



WALTER SISULU LOCAL MUNICIPALITY

ESTABLISHMENT OF A NEW LANDFILL SITE IN MALETSWAI LOCAL MUNICIPALITY

77/2024/2025

PRELIMINARY DESIGN REPORT REVISION 2

FEBRUARY 2026

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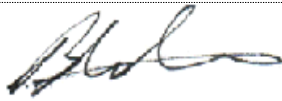
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1. INTRODUCTION

1.1 Preamble

Imbawula Civil Projects (Pty) Ltd were appointed as Professional Service Providers (Project Consultants/Engineers/Employer Agent) by Walter Sisulu Local Municipality (Employer) on 03rd April 2025 for the establishment & rehabilitation of a new municipal landfill site in Maletswai (77/2024/2025) located in Aliwal North, Eastern Cape Province.

The Professional Service Providers' scope of work entails: Initiation, concept and viability design development, documentation, monitoring of the implementation of the project and Close-out of the above-mentioned project. **See Annexure A – Appointment Letter.**

1.2 Context and Mandate

The Walter Sisulu Local Municipality (WSLM) has initiated the development of a new engineered landfill and Material Recycling Facility (MRF) (Figure 1) to address increasing waste management needs and ensure full compliance with national environmental legislation. The is an existing landfill site in Maletswai Local Municipality which has been granted a licence for closure due to operational life reached to implement this project, Imbawula Civil Project has been formally appointed by WSLM to carry out the Environmental Impact Assessment (EIA), compile the Environmental Management Programme (EMPr), obtain the landfill operating license, and prepare both the detailed engineering design and the operating manual.

According to the site selection report (2025), three (3) sites were considered for the proposed landfill site, as indicated in Figure 1 below. The site selection was rated according to the table below, resulting in the site prioritisation.

Table 1: Site Selection

Parameters	Preferred Site	Alternative Site No. 1	Alternative Site No. 2
Visual Impacts	Low	High	High
Proximity to Watercourses	More than 200m	Less than 100m	More than 100 m
Geotechnical	Ideal	Ideal	Difficult to excavate

Parameters	Preferred Site	Alternative Site No. 1	Alternative Site No. 2
Availability of Services	Road and Electricity	Road	None
Future Expansions	Possible	Not possible	Not Possible

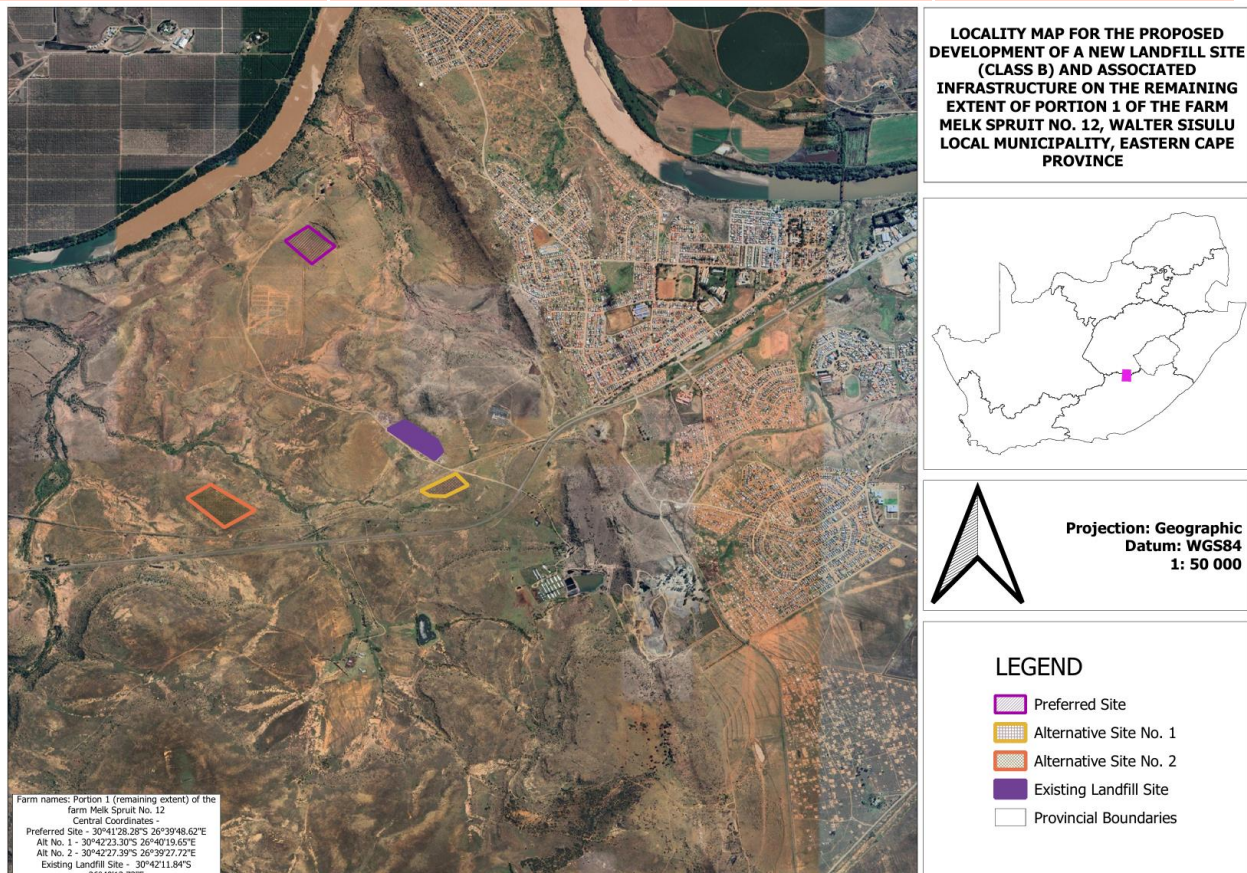


Figure 1 - Locality Map for the proposed site

As part of this appointment, Imbawula Civil Project is responsible for the complete civil design and operating plan for the proposed new Maletswai landfill. This report, therefore, presents the engineering design and operational framework for the planned extension and full development of the Maletswai Landfill Site, providing WSLM with a construction-ready solution that aligns with the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) (NEMWA) and the National Waste Management Strategy (2020).

1.3 Study Objectives

The overarching goal of the Maletswai Landfill project is to deliver an environmentally sound and fully compliant disposal facility that can safely accommodate the municipality's general solid-waste requirements for the next 20 years. Within this long-term vision, the current engineering design phase pursues the following specific objectives:

- **Facility classification:** Determine the appropriate classification of the proposed landfill in terms of the anticipated waste types, projected waste-stream volumes, and the potential for leachate generation, in line with national norms and standards.
- **Site confirmation:** Verify the suitability of the identified site and its surrounding conditions for the development of a long-term waste-disposal facility, including geotechnical, geohydrological and environmental considerations.
- **Preliminary design and operating plan:** Develop a comprehensive conceptual design and operating strategy that meets the region's disposal needs and incorporates all necessary engineering controls to mitigate environmental impacts and address critical risk factors.
- **Design documentation for authorisation:** Compile the design criteria, key assumptions, and preliminary engineering details required for inclusion in the Waste Management Licence application and the Environmental Impact Assessment (EIA) reports to be submitted to the competent authorities.

