materials. Further to the CQA Plan, detailed Method Statements will be prepared, as required, for the various components of the liner system, to be submitted by the installer prior to commencement of the work on site, for approval.

The Construction Quality Assurance Plan is attached as **Appendix B of the Design Report**. One amendment to the CQA is shown below:.

### 4.6.2 Geomembrane Placement

- j) Wrinkles caused by panel placement or thermal expansion should be minimised in accordance with Section 4.7b.11 at all times. Wrinkle heights should not exceed 2 times the width of the wrinkle (i.e.  $H < 2W$ ), furthermore the maximum wrinkle height to be 60mm and 200mm in width will be permitted. Should the wrinkle exceed this (during the time stipulated for placement of the cover material), remedial measures indicated by the CQA Engineer must be performed prior to placement of the cover material.

## 8. TABLE OF RESPONSES TO GDE LETTER Ref No. Gaut 002/23-24/W0028

Ref	Query received	Party responsible	Envitech Response
1.1	<p>(Previously known as Multisand application) Middelwater Resource Facility (Pty) Ltd Volume 1b of 4, with reference 002/23-24/W0028, undated, including the following appendices:</p> <p>1.1.1 Appendix 1 - CVs and Certificates.</p> <p>1.1.2 Appendix 2 - Envitech Design Report, Checklist and Drawings (no design report submitted; it's a Construction Quality Assurance (CQA) Plan).</p> <p>1.1.3 Appendix A - Drawings.</p> <p>1.1.4 Appendix B - CQA Plan (which just includes an Appendix A- Lining Specifications).</p> <p>1.1.5 Appendix C - Calculations.</p> <p>1.1.6 Appendix D - Geohydrology Report.</p> <p>1.1.7 Appendix 3 - Envitech Operational Manual.</p>		<p>The Applicant is in possession of proof of submission and internal governance failed to deliver both the full Design Report and full CQA report to the review Engineer initially, as seen by the responses provided.</p>
2.1	<p>Middelwater Resource Facility (Pty) Ltd must provide a flow diagram identifying the source and destination of clean stormwater runoff, polluted stormwater runoff, and leachate, recognising the change to runoff areas with time.</p>	Envitech	<p>Envitech to show a diagram for clean stormwater, polluted water separation per phase. See sketches at the 755-2022-SK01 to SK05 with the project drawings.</p>
2.2	<p>Middelwater Resource Facility (Pty) Ltd must confirm the adequacy of clean water conveyance systems to accommodate the 1:50 year, 24-hour flood event, including freeboard in accordance with the SANRAL drainage manual of 2013 prescripts.</p> <ul style="list-style-type: none"> <li>• This confirmation of adequate capacity must be included in the amended documents and submitted to the Department.</li> </ul>	Envitech	<p>Please see Appendix C of Addendum for drain sizing of clean upslope water diversion drain. Drain sizing was calculated by using the Rational Method, for peak flow calculation and then applying Manning's formular, which meets the SANRAL Drainage Manual (chapter 8) standard.</p>

2.3	<p>For both the polluted storm water runoff and the leachate storage systems (including leachate dam and contaminated stormwater dam and associated conveyance systems), Middelwater Resource Facility (Pty) Ltd must demonstrate the storage capacity to meet or exceed the 1 in 50-year 24-hour storm capacity (using updated rainfall records) for active cells, unless it can be shown that a smaller volume is accepted noting that the Middelwater Resource Facility (Pty) Ltd remains responsible for clean-up of all spill events.</p> <ul style="list-style-type: none"> <li>• The demonstration must be included in the amended documents and submitted to the Department.</li> </ul>		<p>Please see Appendix C for calculations for leachate dam size.</p> <p>Leachate collection dam has been sized for an active cell plus 2 more cells which is adequate as concurrent rehabilitation of cells would occur as they are completed.</p> <p>National rainwater records have not been revised in the last three years. SAWB records were also consulted. The requirement is outside the industry norms and guidelines for MSW facilities.</p>
2.4	<p>Middelwater Resource Facility (Pty) Ltd must provide a general layout arrangement drawing for the leachate collection system (LCS) and the underdrainage pipe collection system.</p> <ul style="list-style-type: none"> <li>• These drawings must clearly illustrate the alignment, component details, and connectivity of the systems.</li> <li>• The signed design drawing must be submitted to the Department for approval.</li> </ul>	Envitech	<p>Please see drawing no: ES755-2022-007 rev B and -013 rev B for LC and LD drainage pipes layout.</p> <p><u>Connectivity</u> LD and LC perforated pipe fittings shown on drawing 755-2022-014. CQA Report details solid HDPE pipe specifications and fusion welding.</p> <p>Pipe penetration detail of crest penetration shown on drawing 755-2022-014 (cells) and -017 sheet 2 (for Leachate dam). Also shown on -017 is the concrete - encased penetration instance.</p> <p>See Design Report drawing no. 755-2022-009 rev B showing decant from cells is via a riser pipe and pumped to a gravity main, which is HDPE, electro-fusion welded. The cells are not inter-connected. The design principle followed is that the cells' leachate systems are not interconnected.</p>

			All drawings submitted with the Addendum are signed by an ECSA registered Professional Engineer.
2.5	Middelwater Resource Facility (Pty) Ltd must confirm that the base preparation layer meets at least the minimum thickness requirements as stipulated in NEMWA Regulation 636 of 2013. <ul style="list-style-type: none"> <li>This confirmation must be attached to the amended documents and submitted to the Department.</li> </ul>	Envitech	Base preparation layer (in-situ layer) thickness in GNR 636 is 150mm thick, same as on the design drawings, no amendment required in this regard. The landfill is not a hazardous waste cell.  Please see drawings no: ES755-2022-009, 017, 020
2.6	Middelwater Resource Facility (Pty) Ltd must confirm that the veneer stability for the waste cell meets the factor of safety as reported in the design report, using actual materials (geosynthetics and natural) used in all the pollution control works. <ul style="list-style-type: none"> <li>The veneer stability should take cognisance of construction loading (vehicular) as well as give particular attention to the determination and selection of critical interface as the existing veneer stability analysis makes use of the geomembrane/geosynthetic clay liner interface rather than geomembrane/geotextile or other potentially more critical interface.</li> <li>This confirmation must be attached to the amended documents and submitted to the Department.</li> </ul>		Theoretical values used for materials at design phase, actual values to be confirmed during construction with actual materials and reported with the Construction Close-out Report. Stability calculations undertaken using historical values from relevant previous projects, on materials compliant with SANS 1526. The geotechnical report was consulted for in-situ soil properties.  FoS obtained at this stage:  Landfill Cell – GM/GCL = 2.68 GM/GTX = 2.01 CSWD - GM/GCL = 3.42 CSWD GM/GTX = 1.71 Leachate Dam – GM/GCL = 3.65 Leachate Dam – GM/GTX = 1.94 Leachate Dam – GM/Cuspated Sheet = 2.06 Leachate Dam – GCL/Cuspated Sheet = 4.08  Please see Appendix C for calculation sheets. All Factors of Safety obtained are greater than 1.5. Both construction and operational loading were considered.

2.7	<p>Middelwater Resource Facility (Pty) Ltd must confirm the veneer stability of the barrier system using actual materials used in the pollution control works to meet or exceed a factor of safety of 1.5, taking construction and operational loading into account.</p> <ul style="list-style-type: none"> <li>• The written confirmation must be attached to the amended documents and submitted to the Department.</li> </ul>		<p>Theoretical values used for materials at design phase, actual values to be confirmed during construction with actual materials and reported with the Construction Close-out Report. Response 2.6 above addresses the same query.</p>
2.8	<p>Middelwater Resource Facility (Pty) Ltd must demonstrate the adequacy of drainage pipes, including their joints, to maintain containment equivalent to the barrier system from point of penetration of the liner system up to and including external leachate sumps and/or leachate storage facilities.</p>		<p>Type of pipes for leachate drainage system are Class 12 HDPE pressure pipes with a penetration seal both at the leachate dam and the landfill cell where pipe penetrate the geomembrane. Riser pipes are within the cell containment and thereafter leachate is pumped into the solid wall HDPE gravity pipeline. The HDPE pipeline is electro-fusion welded.</p> <p>Also refer to item response 2.4 above.</p> <p>The design is accordance with engineering practice. There is no down-drag due to waste, in the leachate dam or the CW dam. At the dams, there is no stone or sand placement over the barrier system base or slopes which would require heavy plant to install.</p> <p>L.C. pipes are to be joined with fusion weld both on pipe ends and welded at the HDPE leachate collection manhole. Pressure Testing on pipes to be conducted. Please see drawing no: ES755-2022-014 and-022: Penetration Detail Please see drawing no: ES755-2022-009 and 013: Leachate Collection System</p>
2.9	<p>Middelwater Resource Facility (Pty) Ltd must develop a design drawing which details and confirms the continuity of</p>		<p>Please see drawing no: ES755-2022-008 rev B for separation berm details.</p>

	<p>containment for the separation of berm anchor trenches between successive waste cells.</p> <ul style="list-style-type: none"> <li>• The design drawing must be submitted to the Department for approval, together with the amended documents.</li> </ul>		
2.10	<p>Middelwater Resource Facility (Pty) Ltd must develop a design drawing which details and confirms the continuity of containment for the proposed contaminated stormwater channels.</p> <ul style="list-style-type: none"> <li>• The design drawing must be submitted to the Department for approval, together with the amended documents.</li> </ul>		<p>Please see drawing no: ES755-2022-021 rev A for spillway detail. Contaminated water drains inlets will be similar and further details provided at detail design stage. The transition over the crest of the dam will ensure continuity of the barrier system along the crest and to drain invert up to dam “Full Supply Level” elevation at least.</p> <p>Contaminated water is conveyed in lined channels which is in accordance with DWS guideline, noting that a concrete lined channel is a conveyance, not a leachate storage facility.</p>
2.11	<p>The construction quality assurance (CQA) plan must be amended to include a record of the nature and extent of wrinkles in geomembranes, records of geomembrane temperature at time of welding and placement of cover material, records of wedge weld thickness of samples taken for destructive testing and records of independent testing of other geosynthetic materials (such as geosynthetic clay liners, geotextile cushion layers, geodrains and geopipes) and in accordance with advances in technology and accepted engineering practice, as well as the following:</p> <ul style="list-style-type: none"> <li>• The CQA must be amended to ensure that the maximum wrinkle height may not exceed half of the width, with a maximum wrinkle height of 6 cm.</li> <li>• The CQA must be amended to ensure that hydraulic conductivity and Visual-Method Soil Classification for construction testing of the drainage gravel layer and leachate</li> </ul>		<p>Wrinkle recording and documentation to be as per item XIII on page 39. Wrinkle remedial repairs as per item e on page 31 of the <b>CQA Plan</b>.</p> <p>All seaming procedures are covered on page 27 (Geomembrane Placement) and page 30 (Seaming Procedures).</p> <p>Destructive testing procedures, which highlight the thickness of samples and frequency and number of tests, are described on page 37-40 of the CQA Plan. Independent testing of various geosynthetic materials i.e. GCL, geotextiles etc is covered in relevant sections of the CQA Plan, with the test results from the testing Laboratory serving as records of the tests being performed.</p>

	<p>collection system drainage layer are conducted.</p>		<p>Wrinkle height to width ratio of <math>H &lt; 2W</math> (Page 28) to be maintained with the maximum height restriction of 6cm for wrinkles. <u>Please see excerpt Section 4.6.2 below.</u></p> <p>j) Wrinkles caused by panel placement or thermal expansion should be minimised in accordance with Section 4.7b.11 at all times. Wrinkle heights should not exceed 2 times the width of the wrinkle (i.e. <math>H &lt; 2W</math>), furthermore the maximum wrinkle height to be 60mm and 200mm in width will be permitted. Should the wrinkle exceed this (during the time stipulated for placement of the cover material), remedial measures indicated by the CQA Engineer must be performed prior to placement of the cover material.</p> <p>Visual Method and Soil Classification for drainage/ Leachate Collection System covered in the CQA Plan Table 5 on page 66 i.e. sieve analysis, aggregate crushing values and flakiness index. During construction all visual observations to be conducted by the CQA Officer to ensure LCS conforms to design requirements. Hydraulic Conductivity testing on LCS layer is not necessary due to the nature and function of the layer that is naturally permeable and in accordance to NEMWA Regulation 636 of 2013 (Wasteful Expenditure).</p> <p>No amendment of CQA Plan is required in this regard.</p>
2.12	<p>Middelwater Resource Facility (Pty) Ltd must provide a comprehensive motivation demonstrating the need and desirability for the proposed Class B landfill site instead of a Class D landfill site.</p>	<p>Owner/ Envitech</p>	<p>Private funds being utilised.</p> <p>Greater protection to the environment preferred, and design in accordance with to R636 for General Waste.</p>

2.13	Given the existence of cemeteries in proximity to the proposed site and the associated activities, as well as the absence of comments from the Provincial Heritage Resources Authority in the final EIR, Middelwater Resource Facility (Pty) Ltd must commission and provide an archaeological and heritage study.	EAP	<b>EAP to address</b>
2.14	All comments submitted by registered interested and affected parties must be comprehensively and properly addressed. Where specific comments or objections could not be addressed, the amended documents must clearly indicate this and provide well motivated reasons for the inability to address such issues.	EAP	<b>EAP to address</b>
2.15	All additional comments received, together with the corresponding responses, must be submitted as part of the amended documents.		<b>EAP to address</b>
2.16	The above-mentioned amended documents must be submitted to the Department within <b>ninety (90) days</b> from the date of signature of this letter.	EAP Envitech	EAP to submit

## 9. SCHEDULE OF DRAWINGS (ADDENDUM DRAWINGS)

The following drawings (A3 size) are included in Appendix A whereas a set of A2 size drawings are bound into a separate "Book of Design Drawings":

<b>Drawing Number:</b>	<b>Revision</b>	<b>Drawing Title</b>
755-2022-000	B	Schedule of Drawings
755-2022-007	B	Cell 1 Excavation Layout Plan
755-2022-008	B	Cell 1 Sections
755-2022-009	B	Landfill Typical Liner Details
755-2022-013	B	General Leachate Management Plan
755-2022-014	B	Leachate Management Typical Details
755-2022-017	B	Leachate Dam Typical Details (2 sheets)
755-2022-018	B	Stormwater Management Layout and details (2 sheets)
755-2022-020	B	Contaminated Stormwater Dam Details (2 sheets)
755-2022-021	B	Dams Spillway Details
755-2022-022	B	Leachate dam pipe penetration details

## 10. REPORT SIGNATURE

---

**BL Jewaskiewitz (PrEng ECSA 20170189)**

Envitech Solutions (Pty) Ltd

27 January 2026

Job No.755-2022

## 11. REFERENCES

1. **Geological Survey**, 1981. 1:250 000 scale geological map 2526 Rustenburg. Council for Geoscience, Pretoria.
2. **Report on the Geological, geotechnical and geohydrological investigation of the Multisand Site for a proposed regional waste disposal facility – Gauteng Province**, Report no. 6410-JD/01, November 2014. JD Geotechnical Services.
3. **Environmental Impact Assessment and Environmental Management Programme**. 15 January 2017 (reviewed 2021) by HMS.
4. **Minimum Requirements for Waste Disposal by Landfill. Second Edition**. Department of Water Affairs and Forestry, Pretoria. (Waste Management Series.1998).
5. **Multisand Regional Waste Disposal Facility: Preliminary Design Report**, Report No. 60326779/02 January 2015, AECOM SA (Pty) Ltd.
6. **RECORD OF DECISION/ REQUEST FOR ADDITIONAL INFORMATION ON THE DETAILED DESIGN DRAWING REPORT FOR THE PROPOSED DEVELOPMENT OF THE MIDDELWATER GENERAL WASTE RESOURCE FACILITY LOCATED ON PORTION MIDDELWATER 593JQ, VISSERSHOEK 435JQ, WILDEBEESTHOEK 310JR WITHIN THE CITY OF TSHWANE METROPOLITAN MUNICIPALITY**, Reference No. GAUT 002/23-24/W0028, 28 November 2025 Gauteng Department of Environment.
7. **National Norms and Standards** as published in Government Gazette: Notices 634, 635 and 636 of 2013

## APPENDIX A

**Letter Reference No. GAUT 002/23-24/W0028, 28 November  
2025 Gauteng Department of Environment**



## GAUTENG PROVINCE

ENVIRONMENT  
REPUBLIC OF SOUTH AFRICA

**Enquiries:** Ms. Khensani Mahatlani  
**Directorate:** Pollution and Waste Management  
**Telephone:** +27 (0)11 240 3155  
**Email:** [Khensani.Mahatlani@gauteng.gov.za](mailto:Khensani.Mahatlani@gauteng.gov.za)  
**Reference No.:** Gaut 002/23-24/W0028

Ms. San Oosthuizen  
EcoPartners (Pty) Ltd  
P. O. Box 73513  
Fairland  
Johannesburg  
2030

Email: [san@ecopartners.co.za](mailto:san@ecopartners.co.za)

Dear Ms. Oosthuizen,

**RE: REQUEST FOR ADDITIONAL INFORMATION ON THE DETAIL DESIGN DRAWING REPORT FOR THE PROPOSED DEVELOPMENT OF THE MIDDELWATER GENERAL WASTE RESOURCE FACILITY LOCATED ON PORTION MIDDELWATER 593 JQ, VISSERSHOEK 435 JQ, WILDEBEESTHOEK 310 JR WITHIN THE CITY OF TSHWANE METROPOLITAN MUNICIPALITY**

The Middelwater Resource Facility (Pty) Ltd proposed new lining cell for the Middelwater Landfill Development, phase 1 (Cells 1 to 6) dated February 2023 as recorded in the report titled, Environmental Impact Report and Environmental Management Programme dated 22 August 2024, in support of the Middelwater Waste Management Licence Application (Previously known as the Multisand application), received by the Department on 27 September 2024, and the additional information received by the Department on 18 October 2024, has reference.

Please be advised that based on the technical assessment of the submitted documents for the proposed development of the Middelwater Resource Facility (Pty) Ltd Class B landfill site (Cell 1 to Cell 6) and Associated Works Detail Design Report (Reference: 755-2022) compiled by Envitech Solutions (Pty) Ltd and signed by K.P. Mutolovich (PrEng #20190729), the Department has decided to request for additional information.

**1. Aspects and Reports taken into consideration.**

- 1.1 The Environmental Impact Assessment Report and Environmental Management Programme for Comment in support of the Middelwater Resource Facility (Pty) Ltd Waste Management Licence Application

- (Previously known as Multisand application) Middelwater Resource Facility (Pty) Ltd Volume 1b of 4, with reference 002/23-24/W0028, undated, including the following appendices:
- 1.1.1 Appendix 1 - CVs and Certificates.
  - 1.1.2 Appendix 2 - Envitech Design Report, Checklist and Drawings (no design report submitted; it's a Construction Quality Assurance (CQA) Plan).
  - 1.1.3 Appendix A - Drawings.
  - 1.1.4 Appendix B - CQA Plan (which just includes an Appendix A- Lining Specifications).
  - 1.1.5 Appendix C - Calculations.
  - 1.1.6 Appendix D - Geohydrology Report.
  - 1.1.7 Appendix 3 - Envitech Operational Manual.
- 1.2 MBHE Environmental (Pty) Ltd Middelwater Landfill Development proposed Middelwater Class B Waste Facility Design Report with reference 755-2022, dated February 2023, compiled by Envitech Solutions (Pty) Ltd, signed by K.P. Mutolovich PrEng#20190729.
- 1.3 Drawings: Twenty-two (22) A3 signed drawings (signed by K.P. Matulovich PrEng #20190729): Hydrogeological Investigation:
- 1.3.1 755-2022-001 Rev A Schedule of Drawings.
  - 1.3.2 755-2022-002 Rev A General Survey and Farm Portions.
  - 1.3.3 755-2022-003 Rev A Site Infrastructure Layout.
  - 1.3.4 755-2022-004 Rev A General Cell Layout Plan.
  - 1.3.5 755-2022-005 Rev A Phase 1 Layout Plan.
  - 1.3.6 755-2022-006 Rev A Phase 1 Sections.
  - 1.3.7 755-2022-007 Rev A Cell 1 Excavation Layout Plan.
  - 1.3.8 755-2022-008 Rev A Cell 1 Sections.
  - 1.3.9 755-2022-009 Rev A Landfill Typical Liner Details.
  - 1.3.10 755-2022-010 Rev A Phase 1 Fill Model.
  - 1.3.11 755-2022-011 Rev A Phase 1 Fill Model Sections.
  - 1.3.12 755-2022-012 Rev A Site Complete Fill Model and Capping General Layout Plan.
  - 1.3.13 755-2022-013 Rev A General Leachate Management Plan.
  - 1.3.14 755-2022-014 Rev A Leachate Management Typical Details (Entire Site).
  - 1.3.15 755-2022-015 Rev A Leachate Dam Layout Plan.
  - 1.3.16 755-2022-016 Rev A Leachate Dam Sections.
  - 1.3.17 755-2022-017 Rev A Leachate Dam Typical Details.
  - 1.3.18 755-2022-018 Rev A Stormwater Dam Layout.
  - 1.3.19 755-2022-019 Rev A Contaminated Stormwater Dam Layout.
  - 1.3.20 755-2022-020 Rev A Contaminated Stormwater Dam Details Sheet 1 of 2.
  - 1.3.21 755-2022-020 Rev A Contaminated Stormwater Dam Details Sheet 2 of 2.
  - 1.3.22 755-2022-021 Rev A Dams Spillway Details.
- 1.4 The Gauteng Department of Agriculture and Rural Development now known as the Gauteng Department of Environment Checklist, signed for the Applicant by Gert van Rensburg (17 September 2024) and for the Engineer by KP Matulovich PrEng #20190729 (20 February 2023).
- 1.5 The Department of Water and Sanitation Directorate Water Abstraction and In-stream Impact Geohydrology comments dated 12 March 2025.
- 1.6 The Department of Water and Sanitation Chief Directorate Engineering Services comments dated 27 June 2025.
- 1.7 The Department of Water and Sanitation Record of Decision with reference 16/2/7/A210/C346, dated 31 December 2015, issued to Multisand Regional Waste Disposal Facility (currently known as Middelwater Resource Facility (Pty) Ltd).

1.8 The Department of Water and Sanitation Record of Decision dated 31 July 2025, issued to Middelwater Resource Facility (Pty) Ltd (previously known as Multisand Regional Waste Disposal Facility).

## **2 Additional and/or Amendments Requested:**

- 2.1 Middelwater Resource Facility (Pty) Ltd must provide a flow diagram identifying the source and destination of clean stormwater runoff, polluted stormwater runoff, and leachate, recognising the change to runoff areas with time.
- 2.2 Middelwater Resource Facility (Pty) Ltd must confirm the adequacy of clean water conveyance systems to accommodate the 1:50 year, 24-hour flood event, including freeboard in accordance with the SANRAL drainage manual of 2013 prescripts.
  - This confirmation of adequate capacity must be included in the amended documents and submitted to the Department.
- 2.3 For both the polluted storm water runoff and the leachate storage systems (including leachate dam and contaminated stormwater dam and associated conveyance systems), Middelwater Resource Facility (Pty) Ltd must demonstrate the storage capacity to meet or exceed the 1 in 50-year 24-hour storm capacity (using updated rainfall records) for active cells, unless it can be shown that a smaller volume is accepted noting that the Middelwater Resource Facility (Pty) Ltd remains responsible for clean-up of all spill events.
  - The demonstration must be included in the amended documents and submitted to the Department.
- 2.4 Middelwater Resource Facility (Pty) Ltd must provide a general layout arrangement drawing for the leachate collection system (LCS) and the underdrainage pipe collection system.
  - These drawings must clearly illustrate the alignment, component details, and connectivity of the systems.
  - The signed design drawing must be submitted to the Department for approval.
- 2.5 Middelwater Resource Facility (Pty) Ltd must confirm that the base preparation layer meets at least the minimum thickness requirements as stipulated in NEMWA Regulation 636 of 2013.
  - This confirmation must be attached to the amended documents and submitted to the Department.
- 2.6 Middelwater Resource Facility (Pty) Ltd must confirm that the veneer stability for the waste cell meets the factor of safety as reported in the design report, using actual materials (geosynthetics and natural) used in all the pollution control works.
  - The veneer stability should take cognisance of construction loading (vehicular) as well as give particular attention to the determination and selection of critical interface as the existing veneer stability analysis makes use of the geomembrane/geosynthetic clay liner interface rather than geomembrane/geotextile or other potentially more critical interface.
  - This confirmation must be attached to the amended documents and submitted to the Department.
- 2.7 Middelwater Resource Facility (Pty) Ltd must confirm the veneer stability of the barrier system using actual materials used in the pollution control works to meet or exceed a factor of safety of 1.5, taking construction and operational loading into account.
  - The written confirmation must be attached to the amended documents and submitted to the Department.
- 2.8 Middelwater Resource Facility (Pty) Ltd must demonstrate the adequacy of drainage pipes, including their joints, to maintain containment equivalent to the barrier system from point of

penetration of the liner system up to and including external leachate sumps and/or leachate storage facilities.

- 2.9 Middelwater Resource Facility (Pty) Ltd must develop a design drawing which details and confirms the continuity of containment for the separation of berm anchor trenches between successive waste cells.
- The design drawing must be submitted to the Department for approval, together with the amended documents.
- 2.10 Middelwater Resource Facility (Pty) Ltd must develop a design drawing which details and confirms the continuity of containment for the proposed contaminated stormwater channels.
- The design drawing must be submitted to the Department for approval, together with the amended documents.
- 2.11 The construction quality assurance (CQA) plan must be amended to include a record of the nature and extent of wrinkles in geomembranes, records of geomembrane temperature at time of welding and placement of cover material, records of wedge weld thickness of samples taken for destructive testing and records of independent testing of other geosynthetic materials (such as geosynthetic clay liners, geotextile cushion layers, geodrains and geopipes) and in accordance with advances in technology and accepted engineering practice, as well as the following:
- The CQA must be amended to ensure that the maximum wrinkle height may not exceed half of the width, with a maximum wrinkle height of 6 cm.
  - The CQA must be amended to ensure that hydraulic conductivity and Visual-Method Soil Classification for construction testing of the drainage gravel layer and leachate collection system drainage layer are conducted.
- 2.12 Middelwater Resource Facility (Pty) Ltd must provide a comprehensive motivation demonstrating the need and desirability for the proposed Class B landfill site instead of a Class D landfill site.
- 2.13 Given the existence of cemeteries in proximity to the proposed site and the associated activities, as well as the absence of comments from the Provincial Heritage Resources Authority in the final EIR, Middelwater Resource Facility (Pty) Ltd must commission and provide an archaeological and heritage study.
- 2.14 All comments submitted by registered interested and affected parties must be comprehensively and properly addressed. Where specific comments or objections could not be addressed, the amended documents must clearly indicate this and provide well motivated reasons for the inability to address such issues.
- 2.15 All additional comments received, together with the corresponding responses, must be submitted as part of the amended documents.
- 2.16 The above-mentioned amended documents must be submitted to the Department within **ninety (90) days** from the date of signature of this letter.

Should you have any enquiries regarding this letter, please contact Ms. Khensani Mahatlani on the contact details given above.

Kind regards,



**Ms. P Mathibeli**  
**Director: Pollution and Waste Management**  
**Date:** 28/11/2025

CC:

Middelwater Resource Facility (Pty) Ltd

Attn: Mr. G. van Rensburg  
Email: [geri@multisand.co.za](mailto:geri@multisand.co.za)

GDEnv: Compliance and Monitoring

Attn: Mr S. Skosana  
Email: [Sandile.Skosana@gauteng.gov.za](mailto:Sandile.Skosana@gauteng.gov.za)

GDEnv: Compliance Monitoring

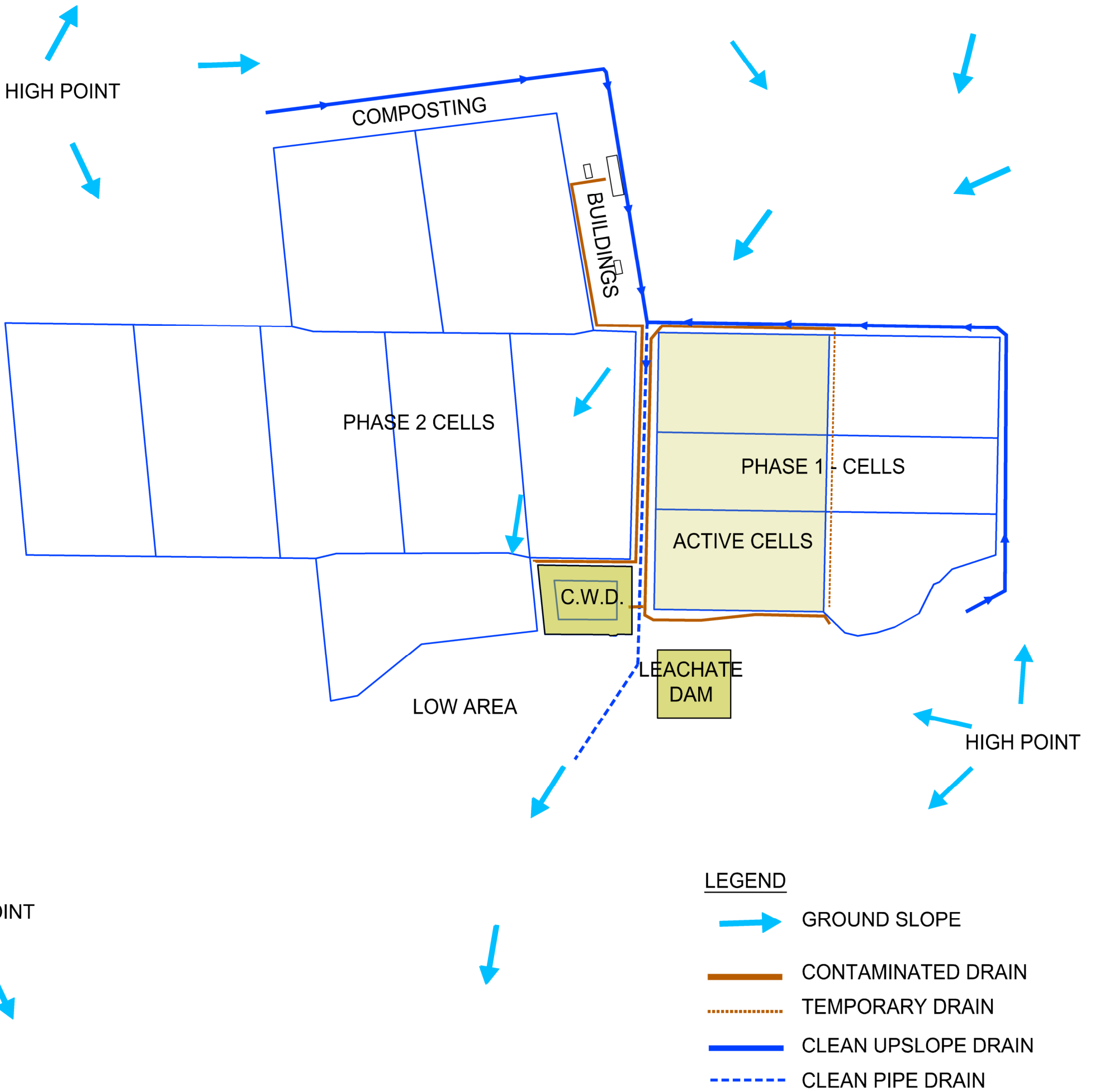
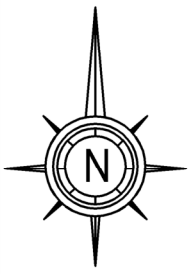
Attn: Ms. S. Sekhotha  
Email: [Sasa.Sekhotha@gauteng.gov.za](mailto:Sasa.Sekhotha@gauteng.gov.za)

GDEnv: Pollution and Waste Management

Attn: Ms. L. Lukhele  
Email: [Lerato.Lukhele@gauteng.gov.za](mailto:Lerato.Lukhele@gauteng.gov.za)