This design report therefore records the technical parameters, assumptions and preliminary engineering framework that will inform regulatory approvals to be incorporated into the Waste Management Licence application to be submitted to the regulatory authority..

1.4 Extent of Work

The scope of this engineering design assignment encompasses the full preliminary/ conceptual design of a new on site landfill disposal facility that will serve the Maletswai area for at least twenty years while protecting both the natural environment and surrounding communities. The design must comply with the most recent South African regulatory framework, including the National Environmental Management: Waste Act, 2008 (Act 59 of 2008), the National Waste

Management Strategy (2020, updated 2024), and the National Norms and Standards for the Disposal of Waste to Landfill (GN 639 of 2013 as amended in 2024). These instruments prescribe the latest requirements for landfill classification, site selection, liner systems, leachate control, groundwater protection, environmental monitoring and operational management, and replace the older “Minimum Requirements” series.

Within this framework, the engineering team will determine the projected types and quantities of municipal solid waste to be managed over the twenty-year design life and translate these projections into airspace and leachate-management requirements. A detailed description of the size of the site, based on topographical maps and geotechnical and geohydrological investigations, will confirm its suitability for long-term waste disposal. Using these data, the team will develop a complete preliminary and detailed engineering design for all infrastructure components, including access roads, internal drainage networks, composite liner systems, landfill cells and phased development plans, leachate collection and treatment facilities, storm-water controls, recycling and sorting facilities, a dead-animal pit, weighbridge, perimeter security measures, electrical reticulation and the necessary administration and workshop buildings.

A comprehensive operating plan will be prepared to guide day-to-day procedures such as waste acceptance, placement, compaction, daily cover, environmental monitoring, record-keeping and emergency response, all in accordance with the 2024 National Norms and Standards for Disposal of Waste to Landfill. The scope also includes preparation of a construction quality-assurance framework and a complete package of design drawings, specifications and a priced bill of quantities suitable for incorporation into the Waste Management Licence application and for use during the tender and construction phases. Monitoring and compliance systems for groundwater quality, leachate generation and air-quality impacts will be integrated to ensure ongoing regulatory conformity.

Through these tasks, the Walter Sisulu Local Municipality will receive a construction ready, regulator approved design that meets the highest current standards for environmental protection, public health and sustainable waste management in South Africa.

2. Site Description

The project site is located **Figure 2** at 30°41'28.34"S, 26°39'52.36"E, near Aliwal North in the Eastern Cape Province, close to the boundary with the Free State. Primary access to the site is via the N6 national road, which links East London to Bloemfontein and passes directly through Aliwal North. From Aliwal North, access is obtained by turning onto provincial and local gravel roads leading south-east towards the project area. These access roads are currently used for agricultural activities and are suitable for light to medium construction vehicles.

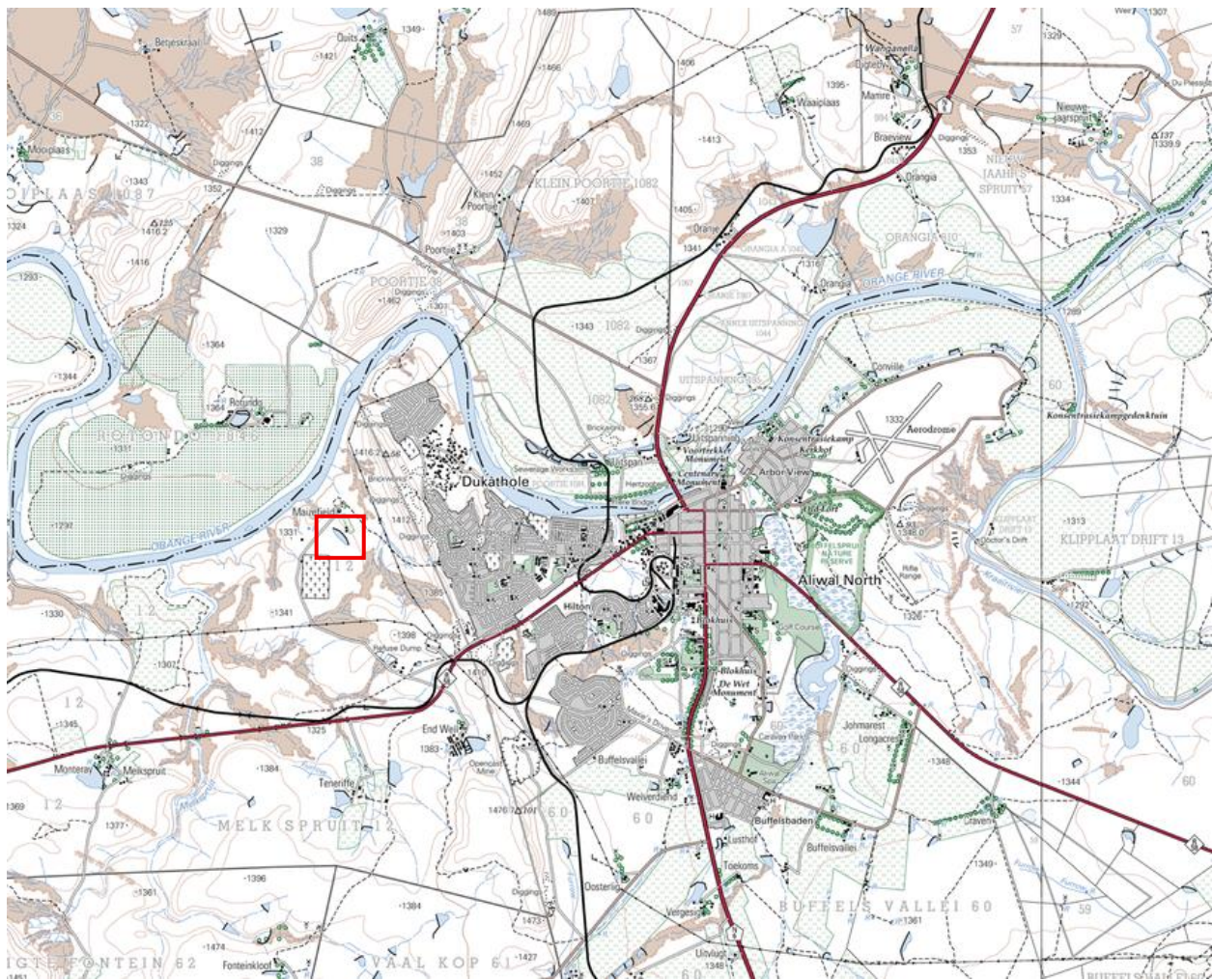


Figure 2: Locality

The final approach to the site is via existing farm access roads, which may require minor upgrading or maintenance to accommodate construction traffic, particularly during wet weather conditions. No new permanent access roads are anticipated, as existing infrastructure provides adequate access to the site

3. SITE CLASSIFICATION AND WASTE DISPOSAL NEED

3.1 Current volumes

The current volumes for the Maletswai waste disposal was source from the Integrated Waste Management Plan 2024-2026 which presented the total disposal volumes for the whole district municipality of Walter Sisulu. Table 2 below is a summary of district volume per local municipality per year.

Table 2: Showing estimated waste volumes in each landfill site- (Source: WSLM, IWMP2024-2029 pg 65)

Landfill Site	Estimated Volumes of Waste
Maletswai	12,225,67 tons
Burgersdorp	5,606,83 tons,
Steynsburg	1,828,9tons,
James Calata	784 tons
Venterstad	735 tons.

Using the data presented in Table 2, it is estimated that approximately 12,256 tonnes of waste per annum were disposed of at the existing landfill during the 2024 base year. Based on an assumed 260 operational days per year, this corresponds to an average disposal rate of approximately 47.1 tonnes per day in 2024.

Applying a conservative annual growth rate of 1.5%, and projecting waste quantities forward to 2027, which is assumed to be the commencement year of disposal at the proposed landfill, the estimated annual waste quantity increases to approximately 12,780.6 tonnes per annum. This translates to an Initial Rate of Deposition (IRD) of approximately 49.1 tonnes per day.

3.2 Sizing of the Landfill

The estimated size of the generated waste stream as discussed was based on the IWMP for Walter Sisulu District Municipality as 49.1 ton of waste per day which is inclusive of public and private disposal in the area.

Table 3 Landfill Size Classes

Landfill Size Class	Maximum Rate of Deposition (MRD) (Tonnes per day) 1998
Communal	<25
Small	>25 <150
Medium	>150 <500
Large	>500

The size of the Landfill is calculated as follows

- $MRD = (IRD)(1+d)^t$
- IRD- (Initial rate of deposition on site in T/day) = 49.1 (2027)
- d -(Expected annual development rate) = 1.5%
- t -(years since deposition started at IRD) = 20
- MRD -(Maximum rate of Deposition after t years) = 66.1 ton/day

The maximum rate of deposition (MRD) for Maletswai site is calculated as follows:

$$MRD = 49.1 \text{ tons /day} \times (1+0.015)^{20} = 66.1 \text{ ton/ day}$$

Base on **Table 3** the Maletswai site will be classified as an S or Small site according to MRs

3.3 Conceptual Design of Landfill Facility

The conceptual design process considered both the current waste volumes at Maletswai and expected growth over the design life of the facility. Key factors included daily and annual waste intake, compaction methods, cover material requirements, and site geometry, including side slopes, excavation depth, and final height above ground level. Operational assumptions, such as

the use of landfill compactors and the anticipated ratio of cover to waste, were incorporated to provide a realistic estimate of airspace requirements and overall site capacity.

The proposed cell layout and design parameters were developed to optimize the use of available airspace while ensuring safe, environmentally compliant operations. Consideration was also given to potential operational efficiencies, such as waste diversion and recycling initiatives, which could extend the lifespan of the landfill beyond the initially projected period. The preliminary design serves as a basis for further detailed engineering, allowing for refinement of cell geometry, drainage, and cover strategies once more site-specific investigations have been completed.

3.4 Disposals need / Airspace required

The airspace utilisation calculations for the proposed Maletswai landfill are based on projected waste generation volumes for the Maletswai service area. The base year waste generation was 12,225.67 t in 2024, which, assuming a waste density of 0.8 t/m³, corresponds to approximately 15,282 m³. An annual growth rate of 1.5% was applied to project future waste volumes.

Although the base year is 2024, the landfill is anticipated to become operational in year 2027, meaning the first actual disposal year is 2027. Using the growth rate, the waste volume in 2027 is projected to be approximately 15,960 m³:

$$\text{Waste}_{2027} = 15,282.1 \times (1.015)^3 = 15,960 \text{ m}^3$$

In addition to the waste itself, allowance was made for daily and final cover material. A cover-to-waste ratio of 1:4 was applied, resulting in a total airspace requirement equal to 1.25 times the waste volume.

The projected waste generation volumes, cumulative waste volumes, and total airspace utilisation over the 20-year design life are summarised in **Table 4**. Based on these projections, the Maletswai landfill will require a total airspace of approximately 460,880 m³, including cover.

These calculations provide the basis for preliminary site layout and design, ensuring sufficient capacity for the projected growth in waste disposal.

Table 4 Waste Generation Volumes and Airspace Required

No.	Year	Waste Volume Generated (m ³)	Cumulative Waste (m ³)	Total Airspace Used (m ³)
1	2027	15,960	15,960	19,950
2	2028	16,199	32,159	40,199
3	2029	16,441	48,600	60,750
4	2030	16,686	65,286	81,607
5	2031	16,936	82,222	102,778
6	2032	17,190	99,412	124,265
7	2033	17,447	116,859	146,073
8	2034	17,708	134,567	168,209
9	2035	17,973	152,540	190,675
10	2036	18,241	170,781	213,476
11	2037	18,513	189,294	236,618
12	2038	18,788	208,082	260,103
13	2039	19,067	227,149	283,936
14	2040	19,349	246,498	308,123
15	2041	19,635	266,133	332,667
16	2042	19,923	286,056	357,570
17	2043	20,215	306,271	382,839
18	2044	20,511	326,782	408,478
19	2045	20,810	347,592	434,490
20	2046	21,113	368,705	460,881

From Table 4 it can be deduced that, for a landfill site life of 20 years, a total airspace of approximately 460 881 m³ is required. These values are approximate and depend on several operational variables, including compaction efficiency, waste composition, and settlement of the waste mass over time

3.5 Available airspace

A conceptual landfill cell layout was developed to determine the available airspace for the Maletswai site. The disposal cell footprint area measures approximately **46,985 m²**, and the design parameters are:

- Excavation to approximately 3 m below ground level.
- A final landfill height of approximately 10 m above ground level.
- Side slopes of 1:3 (vertical: horizontal);
- Sufficient working area on the top platform for vehicle manoeuvring.

The total available airspace was calculated using:

Gross volume = Footprint area × (Final height + excavation depth) × Slope factor

$$= 46,985 \text{ m}^2 \times 13 \text{ m} \times 0.85 = 519\,184 \text{ m}^3$$

his gross airspace includes the full landfill volume and accounts for the slope factor to reflect the side slopes of the cell. The calculation demonstrates that the proposed Maletswai landfill has sufficient capacity to accommodate projected waste disposal volumes, including allowance for cover material, over its 20-year operational life.

3.6 Landfill airspace demand

The total gross landfill airspace requirement for the Maletswai Landfill over the 20-year design horizon has been calculated at approximately 460 881 m³, which includes a 1:4 waste to cover ration allowance for daily and intermediate cover, final capping, and operational inefficiencies. This figure represents the volumetric capacity that must be provided through a combination of landfill footprint and waste height. Selecting the appropriate height is therefore essential to balance land-use efficiency, engineering feasibility, environmental risk, and cost.