## **APPENDIX B**

**Drawings A3 size**



**DRAINAGE STAGE 1 FLOW DIAGRAM**

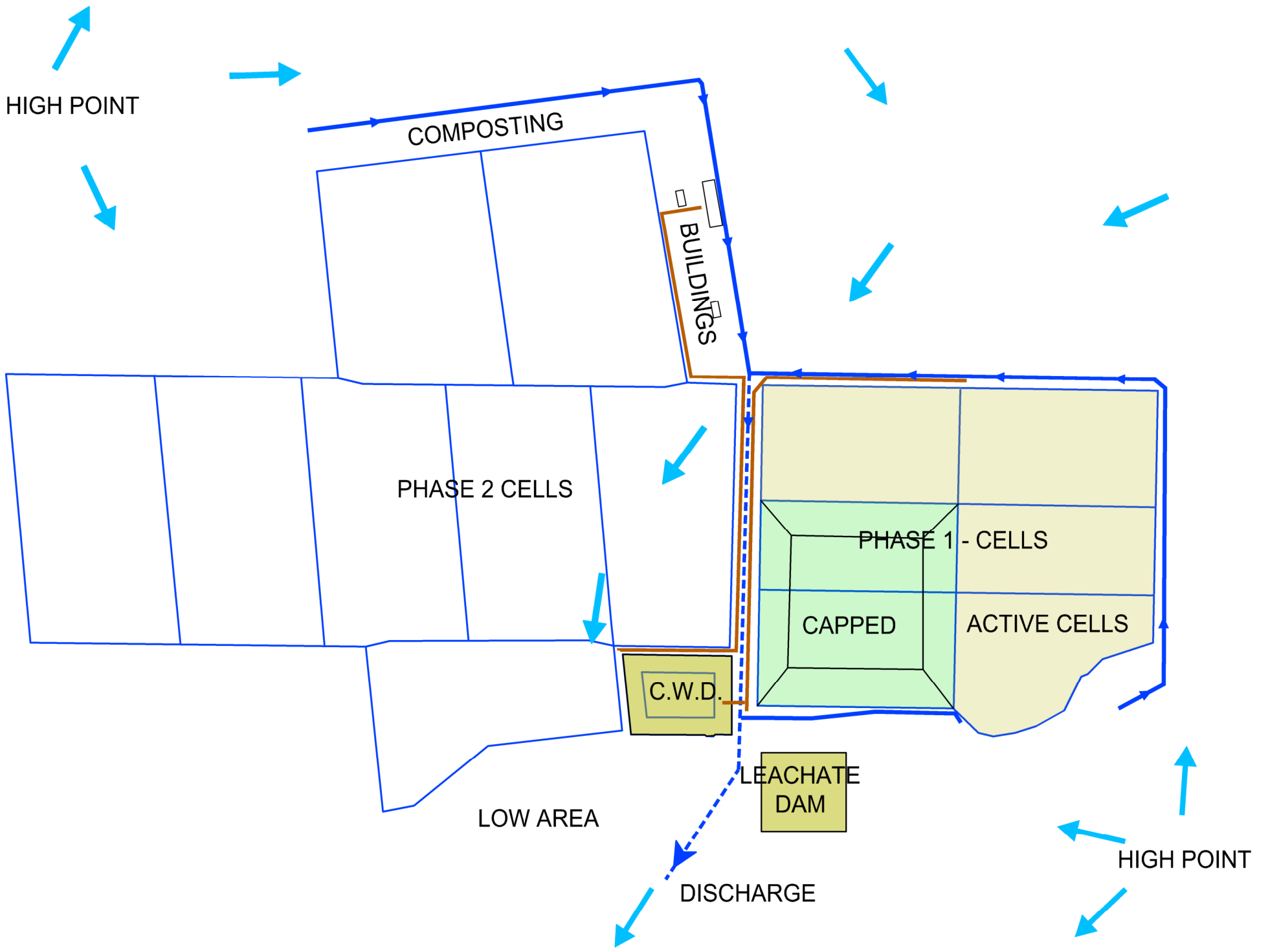
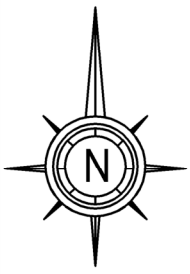


  
 B.L. JEWASKIEWITZ  
 Pr. Eng. 20170189  
 DATE:.....16/01/26



DRAWING TITLE:  
**MIDDELWATER RESOURCE FACILITY  
 SURFACE DRAINAGE SHEET 1**

OWNER:	BY	DATE
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DESIGNED	MM	16.01.26
CHECKED / REVIEW	BLJ	16.01.26
SCALE	AS SHOWN	SHEET SIZE
		A4
DRAWING No.	755-2022-SK01	
	REVISION	
	0	



**LEGEND**

- GROUND SLOPE
- CONTAMINATED DRAIN
- TEMPORARY DRAIN
- CLEAN UPSLOPE DRAIN
- CLEAN PIPE DRAIN

**DRAINAGE STAGE 2 FLOW DIAGRAM**

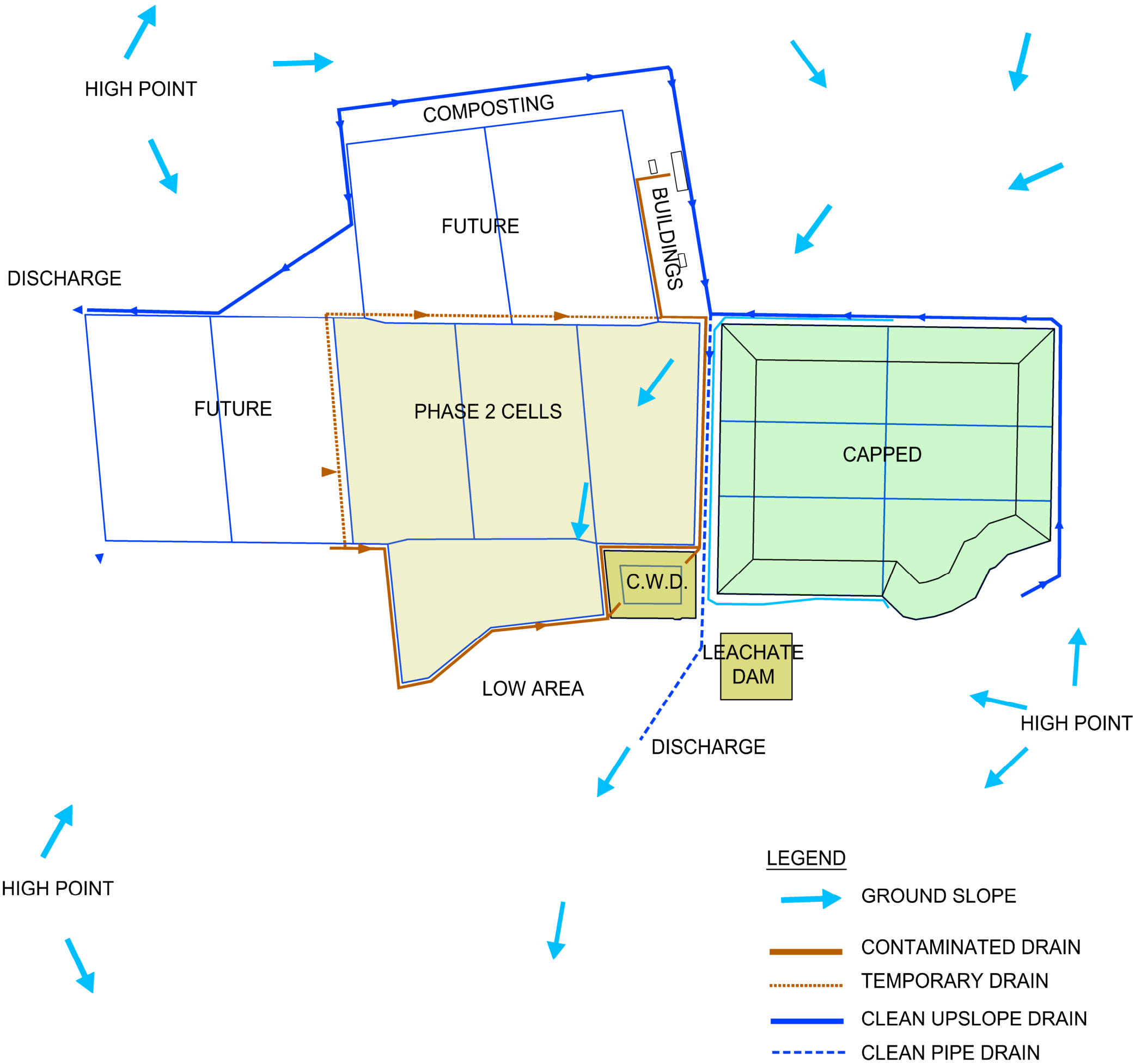
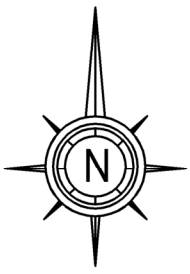


B.L. JEWASKIEWITZ  
 Pr. Eng. 20170189  
 DATE:.....16/01/26




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DESIGNED	MM	16.01.26
CHECKED / REVIEW	BLJ	16.01.26
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DRAWING No.	755-2022-SK02	
	REVISION	
	0	



**DRAINAGE STAGE 3 FLOW DIAGRAM**

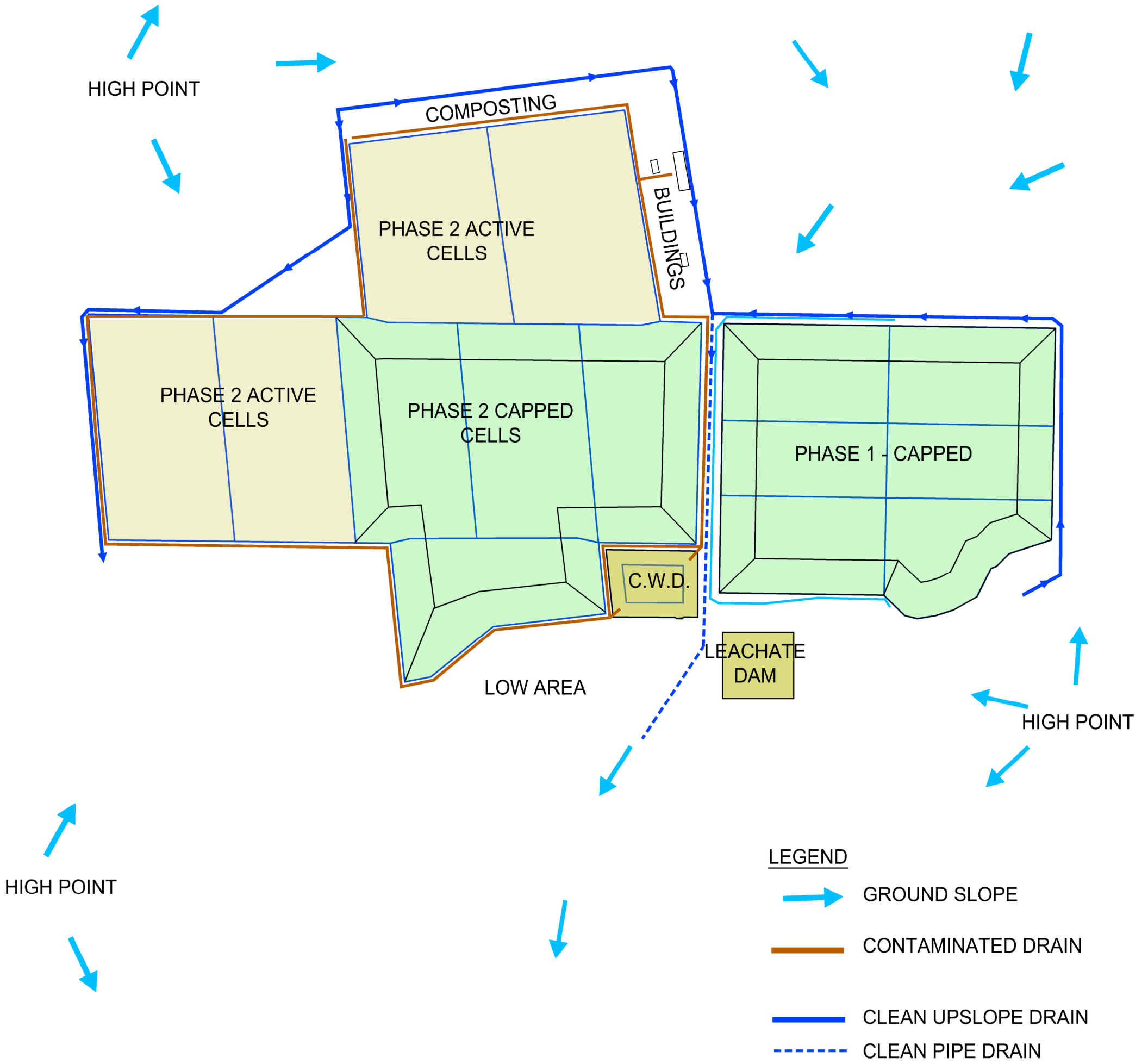
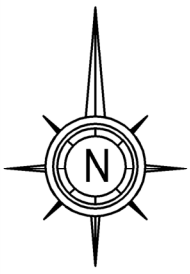


  
 B.L. JEWASKIEWITZ  
 Pr. Eng. 20170189  
 DATE:.....16/01/26



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 SURFACE DRAINAGE SHEET 3**

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DESIGNED	MM	16.01.26
CHECKED / REVIEW	BLJ	16.01.26
SCALE	AS SHOWN	SHEET SIZE
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DRAWING No.	755-2022-SK03	
	REVISION	
	0	



**LEGEND**

- GROUND SLOPE
- CONTAMINATED DRAIN
- CLEAN UPSLOPE DRAIN
- CLEAN PIPE DRAIN

**DRAINAGE STAGE 4 FLOW DIAGRAM**

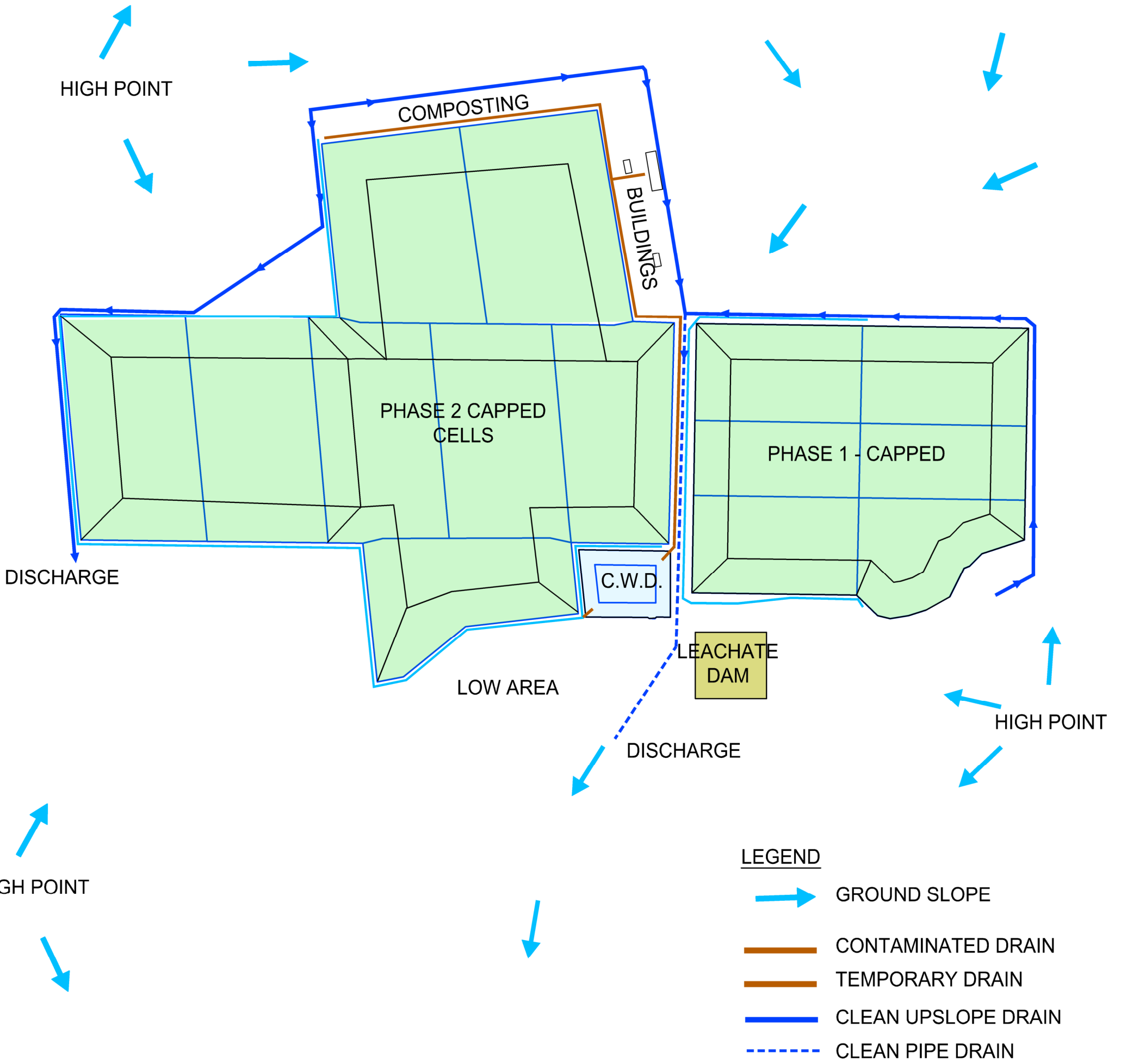
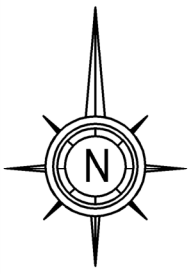


B.L. JEWASKIEWITZ  
 Pr. Eng. 20170189  
 DATE:.....16/01/26




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DESIGNED	MM	16.01.26
CHECKED / REVIEW	BLJ	16.01.26
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DRAWING No.	755-2022-SK04	
	REVISION	
	0	



**DRAINAGE STAGE 5 FLOW DIAGRAM**



  
 B.L. JEWASKIEWITZ  
 Pr. Eng. 20170189  
 DATE:.....16/01/26



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**MIDDELWATER RESOURCE FACILITY  
 SURFACE DRAINAGE SHEET 5**

OWNER:	BY	DATE
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DESIGNED	MM	16.01.26
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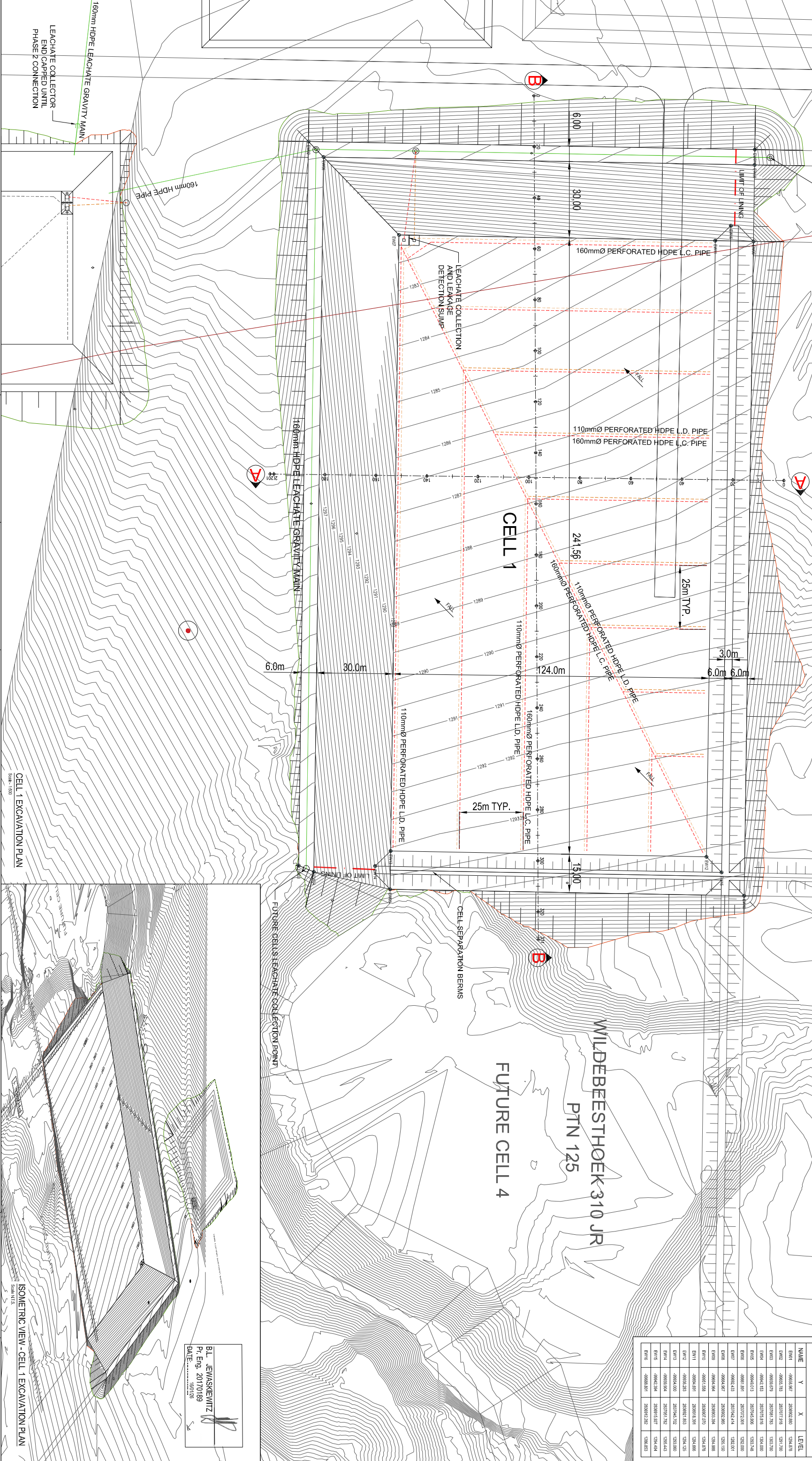
FUTURE CELL 2

PHASE 1

FUTURE CELL 5

WILDBEESTHOEK 310 JR  
PTN 125

FUTURE CELL 4



**LEGEND:**

- LANDFILL FOOTPRINT
- CELL SEPARATION BERMS
- LEACHATE DRAINS
- LEACHATE COLLECTOR PIPES

**CELL SETTING OUT DATA**

NAME	Y	X	LEVEL
EM01	49984.847	283802.300	1264.83
EM02	49984.833	283817.718	1261.70
EM03	49984.829	283831.733	1263.700
EM04	49984.833	283875.816	1264.000
EM05	49984.833	283914.906	1263.14
EM06	49984.831	283932.211	1262.00
EM07	49984.833	283942.514	1262.00
EM08	49984.837	283892.866	1263.150
EM09	49984.834	283803.344	1264.888
EM10	49984.831	283807.270	1264.93
EM11	49984.831	283803.131	1264.888
EM12	49984.833	283867.853	1264.15
EM13	49984.830	283934.572	1263.000
EM14	49984.804	283931.382	1263.443
EM15	49984.234	283891.527	1264.44
EM16	49984.801	283891.282	1263.83

NO.	DATE	APPROVED	DESCRIPTION
A	21-11-2022	KPM	ISSUED FOR LICENSING
B	16-01-2026	BLJ	LEACHATE AND LEAKAGE COLLECTION PIPES SHOWN

DESIGNED	DESIGN CHECKED	ENGINEER
KPM	MM	Pt. Eng. 20170189

DATE	CLIENT
16 JAN. 2026	

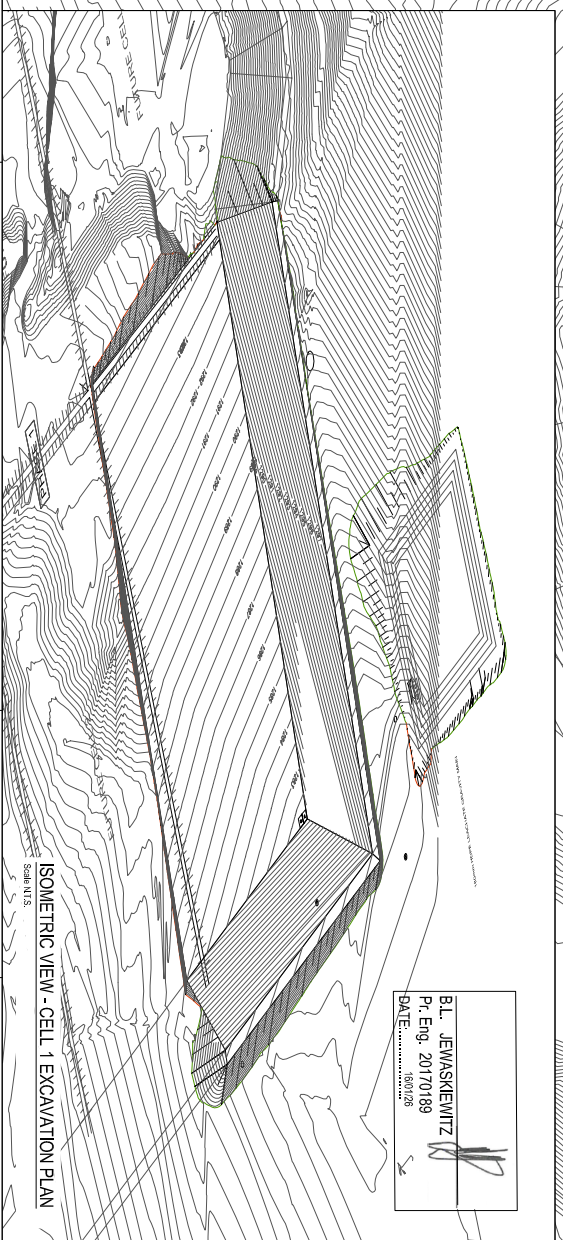
**envitech solutions**

22 Swettenham Avenue  
Bentong, 3501  
Selat Petai, 3510  
Sungai Besi, 3510  
Tel: +27 11 425 2816  
Fax: +27 11 425 2855  
info@envitech.co.za

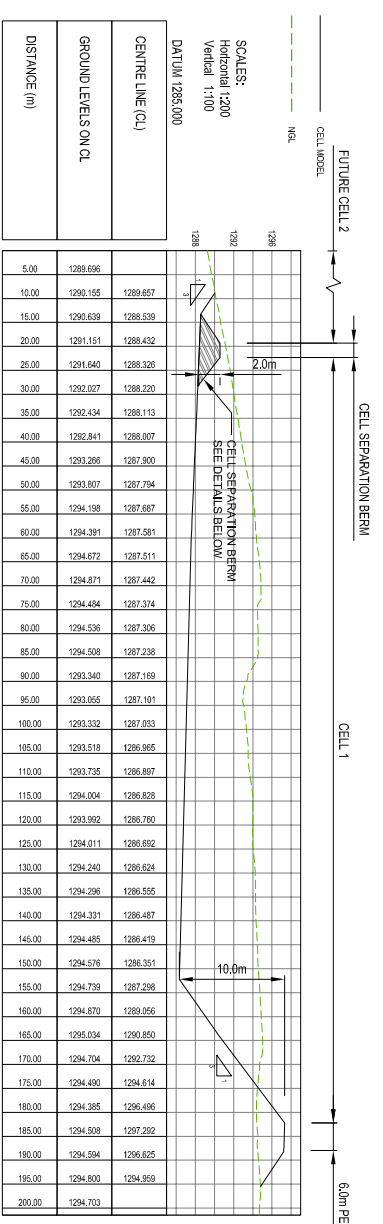
**MBHE ENVIRONMENTAL (PTY) LTD**

1100/241 Bhebe  
1100/241 Bhebe  
Bhebe, 3510  
Gillies, 3510  
Tel: +27 11 425 2816  
Fax: +27 11 425 2855  
info@mbhe.co.za

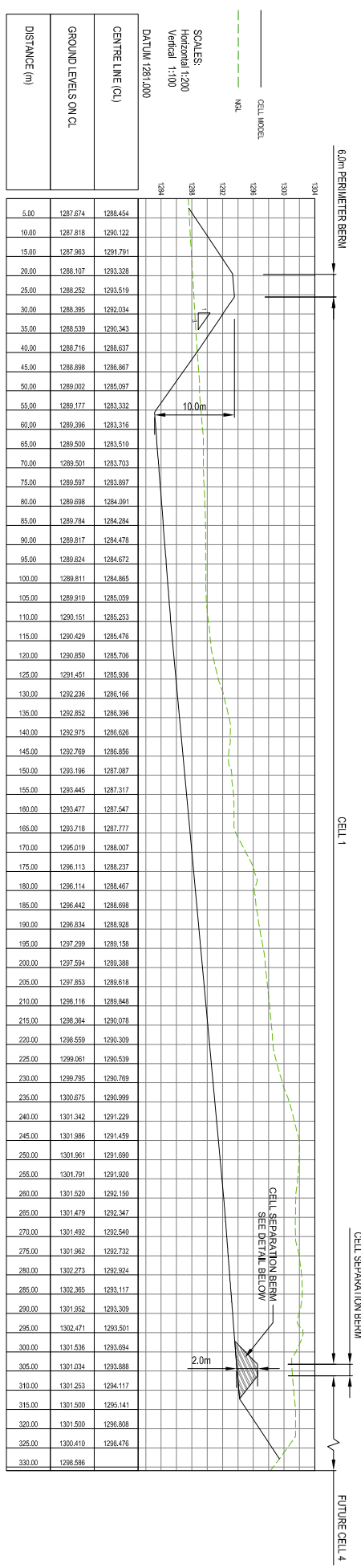
PROJECT TITLE	SCALE
MIDDELWATER RESOURCE FACILITY	AS SHOWN



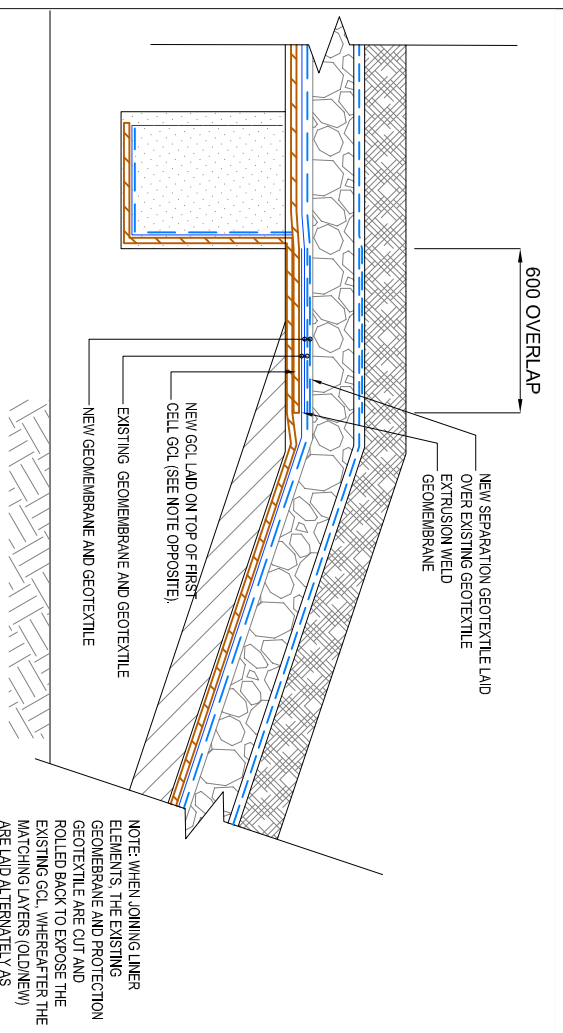
BL. JEWASKIEWITZ  
Pt. Eng. 20170189  
DATE: 16/01/2026



SECTION A-A  
FROM 0.000 TO 201.493

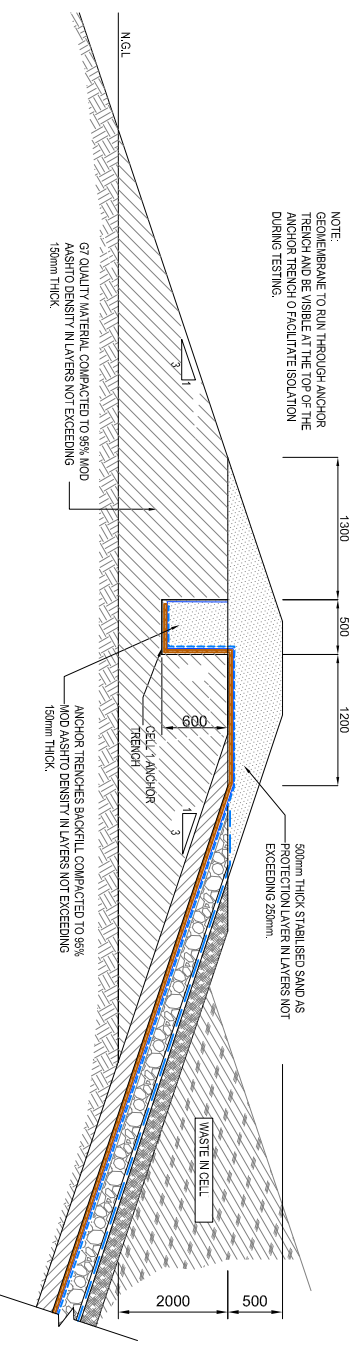


SECTION B-B  
FROM 0.000 TO 330.928



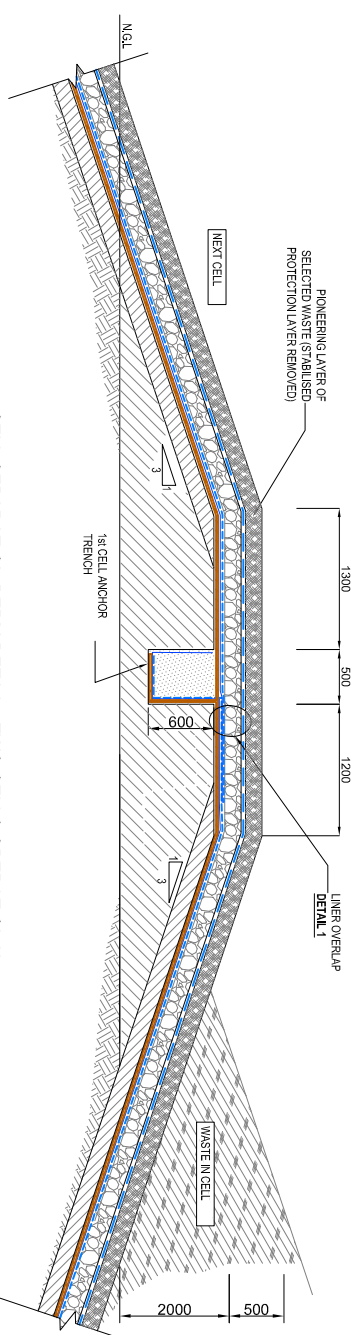
DETAIL 1 - SEPARATION BERM LINER OVERLAP  
EXISTING LINER LAYERS CONNECTED TO NEW LINER LAYERS  
SCALE 1:10

NOTE: WHEN JOINING LINER ELEMENTS, THE EXISTING GEOMEMBRANE AND PROTECTION GEOTEXTILE ARE CUT AND ROLLED BACK TO EXPOSE THE EXISTING GCL. WHEREAFTER THE MATCHING LAYERS (OLD/NEW) ARE LAID ALTERNATIVELY AS SHOWN.