To assess the effect of varying landfill heights, the gross airspace requirement with 0.85 shape factor was compared across four scenarios: 5 m, 10 m, 15 m, and 20 m above-ground fill heights, each combined with a 3 m excavation depth. The effective containment heights were therefore 8 m, 13 m, 18 m, and 23 m, respectively. As shown in the table below, increasing the landfill height significantly reduces the required footprint area. For instance, at 5 m above ground, the landfill would require more than 5.7 ha of net footprint, while at 10 m the net footprint reduces to approximately 3.5 ha.

Table 5: Containment heights considerations

Above-ground Fill (m)	Effective Height (m)	Net Footprint (m ²)	Net (ha)
5	8	57 610	5.7
10	13	35 452	3.5
15	18	25 604	2.5
20	23	20 038	2.0

The 10 m above-ground height (effective 13 m with excavation) is considered the optimal balance for the proposed site. It provides a compact footprint of 3.5 ha, which increases to approximately 6 ha gross once ancillary infrastructure is included. This size fits comfortably within a practical 5-8 ha development needs, allowing space for leachate ponds, access roads, buffer zones, and support facilities. Compared with shallower fills, the 10 m configuration significantly reduces visual impact, stability problems and wind blow effect.

4. Leachate Generation Potential

4.1. Water balance under local climate

The potential for leachate generation is one of the most critical factors in landfill design, as uncontrolled leachate can contaminate groundwater, surface water, and soils. The likelihood and volume of leachate depend primarily on the climatic water balance of the site and are further influenced by site-specific conditions such as the moisture content of incoming waste, groundwater ingress, and the effectiveness of surface water management. Assessing these variables allows the landfill to be appropriately classified and determines whether a leachate management system is required under the National Environmental Management: Waste Act (Act 59 of 2008) and the 2024 Norms and Standards for Disposal of Waste to Landfill.

4.2 Regional Hydrology

The proposed Maletswai Landfill site is located within the Upper Orange Water Management Area (WMA 13) Figure 3, specifically in Quaternary Catchment D14A. This drainage system ultimately discharges north-westward into the Orange River, forming part of the larger Orange–

Senqu basin. The regional hydrology is therefore defined by a semi-arid inland drainage network comprising predominantly non-perennial streams and ephemeral drainage lines that flow only during significant rainfall events.

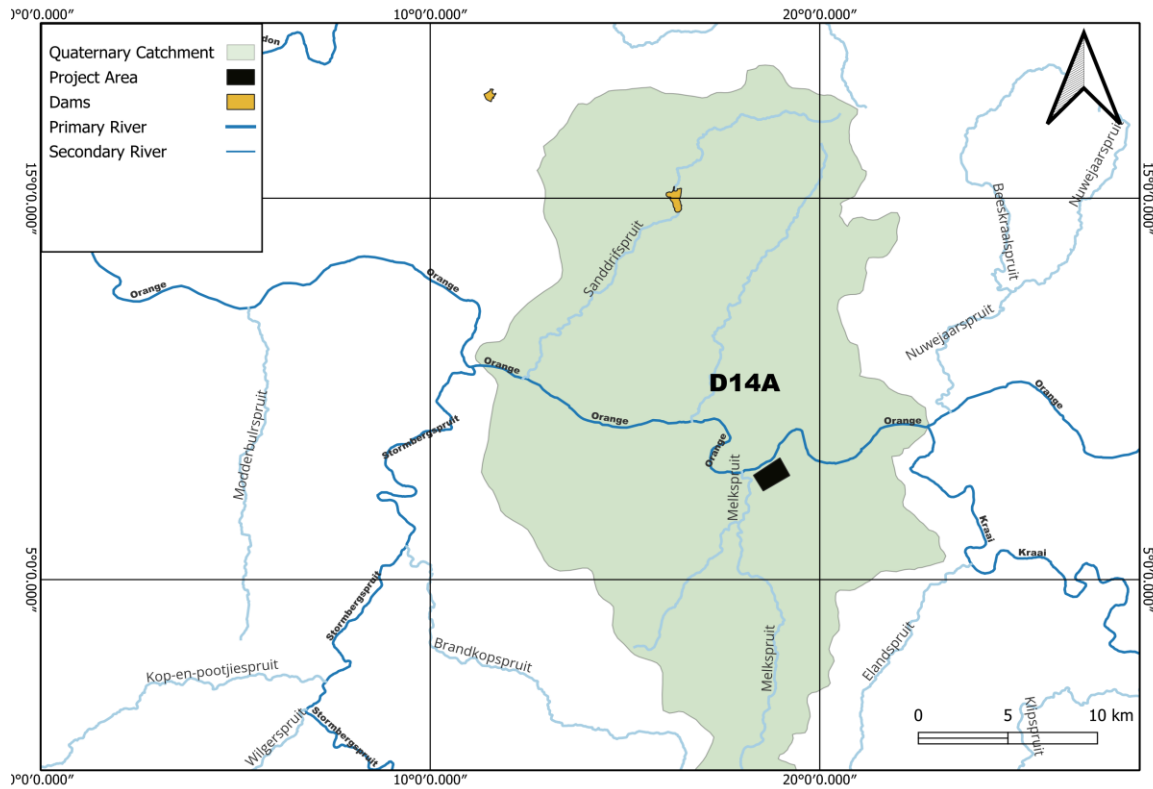


Figure 3 Regional Hydrological Setting

The topography of the Maletswai area is gently undulating, with surface gradients ranging from 1 % to 5 %, directing overland flow toward minor tributary channels situated north-west of the proposed landfill footprint. The regional mean annual precipitation is approximately 493 mm/year, while mean annual potential evaporation is around 1,675 mm/year, resulting in a strongly negative climatic water balance. Under such conditions, runoff volumes are low, infiltration is limited, and streamflow occurs mainly as short-duration flash events during the summer rainfall period (November – April).

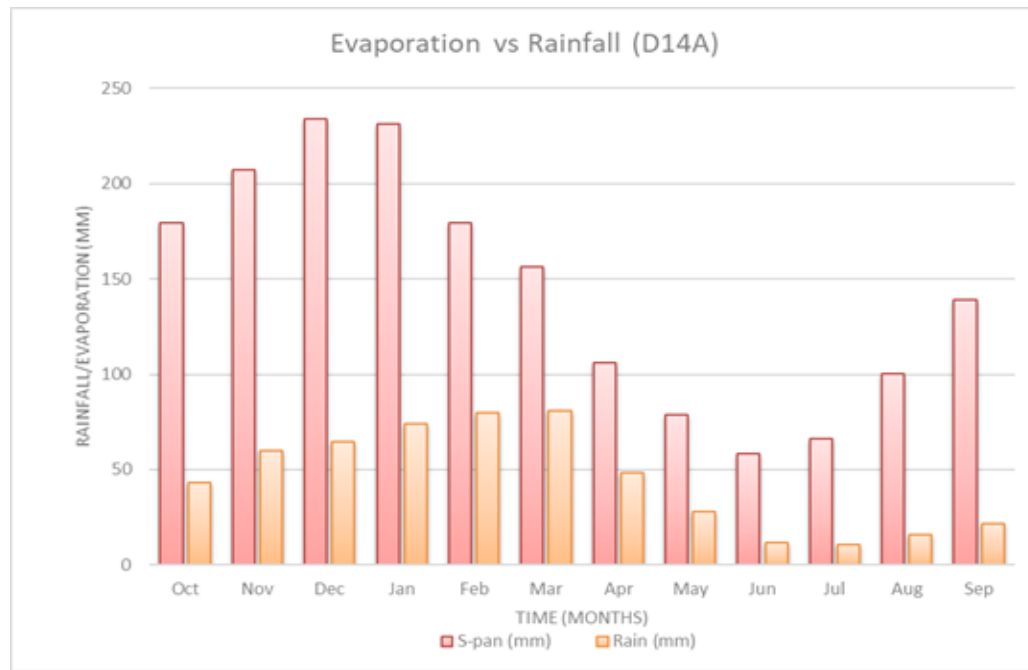


Figure 4 Catchment Rainfall and Evaporation

4.3 Climatic Water Balance

The potential for significant leachate generation at a landfill site is governed primarily by the site water balance. This balance is controlled by regional climatic conditions, together with site-specific factors such as the moisture content of incoming waste and the potential ingress of surface water runoff or groundwater into the waste body. In accordance with the Minimum Requirements for Waste Disposal by Landfill, the climatic water balance provides the basis for assessing whether a landfill is likely to generate significant quantities of leachate and for assigning the appropriate B- or B+ classification.

The climatic water balance (B) for the proposed Maletswai Landfill site has been calculated using the standard equation:

$$B = R - E$$

where:

- B is the climatic water balance (mm),

- R is the mean annual rainfall (mm), and
- E is evaporation from a soil surface (mm), taken as either $0.7 \times A$ -pan evaporation or $0.88 \times S$ -pan evaporation, in accordance with the Minimum Requirements.

Climatic data for the Maletswai area indicate a mean annual rainfall of approximately 493 mm, while mean annual S-pan evaporation is approximately 1,675 mm, resulting in an estimated soil evaporation of approximately 1 340 mm ($1675 \text{ mm} \times 0.8$). On this basis, the calculated long-term climatic water balance for the site is strongly negative:

$$B = 493 \text{ mm} - 1340 \text{ mm} = -847 \text{ mm}$$

The Minimum Requirements require that the climatic water balance be evaluated for the wet season of the wettest year on record to determine whether the balance is positive for more than one year in five. Based on available regional climatic records, the water balance for the Maletswai area is negative in most years, indicating that evaporation significantly exceeds rainfall under normal conditions.

Table 6 Climatic Water Balance for the 10 Wettest Years

Year (Wettest Years)	Rainfall(mm) (R)	Evaporation (mm) (E)	Climatic Balance (B)
1966/67	578.3	863.28	-284.98
1973/74	742.8	907.76	-164.96
1975/76	688.3	996.88	-308.58
1987/88	636.9	1156.72	-519.82
2001/02	580.3	1069.04	-488.74
2005/06	578.1	1057.68	-479.58
2009/10	483	1074.4	-591.4
2010/11	591	1024.4	-433.4
2021/22	639.1	1221.36	-582.26
2022/23	492.3	1197.6	-705.3

Where the climatic water balance is negative for more than four out of five years, the landfill is classified as B-, and significant leachate generation is not expected under properly designed and operated conditions. In such cases, the Minimum Requirements indicate that a leachate management system may not be strictly necessary from a climatic perspective alone.

Notwithstanding the B- climatic classification, other site-specific factors must also be considered. These include the moisture content of incoming waste, the potential for stormwater ingress, and the need to protect groundwater resources in accordance with the National Environmental Management: Waste Act. For the Maletswai Landfill, no significant volumes of high-moisture waste are anticipated, and the design includes perimeter diversion drains and surface water management measures to prevent the ingress of upslope runoff onto the waste body. To protect the receiving environment a leachate pollution dam will be constructed to collect all the leachate and also capture the runoff from rainfall.

4.4 Other Site-Specific Factors

While the climatic water balance suggests minimal leachate potential, several site-specific considerations must be considered:

- **Moisture content of waste:** The projected waste stream is dominated by household refuse and putrescibles with moderate moisture content. While this may contribute to localized leachate, the overall low rainfall and high evaporation balance will limit accumulation.
- **Ingress of groundwater:** Geotechnical investigations confirm that groundwater levels at the site are deeper than 5–6 m below ground surface, well below the planned excavation depth of 3 m, reducing the likelihood of groundwater inflow into the waste body.
- **Surface water management:** The site is located on gently sloping terrain. If properly engineered, upslope drainage channels, diversion berms, and stormwater cut-offs are installed, stormwater ingress into the landfill cells will be minimal.
- **Operational practices:** Daily and intermediate cover will further reduce infiltration and percolation. Capping closed cells with a low-permeability cover system will also limit rainfall ingress.

Taken together, these factors reinforce the conclusion that the Maletswai landfill has low inherent potential for leachate generation. However, in line with the precautionary principle and the fact that the old Aliwal North landfill has historically impacted groundwater, it is

recommended that the new landfill be constructed with a composite liner system and a leachate detection and collection system. This ensures compliance with the 2024 Norms and Standards, safeguards groundwater resources, and provides assurance to regulators and the community.

5. GEOLOGY, SOILS AND GROUNDWATER

5.1. Regional and Site Geology

The proposed Maletswai landfill site is underlain by geological formations typical of the Karoo Supergroup, with the regional stratigraphy consisting of intercalated arenaceous and argillaceous strata belonging to the Beaufort Group.



Figure 5: Map showing the geology of the area.

According to the Council for Geoscience geological mapping, the site is predominantly classified as Quaternary deposits consisting of unconsolidated alluvial sediments, sands, and calcrete

horizons, overlying weathered sedimentary rocks. Lithological descriptors include a combination of sand, silt, and calcareous material, with Beaufort mudstones forming the deeper parent material.

These conditions are consistent with the geotechnical investigation, which identified a surficial veneer of transported soil and hillwash material, underlain by residual silty clays derived from in-situ weathering of mudstones and shales. The bedrock comprises Beaufort mudstone, which is moderately weathered near the surface but becomes competent at greater depths. The overall geological profile is favourable for landfill development, as it provides both natural containment (in the form of low-permeability residual soils) and a competent founding stratum for engineered liner systems.

5.2. Soils

The geotechnical investigation confirmed the presence of several distinct soil horizons:

- **Topsoil/hillwash layer:** Approximately 0.3–0.5 m thick, composed of loose sandy silts with occasional gravel. This material is unsuitable for liner construction but can be stripped and reused as daily cover or for site rehabilitation.
- **Residual silty clay horizon:** Typically 2–3 m thick, comprising reworked clayey soils derived from Beaufort mudstone. These soils exhibit moderate plasticity (Plasticity Index ~10–18) and low natural permeability. Laboratory tests indicate that, when compacted to 98% of Standard Proctor density at optimum moisture content.
- **Weathered mudstone/shale:** Found below the residual clay, offering moderate ripability. This unit provides a competent foundation with an allowable bearing capacity of approximately 150 kPa, sufficient for supporting landfill infrastructure such as haul roads, berms, and leachate collection systems.