CELL SEPARATION BERM DETAIL  
SCALE 1:25

NOTE:  
GEOMEMBRANE TO RUN THROUGH ANCHOR TRENCH AND BE VISIBLE IN THE TOP OF THE ANCHOR TRENCH TO FACILITATE ISOLATION DURING TESTING.



CELL SEPARATION BERM DETAIL - TWO CELLS OPERATIONAL  
SCALE 1:25

NO.	DATE	APPROVED	DESCRIPTION	DESIGNED	ENGINEER
A	21-11-2022	KPM	ISSUED FOR LICENSING	KPM	Pt. Eng. 20170189
B	16-01-2028	BLJ	SEPARATION BERM DETAILS SHOWN	KPM	DATE: 16 JAN. 2028

CONSULTANT

27 Swartha Avenue  
Northmead, NSW 1591  
Tel: +27-11-465 2810  
Fax: +27-11-464 8555  
info@envitech.co.za

CLIENT

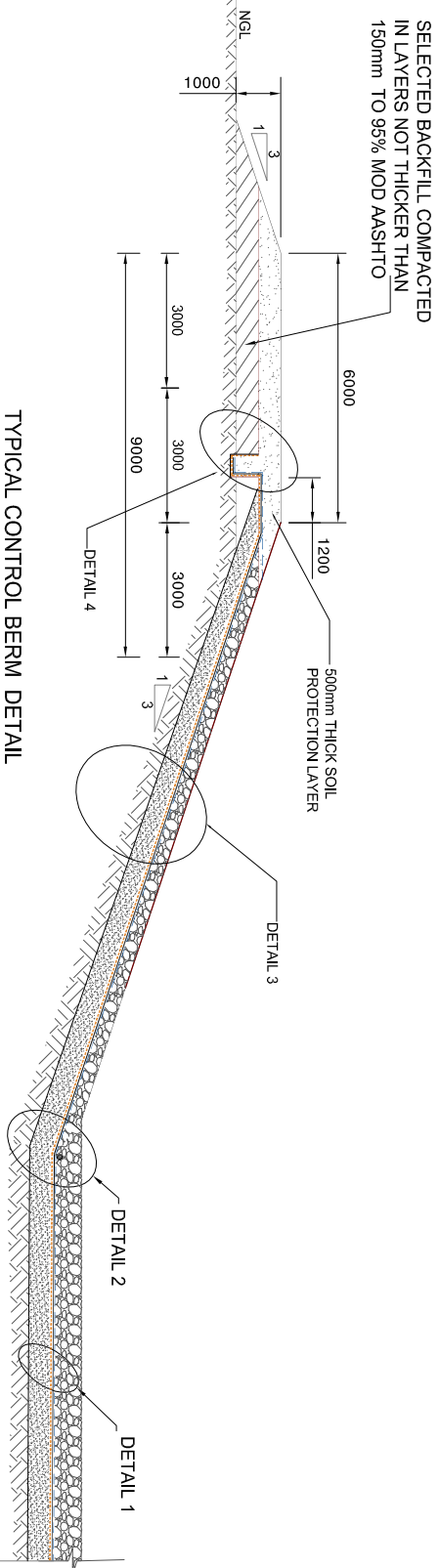
PROJECT TITLE	SCALE
MIDDELWATER RESOURCE FACILITY	AS SHOWN

DRAWING TITLE	SHEET NO.	DRAWING NO.
CELL 1 SECTIONS	1 OF 1	755 - 2022 - 008 - REV-B

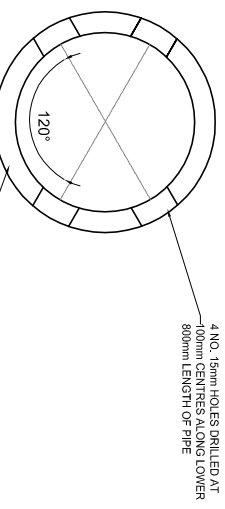
BL. JEMASKIEWITZ  
Pt. Eng. 20170189  
DATE: 16/01/28

LABEL	DESCRIPTION
1	WASTE BODY (1m PIONEERING WASTE LAYER)
2	WOVEN GEOTEXTILE MINIMUM NOMINAL MASS 200g/m <sup>2</sup> WITH MIN. THROUGHFLOW 50 l/s/m <sup>2</sup> UNDER 100mm HEAD.
3	300mm THICK STONE (22-34mm SIZE) LEACHATE DRAINAGE LAYER ON BASE AND 150mm THICK LAYER ON SIDE SLOPES
4	NEEDLE PUNCHED NON-WOVEN GEOTEXTILE MINIMUM NOMINAL MASS 1200g/m <sup>2</sup>
5	1.5mm HDPE GEOMEMBRANE LINER (SMOOTH ON BASE AND DOUBLE TEXTURED ON SIDE SLOPES)
6	3.7kg/m <sup>2</sup> GEOSYNTHETIC CLAY LINER
7	100mm SELECTED SANDY FILL LAYER COMPACTED TO 93% MOD AASHTO
8	150mm BASE PREPARATION LAYER COMPACTED TO 93% MOD AASHTO

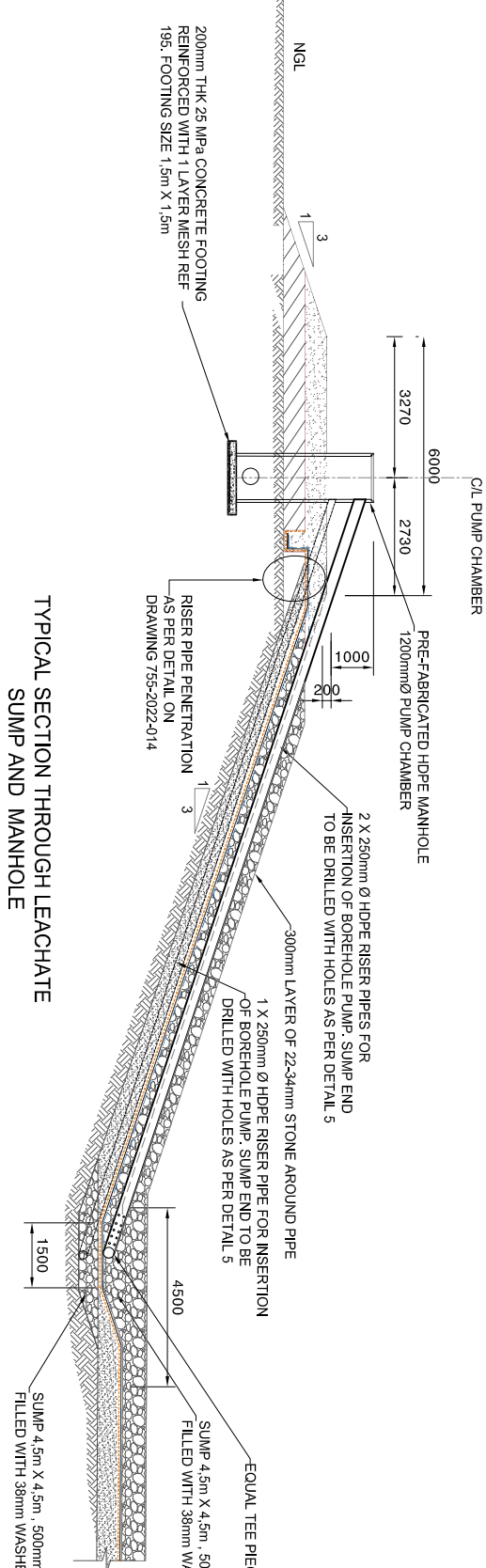
DETAIL 1  
GENERAL LANDFILL CONTAINMENT BARRIER SYSTEM (CLASS B) - ON BASE  
SCALE 1:20



TYPICAL CONTROL BERM DETAIL  
1:100

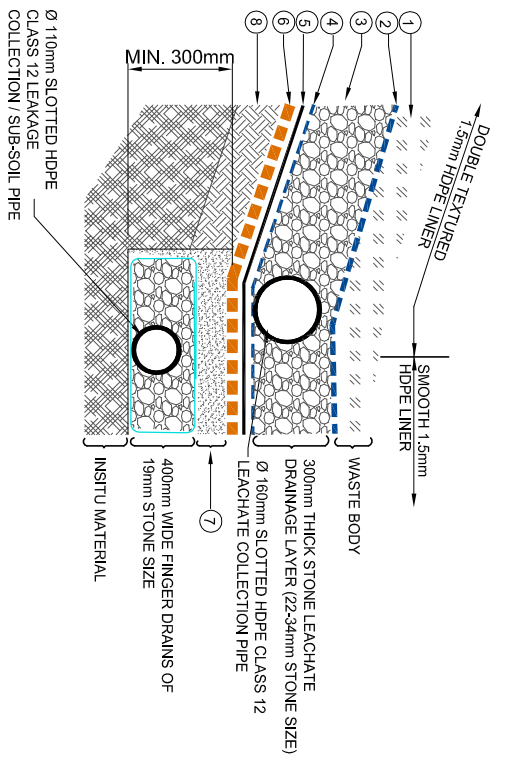


SECTION THROUGH LEACHATE SUMP RISER PIPE



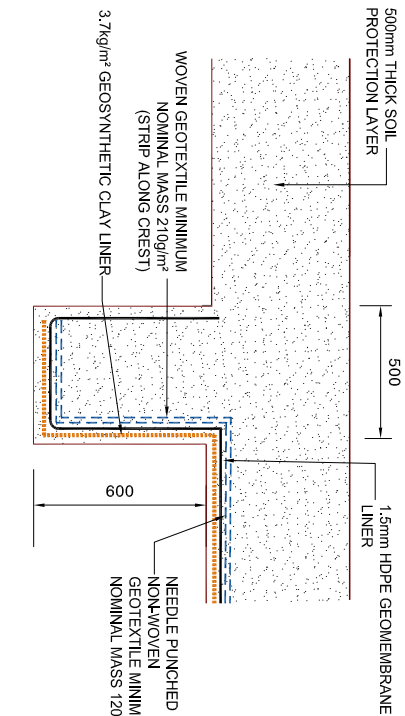
TYPICAL SECTION THROUGH LEACHATE SUMP AND MANHOLE  
1:100

DETAIL 2  
LANDFILL CONTAINMENT BARRIER SYSTEM SLOPING & HORIZONTAL LINER INTERFACE N.T.S.

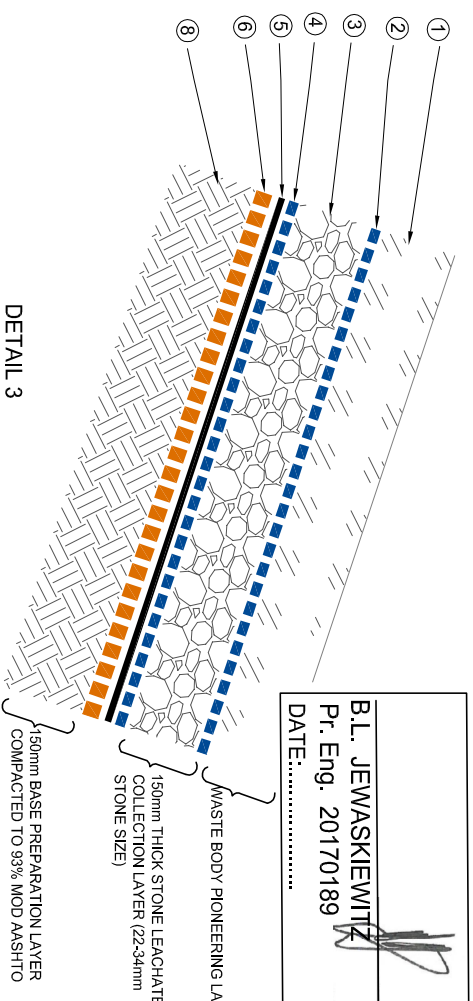


LANDFILL CONTAINMENT BARRIER SYSTEM LAYER WORKS CONFIGURATION AROUND PIPES  
N.T.S.

DETAIL 4  
ANCHOR TRENCH DETAIL



DETAIL 3  
GENERAL LANDFILL CONTAINMENT BARRIER SYSTEM (CLASS B) - ON SIDE SLOPE  
SCALE 1:20



NO.	DATE	APPROVED	SUBMITTAL	REVISION	DESIGNED	ENGINEER	CLIENT
A	10/10/2022	KPM	BLJ	ISSUED FOR CLIENT APPROVAL	MM	P. Eng. 20170189	
B	16/01/2026	KPM	BLJ	BASE PREPARATION LAYER SHOWN AS 200mm THICK	MM	16 JAN. 2026	

**envitech** solutions

22 Sawmill Avenue  
Nedlerville, 1501  
Stellenbosch, 7600  
Tel: +27-11-426 2810  
Fax: +27-11-426 4731  
info@envitech.co.za

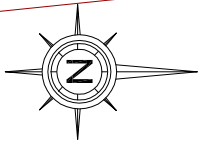
**MBHE** ENVIRONMENTAL (PTY) LTD

Unit B1 Mayfield Park  
2 Mayfield Park  
Glenelg, 5810  
Stellenbosch, 7600  
Tel: +27-21-423 9880  
Fax: +27-11-426 4731  
brenden@mbhe.co.za

PROJECT TITLE	SCALE
MIDDELWATER RESOURCE FACILITY	AS SHOWN

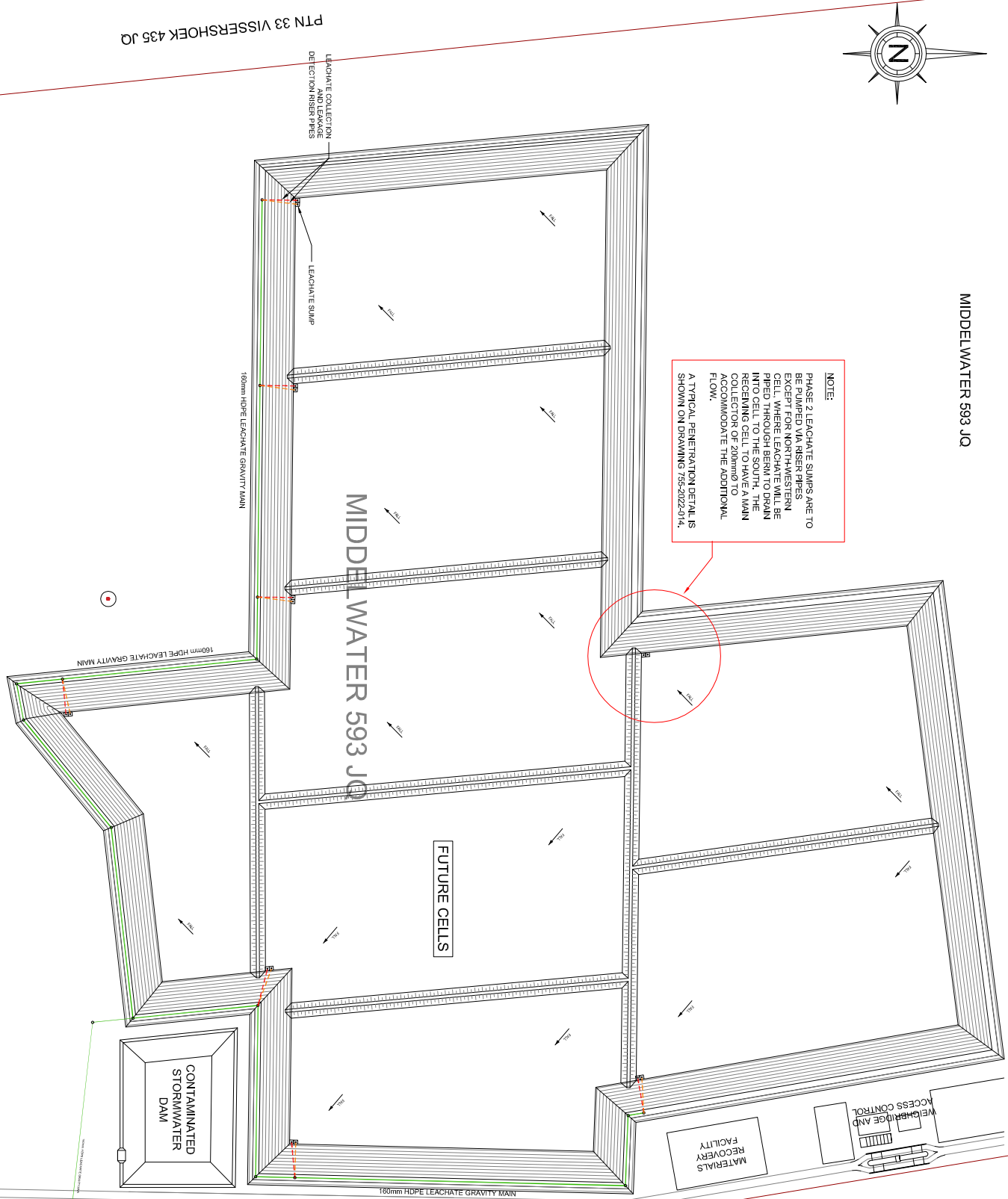
DRAWING TITLE	SHEET NO.	JOB NUMBER	DATE
LANDFILL CELLS LINER TYPICAL DETAILS	1	ES755-2022	755-2022-009 REV B

B.L. JEWASKIEWITZ  
P. Eng. 20170189  
DATE: .....

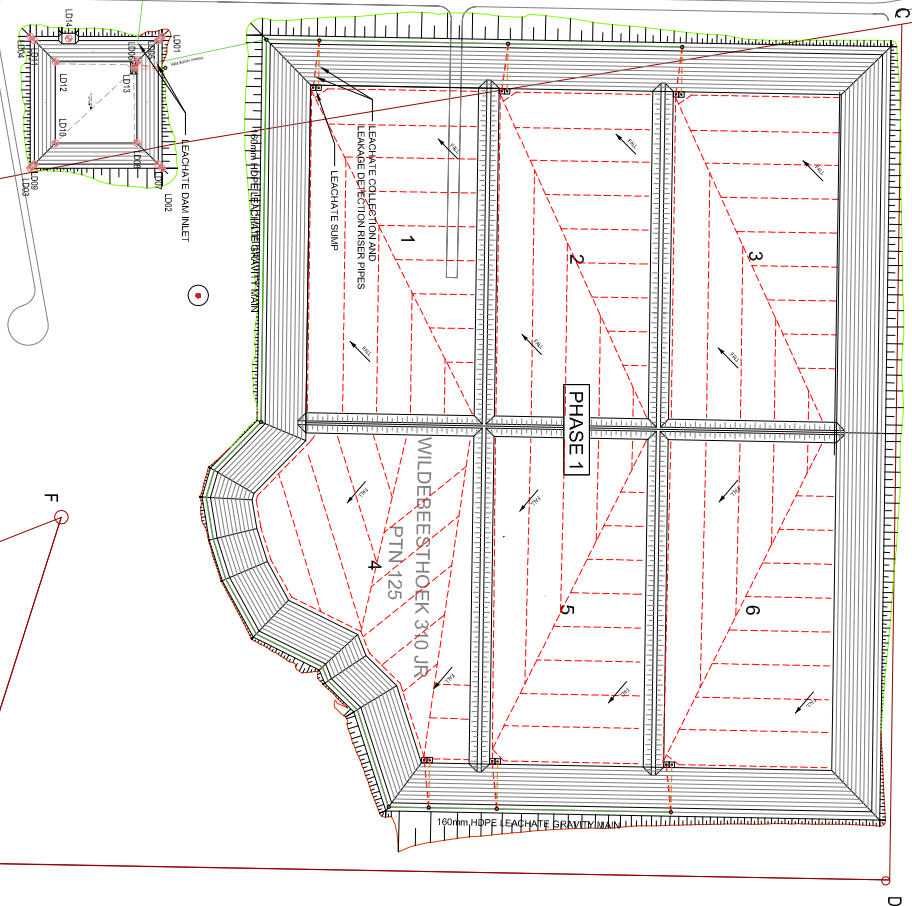


MIDDELWATER 593 JQ

**NOTE:**  
 PHASE 2 LEACHATE SUMPS ARE TO BE PROVIDED FOR ALL FUTURE CELLS EXCEPT FOR NORTHWESTERN CELL, WHERE LEACHATE WILL BE PIPED THROUGH BEAM TO DRAIN INTO CELL TO THE SOUTH, THE RECEIVING CELL TO HAVE A MAIN COLLECTOR OF 200mm Ø TO ALLOW FOR FUTURE ADDITIONAL FLOW.  
 A TYPICAL PENETRATION DETAIL IS SHOWN ON DRAWING 755-2022-014.



PTN 124 WILDEBEESTHOEK 310 JR



**LEGEND:**

	LANDFILL FOOTPRINT
	CELL SEPARATION BERM
	CADASTRAL BOUNDARY
	LEACHATE RETICULATION PIPE
	LEACHATE COLLECTION RISER PIPE
	LEAKAGE DETECTION RISER PIPE
	LEACHATE MANHOLE

**NOTE:**  
 1. PHASE 2 LEACHATE COLLECTORS (180mm Ø) TO BE SPACED AT 25m AND TO BE FINISHED TO PHASE 1 TO BE FINALISED WITH UPDATED SURVEY AT THE TIME OF DEVELOPMENT.  
 2. LEACHATE DETECTION SYSTEM BELOW THE LINER MEMBRANE THE LEACHATE COLLECTION SYSTEM ABOVE IN 110mm Ø PIPES, DRAINING TO A SEPARATE SUMP.

NO.	DATE	APPROVED	DESCRIPTION	DESIGNED	ENGINEER
A	21-11-2022	KPM	ISSUED FOR LICENSING	KPM	Pr. Eng. 20170189
B	16-01-2026	BUJ	LEACHATE COLLECTORS SHOWN	BUJ	DATE: 16 JAN, 2026

**CONSULTANT**

22 Spierens Avenue  
 Belmont, 1011  
 South Africa  
 Tel: +27-11-4232810  
 Fax: +27-11-4232855  
 info@envitech.co.za

**CLIENT**

81 Myntekton Park  
 Gillies, 3510  
 South Africa  
 Tel: +27-11-484 3555  
 Fax: +27-11-484 3555  
 info@mbhe.co.za

**PROJECT TITLE**

MIDDELWATER RESOURCE FACILITY

**DRAWING TITLE**

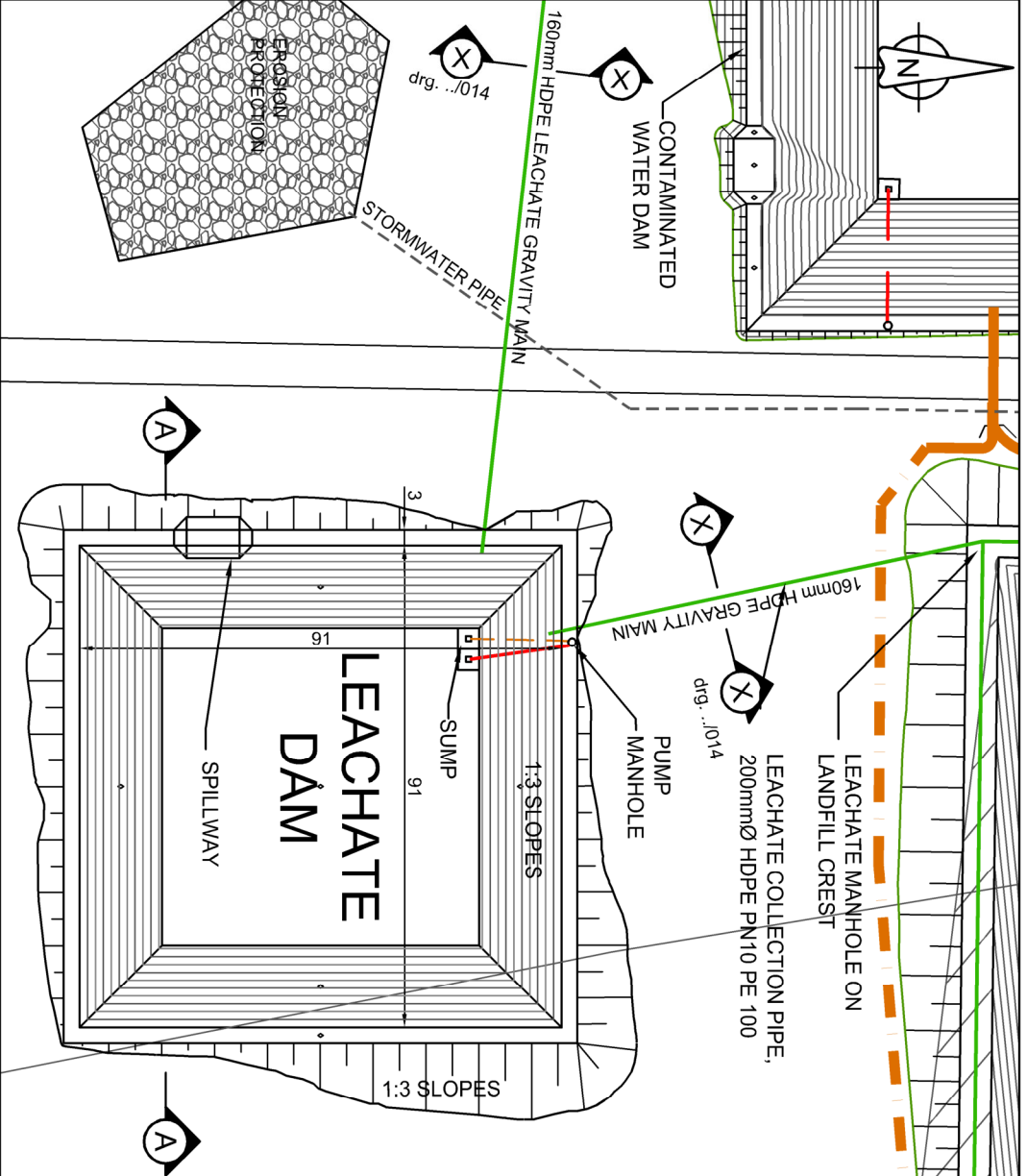
GENERAL LEACHATE MANAGEMENT PLAN

<b>SCALE</b>	1:2000	<b>SCALE</b>	A0
<b>JOB NUMBER</b>	755-2022	<b>SHEET NO.</b>	1 OF 1
<b>DRAWING NO.</b>	755 - 2022 - 013 - REV-B		

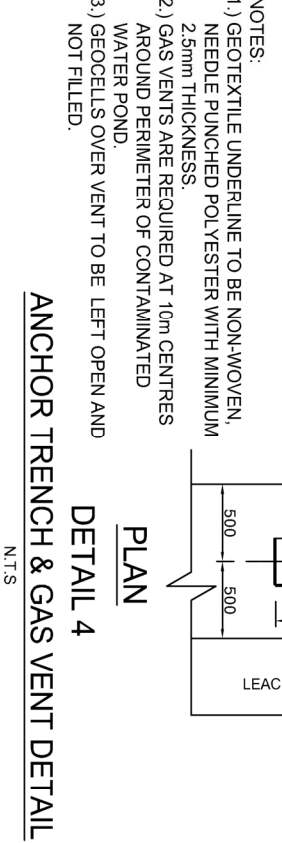
B.L. JEWASKIEWITZ  
 Pr. Eng. 20170189  
 DATE: 16 JAN 2026

ALPHABETICAL LETTERS (A-Z, AA-ZZ) FOR CONSTRUCTION, NAME NUMBERS (01-24) FOR CONSTRUCTION NUMBERS

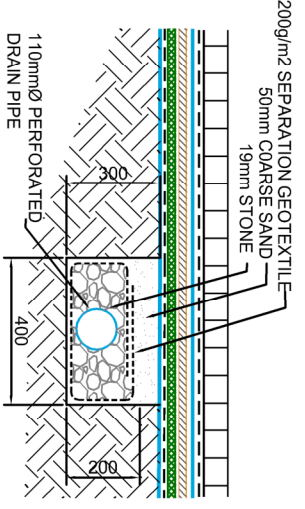




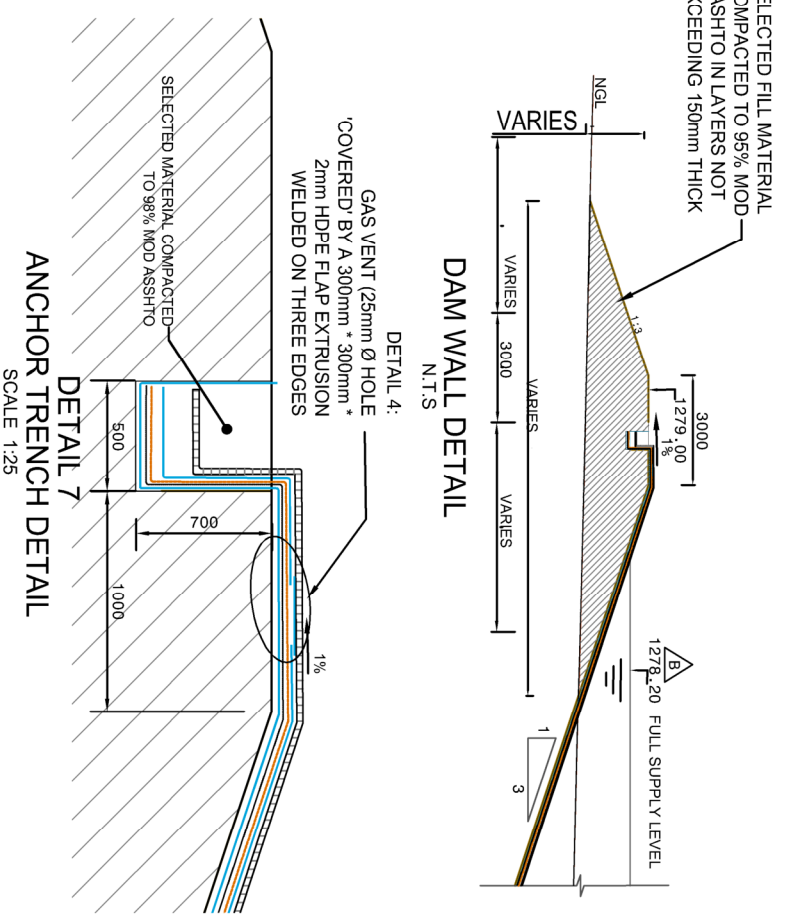
**LEACHATE DAM KEY PLAN**  
SCALE 1:100



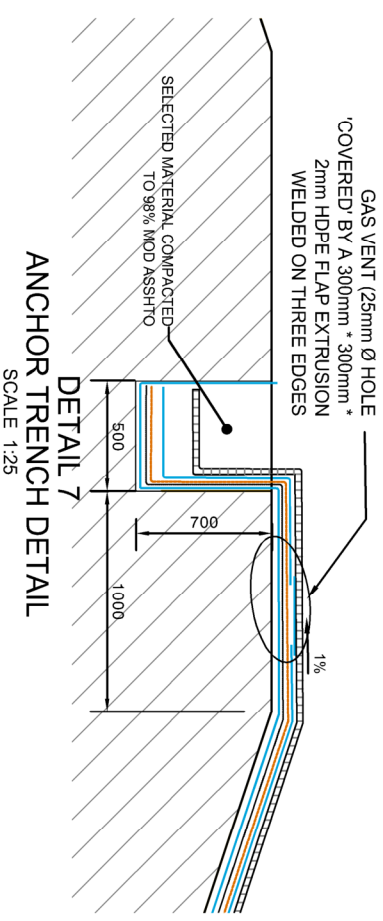
**DETAIL 4**  
ANCHOR TRENCH & GAS VENT DETAIL  
N.T.S.