These soil conditions are advantageous because they provide both cover material sources (from topsoil and clay) and liner construction material (residual silty clays). However, further laboratory testing and a trial CCL strip are recommended to confirm that site-derived clay consistently achieves the required permeability and compaction specifications. If variability in

clay properties is observed, a geosynthetic clay liner (GCL) option should be considered as an alternative or supplementary barrier.

5.3. Groundwater Conditions and Classification

Groundwater levels in the area are relatively deep, with the geotechnical investigation indicating no perched groundwater within the upper 3 – 4 m of test pits. Regional hydrogeological mapping suggests that the static groundwater table lies at depths greater than 5–6 m below the surface. This is significantly deeper than the proposed excavation depth of 3 m, reducing the risk of groundwater ingress into landfill cells during construction or operation.

Furthermore, the mudstones of the Beaufort Group are known to have low primary permeability, with groundwater movement typically confined to fractures and weathered zones. The combination of a deep-water table, low-permeability soils, and engineered liner systems greatly reduces the likelihood of significant groundwater contamination from landfill operations. Nevertheless, as a precaution, it is recommended that groundwater monitoring boreholes be installed around the site perimeter to provide early warning of any contamination, in line with the 2024 Norms and Standards for Disposal of Waste to Landfill.

This Geology, Soils and Groundwater section establishes that the site is geologically suitable for landfill development, with available clay materials for liner construction and low groundwater risk.

5.4 Engineering Implications

The geological and geotechnical conditions of the landfill site have direct implications for the design, construction, and long-term performance of the facility. Firstly, the presence of a relatively thick horizon of residual silty clays is favorable for landfill liner construction. Laboratory results indicate that these materials, when compacted at optimum moisture, can achieve hydraulic conductivities in the order of 10^{-9} m/s, which aligns with the minimum barrier performance requirements stipulated in the 2024 Norms and Standards for Disposal of Waste to Landfill. This suggests that the site can provide in-situ materials for constructing a Compacted Clay Liner (CCL), thereby potentially reducing the reliance on imported materials. However, due

to variability in the clay's plasticity and fines content, it is recommended that additional laboratory testing and a trial liner strip be completed before construction to confirm suitability and consistency across the site.

Secondly, while the local soils are suitable for use as cover material and liners, the availability of sufficient uniform clayey material to line the entire 3.5-4 ha landfill footprint may be limited. In such cases, the adoption of a composite liner system comprising a geomembrane underlain by either a CCL or a Geosynthetic Clay Liner (GCL) will provide an added layer of protection against seepage. This approach is aligned with modern engineering best practice and provides redundancy in the barrier system. A composite system is particularly advisable given the moderate permeability of residual soils and the need to safeguard against variability in locally sourced clay.

Thirdly, the competent Beaufort mudstone bedrock provides a stable foundation with good load-bearing capacity for landfill embankments, leachate collection systems, and access infrastructure. Its moderate rip ability means excavation of the 3 m subgrade is feasible with conventional plants, although allowances must be made for harder zones that may require ripping or breaking. The combination of competent founding strata and deep groundwater reduces the risk of slope instability, basal heave, or groundwater inflow into the landfill cells.

Finally, the negative climatic water balance and relatively deep groundwater table further reduce the risk of uncontrolled leachate migration. Nevertheless, engineering prudence requires that a leachate detection and collection system be incorporated into the base design. This system will include a drainage blanket over the liner, perforated HDPE collector pipes sloped to sumps, and pumping facilities to ensure leachate removal. The system will not only manage potential leachate volumes but also serve as an early-warning mechanism should liner performance degrade over time.

In summary, the geology and soils at the Maletswai site are favorable for landfill development. While local clay resources can be used for liner construction, a composite liner system (geomembrane + CCL or GCL) is recommended to achieve regulatory compliance and enhance

environmental protection. Excavation to 3 m is feasible within the geotechnical conditions, and slope stability is not expected to be a limiting factor. These conditions, combined with proper stormwater management and groundwater monitoring, provide confidence that the landfill can be engineered to operate safely and sustainably over its 20-year design life.

6. LINER MATERIAL SELECTION

6.1. Design objective and regulatory context

The primary objective of the barrier selection is to provide a long-term, low-permeability basal system that prevents the downward migration of leachate into the foundation soils and groundwater, in full compliance with the 2024 National Norms and Standards for Disposal of Waste to Landfill. Accordingly, the preferred design for the Maletswai site is a Class B barrier system, which provides an appropriate level of environmental protection for general waste disposal facilities.

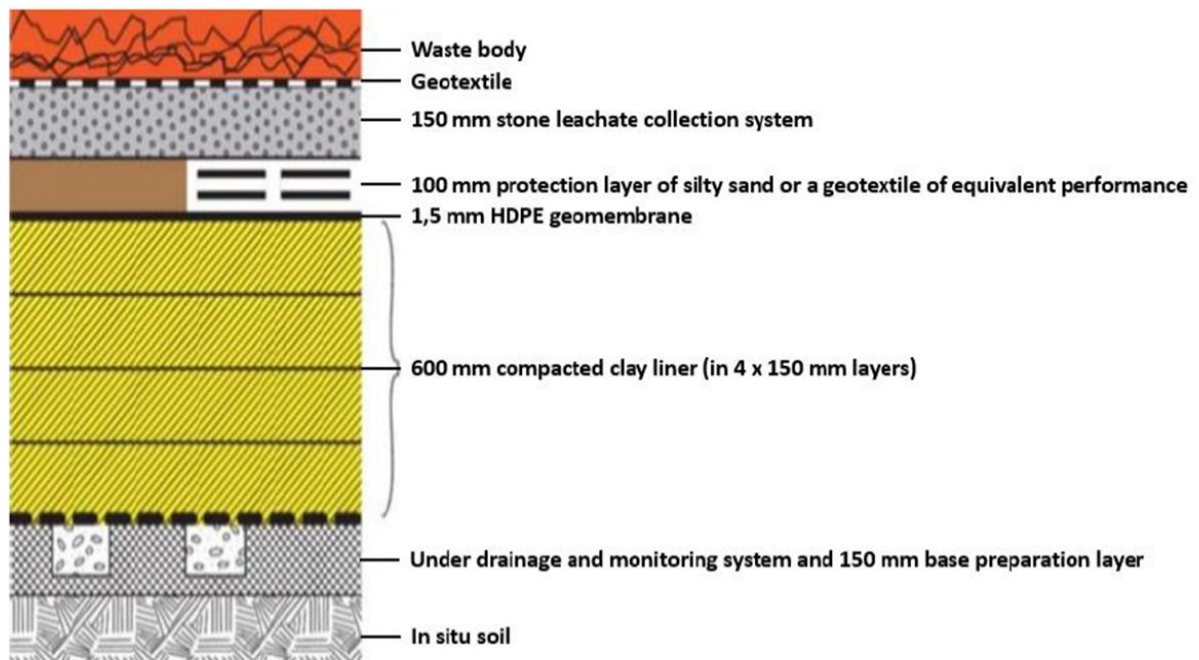


Figure 6: Class B containment system

The engineering solution must be durable, demonstrably verifiable through field and laboratory testing, compatible with the anticipated leachate chemistry, and feasible given the available site materials, access, and construction resources. Although the Maletswai site exhibits a low climatic leachate generation potential, the historical evidence of groundwater impacts at the older landfill necessitates a conservative and redundant approach. Therefore, the barrier system should comprise either a properly constructed Compacted Clay Liner (CCL) or a Geosynthetic Clay Liner (GCL), or preferably a composite system combining a geomembrane with a clay liner, to ensure long-term containment performance and regulatory compliance. (geomembrane).

6.2 Geotechnical basis for using on-site clay (CCL potential)

The Aliwal North geotechnical investigation demonstrates a near-surface profile of 0.3–0.5 m topsoil, underlain by 2–3 m of residual silty clay over moderately weathered Beaufort mudstone. Laboratory index tests show moderate plasticity ($PI \approx 10\text{--}18$) and natural low permeability. Importantly, the Geotech report indicates that the residual silty clay is workable and, when processed and compacted, is likely capable of meeting the performance targets for a CCL (target compacted permeability $k \leq 1 \times 10^{-9}$ m/s) — but not guaranteed across the entire footprint without additional verification.

Because the clay horizon is of sufficient thickness and continuity in the investigation boreholes, an on-site CCL is an attractive option: it reduces import volumes and provides long-term durability when properly constructed and quality-assured. Critical caveats are: (a) the thin topsoil/hillwash must be stripped and not used in the liner, (b) selective borrow sampling is required to identify uniform clay pockets, and (c) trial compaction and permeability tests are mandatory to prove performance prior to committing to CCL in tender documents.

6.3 Practical engineering comparison (performance & constructability)

CCL (Compacted Clay Liner)

- **Performance:** Durable, long-term hydraulic barrier when compacted to 98% Standard Proctor at specified OMC; low diffusivity and robust to puncture under proper cover. Performance depends on consistent material quality and strict field QA.

- **Constructability:** Requires large earthworks (stripping, borrow, moisture conditioning, thin-lift compaction), plant (sheepsfoot rollers) and favourable weather during placement. Sensitive to moisture: excessive wetness or dryness reduces achievable density and increases permeability.
- **Verification:** Trial strip, flexible-wall permeability tests on remoulded compacted specimens, frequent in-situ density testing and field permeability checks.
- **Long-term:** Excellent if installed correctly; little long-term chemical degradation risk compared with some geosynthetics.

GCL (Geosynthetic Clay Liner)

- **Performance:** Factory-controlled bentonite layer provides reliable low hydraulic conductivity (typically $k \leq 1 \times 10^{-11} - 1 \times 10^{-12}$ m/s in hydrated state) and can self-seal around small punctures. Good redundancy when used beneath a geomembrane or under a cover.
- **Constructability:** Rapid installation and thinner barrier; however, needs a careful protection layer (geotextile/sand) to avoid puncture and to provide a stable interface shear. Installation requires specialist seaming and QA (roll handling, seaming, seam testing).
- **Verification:** Supplier certificates, seam testing, and field monitoring; compatibility testing with representative leachate needed in some cases.
- **Long-term:** Good hydraulic performance but requires protection from damage and verification of chemical compatibility and long-term hydration/creep behavior.

6.4 Cost comparison (indicative) scaled to selected cell area

The selection of the barrier system for the proposed Maletswai Landfill Cell 1 is one of the most significant cost and risk drivers in the project. Two technically viable options have been assessed in line with the 2024 Norms and Standards for Disposal of Waste to Landfill: (i) a compacted clay liner (CCL) combined with a high-density polyethylene (HDPE) geomembrane, and (ii) a geosynthetic clay liner (GCL) combined with an HDPE geomembrane. In both cases, the geomembrane provides the primary hydraulic barrier, while the clay or geosynthetic component

acts as a secondary attenuation layer and provides redundancy against geomembrane defects. Both alternatives require ancillary protective soil cover, leachate drainage aggregate, and pipework.

Based on the detailed bill of quantities and mid-market cost rates, Table 7, the CCL–HDPE system is estimated at approximately R14. million for the 3.5 hectare cell at an effective depth of 13 m. This cost reflects 24,000 m³ of clay material placed and compacted to a 600 mm thickness at an indicative rate of R450 per cubic meter, combined with the supply and welding of 40,000 m² of 2 mm HDPE geomembrane at R180 per square meter. Additional volumes are allocated for a 200 mm drainage aggregate layer and 200 mm protective soil cover, along with allowance for ancillary works including access roads, stormwater control, and fencing.

Table 7: Comparative Rates compares between (CCL and GCL in association with HDPE)

Component	Basis	CCL + HDPE	GCL + HDPE
Liner system	0.6 m CCL (24,000 m ³ @ R200/m ³) OR GCL (40,000 m ² @ R150/m ²)	R4.8 M	R6.0 M
HDPE geomembrane	40,000 m ² @ R180/m ²	R7.2 M	R7.2 M
Drainage + protective layers	Leachate gravel + cover soil	R0.6 M	R0.6 M
Ancillaries (roads, stormwater, fencing)	Lump sum	R0.0–1.0 M (incl.)	R0.0–1.0 M (incl.)
Subtotal – liner works		R13 M	R15 M
Studies & trials (common to both)	Borrow mapping, lab tests, permeability, trial strip, interface tests, report	+R 1 M	+R1.02 M
Indicative Total		R14 M	R16 M

By contrast, the GCL–HDPE system is estimated at approximately R16. million for the same cell footprint. The higher cost reflects the premium associated with geosynthetic products and specialist installation, with GCL supply and placement cost at R150 per square meter. While this option requires less bulk clay handling on site, the geomembrane installation remains identical, and drainage and cover requirements are unchanged. The result is that the GCL–HDPE

composite is approximately R1 million more expensive than the CCL–HDPE equivalent on a first-cost basis.

It is important to note that in both cases, an additional R1.02 million must be provisionally allocated to cover geotechnical investigations and trial works. This includes borrow-pit mapping, laboratory index and compaction testing, remolded and in-situ permeability tests, chemical compatibility assessments, interface shear testing, and the construction of a trial clay liner strip. These studies are mandatory to demonstrate compliance with the minimum permeability requirements of $\leq 1 \times 10^{-9}$ m/s and to provide confidence in the long-term performance of the barrier system.

Should the trial program confirm that locally sourced clay can reliably achieve the required hydraulic conductivity under field conditions, the CCL–HDPE system provides a robust and cost-effective solution. However, if trial results show variability or marginal compliance, the Employer will be obliged to revert to the pre-priced GCL–HDPE option to ensure regulatory approval and long-term environmental protection.