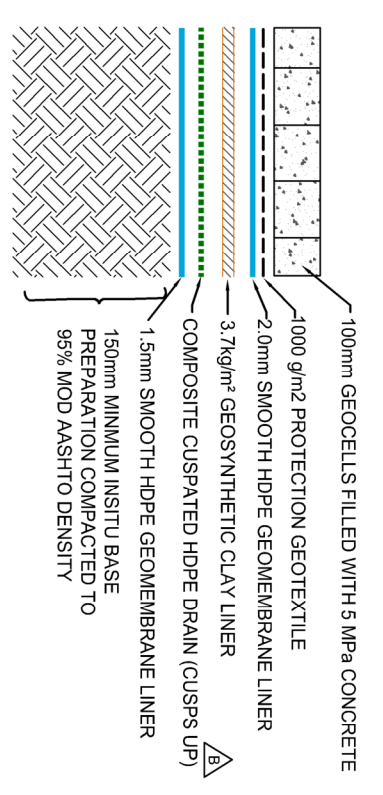
**DETAIL 8**  
SUB-SOIL COLLECTOR TRENCH  
N.T.S.



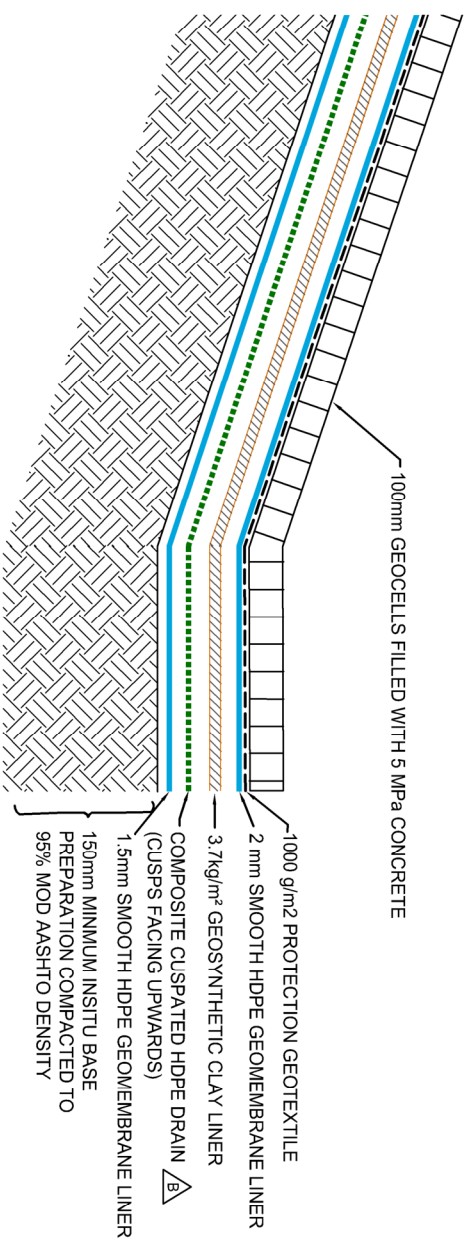
**DETAIL 4:**  
DAM WALL DETAIL  
N.T.S.



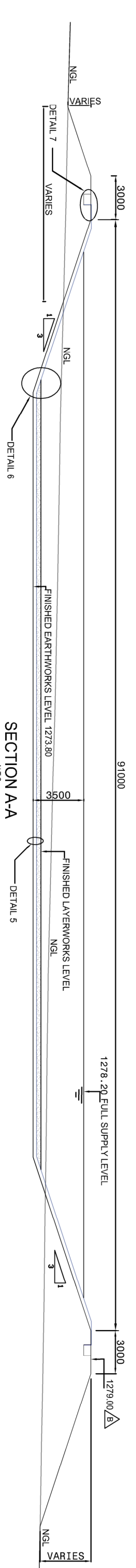
**DETAIL 7**  
ANCHOR TRENCH DETAIL  
SCALE 1:25



**DETAIL 5**  
GENERAL LEACHATE DAM  
CONTAINMENT BARRIER SYSTEM  
N.T.S.



**DETAIL 6**  
GENERAL LEACHATE DAM  
CONTAINMENT BARRIER SYSTEM  
N.T.S.



**SECTION A-A**  
N.T.S.

**NOTES**

- 1) AREA TO BE LINED MUST BE FREE OF PROTRUSIONS, STONES, ROOTS AND VEGETATION - A MAXIMUM OF 3mm WILL BE ALLOWED.
- 2) THE BASE MUST BE AT A SLOPE OF 1:200.
- 3) THE EMBANKMENT SLOPES TO BE 1:3
- 4) ALL COMPACTION ON THE BASE AND SLOPE TO ACHIEVE 98% MOD AASHTO AT OMC.
- 5) ANCHOR TRENCH TO BE FILLED WITH SELECTED AND APPROVED MATERIAL WHICH SHALL BE FREE OF ROCKS AND STONE.
- 6) ALL GEOMEMBRANE PREPARATION AND INSTALLATION TO COMPLY WITH THE REQUIREMENTS OF SANS 10409 & SANS 1526.
- 7) SPILLWAY DETAILS ON DRAWING 755-2022-09

B.L. JEWASKIEWITZ  
Pr. Eng. 20170189  
DATE: 16/01/26

NO.	DATE	APPROVED	DESCRIPTION	DESIGNED	ENGINEER	CLIENT
A	23/11/2022		ISSUED FOR CLIENT APPROVAL	MM	Pr. Eng. 20170189	
B	16/01/2026		CUSPATED DRAIN DESCRIPTION, UPDATED MODEL LEVELS	KPM	DATE: 16 JAN, 2026	
				MM		
				GF		

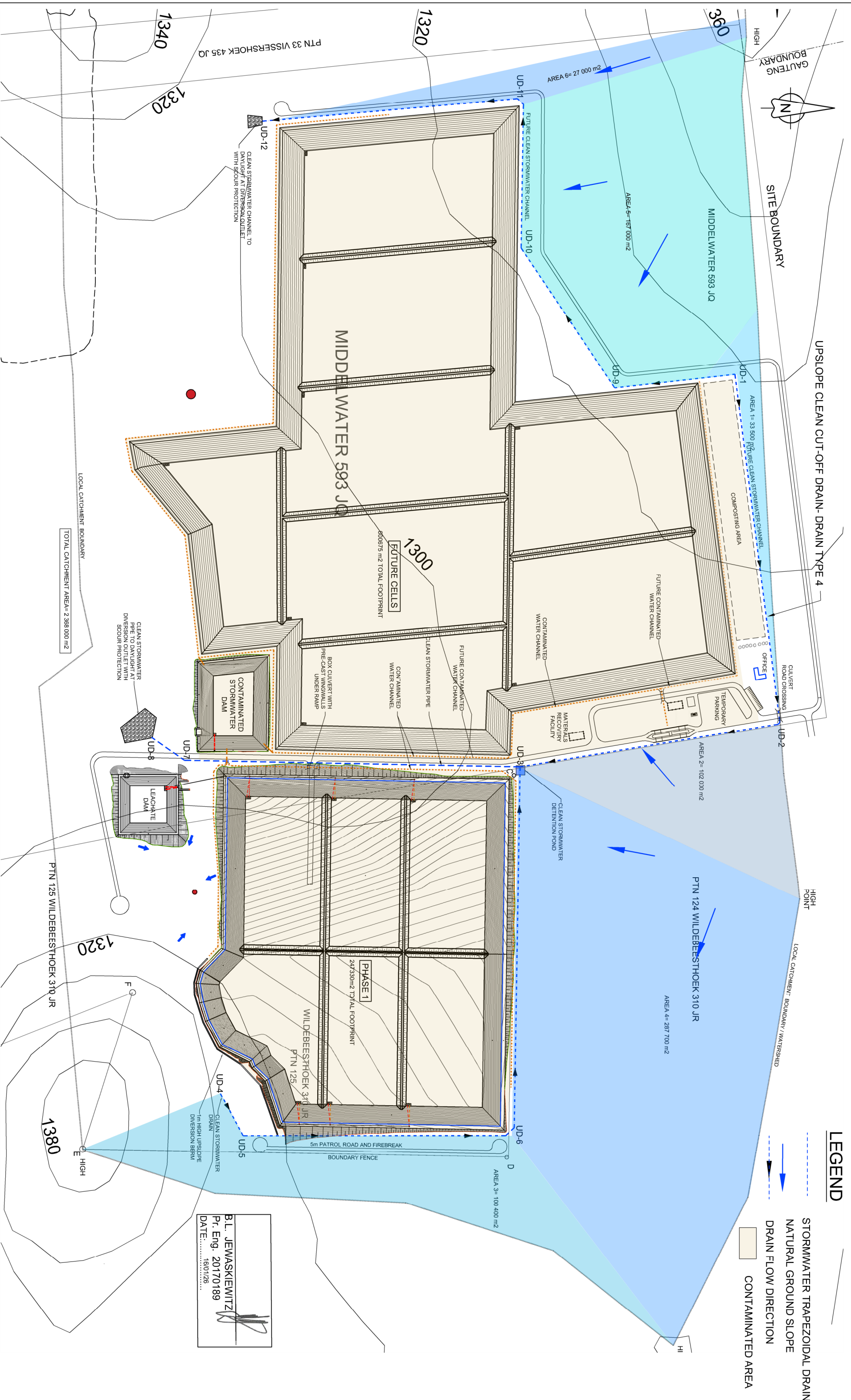
  

CONTRACT	CLIENT	PROJECT TITLE
enviotech SOLUTIONS	MBHE ENVIRONMENTAL (PTY) LTD	MIDDELWATER RESOURCE FACILITY

SCALE	AS SHOWN
JOB NUMBER	EST755-2022
SHEET NO	1 OF 2
DRAWING NO	755-2022-017 REV B





NO.	DATE	APPROVED	DESCRIPTION
A	10/10/2022	KPM	ISSUED FOR CLIENT APPROVAL
B	16/01/2026	BLJ	CATCHMENT DETAILS ADDED

DESIGNED	ENGINEER
MM	P. Eng. 20170189
MM	DATE: 16 JAN. 2026

**envittech**  
SOLUTIONS

22 Swerth Avenue  
Norwood  
South Africa  
Tel: +27-11-425 2810  
Fax: +27-11-425 4731  
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Unit B1 Kensington Park  
2 Kensington Place, Claremont, 7810  
Tel: +27-21-423 0850  
Fax: +27-21-423 0850  
ben@envitech.co.za

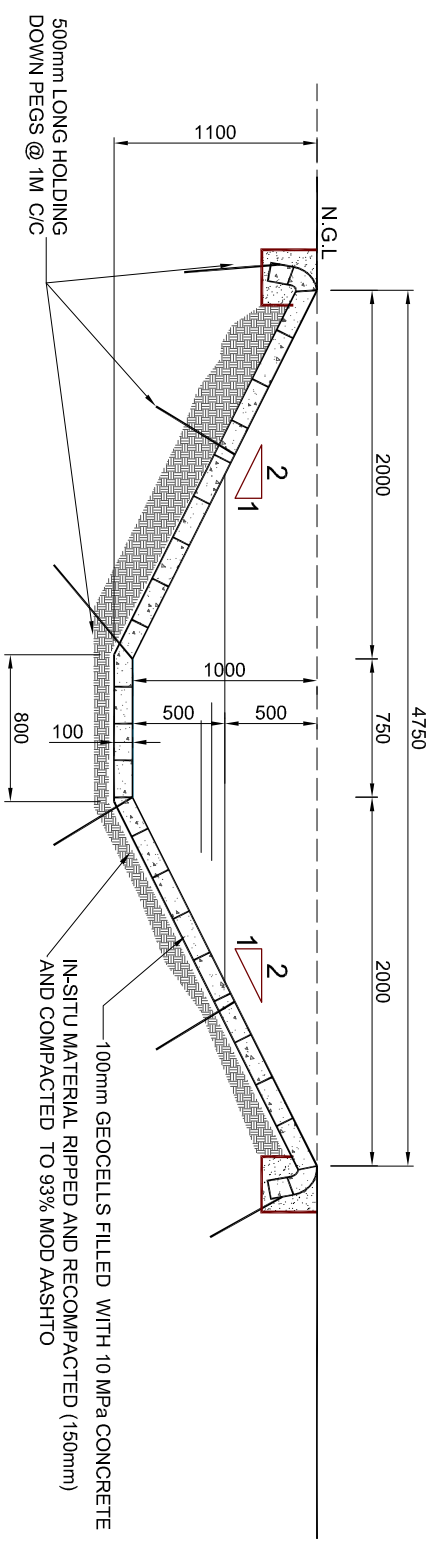
**MBHE**  
ENVIRONMENTAL (PTY) LTD

PROJECT TITLE  
**MIDDELWATER RESOURCE FACILITY**

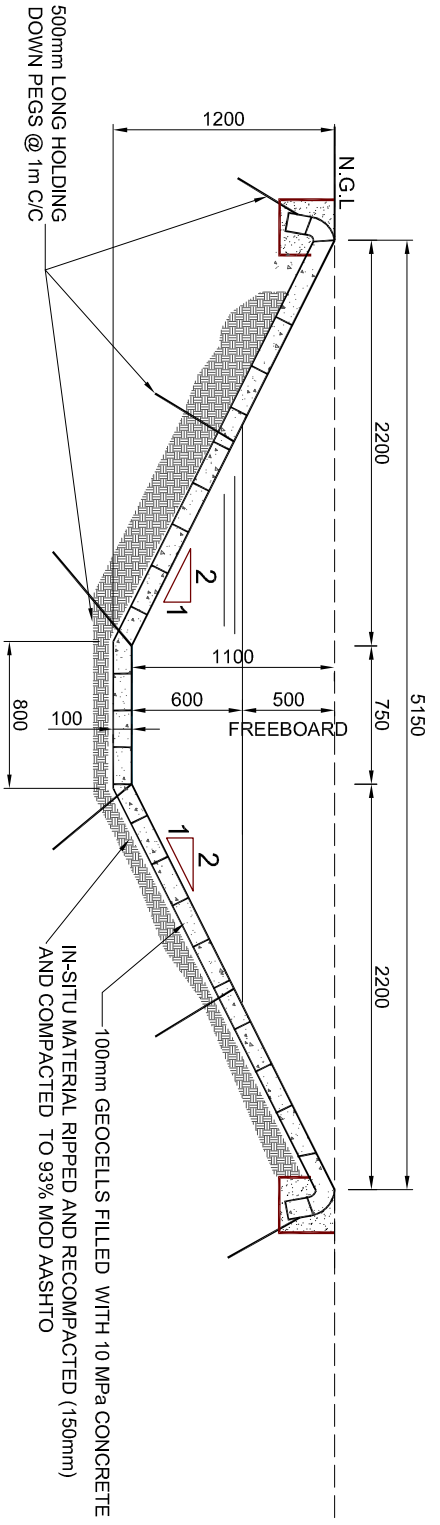
DRAWING TITLE  
**STORMWATER LAYOUT**

SCALE	SHEET NO.
1:2500	A2
JOB NUMBER	SHEET 1 OF 2
ES755-2022	
DRAWING NO.	
755-2022-018 REV B	

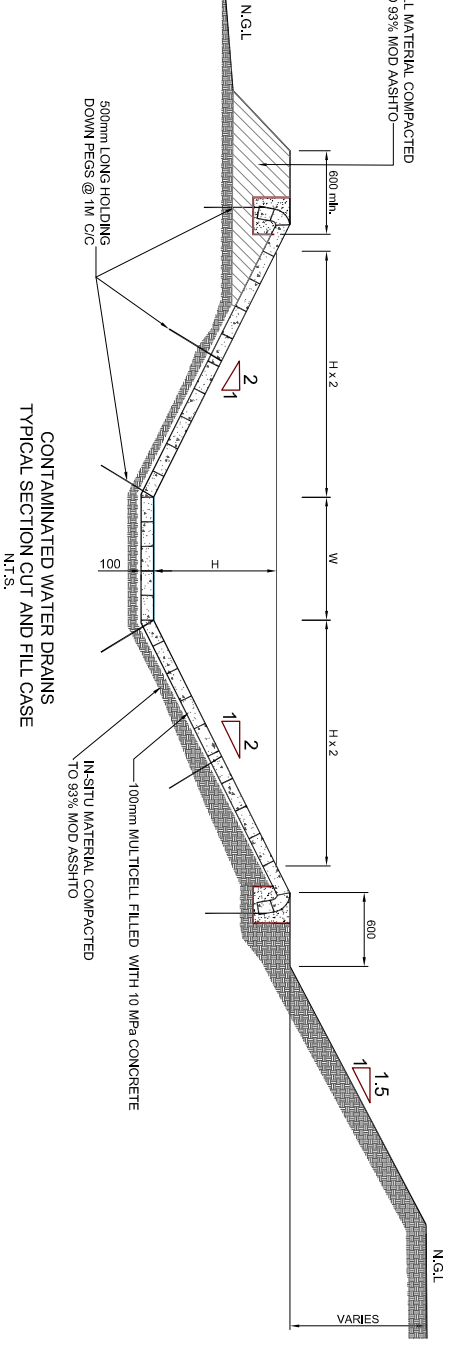
**B.L. JEWASKIEWITZ**  
P. Eng. 20170189  
DATE: 16/01/26



**TYPE 4- DRAIN  
TYPICAL SECTION**  
SCALE 1:30



**TYPE 5- DRAIN  
TYPICAL SECTION**  
SCALE 1:30

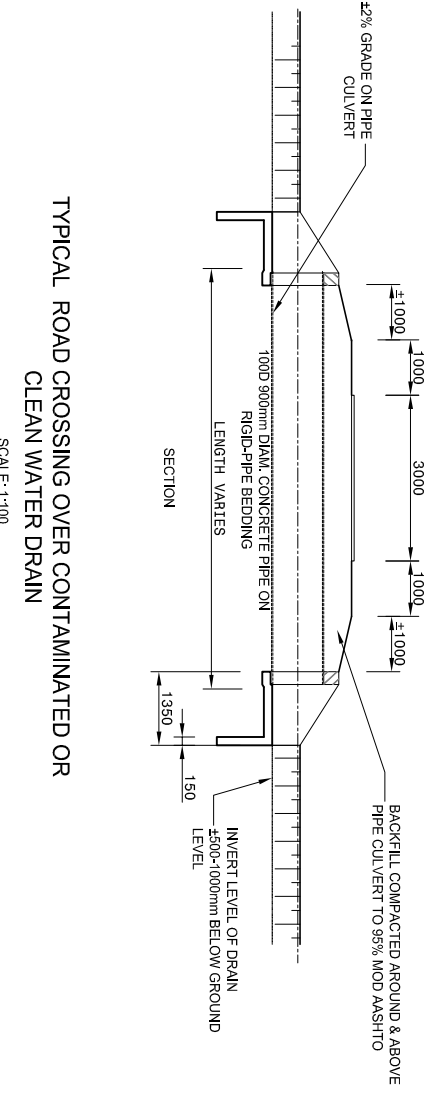
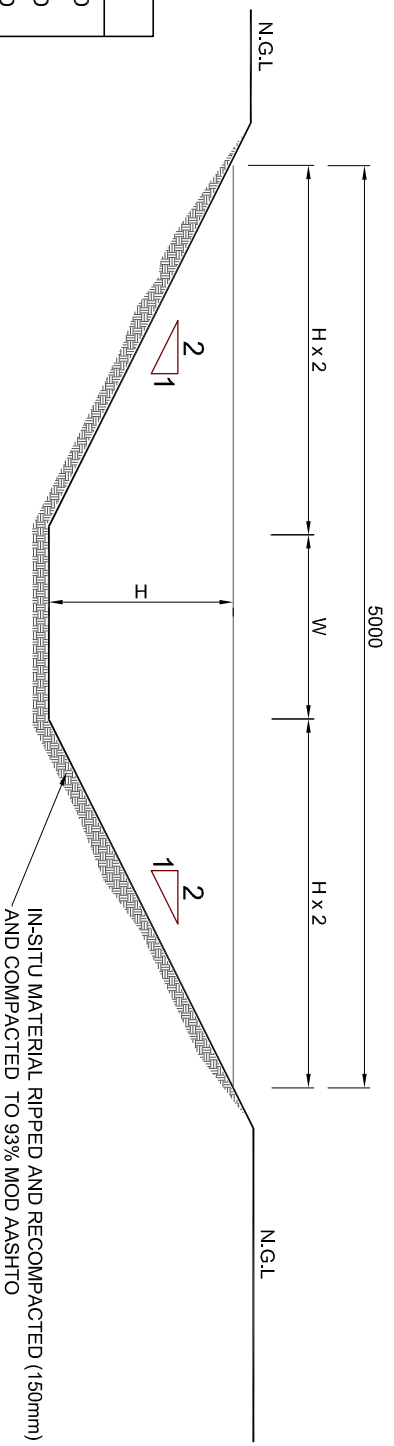


**CONTAMINATED WATER DRAINS  
TYPICAL SECTION CUT AND FILL CASE  
N.T.S.**

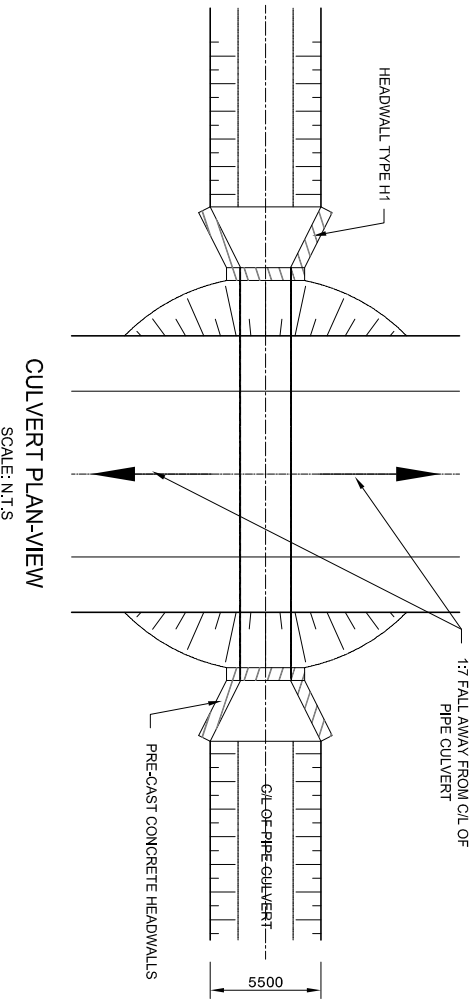
DRAIN	TYPE	H (mm)	W (mm)
<b>PHASE 1</b>			
PH1-CW-NORTH	TYPE 4	500	750
PH1-CW-SOUTH	TYPE 4	500	750
PH1-CW-SOUTH	TYPE 4	500	750
<b>PHASE 2</b>			
PH2-CW-NORTH	TYPE 4	500	750
PH2-CW-NWEST	TYPE 4	500	750
PH2-CW-EAST	TYPE 5	600	750
PH2-CW-WEST	TYPE 4	500	750
PH2-CW-SOUTH	TYPE 5	600	750

DRAIN	TYPE	H (mm)	W (mm)	LINED
UD1-UD2	TYPE 1	500	500	UNLINED
UD2-UD3	TYPE 2	1000	600	UNLINED
UD4-UD5	TYPE 2	1000	600	UNLINED
UD5-UD6	TYPE 2	1000	600	UNLINED
UD6-UD3	TYPE 3	1000	750	UNLINED

**UNLINED CLEAN WATER DRAIN  
TYPICAL SECTION**  
SCALE 1:30



**TYPICAL ROAD CROSSING OVER CONTAMINATED OR  
CLEAN WATER DRAIN**  
SCALE: 1:100



**CULVERT PLAN-VIEW**  
SCALE: N.T.S

B.L. JEWASKIEWITZ  
Pr. Eng. 20170189  
DATE: 16/01/26

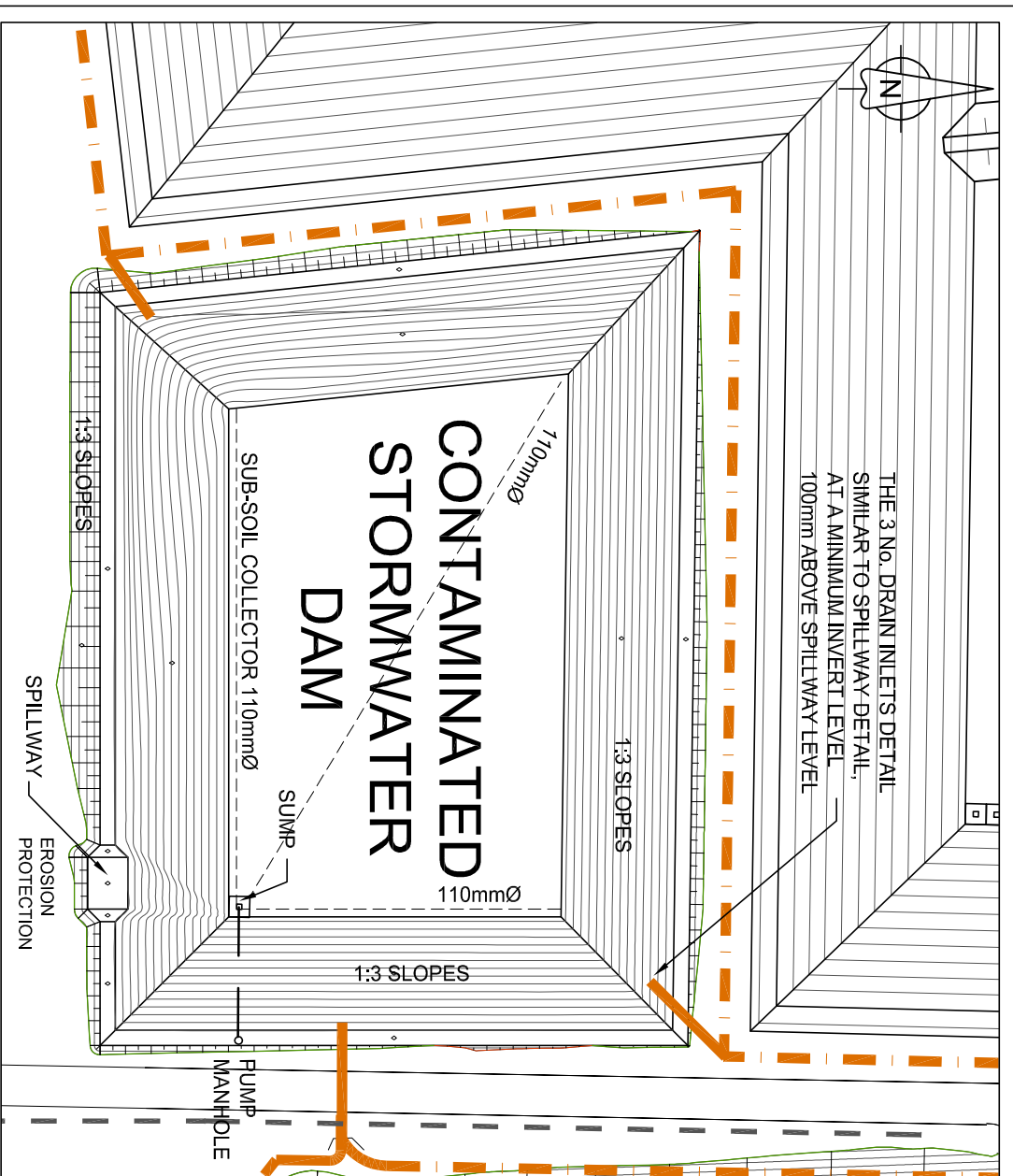
NO.		DATE	APPROVED	DESCRIPTION	DESIGNED	ENGINEER	CLIENT
A	10/10/2022	KPM	ISSUED FOR APPROVAL	TABLE ADDED WITH DRAIN TYPE DESCRIPTION	MM	Pr. Eng. 20170189	
B	16/01/2026	BLJ	TABLE ADDED WITH DRAIN TYPE DESCRIPTION		BLJ	DATE: 16 JAN. 2026	

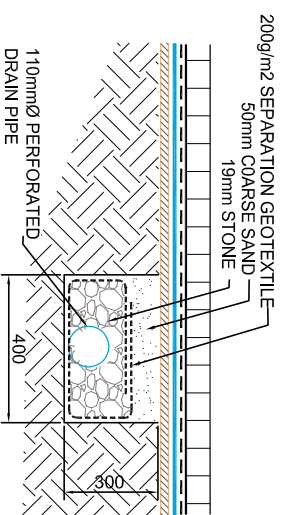
CONSULTANT		CLIENT	
<b>envitech</b> solutions 27 Swainin Avenue Northmead, NSW 1501 Tel: +27-11-425 2810 Fax: +27-11-425 4731 info@envitech.co.za		2 Mairdoun Pines South Africa Tel: +27-11-425 0980 Fax: +27-11-425 4731 info@mbhe.com	

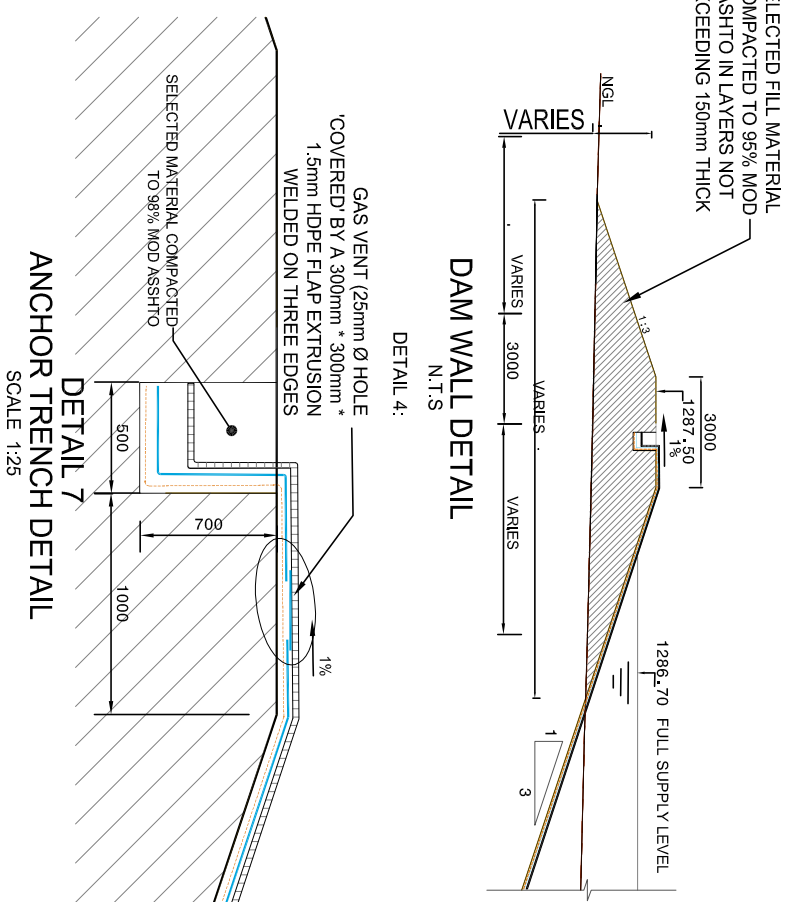
PROJECT TITLE		SCALE	
MIDDELWATER RESOURCE FACILITY		AS SHOWN	
DRAWING TITLE		JOB NUMBER	
STORMWATER DETAILS		EST55-2022	
SHEET NO.		SHEET 2 OF 2	
DRAWING NO.		755-2022-018 REV B	



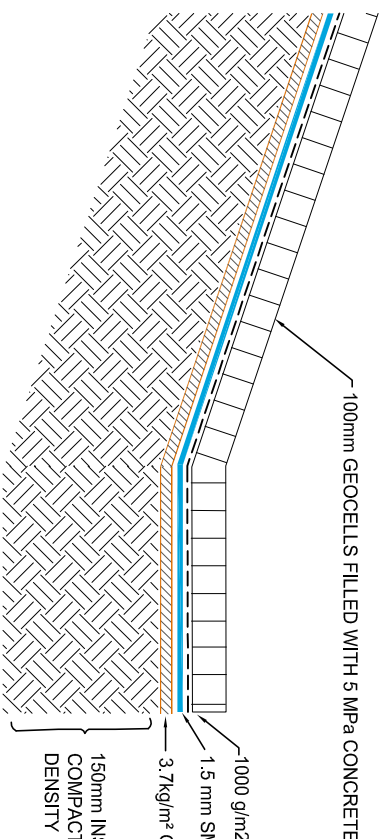
**CONTAMINATED WATER DAM KEY PLAN**  
SCALE 1:100



**DETAIL 8**  
SUB-SOIL COLLECTOR TRENCH

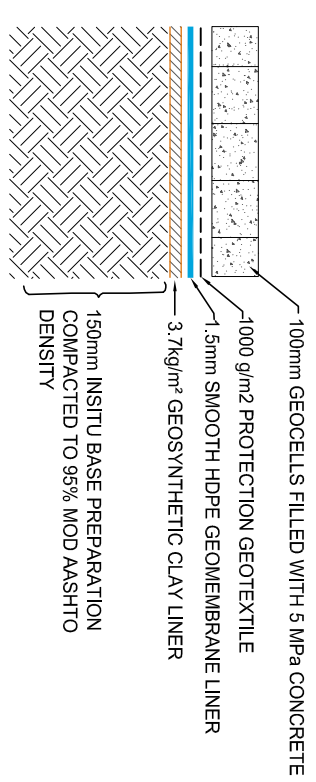


**DETAIL 4:**  
DAM WALL DETAIL  
N.T.S



**DETAIL 7**  
ANCHOR TRENCH DETAIL  
SCALE 1:25

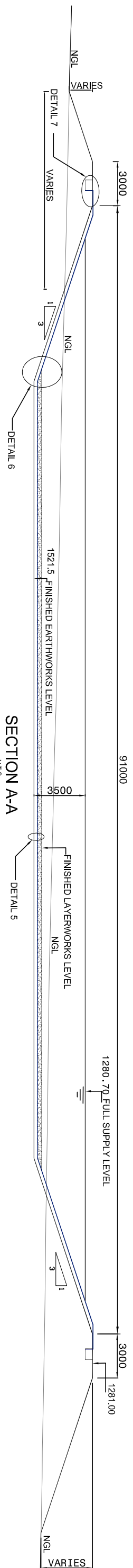
**DETAIL 6**  
GENERAL CONTAMINATED DAM  
CONTAINMENT BARRIER SYSTEM  
N.T.S



**DETAIL 5**  
CONTAMINATED WATER DAM  
CONTAINMENT BARRIER SYSTEM  
N.T.S

**NOTES**

- 1) AREA TO BE LINED MUST BE FREE OF PROTRUSIONS, STONES, ROOTS AND VEGETATION - A MAXIMUM OF 3mm WILL BE ALLOWED.
- 2) THE BASE MUST BE AT A SLOPE OF 1:200.
- 3) THE EMBANKMENT SLOPES TO BE 1:3
- 4) ALL COMPACTION ON THE BASE AND SLOPE TO ACHIEVE 95% MOD AASHTO AT OMC.
- 5) ANCHOR TRENCH TO BE FILLED WITH SELECTED AND APPROVED MATERIAL WHICH SHALL BE FREE OF ROCKS AND STONE.
- 6) ALL GEOMEMBRANE PREPARATION AND INSTALLATION TO COMPLY WITH THE REQUIREMENTS OF SANS 10409 & SANS 1526.
- 7) SPILLWAY DETAILS ON DRAWING 755-2022-021



**SECTION A-A**  
N.T.S

NO.	DATE	APPROVED	DESCRIPTION
A	23 / 11 / 2022		ISSUED FOR CLIENT APPROVAL
B	16 / 01 / 2026		SUB-SOIL DRAINS INDICATED ON PLAN VIEW, GAS VENTS REMOVED.

DESIGNED	CHECKED	DATE	CLIENT
MM	KPM	16 JAN. 2026	

**envitech** SOLUTIONS

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Northmead  
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Fax: +27-11-425 4731  
info@envitech.co.za

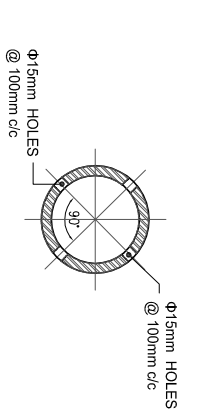
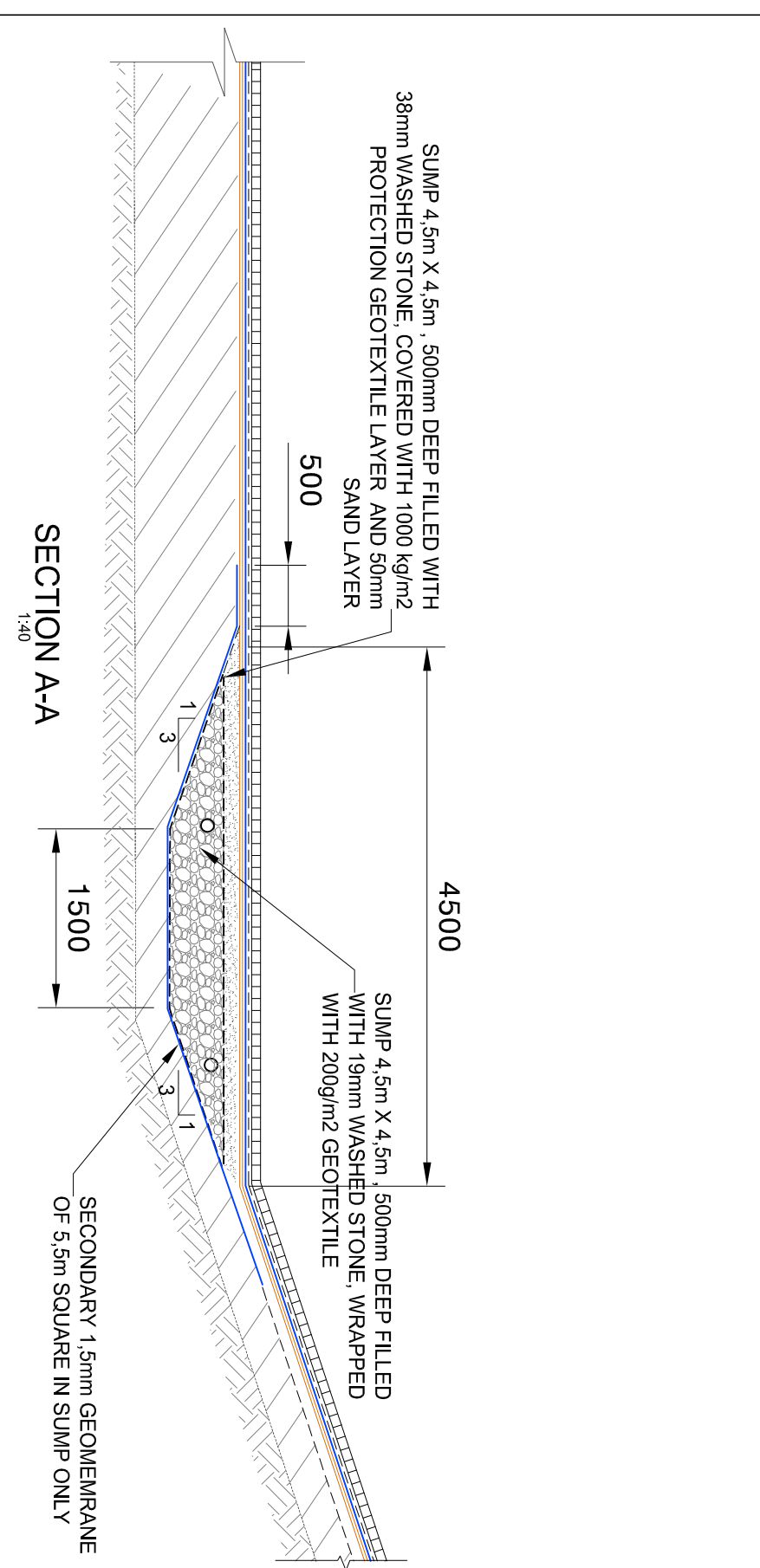
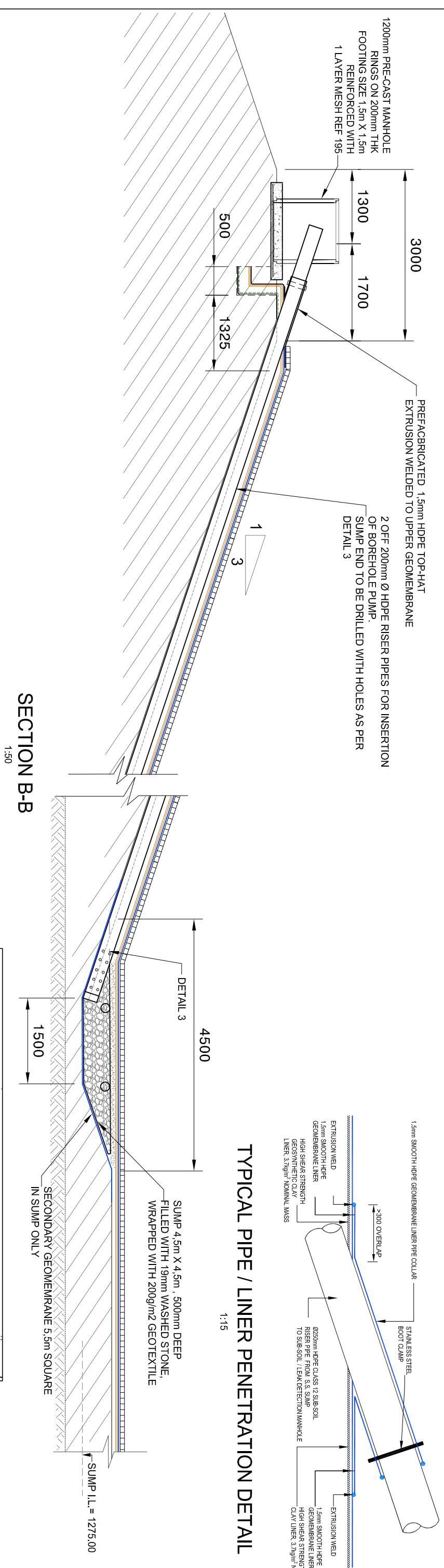
Unit B1, Middelwater Resource Facility  
2 Middelwater Resource Facility  
South Africa  
Tel: +27-31-023 0980  
Fax: +27-31-023 0980  
brendon@envitech.co.za

**MBHE** ENVIRONMENTAL (PTY) LTD

PROJECT TITLE	DRAWING TITLE
MIDDELWATER RESOURCE FACILITY	CONTAMINATED WATER DAM SECTIONS AND DETAILS

SCALE	SHEET NO.	DATE
AS SHOWN	1 OF 2	755-2022-020 REV B

B.L. JEWASKIEWITZ  
Pr. Eng. 20170189  
DATE: 16/01/26



**DETAIL 3**  
NOT TO SCALE

**B.L. JEWASKIEWITZ**  
Pr. Eng. 20170189  
DATE: 16/01/26

NO.	DATE	APPROVED	DESCRIPTION	REVISION	BY	DATE
A	23/11/2022	KM	ISSUED FOR CLIENT APPROVAL	MM	MM	
B	16/01/2026	BLJ	SECOND SUMP NOT REQUIRED FOR SINGLE GEOMEMBRANE BARRIER	BLJ	BLJ	Pr. Eng. 20170189 DATE: 16 JAN. 2026

AMENDMENTS	DESCRIPTION	BY	DATE
1	ISSUED FOR CLIENT APPROVAL	MM	
2	SECOND SUMP NOT REQUIRED FOR SINGLE GEOMEMBRANE BARRIER	BLJ	16 JAN. 2026

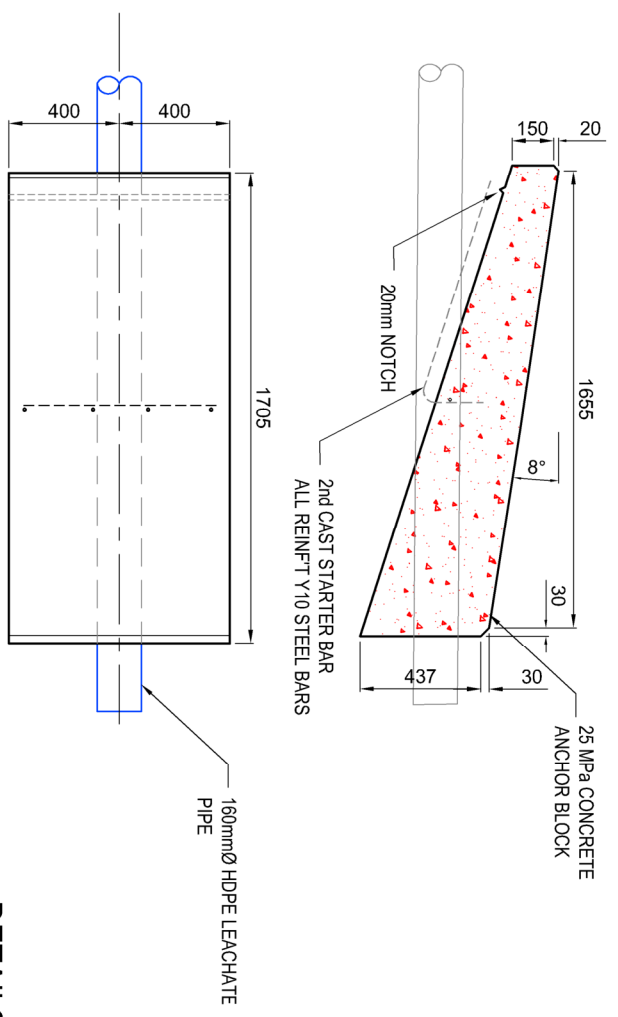
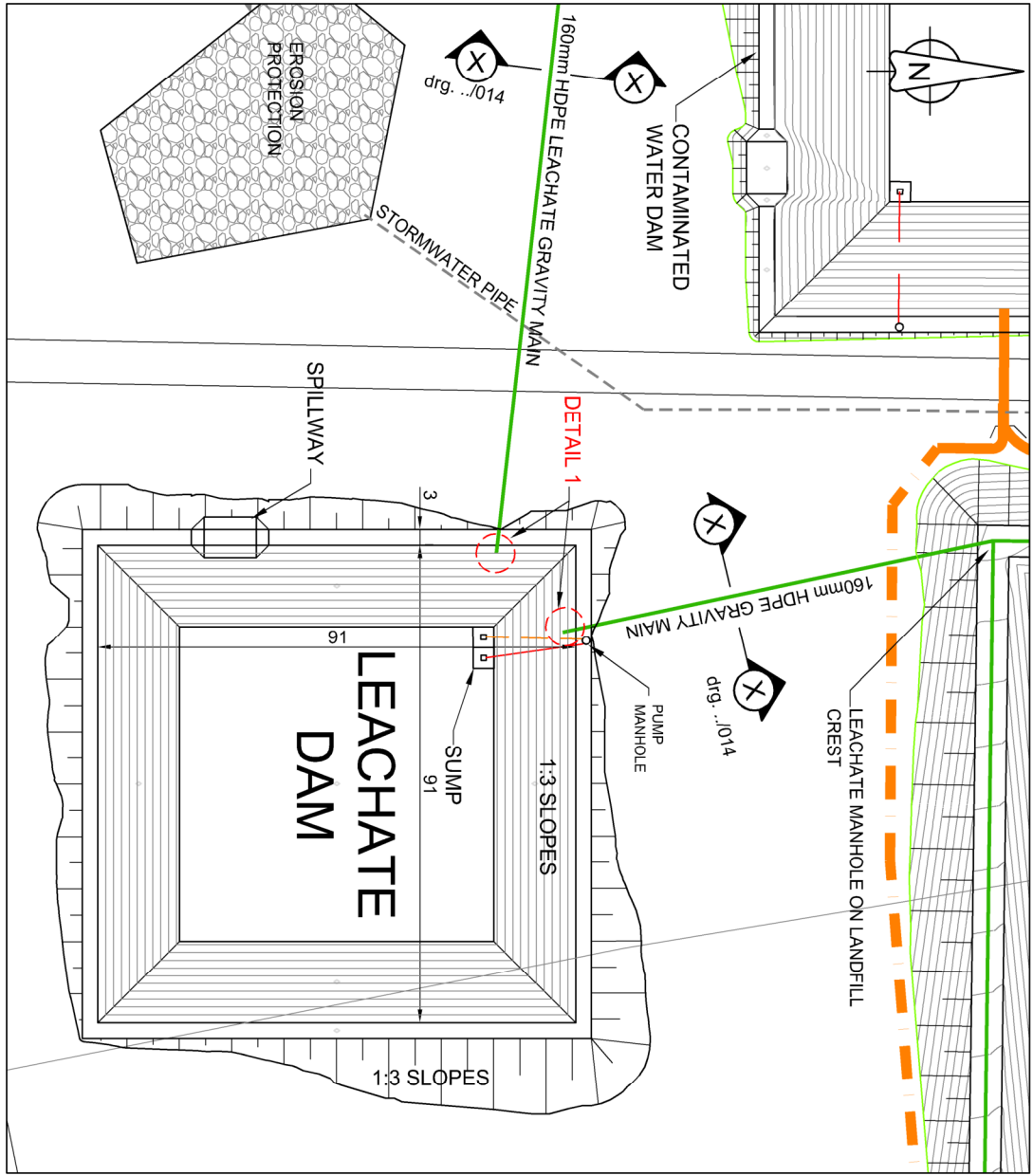
CONSULTANT	CLIENT
<b>envitech</b> solutions 2 Mervyn Road Northmead, 1501 South Africa Tel: +27-11-425 2810 Fax: +27-11-425 4731 info@envitech.co.za	Unit B1 Mervyn Road Northmead, 1501 South Africa Tel: +27-11-425 2810 Fax: +27-11-425 4731 brendon@envitech.co.za

PROJECT TITLE	DRAWING TITLE
MIDDELWATER RESOURCE FACILITY	CONTAMINATED WATER DAM SECTIONS AND DETAILS

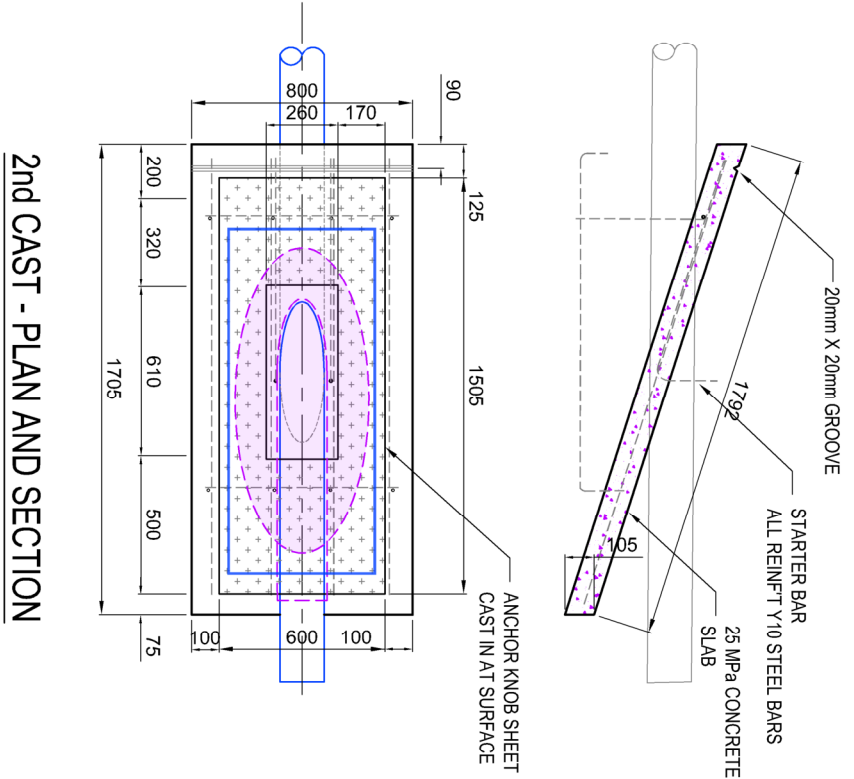
  

SCALE	SHEET NO.	DRAWING NO.
AS SHOWN	2 OF 2	755-2022-020 REV B

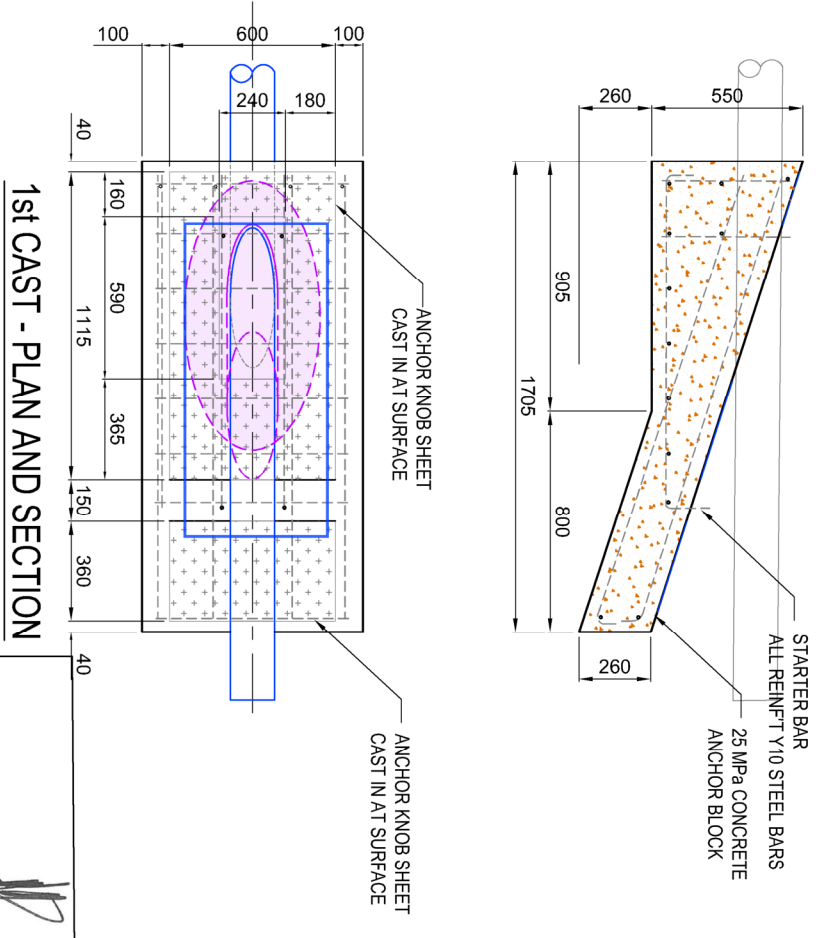


**3rd CAST - PLAN AND SECTION**

**DETAILS OF LINER PENETRATION ANCHOR BLOCK**  
SCALE 1:20

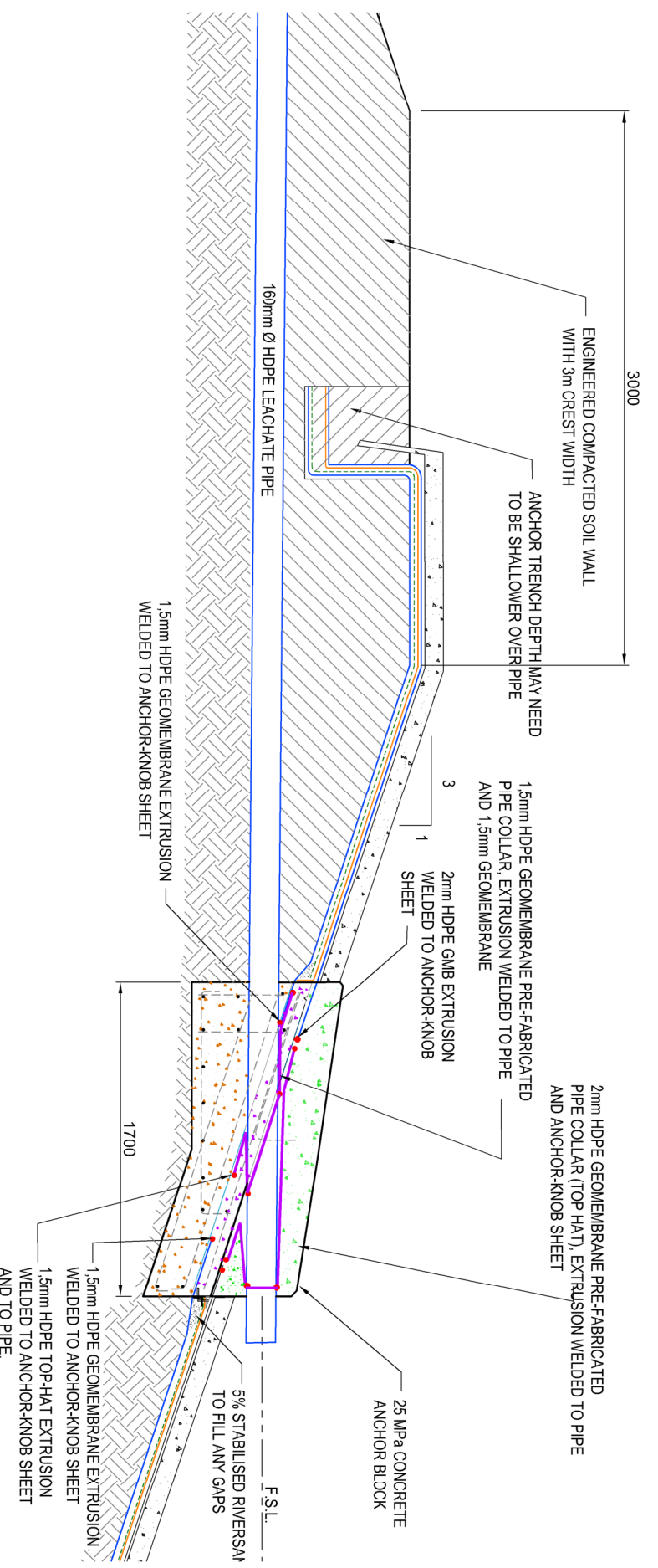


**2nd CAST - PLAN AND SECTION**



**1st CAST - PLAN AND SECTION**

**DETAIL 1 - TYPICAL LEACHATE DAM INLETS LINER PENETRATION DETAIL**  
SCALE 1:25



NO.	DATE	APPROVAL	DESCRIPTION
A	14/01/2026		ISSUED FOR APPROVAL

DESIGNED	MM	ENGINEER	MM
DESIGNED/checked	BLJ	Pr. Eng: 20170189	DATE: 16 JAN. 2026
DRAWING/checked	MM	CLIENT	DATE

COMPLIANT

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PROJECT TITLE

**MIDDELWATER RESOURCE FACILITY**

DRAWING TITLE

**LEACHATE DAM SECTIONS AND DETAILS**

SCALE

AS SHOWN

JOB NUMBER

**ES755-2022**

SHEET NO.

1 OF 1

DRAWING NO.

**755-2022-022 REV A**

B.L. JEWASKIEWITZ  
Pr. Eng: 20170189  
DATE: 16/01/26

# APPENDIX C

## Calculations

MANNINGS FORMULA PIPE CAPACITY												
n	1/n	PI	D	D^2	(PI(D^2))/4	D^2/4	D/4	(D/4)^0.667	slope 1:x	S	S^0.5	Q m3/S
0.013	76.923	3.1429	0.5000	0.250	0.196	0.063	0.125	0.250	32.000	0.031	0.17678	0.667
0.013	76.923	3.143	1.000	1.000	0.786	0.250	0.250	0.397	50.000	0.020	0.14142	3.390
0.013	76.923	3.143	0.900	0.810	0.636	0.203	0.225	0.370	75.000	0.013	0.11547	2.090
0.013	76.923	3.143	1.000	1.000	0.786	0.250	0.250	0.397	100.000	0.010	0.10000	2.397
0.013	76.923	3.143	<b>1.250</b>	1.563	1.228	0.391	0.313	0.460	<b>100.000</b>	0.010	0.10000	4.347

FLOW DEPTH	FROUDE	CHECK VELOCITY
	$Fr=V/(9.81 \cdot D^{0.8})^{0.5}$	$V=Q/A$
0.400		3.3972
0.800	1.540	4.3152
0.720	1.236	3.2842
0.800	1.089	3.0513
1.000	<b>0.819</b> OK	2.5658

Drain	Peak Flow	Type
<b>UD3-UD8</b>	3.15	<b>1250 dia.</b>

MANNINGS FORMULA TRAPEZOIDAL CAPACITY															
n	1/n	bottom width	side slope 1:x	flow depth	A	2y	z^2	(1+z^2)^0.5	P	slope 1:x	S	S^0.5	R	R^0.667	Q m3/S
		<b>b</b>	<b>z</b>	<b>y</b>	<b>y(b+zy)</b>			<b>1+2y(1+z^2)^0.5</b>					<b>A/P</b>		<b>(1/n)(A) (R^0.667) (S^0.5)</b>
0.015	66.667	0.750	2.000	0.400	0.620	0.800	4.000	2.236	2.789	100	0.010	0.100	0.222	0.367	1.516
0.015	66.667	0.750	2.000	0.400	0.620	0.800	4.000	2.236	2.789	200	0.005	0.071	0.222	0.367	1.072
0.015	66.667	0.750	2.000	0.500	0.875	1.000	4.000	2.236	3.236	200	0.005	0.071	0.270	0.418	1.724
0.015	66.667	0.750	2.000	0.500	0.875	1.000	4.000	2.236	3.236	200	0.005	0.071	0.270	0.418	1.724
0.015	66.667	0.750	2.000	0.400	0.620	0.800	4.000	2.236	2.789	200	0.005	0.071	0.222	0.367	1.072
0.015	66.667	0.750	2.000	0.600	1.170	1.200	4.000	2.236	3.683	200	0.005	0.071	0.318	0.465	2.567
0.015	66.667	0.750	2.000	0.400	0.620	0.800	4.000	2.236	2.789	200	0.005	0.071	0.222	0.367	1.072
0.015	66.667	0.750	2.000	0.600	1.170	1.200	4.000	2.236	3.683	200	0.005	0.071	0.318	0.465	2.567
0.022	45.455	0.500	2.000	0.500	0.750	1.000	4.000	2.236	3.236	200	0.005	0.071	0.232	0.377	0.909
0.022	45.455	1.000	2.000	0.600	1.320	1.200	4.000	2.236	3.683	200	0.005	0.071	0.358	0.504	2.140
0.022	45.455	1.000	2.000	0.600	1.320	1.200	4.000	2.236	3.683	250	0.004	0.063	0.358	0.504	1.914
0.022	45.455	1.000	2.000	0.600	1.320	1.200	4.000	2.236	3.683	200	0.005	0.071	0.358	0.504	2.140
0.022	45.455	1.000	2.000	0.750	1.875	1.500	4.000	2.236	4.354	200	0.005	0.071	0.431	0.570	3.436
0.022	45.455	1.000	2.000	0.600	1.320	1.200	4.000	2.236	3.683	200	0.005	0.071	0.358	0.504	2.140
0.022	45.455	1.000	2.000	0.600	1.320	1.200	4.000	2.236	3.683	250	0.004	0.063	0.358	0.504	1.914
0.022	45.455	1.000	2.000	0.600	1.320	1.200	4.000	2.236	3.683	250	0.004	0.063	0.358	0.504	1.914
0.022	45.455	1.000	2.000	0.750	1.875	1.500	4.000	2.236	4.354	200	0.005	0.071	0.431	0.570	3.436

Drain	Peak Flow	Type
<b>PH1-CW-north</b>	1.198	Type 4
<b>PH1-CW-south</b>	0.625	Type 4
<b>PH1-CW-west</b>	1.474	Type 4
<b>PH2-CW-north</b>	1.259	Type 4
<b>PH2-CW-nw</b>	0.918	Type 4
<b>PH2-CW-east</b>	2.623	Type 5
<b>PH2-CW-west</b>	0.493	Type 4
<b>PH2-CW-south</b>	1.858	Type 5
<b>UD1-UD2</b>	0.689	Type 1
<b>UD2-UD3</b>	1.510	Type 2
<b>UD4-UD5</b>	1.842	Type 2
<b>UD5-UD6</b>	1.624	Type 2
<b>UD6-UD3</b>	3.191	Type 3
<b>UD1-UD9</b>	1.500	Type 2
<b>UD9-UD10</b>	1.300	Type 2
<b>UD10-UD11</b>	1.500	Type 2
<b>UD10-UD12</b>	2.900	Type 3

# RATIONAL METHOD CALCULATION SHEET

Project Description: <b>Middelwater / catchments to CWP</b>	Project Code: <b>ES755-2022</b>	Date: <b>2026/01/19</b>
Calculated by: <b>M. McLENNAN</b>		

Calculation: **Phase 1 northern half**

Physical Characteristics		Area Distribution Factors		
Size of catchment (A):	<b>0.1237</b> km <sup>2</sup>	Rural	Urban	Lakes
Longest water course (L):	<b>0.5800</b> km	$\alpha$ : <b>100.0%</b>	$\beta$ : <b>0.0%</b>	$\gamma$ : <b>0.0%</b>
Average slope (S):	<b>0.0050</b> m/m	Note: ( $\alpha + \beta + \gamma = 100\%$ )		
Dolomitic % (D):	<b>0.0%</b>			

Runoff Coefficient							
Rural				Urban			
Surface Slope (%)		Permeability (%)		Vegetation (%)		Use (%)	
Vleis & Pans	<b>90.0%</b>	Very Permeable	<b>0.0%</b>	Thick Bush; Plantation	<b>0.0%</b>	Lawns & Parks	<b>0.0%</b>
Flat Areas	<b>10.0%</b>	Permeable	<b>20.0%</b>	Light Bush; Farmland	<b>0.0%</b>	Industrial Areas	<b>0.0%</b>
Hilly	<b>0.0%</b>	Semi-Permeable	<b>80.0%</b>	Grassland	<b>100.0%</b>	City / Residential	<b>0.0%</b>
Steep Areas	<b>0.0%</b>	Impermeable	<b>0.0%</b>	No vegetation	<b>0.0%</b>	Streets	<b>100.0%</b>

Rainfall							
Roughness Coefficient				Time of concentration		Rainfall Information	
Clean compacted soil, no stones	<b>0.0%</b>	<b>0.10</b>	<input checked="" type="radio"/> Overland Flow <input type="radio"/> Watercourse $r = 0.5$ $T_c =$ <b>1.11</b> hours	MAR: <b>613.5</b> mm Rainfall region: Summer <input checked="" type="checkbox"/> Throughout year <input type="checkbox"/> Winter <input type="checkbox"/>			
Paved areas	<b>0.0%</b>	<b>0.02</b>					
Sparse grass over fairly rough surface	<b>30.0%</b>	<b>0.30</b>					
Medium grass cover	<b>30.0%</b>	<b>0.40</b>					
Thick grass cover	<b>30.0%</b>	<b>0.80</b>					

Rainfall Station:  Hydrology  Average

Rainfall Intensity (I)								
Return Period T (years)	2	5	10	25	50	100	200	Notes
Point Rainfall (mm)	54.3	87.8	87.8	105.1	121.8	138.0	154.8	
Point Intensity (mm/h)	48.8	78.9	78.9	94.5	109.5	124.2	139.2	
Area Reduction Factor	100%	100%	100%	100%	100%	100%	100%	
Average Intensity (mm/h)	<b>48.8</b>	<b>78.9</b>	<b>78.9</b>	<b>94.5</b>	<b>109.5</b>	<b>124.2</b>	<b>139.2</b>	

Run-off Factor								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Rural $C_1$	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
Urban $C_2$	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
Lakes $C_3$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
$C = \alpha C_1 + \beta C_2 + \gamma C_3$	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
$C_{final}$	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	

Peak Flow								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Peak Flow $Q = C \cdot I \cdot A$ (m <sup>3</sup> /s)	<b>0.608</b>	<b>0.983</b>	<b>0.983</b>	<b>1.178</b>	<b>1.364</b>	<b>1.547</b>	<b>1.734</b>	
Saturation Factor $F_t$	0.60	0.65	0.70	0.76	0.88	1.00	1.00	
Adjusted Peak $Q \cdot F_t$	<b>0.36</b>	<b>0.639</b>	<b>0.688</b>	<b>0.897</b>	<b>1.198</b>	<b>1.547</b>	<b>1.734</b>	

# RATIONAL METHOD CALCULATION SHEET

Project Description: <b>Middelwater / catchments to CWP</b>	Project Code: <b>ES755-2022</b>	Date: <b>2026/01/19</b>
Calculated by: <b>M. McLENNAN</b>		

Calculation: **Phase 1 southeastern half**

Physical Characteristics		Area Distribution Factors		
Size of catchment (A):	<b>0.0618</b> km <sup>2</sup>	Rural	Urban	Lakes
Longest water course (L):	<b>0.5300</b> km	$\alpha$ : <b>100.0%</b>	$\beta$ : <b>0.0%</b>	$\gamma$ : <b>0.0%</b>
Average slope (S):	<b>0.0050</b> m/m	Note: ( $\alpha + \beta + \gamma = 100\%$ )		
Dolomitic % (D):	<b>0.0%</b>			

Runoff Coefficient							
Rural				Urban			
Surface Slope (%)		Permeability (%)		Vegetation (%)		Use (%)	
Vleis & Pans	<b>90.0%</b>	Very Permeable	<b>0.0%</b>	Thick Bush; Plantation	<b>0.0%</b>	Lawns & Parks	<b>0.0%</b>
Flat Areas	<b>10.0%</b>	Permeable	<b>20.0%</b>	Light Bush; Farmland	<b>0.0%</b>	Industrial Areas	<b>0.0%</b>
Hilly	<b>0.0%</b>	Semi-Permeable	<b>80.0%</b>	Grassland	<b>100.0%</b>	City / Residential	<b>0.0%</b>
Steep Areas	<b>0.0%</b>	Impermeable	<b>0.0%</b>	No vegetation	<b>0.0%</b>	Streets	<b>100.0%</b>

Rainfall							
Roughness Coefficient				Time of concentration		Rainfall Information	
Clean compacted soil, no stones	<b>0.0%</b>	<b>0.10</b>	<input checked="" type="radio"/> Overland Flow <input type="radio"/> Watercourse $r = 0.5$ $T_c =$ <b>1.07</b> hours	MAR: <b>613.5</b> mm Rainfall region: Summer <input checked="" type="checkbox"/> Throughout year <input type="checkbox"/> Winter <input type="checkbox"/>			
Paved areas	<b>0.0%</b>	<b>0.02</b>					
Sparse grass over fairly rough surface	<b>30.0%</b>	<b>0.30</b>					
Medium grass cover	<b>30.0%</b>	<b>0.40</b>					
Thick grass cover	<b>30.0%</b>	<b>0.80</b>					

Rainfall Station:  Hydrology  Average

Rainfall Intensity (I)								
Return Period T (years)	2	5	10	25	50	100	200	Notes
Point Rainfall (mm)	54.3	87.8	87.8	105.1	121.8	138.0	154.8	
Point Intensity (mm/h)	50.9	82.3	82.3	98.6	114.2	129.5	145.2	
Area Reduction Factor	100%	100%	100%	100%	100%	100%	100%	
Average Intensity (mm/h)	<b>50.9</b>	<b>82.3</b>	<b>82.3</b>	<b>98.6</b>	<b>114.2</b>	<b>129.5</b>	<b>145.2</b>	

Run-off Factor								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Rural $C_1$	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
Urban $C_2$	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
Lakes $C_3$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
$C = \alpha C_1 + \beta C_2 + \gamma C_3$	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
$C_{final}$	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	

Peak Flow								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Peak Flow $Q = C \cdot I \cdot A$ (m <sup>3</sup> /s)	<b>0.317</b>	<b>0.513</b>	<b>0.513</b>	<b>0.614</b>	<b>0.712</b>	<b>0.806</b>	<b>0.904</b>	
Saturation Factor $F_t$	0.60	0.65	0.70	0.76	0.88	1.00	1.00	
Adjusted Peak $Q \cdot F_t$	<b>0.19</b>	<b>0.333</b>	<b>0.359</b>	<b>0.468</b>	<b>0.625</b>	<b>0.806</b>	<b>0.904</b>	

# RATIONAL METHOD CALCULATION SHEET

Project Description: <b>Middelwater / catchments to CWP</b>	Project Code: <b>ES755-2022</b>	Date: <b>2026/01/19</b>
Calculated by: <b>M. McLENNAN</b>		

Calculation: **Phase 1 eastern third including Ph1-3**

Physical Characteristics		Area Distribution Factors		
Size of catchment (A):	<b>0.1855</b> km <sup>2</sup>	Rural	Urban	Lakes
Longest water course (L):	<b>1.0240</b> km	$\alpha$ : <b>100.0%</b>	$\beta$ : <b>0.0%</b>	$\gamma$ : <b>0.0%</b>
Average slope (S):	<b>0.0067</b> m/m	Note: ( $\alpha + \beta + \gamma = 100\%$ )		
Dolomitic % (D):	<b>0.0%</b>			

Runoff Coefficient							
Rural				Urban			
Surface Slope (%)		Permeability (%)		Vegetation (%)		Use (%)	
Vleis & Pans	<b>90.0%</b>	Very Permeable	<b>0.0%</b>	Thick Bush; Plantation	<b>0.0%</b>	Lawns & Parks	<b>0.0%</b>
Flat Areas	<b>10.0%</b>	Permeable	<b>20.0%</b>	Light Bush; Farmland	<b>0.0%</b>	Industrial Areas	<b>0.0%</b>
Hilly	<b>0.0%</b>	Semi-Permeable	<b>80.0%</b>	Grassland	<b>100.0%</b>	City / Residential	<b>0.0%</b>
Steep Areas	<b>0.0%</b>	Impermeable	<b>0.0%</b>	No vegetation	<b>0.0%</b>	Streets	<b>100.0%</b>

Rainfall							
Roughness Coefficient				Time of concentration		Rainfall Information	
Clean compacted soil, no stones	<b>0.0%</b>	<b>0.10</b>	<input checked="" type="radio"/> Overland Flow <input type="radio"/> Watercourse $r = 0.5$ $T_c =$ <b>1.36</b> hours			MAR: <b>613.5</b> mm	
Paved areas	<b>0.0%</b>	<b>0.02</b>				Rainfall region:	
Sparse grass over fairly rough surface	<b>30.0%</b>	<b>0.30</b>				Summer	<b>x</b>
Medium grass cover	<b>30.0%</b>	<b>0.40</b>				Throughout year	
Thick grass cover	<b>30.0%</b>	<b>0.80</b>				Winter	

Rainfall Station: **Hydrology Average**

Rainfall Intensity (I)								
Return Period T (years)	2	5	10	25	50	100	200	Notes
Point Rainfall (mm)	54.3	87.8	87.8	105.1	121.8	138.0	154.8	
Point Intensity (mm/h)	40.0	64.7	64.7	77.5	89.8	101.8	114.2	
Area Reduction Factor	100%	100%	100%	100%	100%	100%	100%	
Average Intensity (mm/h)	<b>40.0</b>	<b>64.7</b>	<b>64.7</b>	<b>77.5</b>	<b>89.8</b>	<b>101.8</b>	<b>114.2</b>	

Run-off Factor								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Rural $C_1$	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
Urban $C_2$	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
Lakes $C_3$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
$C = \alpha C_1 + \beta C_2 + \gamma C_3$	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
$C_{final}$	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	

Peak Flow								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Peak Flow $Q = C \cdot I \cdot A$ (m <sup>3</sup> /s)	<b>0.748</b>	<b>1.210</b>	<b>1.210</b>	<b>1.449</b>	<b>1.678</b>	<b>1.903</b>	<b>2.133</b>	
Saturation Factor $F_t$	0.60	0.65	0.70	0.76	0.88	1.00	1.00	
Adjusted Peak $Q \cdot F_t$	<b>0.45</b>	<b>0.786</b>	<b>0.847</b>	<b>1.104</b>	<b>1.474</b>	<b>1.903</b>	<b>2.133</b>	

# RATIONAL METHOD CALCULATION SHEET

Project Description: <b>Middelwater / catchments to CWP</b>	Project Code: <b>ES755-2022</b>	Date: <b>2026/01/19</b>
Calculated by: <b>M. McLENNAN</b>		

Calculation: **Phase 2 composting area**

Physical Characteristics		Area Distribution Factors		
Size of catchment (A):	<b>0.1000</b> km <sup>2</sup>	Rural	Urban	Lakes
Longest water course (L):	<b>0.4750</b> km	$\alpha$ : <b>100.0%</b>	$\beta$ : <b>0.0%</b>	$\gamma$ : <b>0.0%</b>
Average slope (S):	<b>0.0067</b> m/m	Note: ( $\alpha + \beta + \gamma = 100\%$ )		
Dolomitic % (D):	<b>0.0%</b>			

Runoff Coefficient							
Rural				Urban			
Surface Slope (%)		Permeability (%)		Vegetation (%)		Use (%)	
Vleis & Pans	<b>90.0%</b>	Very Permeable	<b>0.0%</b>	Thick Bush; Plantation	<b>0.0%</b>	Lawns & Parks	<b>0.0%</b>
Flat Areas	<b>10.0%</b>	Permeable	<b>20.0%</b>	Light Bush; Farmland	<b>0.0%</b>	Industrial Areas	<b>0.0%</b>
Hilly	<b>0.0%</b>	Semi-Permeable	<b>40.0%</b>	Grassland	<b>100.0%</b>	City / Residential	<b>0.0%</b>
Steep Areas	<b>0.0%</b>	Impermeable	<b>40.0%</b>	No vegetation	<b>0.0%</b>	Streets	<b>100.0%</b>

Rainfall							
Roughness Coefficient				Time of concentration		Rainfall Information	
Clean compacted soil, no stones	<b>0.0%</b>	<b>0.10</b>	<input checked="" type="radio"/> Overland Flow	r = 0.5		MAR: <b>613.5</b> mm	
Paved areas	<b>0.0%</b>	<b>0.02</b>	<input type="radio"/> Watercourse	$T_c =$ <b>0.95</b> hours		Rainfall region:	
Sparse grass over fairly rough surface	<b>30.0%</b>	<b>0.30</b>			Summer		<b>x</b>
Medium grass cover	<b>30.0%</b>	<b>0.40</b>			Throughout year		
Thick grass cover	<b>30.0%</b>	<b>0.80</b>			Winter		

Rainfall Station: **Hydrology Average**

Rainfall Intensity (I)								
Return Period T (years)	2	5	10	25	50	100	200	Notes
Point Rainfall (mm)	54.3	87.8	87.8	105.1	121.8	138.0	154.8	
Point Intensity (mm/h)	57.3	92.7	92.7	111.0	128.6	145.8	163.5	
Area Reduction Factor	100%	100%	100%	100%	100%	100%	100%	
Average Intensity (mm/h)	<b>57.3</b>	<b>92.7</b>	<b>92.7</b>	<b>111.0</b>	<b>128.6</b>	<b>145.8</b>	<b>163.5</b>	

Run-off Factor								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Rural $C_1$	0.40	0.40	0.40	0.40	0.40	0.40	0.40	
Urban $C_2$	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
Lakes $C_3$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
$C = \alpha C_1 + \beta C_2 + \gamma C_3$	0.40	0.40	0.40	0.40	0.40	0.40	0.40	
$C_{final}$	<b>0.40</b>	<b>0.40</b>	<b>0.40</b>	<b>0.40</b>	<b>0.40</b>	<b>0.40</b>	<b>0.40</b>	

Peak Flow								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Peak Flow $Q = C \cdot I \cdot A$ (m <sup>3</sup> /s)	<b>0.639</b>	<b>1.034</b>	<b>1.034</b>	<b>1.238</b>	<b>1.434</b>	<b>1.626</b>	<b>1.823</b>	
Saturation Factor $F_t$	0.60	0.65	0.70	0.76	0.88	1.00	1.00	
Adjusted Peak $Q \cdot F_t$	<b>0.38</b>	<b>0.672</b>	<b>0.724</b>	<b>0.943</b>	<b>1.259</b>	<b>1.626</b>	<b>1.823</b>	

# RATIONAL METHOD CALCULATION SHEET

Project Description: <b>Middelwater / catchments to CWP</b>	Project Code: <b>ES755-2022</b>	Date: <b>2026/01/19</b>
Calculated by: <b>M. McLENNAN</b>		

Calculation: **Phase 2 composting area and entrance area**

Physical Characteristics		Area Distribution Factors		
Size of catchment (A):	<b>0.1000</b> km <sup>2</sup>	Rural	Urban	Lakes
Longest water course (L):	<b>0.9350</b> km	$\alpha$ : <b>100.0%</b>	$\beta$ : <b>0.0%</b>	$\gamma$ : <b>0.0%</b>
Average slope (S):	<b>0.0067</b> m/m	Note: ( $\alpha + \beta + \gamma = 100\%$ )		
Dolomitic % (D):	<b>0.0%</b>			

Runoff Coefficient							
Rural				Urban			
Surface Slope (%)		Permeability (%)		Vegetation (%)		Use (%)	
Vleis & Pans	<b>90.0%</b>	Very Permeable	<b>0.0%</b>	Thick Bush; Plantation	<b>0.0%</b>	Lawns & Parks	<b>0.0%</b>
Flat Areas	<b>10.0%</b>	Permeable	<b>20.0%</b>	Light Bush; Farmland	<b>0.0%</b>	Industrial Areas	<b>0.0%</b>
Hilly	<b>0.0%</b>	Semi-Permeable	<b>40.0%</b>	Grassland	<b>100.0%</b>	City / Residential	<b>0.0%</b>
Steep Areas	<b>0.0%</b>	Impermeable	<b>40.0%</b>	No vegetation	<b>0.0%</b>	Streets	<b>100.0%</b>

Rainfall							
Roughness Coefficient				Time of concentration		Rainfall Information	
Clean compacted soil, no stones	<b>0.0%</b>	<b>0.10</b>	<input checked="" type="radio"/> Overland Flow	$r = 0.5$ $T_c =$ <b>1.30</b> hours		MAR: <b>613.5</b> mm	
Paved areas	<b>0.0%</b>	<b>0.02</b>	<input type="radio"/> Watercourse			Rainfall region:	
Sparse grass over fairly rough surface	<b>30.0%</b>	<b>0.30</b>				Summer <input checked="" type="checkbox"/>	
Medium grass cover	<b>30.0%</b>	<b>0.40</b>				Throughout year <input type="checkbox"/>	
Thick grass cover	<b>30.0%</b>	<b>0.80</b>				Winter <input type="checkbox"/>	

Rainfall Station:  Hydrology  Average

Rainfall Intensity (I)								
Return Period T (years)	2	5	10	25	50	100	200	Notes
Point Rainfall (mm)	54.3	87.8	87.8	105.1	121.8	138.0	154.8	
Point Intensity (mm/h)	41.8	67.6	67.6	80.9	93.7	106.2	119.1	
Area Reduction Factor	100%	100%	100%	100%	100%	100%	100%	
Average Intensity (mm/h)	<b>41.8</b>	<b>67.6</b>	<b>67.6</b>	<b>80.9</b>	<b>93.7</b>	<b>106.2</b>	<b>119.1</b>	

Run-off Factor								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Rural $C_1$	0.40	0.40	0.40	0.40	0.40	0.40	0.40	
Urban $C_2$	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
Lakes $C_3$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
$C = \alpha C_1 + \beta C_2 + \gamma C_3$	0.40	0.40	0.40	0.40	0.40	0.40	0.40	
$C_{final}$	<b>0.40</b>	<b>0.40</b>	<b>0.40</b>	<b>0.40</b>	<b>0.40</b>	<b>0.40</b>	<b>0.40</b>	

Peak Flow								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Peak Flow $Q = C \cdot I \cdot A$ (m <sup>3</sup> /s)	<b>0.466</b>	<b>0.753</b>	<b>0.753</b>	<b>0.902</b>	<b>1.045</b>	<b>1.185</b>	<b>1.329</b>	
Saturation Factor $F_t$	0.60	0.65	0.70	0.76	0.88	1.00	1.00	
Adjusted Peak $Q \cdot F_t$	<b>0.28</b>	<b>0.490</b>	<b>0.527</b>	<b>0.688</b>	<b>0.918</b>	<b>1.185</b>	<b>1.329</b>	

# RATIONAL METHOD CALCULATION SHEET

Project Description: <b>Middelwater / catchments to CWP</b>	Project Code: <b>ES755-2022</b>	Date: <b>2026/01/19</b>
Calculated by: <b>M. McLENNAN</b>		

Calculation: **Phase 2 composting, entrance and eastern cells area**

Physical Characteristics	
Size of catchment (A):	<b>0.3000</b> km <sup>2</sup>
Longest water course (L):	<b>0.8340</b> km
Average slope (S):	<b>0.0067</b> m/m
Dolomitic % (D):	<b>0.0%</b>

Area Distribution Factors		
Rural	Urban	Lakes
$\alpha$ : <b>100.0%</b>	$\beta$ : <b>0.0%</b>	$\gamma$ : <b>0.0%</b>
Note: ( $\alpha + \beta + \gamma = 100\%$ )		

Runoff Coefficient							
Rural				Urban			
Surface Slope (%)		Permeability (%)		Vegetation (%)		Use (%)	
Vleis & Pans	<b>90.0%</b>	Very Permeable	<b>0.0%</b>	Thick Bush; Plantation	<b>0.0%</b>	Lawns & Parks	<b>0.0%</b>
Flat Areas	<b>10.0%</b>	Permeable	<b>20.0%</b>	Light Bush; Farmland	<b>0.0%</b>	Industrial Areas	<b>0.0%</b>
Hilly	<b>0.0%</b>	Semi-Permeable	<b>80.0%</b>	Grassland	<b>100.0%</b>	City / Residential	<b>0.0%</b>
Steep Areas	<b>0.0%</b>	Impermeable	<b>0.0%</b>	No vegetation	<b>0.0%</b>	Streets	<b>100.0%</b>

Rainfall							
Roughness Coefficient				Time of concentration		Rainfall Information	
Clean compacted soil, no stones	<b>0.0%</b>	<b>0.10</b>	<input checked="" type="radio"/> Overland Flow <input type="radio"/> Watercourse $r = 0.5$ $T_c =$ <b>1.23</b> hours	MAR: <b>613.5</b> mm Rainfall region: Summer <input checked="" type="checkbox"/> Throughout year <input type="checkbox"/> Winter <input type="checkbox"/>			
Paved areas	<b>0.0%</b>	<b>0.02</b>					
Sparse grass over fairly rough surface	<b>30.0%</b>	<b>0.30</b>					
Medium grass cover	<b>30.0%</b>	<b>0.40</b>					
Thick grass cover	<b>30.0%</b>	<b>0.80</b>					

Rainfall Station: Hydrology Average

Rainfall Intensity (I)								
Return Period T (years)	2	5	10	25	50	100	200	Notes
Point Rainfall (mm)	54.3	87.8	87.8	105.1	121.8	138.0	154.8	
Point Intensity (mm/h)	44.1	71.3	71.3	85.3	98.9	112.1	125.7	
Area Reduction Factor	100%	100%	100%	100%	100%	100%	100%	
Average Intensity (mm/h)	<b>44.1</b>	<b>71.3</b>	<b>71.3</b>	<b>85.3</b>	<b>98.9</b>	<b>112.1</b>	<b>125.7</b>	

Run-off Factor								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Rural $C_1$	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
Urban $C_2$	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
Lakes $C_3$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
$C = \alpha C_1 + \beta C_2 + \gamma C_3$	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
$C_{final}$	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	

Peak Flow								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Peak Flow $Q = C \cdot I \cdot A$ (m <sup>3</sup> /s)	<b>1.331</b>	<b>2.153</b>	<b>2.153</b>	<b>2.579</b>	<b>2.988</b>	<b>3.386</b>	<b>3.797</b>	
Saturation Factor $F_t$	0.60	0.65	0.70	0.76	0.88	1.00	1.00	
Adjusted Peak $Q \cdot F_t$	<b>0.80</b>	<b>1.400</b>	<b>1.507</b>	<b>1.965</b>	<b>2.623</b>	<b>3.386</b>	<b>3.797</b>	

# RATIONAL METHOD CALCULATION SHEET

Project Description: <b>Middelwater / catchments to CWP</b>	Project Code: <b>ES755-2022</b>	Date: <b>2026/01/19</b>
Calculated by: <b>M. McLENNAN</b>		

Calculation: **Phase 2 western cells area**

<p style="text-align: center;"><b>Physical Characteristics</b></p> <p>Size of catchment (A): <span style="border: 1px solid black; padding: 2px;">0.0500</span> km<sup>2</sup></p> <p>Longest water course (L): <span style="border: 1px solid black; padding: 2px;">0.6450</span> km</p> <p>Average slope (S): <span style="border: 1px solid black; padding: 2px;">0.0067</span> m/m</p> <p>Dolomitic % (D): <span style="border: 1px solid black; padding: 2px;">0.0%</span></p>	<p style="text-align: center;"><b>Area Distribution Factors</b></p> <p> <math>\alpha</math>: <span style="border: 1px solid black; padding: 2px;">100.0%</span> <math>\beta</math>: <span style="border: 1px solid black; padding: 2px;">0.0%</span> <math>\gamma</math>: <span style="border: 1px solid black; padding: 2px;">0.0%</span> </p> <p>Note: (<math>\alpha + \beta + \gamma = 100\%</math>)</p>
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Runoff Coefficient							
Rural				Urban			
Surface Slope (%)		Permeability (%)		Vegetation (%)		Use (%)	
Vleis & Pans	<span style="border: 1px solid black; padding: 2px;">90.0%</span>	Very Permeable	<span style="border: 1px solid black; padding: 2px;">0.0%</span>	Thick Bush; Plantation	<span style="border: 1px solid black; padding: 2px;">0.0%</span>	Lawns & Parks	<span style="border: 1px solid black; padding: 2px;">0.0%</span>
Flat Areas	<span style="border: 1px solid black; padding: 2px;">10.0%</span>	Permeable	<span style="border: 1px solid black; padding: 2px;">20.0%</span>	Light Bush; Farmland	<span style="border: 1px solid black; padding: 2px;">0.0%</span>	Industrial Areas	<span style="border: 1px solid black; padding: 2px;">0.0%</span>
Hilly	<span style="border: 1px solid black; padding: 2px;">0.0%</span>	Semi-Permeable	<span style="border: 1px solid black; padding: 2px;">80.0%</span>	Grassland	<span style="border: 1px solid black; padding: 2px;">100.0%</span>	City / Residential	<span style="border: 1px solid black; padding: 2px;">0.0%</span>
Steep Areas	<span style="border: 1px solid black; padding: 2px;">0.0%</span>	Impermeable	<span style="border: 1px solid black; padding: 2px;">0.0%</span>	No vegetation	<span style="border: 1px solid black; padding: 2px;">0.0%</span>	Streets	<span style="border: 1px solid black; padding: 2px;">100.0%</span>

Rainfall							
Roughness Coefficient				Time of concentration		Rainfall Information	
Clean compacted soil, no stones	<span style="border: 1px solid black; padding: 2px;">0.0%</span>	<span style="border: 1px solid black; padding: 2px;">0.10</span>	<input checked="" type="radio"/> Overland Flow <input type="radio"/> Watercourse $r = 0.5$ $T_c = $ <span style="border: 1px solid black; padding: 2px;">1.09</span> hours	MAR: <span style="border: 1px solid black; padding: 2px;">613.5</span> mm Rainfall region: Summer <span style="border: 1px solid black; padding: 2px;">x</span> Throughout year Winter			
Paved areas	<span style="border: 1px solid black; padding: 2px;">0.0%</span>	<span style="border: 1px solid black; padding: 2px;">0.02</span>					
Sparse grass over fairly rough surface	<span style="border: 1px solid black; padding: 2px;">30.0%</span>	<span style="border: 1px solid black; padding: 2px;">0.30</span>					
Medium grass cover	<span style="border: 1px solid black; padding: 2px;">30.0%</span>	<span style="border: 1px solid black; padding: 2px;">0.40</span>					
Thick grass cover	<span style="border: 1px solid black; padding: 2px;">30.0%</span>	<span style="border: 1px solid black; padding: 2px;">0.80</span>					

Rainfall Station: Hydrology Average

Rainfall Intensity (I)								
Return Period T (years)	2	5	10	25	50	100	200	Notes
Point Rainfall (mm)	54.3	87.8	87.8	105.1	121.8	138.0	154.8	
Point Intensity (mm/h)	49.7	80.3	80.3	96.2	111.5	126.4	141.7	
Area Reduction Factor	100%	100%	100%	100%	100%	100%	100%	
Average Intensity (mm/h)	49.7	80.3	80.3	96.2	111.5	126.4	141.7	

Run-off Factor								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Rural $C_1$	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
Urban $C_2$	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
Lakes $C_3$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
$C = \alpha C_1 + \beta C_2 + \gamma C_3$	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
$C_{final}$	0.36	0.36	0.36	0.36	0.36	0.36	0.36	

Peak Flow								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Peak Flow $Q = C \cdot I \cdot A$ (m <sup>3</sup> /s)	0.250	0.405	0.405	0.485	0.561	0.636	0.714	
Saturation Factor $F_t$	0.60	0.65	0.70	0.76	0.88	1.00	1.00	
Adjusted Peak $Q \cdot F_t$	0.15	0.263	0.283	0.369	0.493	0.636	0.714	

# RATIONAL METHOD CALCULATION SHEET

Project Description: <b>Middelwater / catchments to CWP</b>	Project Code: <b>ES755-2022</b>	Date: <b>2026/01/19</b>
Calculated by: <b>M. McLENNAN</b>		

Calculation: **Phase 2 western and southern cell areas**

<p style="text-align: center;"><b>Physical Characteristics</b></p> <p>Size of catchment (A): <span style="border: 1px solid black; padding: 2px;">0.2503</span> km<sup>2</sup></p> <p>Longest water course (L): <span style="border: 1px solid black; padding: 2px;">1.1840</span> km</p> <p>Average slope (S): <span style="border: 1px solid black; padding: 2px;">0.0067</span> m/m</p> <p>Dolomitic % (D): <span style="border: 1px solid black; padding: 2px;">0.0%</span></p>	<p style="text-align: center;"><b>Area Distribution Factors</b></p> <p>Rural                      Urban                      Lakes</p> <p>α: <span style="border: 1px solid black; padding: 2px;">100.0%</span> β: <span style="border: 1px solid black; padding: 2px;">0.0%</span> γ: <span style="border: 1px solid black; padding: 2px;">0.0%</span></p> <p>Note: (α + β + γ = 100%)</p>
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Runoff Coefficient							
Rural				Urban			
Surface Slope (%)		Permeability (%)		Vegetation (%)		Use (%)	
Vleis & Pans	90.0%	Very Permeable	0.0%	Thick Bush; Plantation	0.0%	Lawns & Parks	0.0%
Flat Areas	10.0%	Permeable	20.0%	Light Bush; Farmland	0.0%	Industrial Areas	0.0%
Hilly	0.0%	Semi-Permeable	80.0%	Grassland	100.0%	City / Residential	0.0%
Steep Areas	0.0%	Impermeable	0.0%	No vegetation	0.0%	Streets	100.0%

Rainfall								
Roughness Coefficient				Time of concentration		Rainfall Information		
Clean compacted soil, no stones	0.0%	0.10	<input checked="" type="radio"/> Overland Flow <input type="radio"/> Watercourse r = 0.5 T <sub>c</sub> = <span style="border: 1px solid black; padding: 2px;">1.45</span> hours			MAR: <span style="border: 1px solid black; padding: 2px;">613.5</span> mm		
Paved areas	0.0%	0.02				Rainfall region:		
Sparse grass over fairly rough surface	30.0%	0.30				Summer		x
Medium grass cover	30.0%	0.40				Throughout year		
Thick grass cover	30.0%	0.80				Winter		

Rainfall Station: Hydrology Average

Rainfall Intensity (I)								
Return Period T (years)	2	5	10	25	50	100	200	Notes
Point Rainfall (mm)	54.3	87.8	87.8	105.1	121.8	138.0	154.8	
Point Intensity (mm/h)	37.4	60.5	60.5	72.5	83.9	95.2	106.7	
Area Reduction Factor	100%	100%	100%	100%	100%	100%	100%	
Average Intensity (mm/h)	37.4	60.5	60.5	72.5	83.9	95.2	106.7	

Run-off Factor								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Rural C <sub>1</sub>	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
Urban C <sub>2</sub>	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
Lakes C <sub>3</sub>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
C = αC <sub>1</sub> + βC <sub>2</sub> + γC <sub>3</sub>	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
C <sub>final</sub>	0.36	0.36	0.36	0.36	0.36	0.36	0.36	

Peak Flow								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Peak Flow Q=C.I.A (m <sup>3</sup> /s)	0.943	1.525	1.525	1.827	2.116	2.399	2.690	
Saturation Factor F <sub>t</sub>	0.60	0.65	0.70	0.76	0.88	1.00	1.00	
Adjusted Peak Q.F <sub>t</sub>	0.57	0.991	1.068	1.392	1.858	2.399	2.690	

<b>RATIONAL METHOD CALCULATION SHEET</b>								
Project Description: <b>Multisand / catchments to CWP</b>				Project Code: <b>ES755-2022</b>		Date: <b>2026/01/19</b>		
				Calculated by: <b>M. McLENNAN</b>				
Calculation: <b>area A1 to drain UD1-UD2</b>								
<b>Physical Characteristics</b> Size of catchment (A): <b>0.0335</b> km <sup>2</sup> Longest water course (L): <b>0.5420</b> km Average slope (S): <b>0.0861</b> m/m Dolomitic % (D): <b>0.0%</b>				<b>Area Distribution Factors</b> Rural: <b>100.0%</b> Urban: <b>0.0%</b> Lakes: <b>0.0%</b> Note: ( $\alpha + \beta + \gamma = 100\%$ )				
Runoff Coefficient								
Rural				Urban				
Surface Slope (%)	Permeability (%)		Vegetation (%)		Use (%)			
Vleis & Pans	<b>0.0%</b>	Very Permeable	<b>0.0%</b>	Thick Bush; Plantation	<b>0.0%</b>	Lawns & Parks	<b>0.0%</b>	
Flat Areas	<b>80.0%</b>	Permeable	<b>20.0%</b>	Light Bush; Farmland	<b>30.0%</b>	Industrial Areas	<b>0.0%</b>	
Hilly	<b>20.0%</b>	Semi-Permeable	<b>80.0%</b>	Grassland	<b>68.0%</b>	City / Residential	<b>0.0%</b>	
Steep Areas	<b>0.0%</b>	Impermeable	<b>0.0%</b>	No vegetation	<b>2.0%</b>	Streets	<b>100.0%</b>	
Rainfall								
Roughness Coefficient				Time of concentration		Rainfall Information		
Clean compacted soil, no stones		<b>0.0%</b>	<b>0.10</b>	<input checked="" type="radio"/> Overland Flow    r = 0.5		MAR: <b>613.5</b> mm		
Paved areas		<b>0.0%</b>	<b>0.02</b>	<input type="radio"/> Watercourse		Rainfall region: Summer <b>x</b>		
Sparse grass over fairly rough surface		<b>30.0%</b>	<b>0.30</b>	$T_c =$ <b>0.58</b> hours		Throughout year		
Medium grass cover		<b>40.0%</b>	<b>0.40</b>			Winter		
Thick grass cover		<b>30.0%</b>	<b>0.80</b>					
Rainfall Station: Hydrology Average								
Rainfall Intensity (I)								
Return Period T (years)	2	<b>5</b>	10	<b>25</b>	<b>50</b>	100	200	Notes
Point Rainfall (mm)	54.3	87.8	87.8	105.1	121.8	138.0	154.8	
Point Intensity (mm/h)	94.1	152.2	152.2	182.3	211.2	239.4	268.4	
Area Reduction Factor	100%	100%	100%	100%	100%	100%	100%	
Average Intensity (mm/h)	<b>94.1</b>	<b>152.2</b>	<b>152.2</b>	<b>182.3</b>	<b>211.2</b>	<b>239.4</b>	<b>268.4</b>	
Run-off Factor								
Return Period T (years)	2	<b>5</b>	10	<b>25</b>	<b>50</b>	100	Max	Notes
Rural $C_1$	0.39	0.39	0.39	0.39	0.39	0.39	0.39	
Urban $C_2$	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
Lakes $C_3$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
$C = \alpha C_1 + \beta C_2 + \gamma C_3$	0.39	0.39	0.39	0.39	0.39	0.39	0.39	
$C_{final}$	<b>0.39</b>	<b>0.39</b>	<b>0.39</b>	<b>0.39</b>	<b>0.39</b>	<b>0.39</b>	<b>0.39</b>	
Peak Flow								
Return Period T (years)	2	<b>5</b>	10	<b>25</b>	<b>50</b>	100	Max	Notes
Peak Flow $Q=C.I.A$ (m <sup>3</sup> /s)	<b>0.345</b>	<b>0.558</b>	<b>0.558</b>	<b>0.668</b>	<b>0.774</b>	<b>0.878</b>	<b>0.984</b>	
Saturation Factor $F_t$	0.63	0.68	0.73	0.79	0.89	1.00	1.00	
Adjusted Peak $Q.F_t$	<b>0.22</b>	<b>0.377</b>	<b>0.405</b>	<b>0.525</b>	<b>0.689</b>	<b>0.878</b>	<b>0.984</b>	

<b>RATIONAL METHOD CALCULATION SHEET</b>								
Project Description: <b>Multisand / catchments to CWP</b>				Project Code: <b>ES755-2022</b>		Date: <b>2026/01/19</b>		
				Calculated by: <b>M. McLENNAN</b>				
Calculation: <b>area A2 to drain UD2-UD3</b>								
<b>Physical Characteristics</b> Size of catchment (A): <b>0.1020</b> km <sup>2</sup> Longest water course (L): <b>0.4570</b> km Average slope (S): <b>0.0222</b> m/m Dolomitic % (D): <b>0.0%</b>				<b>Area Distribution Factors</b> Rural: <b>100.0%</b> Urban: <b>0.0%</b> Lakes: <b>0.0%</b> Note: ( $\alpha + \beta + \gamma = 100\%$ )				
Runoff Coefficient								
Rural				Urban				
Surface Slope (%)	Permeability (%)		Vegetation (%)		Use (%)			
Vleis & Pans	<b>50.0%</b>	Very Permeable	<b>0.0%</b>	Thick Bush; Plantation	<b>0.0%</b>	Lawns & Parks	<b>0.0%</b>	
Flat Areas	<b>50.0%</b>	Permeable	<b>20.0%</b>	Light Bush; Farmland	<b>20.0%</b>	Industrial Areas	<b>0.0%</b>	
Hilly	<b>0.0%</b>	Semi-Permeable	<b>80.0%</b>	Grassland	<b>78.0%</b>	City / Residential	<b>0.0%</b>	
Steep Areas	<b>0.0%</b>	Impermeable	<b>0.0%</b>	No vegetation	<b>2.0%</b>	Streets	<b>100.0%</b>	
Rainfall								
Roughness Coefficient				Time of concentration		Rainfall Information		
Clean compacted soil, no stones	<b>0.0%</b>	<b>0.10</b>	<input checked="" type="radio"/> Overland Flow		r = 0.5	MAR: <b>613.5</b> mm		
Paved areas	<b>0.0%</b>	<b>0.02</b>	<input type="radio"/> Watercourse			Rainfall region:		
Sparse grass over fairly rough surface	<b>30.0%</b>	<b>0.30</b>	T <sub>c</sub> = <b>0.73</b> hours		Summer <input checked="" type="checkbox"/>			
Medium grass cover	<b>40.0%</b>	<b>0.40</b>			Throughout year <input type="checkbox"/>			
Thick grass cover	<b>30.0%</b>	<b>0.80</b>			Winter <input type="checkbox"/>			
<b>Rainfall Station:</b>		Hydrology		Average				
Rainfall Intensity (I)								
Return Period T (years)	2	<b>5</b>	10	<b>25</b>	<b>50</b>	100	200	Notes
Point Rainfall (mm)	54.3	87.8	87.8	105.1	121.8	138.0	154.8	
Point Intensity (mm/h)	74.3	120.1	120.1	143.9	166.7	188.9	211.9	
Area Reduction Factor	100%	100%	100%	100%	100%	100%	100%	
Average Intensity (mm/h)	<b>74.3</b>	<b>120.1</b>	<b>120.1</b>	<b>143.9</b>	<b>166.7</b>	<b>188.9</b>	<b>211.9</b>	
Run-off Factor								
Return Period T (years)	2	<b>5</b>	10	<b>25</b>	<b>50</b>	100	Max	Notes
Rural C <sub>1</sub>	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
Urban C <sub>2</sub>	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
Lakes C <sub>3</sub>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
C = $\alpha C_1 + \beta C_2 + \gamma C_3$	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
C <sub>final</sub>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	
Peak Flow								
Return Period T (years)	2	<b>5</b>	10	<b>25</b>	<b>50</b>	100	Max	Notes
Peak Flow Q=C.I.A (m <sup>3</sup> /s)	<b>0.766</b>	<b>1.239</b>	<b>1.239</b>	<b>1.484</b>	<b>1.720</b>	<b>1.949</b>	<b>2.186</b>	
Saturation Factor F <sub>t</sub>	0.60	0.65	0.70	0.76	0.88	1.00	1.00	
Adjusted Peak Q.F <sub>t</sub>	<b>0.46</b>	<b>0.806</b>	<b>0.868</b>	<b>1.131</b>	<b>1.510</b>	<b>1.949</b>	<b>2.186</b>	

<b>RATIONAL METHOD CALCULATION SHEET</b>								
Project Description: <b>Multisand / catchments to CWP</b>				Project Code: <b>ES755-2022</b>		Date: <b>2026/01/19</b>		
				Calculated by: <b>M. McLENNAN</b>				
Calculation: <b>area A2 to drain UD4-UD5</b>								
<b>Physical Characteristics</b> Size of catchment (A): <b>0.0238</b> km <sup>2</sup> Longest water course (L): <b>0.3110</b> km Average slope (S): <b>0.2500</b> m/m Dolomitic % (D): <b>0.0%</b>				<b>Area Distribution Factors</b> Rural: <b>100.0%</b> Urban: <b>0.0%</b> Lakes: <b>0.0%</b> Note: ( $\alpha + \beta + \gamma = 100\%$ )				
Runoff Coefficient								
Rural				Urban				
Surface Slope (%)	Permeability (%)		Vegetation (%)		Use (%)			
Vleis & Pans	<b>0.0%</b>	Very Permeable	<b>0.0%</b>	Thick Bush; Plantation	<b>0.0%</b>	Lawns & Parks	<b>0.0%</b>	
Flat Areas	<b>5.0%</b>	Permeable	<b>10.0%</b>	Light Bush; Farmland	<b>0.0%</b>	Industrial Areas	<b>0.0%</b>	
Hilly	<b>50.0%</b>	Semi-Permeable	<b>80.0%</b>	Grassland	<b>10.0%</b>	City / Residential	<b>0.0%</b>	
Steep Areas	<b>45.0%</b>	Impermeable	<b>10.0%</b>	No vegetation	<b>90.0%</b>	Streets	<b>100.0%</b>	
Rainfall								
Roughness Coefficient				Time of concentration		Rainfall Information		
Clean compacted soil, no stones		<b>0.0%</b>	<b>0.10</b>	<input checked="" type="radio"/> Overland Flow    r = 0.1		MAR: <b>613.5</b> mm		
Paved areas		<b>70.0%</b>	<b>0.02</b>	<input type="radio"/> Watercourse		Rainfall region: Summer <b>x</b>		
Sparse grass over fairly rough surface		<b>30.0%</b>	<b>0.30</b>	T <sub>c</sub> = <b>0.17</b> hours		Throughout year		
Medium grass cover		<b>0.0%</b>	<b>0.40</b>			Winter		
Thick grass cover		<b>0.0%</b>	<b>0.80</b>					
Rainfall Station: Hydrology Average								
Rainfall Intensity (I)								
Return Period T (years)	2	5	10	25	50	100	200	Notes
Point Rainfall (mm)	54.3	87.8	87.8	105.1	121.8	138.0	154.8	
Point Intensity (mm/h)	217.0	351.0	351.0	420.3	487.0	552.0	619.0	
Area Reduction Factor	100%	100%	100%	100%	100%	100%	100%	
Average Intensity (mm/h)	<b>217.0</b>	<b>351.0</b>	<b>351.0</b>	<b>420.3</b>	<b>487.0</b>	<b>552.0</b>	<b>619.0</b>	
Run-off Factor								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Rural C <sub>1</sub>	0.61	0.61	0.61	0.61	0.61	0.61	0.61	
Urban C <sub>2</sub>	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
Lakes C <sub>3</sub>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
C = $\alpha C_1 + \beta C_2 + \gamma C_3$	0.61	0.61	0.61	0.61	0.61	0.61	0.61	
C <sub>final</sub>	<b>0.61</b>	<b>0.61</b>	<b>0.61</b>	<b>0.61</b>	<b>0.61</b>	<b>0.61</b>	<b>0.61</b>	
Peak Flow								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Peak Flow Q=C.I.A (m <sup>3</sup> /s)	<b>0.872</b>	<b>1.411</b>	<b>1.411</b>	<b>1.690</b>	<b>1.958</b>	<b>2.219</b>	<b>2.489</b>	
Saturation Factor F <sub>t</sub>	0.73	0.78	0.83	0.88	0.94	1.00	1.00	
Adjusted Peak Q.F <sub>t</sub>	<b>0.64</b>	<b>1.102</b>	<b>1.173</b>	<b>1.492</b>	<b>1.842</b>	<b>2.219</b>	<b>2.489</b>	

<b>RATIONAL METHOD CALCULATION SHEET</b>								
Project Description: <b>Multisand / catchments to CWP</b>				Project Code: <b>ES755-2022</b>		Date: <b>2026/01/19</b>		
				Calculated by: <b>M. McLENNAN</b>				
Calculation: <b>area A2 to drain UD5-UD6</b>								
<b>Physical Characteristics</b> Size of catchment (A): <b>0.0766</b> km <sup>2</sup> Longest water course (L): <b>0.4600</b> km Average slope (S): <b>0.0357</b> m/m Dolomitic % (D): <b>0.0%</b>				<b>Area Distribution Factors</b> Rural: <b>100.0%</b> Urban: <b>0.0%</b> Lakes: <b>0.0%</b> Note: ( $\alpha + \beta + \gamma = 100\%$ )				
Runoff Coefficient								
Rural				Urban				
Surface Slope (%)	Permeability (%)		Vegetation (%)		Use (%)			
Vleis & Pans	<b>90.0%</b>	Very Permeable	<b>0.0%</b>	Thick Bush; Plantation	<b>0.0%</b>	Lawns & Parks	<b>0.0%</b>	
Flat Areas	<b>0.0%</b>	Permeable	<b>20.0%</b>	Light Bush; Farmland	<b>0.0%</b>	Industrial Areas	<b>0.0%</b>	
Hilly	<b>5.0%</b>	Semi-Permeable	<b>75.0%</b>	Grassland	<b>10.0%</b>	City / Residential	<b>0.0%</b>	
Steep Areas	<b>5.0%</b>	Impermeable	<b>5.0%</b>	No vegetation	<b>90.0%</b>	Streets	<b>100.0%</b>	
Rainfall								
Roughness Coefficient				Time of concentration		Rainfall Information		
Clean compacted soil, no stones		<b>0.0%</b>	<b>0.10</b>	<input checked="" type="radio"/> Overland Flow    r = 0.5		MAR: <b>613.5</b> mm		
Paved areas		<b>10.0%</b>	<b>0.02</b>	<input type="radio"/> Watercourse		Rainfall region:		
Sparse grass over fairly rough surface		<b>30.0%</b>	<b>0.30</b>	$T_c =$ <b>0.63</b> hours		Summer <input checked="" type="checkbox"/>		
Medium grass cover		<b>30.0%</b>	<b>0.40</b>			Throughout year <input type="checkbox"/>		
Thick grass cover		<b>30.0%</b>	<b>0.80</b>			Winter <input type="checkbox"/>		
<b>Rainfall Station:</b> Hydrology				Average				
Rainfall Intensity (I)								
Return Period T (years)	2	<b>5</b>	10	<b>25</b>	<b>50</b>	100	200	Notes
Point Rainfall (mm)	54.3	87.8	87.8	105.1	121.8	138.0	154.8	
Point Intensity (mm/h)	85.9	138.9	138.9	166.4	192.8	218.5	245.0	
Area Reduction Factor	100%	100%	100%	100%	100%	100%	100%	
Average Intensity (mm/h)	<b>85.9</b>	<b>138.9</b>	<b>138.9</b>	<b>166.4</b>	<b>192.8</b>	<b>218.5</b>	<b>245.0</b>	
Run-off Factor								
Return Period T (years)	2	<b>5</b>	10	<b>25</b>	<b>50</b>	100	Max	Notes
Rural $C_1$	0.45	0.45	0.45	0.45	0.45	0.45	0.45	
Urban $C_2$	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
Lakes $C_3$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
$C = \alpha C_1 + \beta C_2 + \gamma C_3$	0.45	0.45	0.45	0.45	0.45	0.45	0.45	
$C_{final}$	<b>0.45</b>	<b>0.45</b>	<b>0.45</b>	<b>0.45</b>	<b>0.45</b>	<b>0.45</b>	<b>0.45</b>	
Peak Flow								
Return Period T (years)	2	<b>5</b>	10	<b>25</b>	<b>50</b>	100	Max	Notes
Peak Flow $Q=C.I.A$ (m <sup>3</sup> /s)	<b>0.819</b>	<b>1.324</b>	<b>1.324</b>	<b>1.586</b>	<b>1.837</b>	<b>2.083</b>	<b>2.336</b>	
Saturation Factor $F_t$	0.61	0.66	0.71	0.77	0.88	1.00	1.00	
Adjusted Peak $Q.F_t$	<b>0.50</b>	<b>0.877</b>	<b>0.944</b>	<b>1.227</b>	<b>1.624</b>	<b>2.083</b>	<b>2.336</b>	

<b>RATIONAL METHOD CALCULATION SHEET</b>								
Project Description: <b>Multisand / catchments to CWP</b>				Project Code: <b>ES755-2022</b>		Date: <b>2026/01/19</b>		
				Calculated by: <b>M. McLENNAN</b>				
Calculation: <b>area A2 to drain UD6-UD3</b>								
<b>Physical Characteristics</b> Size of catchment (A): <b>0.2877</b> km <sup>2</sup> Longest water course (L): <b>0.9150</b> km Average slope (S): <b>0.0222</b> m/m Dolomitic % (D): <b>0.0%</b>				<b>Area Distribution Factors</b> Rural: <b>100.0%</b> Urban: <b>0.0%</b> Lakes: <b>0.0%</b> Note: ( $\alpha + \beta + \gamma = 100\%$ )				
Runoff Coefficient								
Rural				Urban				
Surface Slope (%)	Permeability (%)	Vegetation (%)	Use (%)					
Vleis & Pans	<b>90.0%</b> Very Permeable	<b>0.0%</b> Thick Bush; Plantation	<b>0.0%</b> Lawns & Parks					
Flat Areas	<b>10.0%</b> Permeable	<b>20.0%</b> Light Bush; Farmland	<b>0.0%</b> Industrial Areas					
Hilly	<b>0.0%</b> Semi-Permeable	<b>80.0%</b> Grassland	<b>100.0%</b> City / Residential					
Steep Areas	<b>0.0%</b> Impermeable	<b>0.0%</b> No vegetation	<b>0.0%</b> Streets					
Rainfall								
Roughness Coefficient				Time of concentration		Rainfall Information		
Clean compacted soil, no stones	<b>0.0%</b>	<b>0.10</b>	<input checked="" type="radio"/> Overland Flow		MAR: <b>613.5</b> mm			
Paved areas	<b>0.0%</b>	<b>0.02</b>	<input type="radio"/> Watercourse		r = 0.5			
Sparse grass over fairly rough surface	<b>30.0%</b>	<b>0.30</b>	$T_c =$ <b>0.97</b> hours		Rainfall region:			
Medium grass cover	<b>30.0%</b>	<b>0.40</b>			Summer		<b>x</b>	
Thick grass cover	<b>30.0%</b>	<b>0.80</b>			Throughout year			
Winter								
Rainfall Station: Hydrology Average								
Rainfall Intensity (I)								
Return Period T (years)	2	5	10	25	50	100	200	Notes
Point Rainfall (mm)	54.3	87.8	87.8	105.1	121.8	138.0	154.8	
Point Intensity (mm/h)	55.9	90.4	90.4	108.3	125.4	142.2	159.4	
Area Reduction Factor	100%	100%	100%	100%	100%	100%	100%	
Average Intensity (mm/h)	<b>55.9</b>	<b>90.4</b>	<b>90.4</b>	<b>108.3</b>	<b>125.4</b>	<b>142.2</b>	<b>159.4</b>	
Run-off Factor								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Rural C <sub>1</sub>	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
Urban C <sub>2</sub>	0.83	0.83	0.83	0.83	0.83	0.83	0.83	
Lakes C <sub>3</sub>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
C = $\alpha C_1 + \beta C_2 + \gamma C_3$	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
C <sub>final</sub>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	<b>0.36</b>	
Peak Flow								
Return Period T (years)	2	5	10	25	50	100	Max	Notes
Peak Flow Q=C.I.A (m <sup>3</sup> /s)	<b>1.619</b>	<b>2.619</b>	<b>2.619</b>	<b>3.137</b>	<b>3.634</b>	<b>4.120</b>	<b>4.620</b>	
Saturation Factor F <sub>t</sub>	0.60	0.65	0.70	0.76	0.88	1.00	1.00	
Adjusted Peak Q.F <sub>t</sub>	<b>0.97</b>	<b>1.703</b>	<b>1.834</b>	<b>2.390</b>	<b>3.191</b>	<b>4.120</b>	<b>4.620</b>	

CATCHMENT	AREA	area km2	LENGTH 1	SLOPE1	G	D	SL	COMMENT	drain	CULVERT	peak flow
A1	33500	0.0335	542	0.086				grass and bushes	UD1-UD2	1	0.689
A2	102000	0.102	457	0.022				grass and less bushes	UD2-UD3		1.510
A3a	23785	0.023785	311	0.250				quarry section	UD4-UD5		1.842
A3b	76615	0.076615	460	0.036				grass	UD5-UD6		1.624
A4	287700	0.2877	915	0.022				grass	UD6-UD3		3.191

summary clean up-slope drains

CATCHMENT	AREA (contaminated)	area km2	LENGTH 1	SLOPE1
ph1-1	123665	0.123665	580	0.005
ph1-2	61832	0.061832	530	0.005
ph1-3	185497	0.185497	1024	0.007
ph2-1	100000	0.100000	475	0.005
ph2-2	200000	0.200000	935	0.007
ph2-3	300000	0.300000	834	0.007
ph2-4	50000	0.050000	645	0.007
ph2-5	250300	0.250300	1184	0.005

COMMENT	drain	CULVERT		peak flow
grass	north			1.198
grass and less b	south	culvert/drift		0.625
grass	east			1.474
rough soil	compost		**	1.259
grass	entrance		**	0.918
grass	east		**	2.623
grass	west		**	0.493
grass	south		**	1.858

\*\* slopes to be confirmed with final design levels

**leachate dam size requirement- review**

ES755-2022 2016/01/26

report  
I value  
93.4mm

SAWB design depth  
122mm

loss factor  
(see

notes

total volume runoff  
Q  
A\*d\*F

cum

Phase 1 cells	disposal area	cumulative
cell 1	47500	47500
cell 2	36600	84100
cell 3	47200	131300
cell 4	43100	174400
cell 5	36300	210700
cell 6	47500	258200
<u>Phase 2 cells</u>		
cell 7	61000	61000
cell 8	71500	132500
cell 9	77200	209700
<u>dam surface area</u>		
leachate	8500	

0.122	0.10	capped	580	580
0.122	0.10	capped	447	1026
0.122	0.10	capped	576	1602
0.122	0.30	interim cap	1577	3179
0.122	0.30	interim cap	1329	4508
0.122	0.30	interim cap	1739	6246
			6246	
0.122	0.30	interim cap	2233	8479
0.122	0.67	cell operational	5844	14323
0.122	0.9	cell open, no waste	8477	22800
			16554	
			<b>22800</b>	
		worst case capacity req'd add 500m3	<b>23000</b>	m3

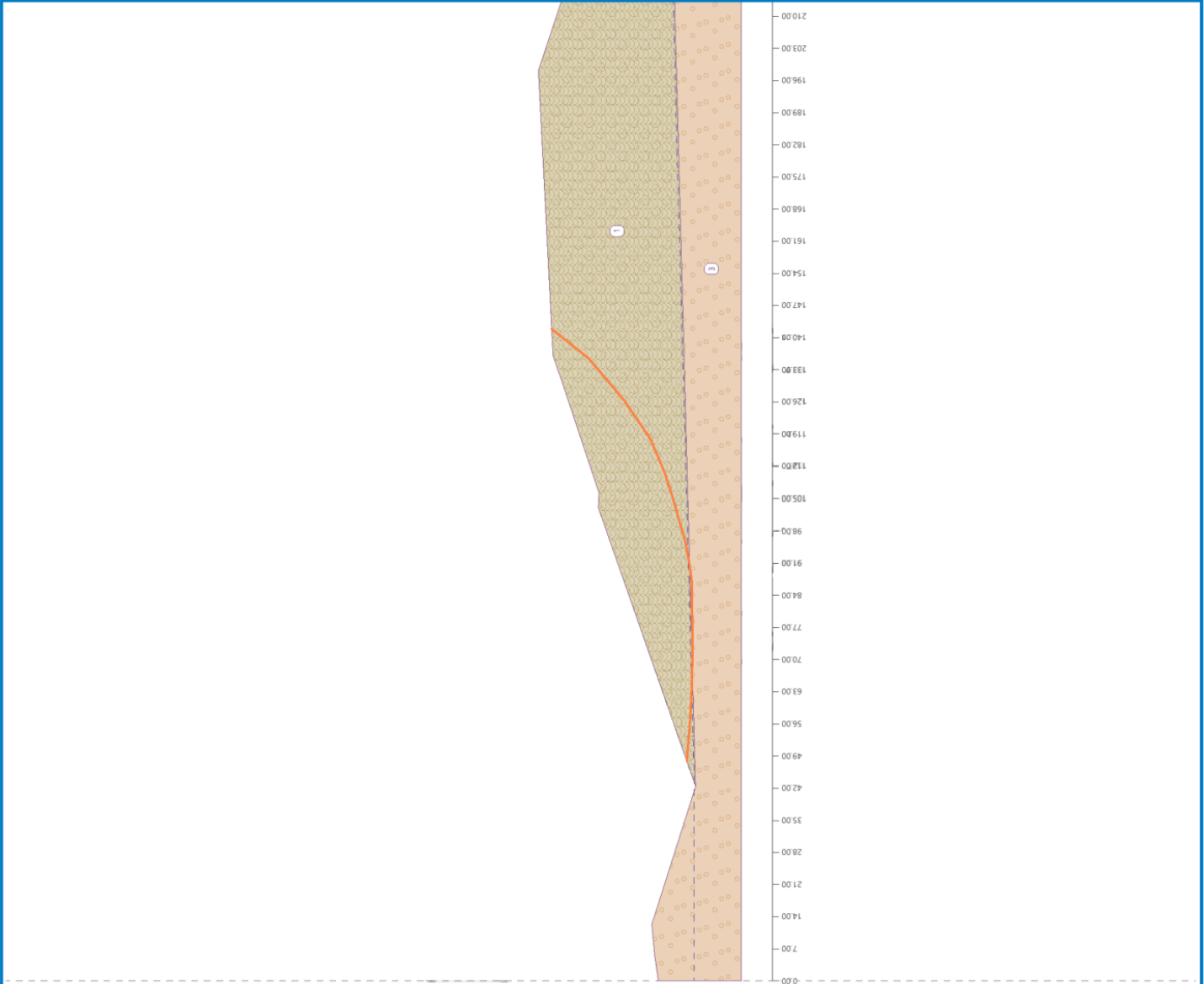
Worst case- (Phase 1 capped, runoff diverted), 2 largest cells Phase 2 open, half all side slopes "contaminated" at one time

contaminated area	area	cumulative		V=A x d (122mm)	F		Qm3
side slopes	5640	5640			0.7	steep slopes, low infiltration	3948
compost area	45000	50640	note: compost area to drain to sump, where runoff quality monitored, discharged to CWD by default, otherwise diverted to LD or environment		0.55	low ground infiltration, high absorption, flat slopes	24750
facilities area, road	25000	75640			0.9	low infiltration	22500
cw dam	15000	90640		11058	1	no losses	15000
							66198

add 500m3 **66700** m3

Name :

Stage - analysis : 1 - 1



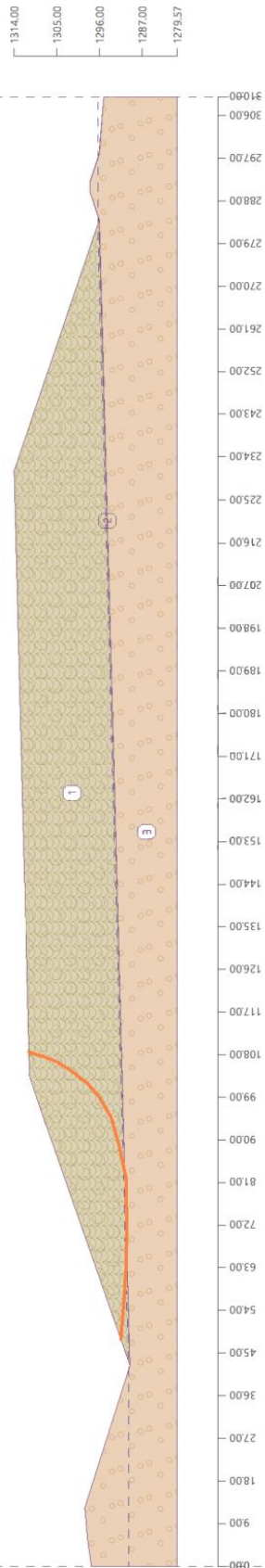
Analysis of the slip surface without optimization.

**Slope stability verification (all methods)**

Sarma : FS = 1.73 > 1.50 **ACCEPTABLE**  
 Spencer : FS = 1.75 > 1.50 **ACCEPTABLE**  
 Janbu : FS = 1.76 > 1.50 **ACCEPTABLE**  
 Morgenstern-Price : FS = 1.77 > 1.50 **ACCEPTABLE**

Name :

Stage - analysis : 1 - 1



Analysis of the slip surface without optimization.

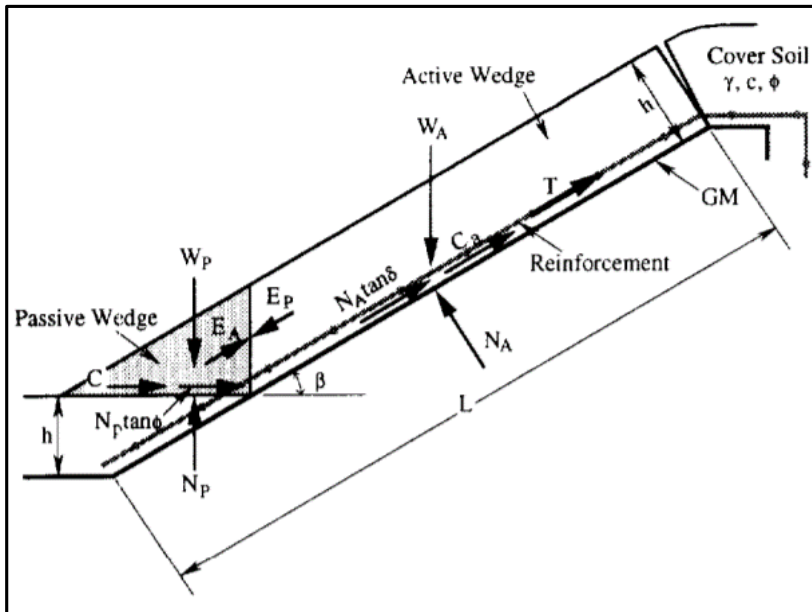
**Slope stability verification (all methods)**

Sarma :	FS = 2.21 > 1.50	<b>ACCEPTABLE</b>
Spencer :	FS = 2.04 > 1.50	<b>ACCEPTABLE</b>
Janbu :	FS = 2.02 > 1.50	<b>ACCEPTABLE</b>
Morgenstern-Price :	FS = 2.02 > 1.50	<b>ACCEPTABLE</b>

**COVER SOIL STABILITY ANALYSIS WORKSHEET**  
 Uniform Cover Soil Thickness with Overlying Geosynthetics



Client: MBHE Environmental (PTY) LTD  
 Project: Middel Water Resource Facility  
 Description: Slope Stability Analysis - Landfill Cell  
 Interface: 1.5mm HDPE Textured and GCL  
 Project No.: ES755-2022  
 Date: January 20, 2026  
 Author: Envitech Solutions (Based on TY Soong and RM Koerner, 2005)



**Calculation of FS**

**Active Wedge:**

W<sub>a</sub> = 341.94 kN  
 N<sub>a</sub> = 324.40 kN

**Passive Wedge:**

W<sub>p</sub> = 2.57 kN

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

a = 32.44  
 b = -92.39  
 c = 14.24

**FS = 2.6846187**

thickness of cover soil = h =	<input type="text" value="0.15"/>	m	
Slope (V:H) 1 in =	<input type="text" value="3"/>		
soil slope angle beneath the geosynthetics = β =	<input type="text" value="18.43"/>	°	= 0.322 (rad.)
length of slope measured along the geosynthetics = L =	<input type="text" value="33.73"/>	m	
unit weight of the cover soil/stone = γ =	<input type="text" value="18.6"/>	kN/m <sup>3</sup>	
unit weight of operating equipment = y =	<input type="text" value="50"/>	kN/m <sup>3</sup>	
friction angle of the cover soil/stone = φ =	<input type="text" value="35"/>	°	= 0.611 (rad.)
cohesion of the cover soil/stone = c =	<input type="text" value="0"/>	kN/m <sup>3</sup>	C = 0 kN
critical interface friction angle (GCL/geomembrane) = δ =	<input type="text" value="29"/>	°	= 0.506 (rad.)
critical interface adhesion (GCL/geomembrane) = ca =	<input type="text" value="17"/>	kN/m <sup>3</sup>	Ca = 86.01 kN

composite strength of the overlying geosynthetic layers = T <sub>ult</sub> =	<input type="text" value="20"/>	kN/m
partial FS for installation damage = (FS) ID =	<input type="text" value="1.2"/>	
partial FS for creep = (FS) CR =	<input type="text" value="2.4"/>	
partial FS for chemical/biological degradation = (FS) CBD =	<input type="text" value="1.2"/>	
partial FS for seams = (FS) SM =	<input type="text" value="1"/>	

$$T_{allow} = T_{ult} \left[ \frac{1}{RF_{ID} \times RF_{CR} \times RF_{CBD} \times RF_{SM}} \right]$$

**allowable value of reinforcement strength = T reqd = 5.8 kN/m**

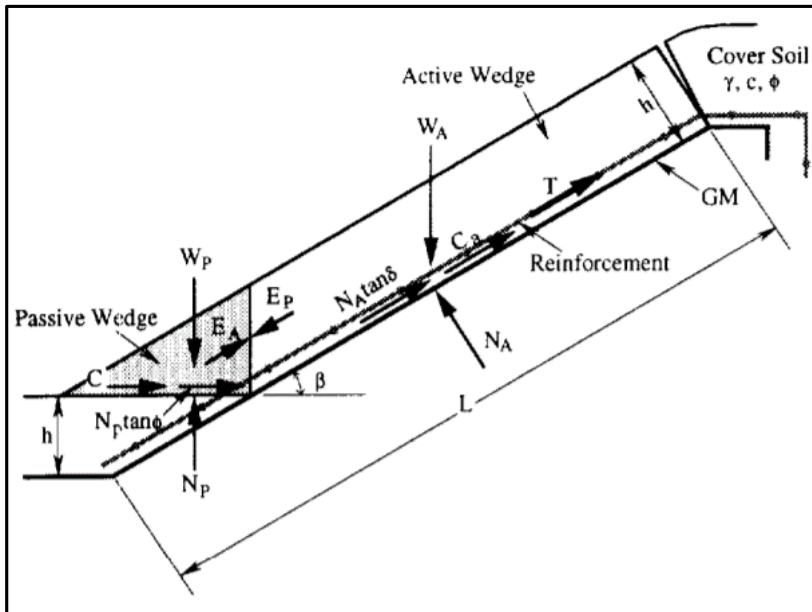
Note:

(From TY Soong and RM Koerner, 2005)

**COVER SOIL STABILITY ANALYSIS WORKSHEET**  
Uniform Cover Soil Thickness with Overlying Geosynthetics



Client: MBHE Environmental (PTY) LTD  
 Project: Middel Water Resource Facility  
 Description: Slope Stability Analysis - Landfill Cell  
 Interface: 1.5mm HDPE Textured and 1200g/m2 GTX  
 Project No.: ES755-2022  
 Date: January 20, 2026  
 Author: Envitech Solutions (Based on TY Soong and RM Koerner, 2005)



**Calculation of FS**

**Active Wedge:**

W<sub>a</sub> = 341.94 kN  
 N<sub>a</sub> = 324.40 kN

**Passive Wedge:**

W<sub>p</sub> = 2.57 kN

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

a = 32.44  
 b = -70.63  
 c = 11.00

**FS = 2.0084768**

thickness of cover soil = h =	<input type="text" value="0.15"/>	m	
Slope (V:H) 1 in =	<input type="text" value="3"/>		
soil slope angle beneath the geosynthetics = β =	<input type="text" value="18.43"/>	°	= <input type="text" value="0.322 (rad.)"/>
length of slope measured along the geosynthetics = L =	<input type="text" value="33.73"/>	m	
unit weight of the cover soil/stone = γ =	<input type="text" value="18.6"/>	kN/m <sup>3</sup>	
unit weight of operating equipment = y =	<input type="text" value="50"/>	kN/m <sup>3</sup>	
friction angle of the cover soil/stone = φ =	<input type="text" value="35"/>	°	= <input type="text" value="0.611 (rad.)"/>
cohesion of the cover soil/stone = c =	<input type="text" value="0"/>	kN/m <sup>3</sup>	C = <input type="text" value="0 kN"/>
critical interface friction angle (GCL/geomembrane) = δ =	<input type="text" value="23.5"/>	°	= <input type="text" value="0.410 (rad.)"/>
critical interface adhesion (GCL/geomembrane) = ca =	<input type="text" value="11"/>	kN/m <sup>3</sup>	Ca = <input type="text" value="55.65 kN"/>
composite strength of the overlying geosynthetic layers = T <sub>ult</sub> =	<input type="text" value="20"/>	kN/m	
partial FS for installation damage = (FS) ID =	<input type="text" value="1.2"/>		
partial FS for creep = (FS) CR =	<input type="text" value="2.4"/>		
partial FS for chemical/biological degradation = (FS) CBD =	<input type="text" value="1.2"/>		
partial FS for seams = (FS) SM =	<input type="text" value="1"/>		

$$T_{allow} = T_{ult} \left[ \frac{1}{RF_{ID} \times RF_{CR} \times RF_{CBD} \times RF_{SM}} \right]$$

**allowable value of reinforcement strength = T reqd = 5.8 kN/m**

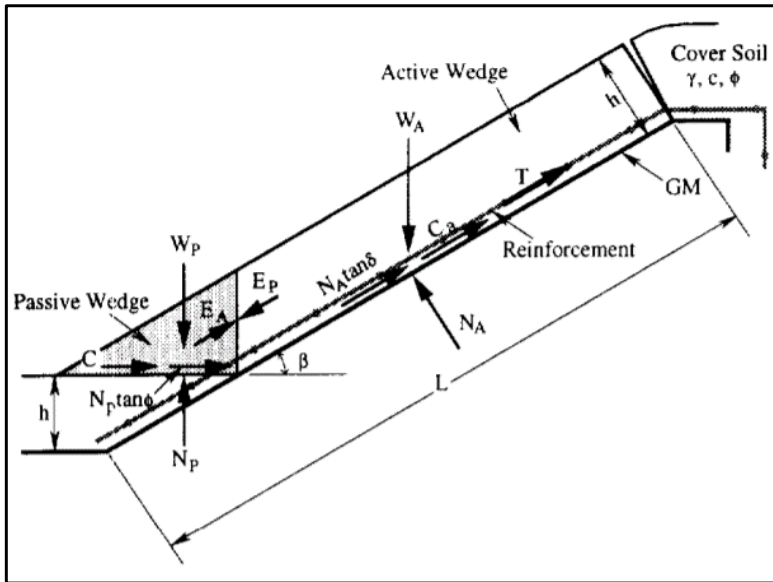
Note:

(From TY Soong and RM Koerner, 2005)

**COVER SOIL STABILITY ANALYSIS WORKSHEET**  
 Uniform Cover Soil Thickness with Overlying Geosynthetics



Client: MBHE Environmental (PTY) LTD  
 Project: Middel Water Resource Facility  
 Description: Slope Stability Analysis - CSWD  
 Interface: 1.5mm HDPE Smooth and GCL  
 Project No.: ES755-2022  
 Date: January 20, 2026  
 Author: Envitech Solutions (Based on TY Soong and RM Koerner, 2005)



**Calculation of FS**

**Active Wedge:**

$W_a = 54,62 \text{ kN}$   
 $N_a = 51,81 \text{ kN}$

**Passive Wedge:**

$W_p = 0,40 \text{ kN}$

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

$a = 5,18$   
 $b = -18,39$   
 $c = 2,21$

**FS = 3,4242014**

thickness of cover soil = h =	<input type="text" value="0,1"/>	m		
Slope (V:H) 1 in =	<input type="text" value="3"/>			
soil slope angle beneath the geosynthetics = $\beta$ =	<i>18,43</i>	$^\circ$	=	<i>0,322 (rad.)</i>
length of slope measured along the geosynthetics = L =	<input type="text" value="23,09"/>	m		
unit weight of the cover soil/stone = $\gamma$ =	<input type="text" value="24"/>	kN/m <sup>3</sup>		
unit weight of operating equipment = $\gamma$ =	<input type="text" value="0"/>	kN/m <sup>3</sup>		
friction angle of the cover soil/stone = $\phi$ =	<input type="text" value="30"/>	$^\circ$	=	<i>0,524 (rad.)</i>
cohesion of the cover soil/stone = c =	<input type="text" value="0"/>	kN/m <sup>3</sup>		$C = 0 \text{ kN}$
critical interface friction angle (GCL/geomembrane) = $\delta$ =	<input type="text" value="24"/>	$^\circ$	=	<i>0,419 (rad.)</i>
critical interface adhesion (GCL/geomembrane) = ca =	<input type="text" value="14"/>	kN/m <sup>3</sup>		$Ca = 32,33 \text{ kN}$

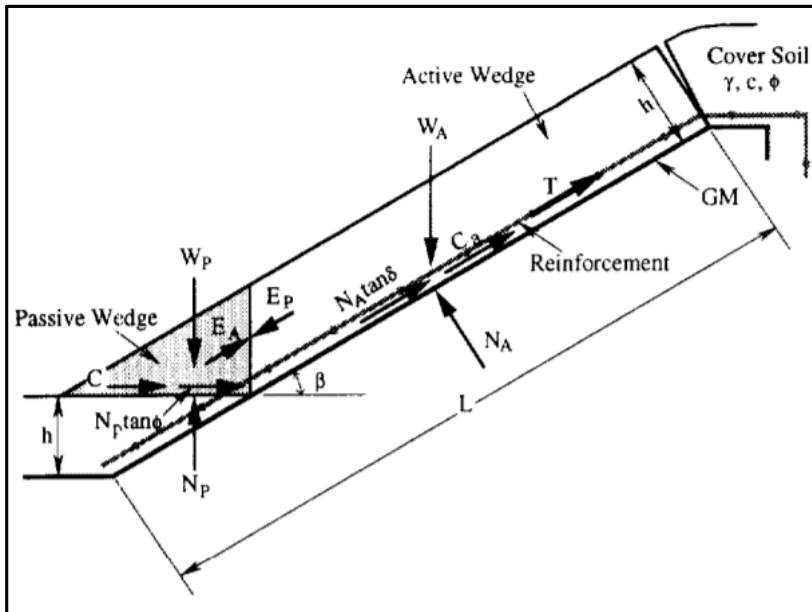
Note:   
 numbers in Italics are calculated values

(From TY Soong and RM Koerner, 2005)

**COVER SOIL STABILITY ANALYSIS WORKSHEET**  
 Uniform Cover Soil Thickness with Overlying Geosynthetics



Client: MBHE Environmental (PTY) LTD  
 Project: Middel Water Resource Facility  
 Description: Slope Stability Analysis - CSWD  
 Interface: 1.5mm HDPE Smooth and 1000g/m<sup>2</sup> GTX  
 Project No.: ES755-2022  
 Date: January 20, 2026  
 Author: Envitech Solutions (Based on TY Soong and RM Koerner, 2005)



**Calculation of FS**

**Active Wedge:**

$W_a = 54.62 \text{ kN}$   
 $N_a = 51.81 \text{ kN}$

**Passive Wedge:**

$W_p = 0.40 \text{ kN}$

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

$a = 5.18$   
 $b = -9.57$   
 $c = 1.19$

**FS = 1.7125624**

thickness of cover soil = h =	<input type="text" value="0.1"/>	m	
Slope (V:H) 1 in =	<input type="text" value="3"/>		
soil slope angle beneath the geosynthetics = $\beta$ =	<b>18.43</b>	$^\circ$	= <b>0.322 (rad.)</b>
length of slope measured along the geosynthetics = L =	<input type="text" value="23.09"/>	m	
unit weight of the cover soil/stone = $\gamma$ =	<input type="text" value="24"/>	kN/m <sup>3</sup>	
unit weight of operating equipment = $\gamma$ =	<input type="text" value="0"/>	kN/m <sup>3</sup>	
friction angle of the cover soil/stone = $\phi$ =	<input type="text" value="30"/>	$^\circ$	= <b>0.524 (rad.)</b>
cohesion of the cover soil/stone = c =	<input type="text" value="0"/>	kN/m <sup>2</sup>	<b>C = 0 kN</b>
critical interface friction angle (GTX/geomembrane) = $\delta$ =	<input type="text" value="15.5"/>	$^\circ$	= <b>0.271 (rad.)</b>
critical interface adhesion (GTX/geomembrane) = $c_a$ =	<input type="text" value="5.5"/>	kN/m <sup>2</sup>	<b>Ca = 12.7 kN</b>

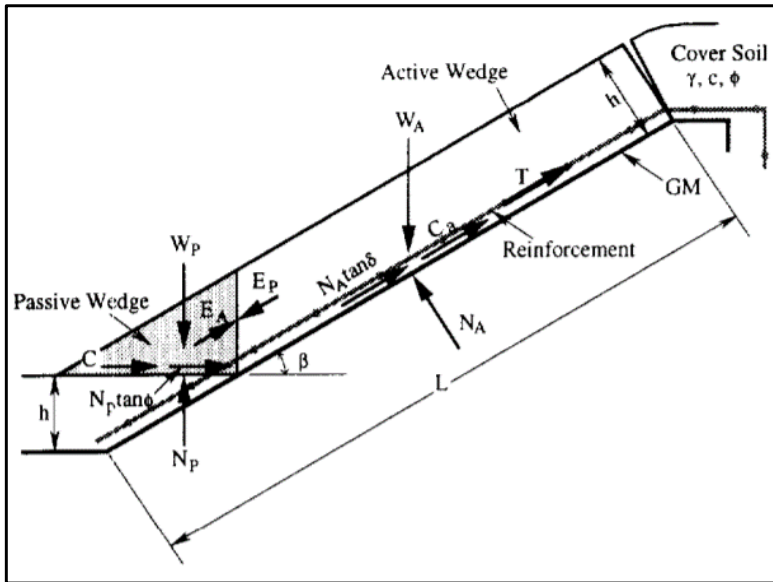
(From TY Soong and RM Koerner, 2005)

Note:   
 numbers in Italics are calculated values

**COVER SOIL STABILITY ANALYSIS WORKSHEET**  
 Uniform Cover Soil Thickness with Overlying Geosynthetics



Client: MBHE Environmental (PTY) LTD  
 Project: Middel Water Resource Facility  
 Description: Slope Stability Analysis - Leachate Dam  
 Interface: GCL and Cuspated Sheet  
 Project No.: ES755-2022  
 Date: January 20, 2026  
 Author: Envitech Solutions (Based on TY Soong and RM Koerner, 2005)



**Calculation of FS**

**Active Wedge:**

$W_a = 38,66 \text{ kN}$   
 $N_a = 36,67 \text{ kN}$

**Passive Wedge:**

$W_p = 0,40 \text{ kN}$

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

$a = 3,67$   
 $b = -12,40$   
 $c = 1,70$

**FS = 3,2375049**

thickness of cover soil = h =	<input type="text" value="0,1"/>	m		
Slope (V:H) 1 in =	<input type="text" value="3"/>			
soil slope angle beneath the geosynthetics = $\beta$ =	<i>18,43</i>	$^\circ$	=	<i>0,322 (rad.)</i>
length of slope measured along the geosynthetics = L =	<input type="text" value="16,44"/>	m		
unit weight of the cover soil/stone = $\gamma$ =	<input type="text" value="24"/>	kN/m <sup>3</sup>		
unit weight of operating equipment = $\gamma$ =	<input type="text" value="0"/>	kN/m <sup>3</sup>		
friction angle of the cover soil/stone = $\phi$ =	<input type="text" value="30"/>	$^\circ$	=	<i>0,524 (rad.)</i>
cohesion of the cover soil/stone = c =	<input type="text" value="0"/>	kN/m <sup>3</sup>		$C = 0 \text{ kN}$
critical interface friction angle (GCL/cuspated sheet) = $\delta$ =	<input type="text" value="23"/>	$^\circ$	=	<i>0,401 (rad.)</i>
critical interface adhesion (GCL/cuspated sheet) = $c_a$ =	<input type="text" value="13"/>	kN/m <sup>3</sup>		$C_a = 21,37 \text{ kN}$

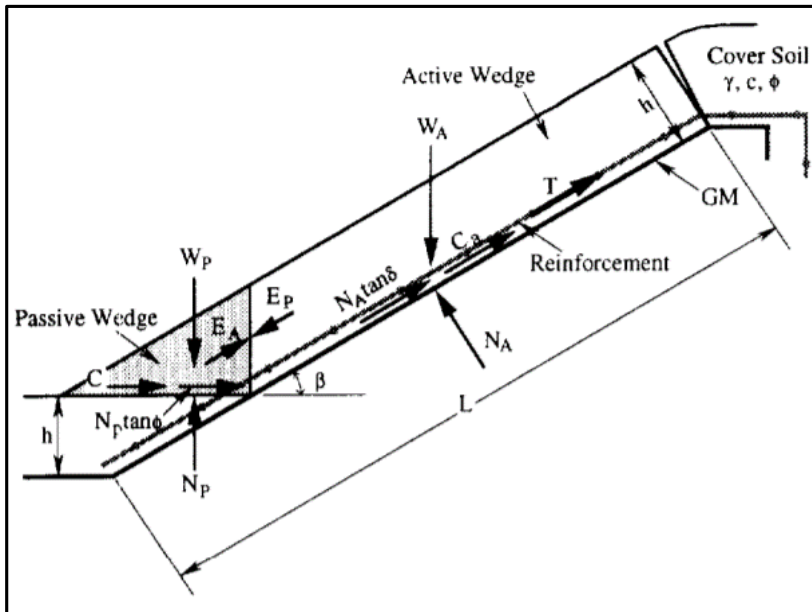
Note:   
 numbers in Italics are calculated values

(From TY Soong and RM Koerner, 2005)

**COVER SOIL STABILITY ANALYSIS WORKSHEET**  
 Uniform Cover Soil Thickness with Overlying Geosynthetics



Client: MBHE Environmental (PTY) LTD  
 Project: Middel Water Resource Facility  
 Description: Slope Stability Analysis - Leachate Dam  
 Interface: 2.0mm HDPE Smooth and GCL  
 Project No.: ES755-2022  
 Date: January 20, 2026  
 Author: Envitech Solutions (Based on TY Soong and RM Koerner, 2005)



**Calculation of FS**

**Active Wedge:**

$W_a = 38.66 \text{ kN}$   
 $N_a = 36.67 \text{ kN}$

**Passive Wedge:**

$W_p = 0.40 \text{ kN}$

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

$a = 3.67$   
 $b = -13.91$   
 $c = 1.92$

**FS = 3.6506509**

thickness of cover soil = h =	<input type="text" value="0.1"/>	m	
Slope (V:H) 1 in =	<input type="text" value="3"/>		
soil slope angle beneath the geosynthetics = $\beta$ =	<i>18.43</i>	$^\circ$	= <i>0.322 (rad.)</i>
length of slope measured along the geosynthetics = L =	<input type="text" value="16.44"/>	m	
unit weight of the cover soil/stone = $\gamma$ =	<input type="text" value="24"/>	$\text{kN/m}^3$	
unit weight of operating equipment = $\gamma$ =	<input type="text" value="0"/>	$\text{kN/m}^3$	
friction angle of the cover soil/stone = $\phi$ =	<input type="text" value="30"/>	$^\circ$	= <i>0.524 (rad.)</i>
cohesion of the cover soil/stone = c =	<input type="text" value="0"/>	$\text{kN/m}^2$	C = <i>0 kN</i>
critical interface friction angle (GTX/geomembrane) = $\delta$ =	<input type="text" value="25"/>	$^\circ$	= <i>0.436 (rad.)</i>
critical interface adhesion (GTX/geomembrane) = $c_a$ =	<input type="text" value="15"/>	$\text{kN/m}^2$	Ca = <i>24.66 kN</i>

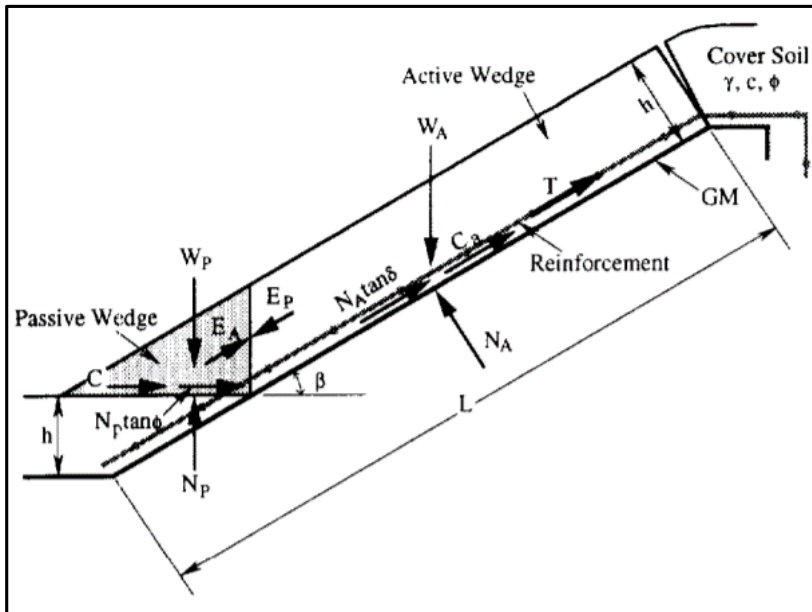
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**COVER SOIL STABILITY ANALYSIS WORKSHEET**  
 Uniform Cover Soil Thickness with Overlying Geosynthetics



Client: MBHE Environmental (PTY) LTD  
 Project: Middel Water Resource Facility  
 Description: Slope Stability Analysis - Leachate Dam  
 Interface: 2.0mm HDPE Smooth and 1000g/m<sup>2</sup> GTX  
 Project No.: ES755-2022  
 Date: January 20, 2026  
 Author: Envitech Solutions (Based on TY Soong and RM Koerner, 2005)



**Calculation of FS**

**Active Wedge:**

$W_a = 38.66 \text{ kN}$   
 $N_a = 36.67 \text{ kN}$

**Passive Wedge:**

$W_p = 0.40 \text{ kN}$

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

$a = 3.67$   
 $b = -7.67$   
 $c = 1.04$

**FS = 1.946859**

thickness of cover soil = h =	<input type="text" value="0.1"/>	m	
Slope (V:H) 1 in =	<input type="text" value="3"/>		
soil slope angle beneath the geosynthetics = $\beta$ =	<b>18.43</b>	$^\circ$	= <b>0.322 (rad.)</b>
length of slope measured along the geosynthetics = L =	<input type="text" value="16.44"/>	m	
unit weight of the cover soil/stone = $\gamma$ =	<input type="text" value="24"/>	kN/m <sup>3</sup>	
unit weight of operating equipment = $\gamma$ =	<input type="text" value="0"/>	kN/m <sup>3</sup>	
friction angle of the cover soil/stone = $\phi$ =	<input type="text" value="30"/>	$^\circ$	= <b>0.524 (rad.)</b>
cohesion of the cover soil/stone = c =	<input type="text" value="0"/>	kN/m <sup>2</sup>	<b>C = 0 kN</b>
critical interface friction angle (GTX/geomembrane) = $\delta$ =	<input type="text" value="15.8"/>	$^\circ$	= <b>0.276 (rad.)</b>
critical interface adhesion (GTX/geomembrane) = $c_a$ =	<input type="text" value="7"/>	kN/m <sup>2</sup>	<b>Ca = 11.51 kN</b>

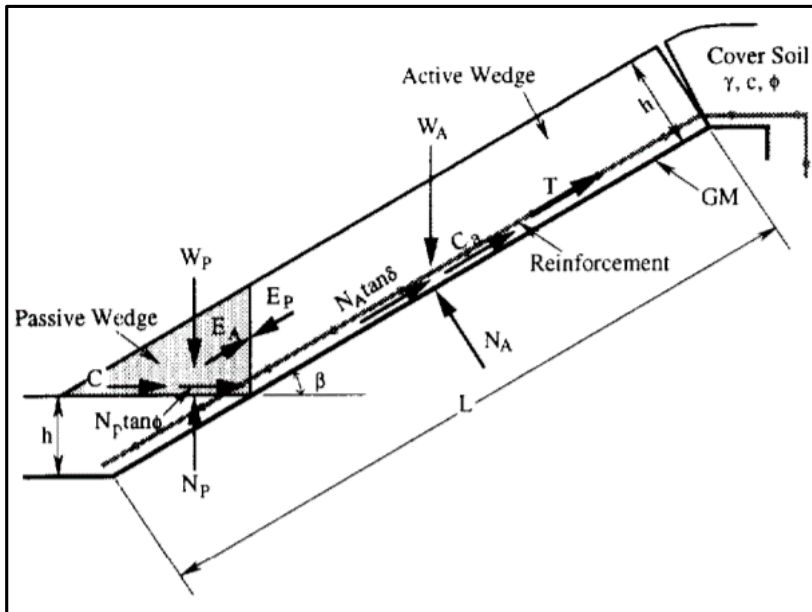
Note:   
 numbers in Italics are calculated values

(From TY Soong and RM Koerner, 2005)

**COVER SOIL STABILITY ANALYSIS WORKSHEET**  
 Uniform Cover Soil Thickness with Overlying Geosynthetics



Client: MBHE Environmental (PTY) LTD  
 Project: Middel Water Resource Facility  
 Description: Slope Stability Analysis - Leachate Dam  
 Interface: 1.5mm HDPE Smooth and Cuspated Sheet  
 Project No.: ES755-2022  
 Date: January 20, 2026  
 Author: Envitech Solutions (Based on TY Soong and RM Koerner, 2005)



**Calculation of FS**

**Active Wedge:**

$W_a = 38.66 \text{ kN}$   
 $N_a = 36.67 \text{ kN}$

**Passive Wedge:**

$W_p = 0.40 \text{ kN}$

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

$a = 3.67$   
 $b = -8.11$   
 $c = 1.15$

**FS = 2.0577549**

thickness of cover soil = h =	<input type="text" value="0.1"/>	m	
Slope (V:H) 1 in =	<input type="text" value="3"/>		
soil slope angle beneath the geosynthetics = $\beta$ =	<b>18.43 °</b>	=	<b>0.322 (rad.)</b>
length of slope measured along the geosynthetics = L =	<input type="text" value="16.44"/>	m	
unit weight of the cover soil/stone = $\gamma$ =	<input type="text" value="24"/>	kN/m <sup>3</sup>	
unit weight of operating equipment = $\gamma$ =	<input type="text" value="0"/>	kN/m <sup>3</sup>	
friction angle of the cover soil/stone = $\phi$ =	<input type="text" value="30"/>	°	= <b>0.524 (rad.)</b>
cohesion of the cover soil/stone = c =	<input type="text" value="0"/>	kN/m <sup>2</sup>	C = <b>0 kN</b>
critical interface friction angle (GTX/geomembrane) = $\delta$ =	<input type="text" value="20"/>	°	= <b>0.349 (rad.)</b>
critical interface adhesion (GTX/geomembrane) = $c_a$ =	<input type="text" value="6"/>	kN/m <sup>2</sup>	Ca = <b>9.864 kN</b>

Note:   
 numbers in Italics are calculated values

(From TY Soong and RM Koerner, 2005)