From a practical engineering standpoint, the CCL–HDPE system offers the advantage of lower direct material cost, but it carries higher construction risk, as it is highly sensitive to compaction control, moisture conditioning, and borrow material uniformity. The GCL–HDPE system, while more expensive, allows faster installation and more consistent quality assurance under site conditions, reducing the risk of delays and non-compliance. For this reason, both options should be carried forward into the tender with firm contractor pricing, with the final choice determined by the outcome of the trial work. This approach provides the Municipality with flexibility, ensures regulatory compliance, and manages cost exposure while safeguarding long-term landfill performance.

7. ENGINEERING RECOMMENDATION

For advancing the preliminary design phase, including leachate generation modelling, seepage analysis, and detailed cell geometry, the CCL–HDPE composite liner system is adopted as the design basis for the Maletswai Landfill. This choice is supported by indicative cost advantages (approximately R2 million less than the GCL–HDPE alternative), the potential to source clay locally as confirmed by the geotechnical investigation, and the alignment with the National Norms and Standards (2024), which allow a CCL liner provided that permeability criteria ($k \leq 1 \times 10^{-9}$ m/s) are demonstrated.

This decision does not preclude the use of a GCL–HDPE system at a later stage should trial strip and laboratory test results show that local clay resources cannot consistently meet the minimum hydraulic conductivity and compaction requirements. However, to progress with engineering design deliverables—including cell capacity calculations, leachate collection system design, and slope stability assessments—the CCL–HDPE composite is taken as the reference system. All subsequent calculations of airspace, leachate volume, seepage rates, and liner performance presented in this report are therefore based on this composite configuration.

7.1. Leachate rate estimation for the selected cell

This section quantifies two aspects of leachate risk: (a) the gross leachate generation potential, which is governed by the climatic water balance and site hydrology, and (b) the expected leakage through the composite barrier system, calculated using the Rowe (2012) wrinkle-and-hole model. Together, these estimates provide a conservative design envelope for sizing leachate collection sump, leak-detection layers, and long-term monitoring program

7.2 Inputs and Assumptions

For the Maletswai Landfill preliminary design, the selected cell footprint is 35,5 00 m² (3.5 ha), representing the working area. Climatic data from the WR2012 dataset indicate a mean annual rainfall of approximately 493 mm, and an S-pan evaporation of 1,675 mm. Applying the correction factor ($E = 0.8 \times \text{S-pan}$), potential soil evaporation is 1,474 mm, yielding a net

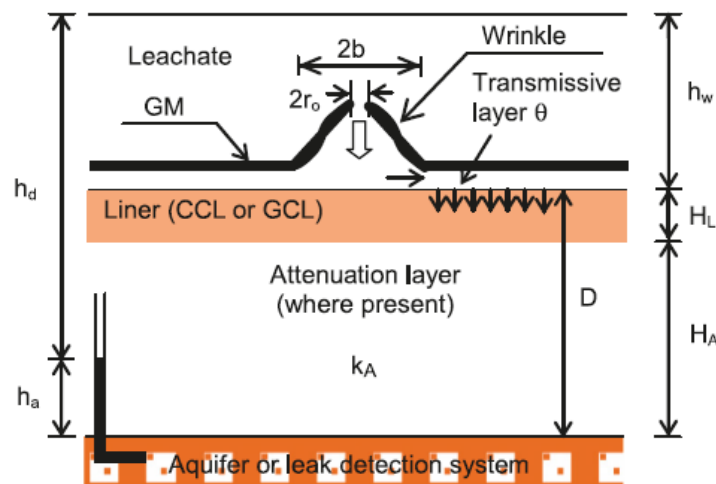
negative climatic water balance. This negative balance indicates that the region is evaporative, and net infiltration into the landfill body is limited under natural conditions.

The liner system is assumed to comprise a compacted clay liner (CCL) of thickness $D = 0.6$ m with a design hydraulic conductivity of $k = 1 \times 10^{-9}$ m/s, overlain by a 2.0 mm HDPE geomembrane. Leachate head on the liner is limited to $h_d = 0.3$ m by design of the drainage layer. For conservative modelling, a wrinkle half-width $b = 0.05$ m and wrinkle half-length $L = 10$ m were adopted, consistent with Rowe's recommended upper-bound assumptions. A transmissivity value $\Theta = 1 \times 10^{-6}$ m²/s was used for the geomembrane–liner interface, representative of a thin sand film beneath a wrinkle. A conservative defect density of one hole or wrinkle–hole interaction per hectare was assumed, recognising that with good construction quality assurance (CQA) actual rates are typically lower.

7.3 Seepage through the Barrier (Rowe 2012)

The Rowe (2012) full wrinkle model was applied, where leakage per wrinkle is expressed as:

$$Q_{\text{per wrinkle}} = 2L(k_b + \sqrt{kD\Theta})h_d/D$$



Design values ($k = 1 \times 10^{-9}$ m/s, $D = 0.6$ m, $\Theta = 1 \times 10^{-6}$ m²/s, $b = 0.05$ m, $L = 10$ m, $h_d = 0.3$ m) yields the following:

- The direct vertical term $k_b = 5 \times 10^{-11}$ m/s.
- The wrinkle transmissive term $\sqrt{kD\Theta} \approx 2.45 \times 10^{-8}$ m/s.

- The combined leakage rate is dominated by the transmissive term, giving $Q \approx 2.45 \times 10^{-7}$ m³/s per wrinkle.

This corresponds to approximately 0.0212 m³/day (21 L/day per wrinkle). With an assumed defect density of one wrinkle–hole per hectare, and a total footprint of 4.0 ha, the expected leakage is 84.8 L/day for the entire cell. Expressed as intensity, this equates to 21 L/ha/day.

7.4 Sensitivity and Interpretation

A sensitivity test with clay of poorer quality ($k = 1 \times 10^{-8}$ m/s) increases leakage to approximately 67 L/day/ha, yielding ~268 L/day for the 4 ha cell. Conversely, if the interface transmissivity is reduced through proper cushioning (e.g., geotextile protection, careful geomembrane placement, and compaction of the clay subgrade), leakage rates fall significantly and can approach point-defect values (<1 L/day/ha).

Overall, under conservative assumptions, the expected leakage is tens to hundreds of litres per day, which is very small compared with leachate collection flows in wetter climates and is considered acceptable for well-constructed composite liner systems. The results highlight the importance of stringent CQA during liner installation, particularly in limiting wrinkle formation, minimizing hole density, and providing adequate interface protection. For Maletswai, the leakage estimates confirm that the proposed CCL–HDPE composite liner, if constructed to specification, will provide adequate environmental protection and regulatory compliance.

7.5 Gross leachate generation from climatic and operational sources

Although the long-term climatic water balance for the Maletswai area is strongly negative, meaning evaporation exceeds rainfall on an annual average, local storm events, seasonal variations in waste moisture, and operational practices still lead to measurable leachate generation. Direct percolation into the waste is expected to be limited under normal conditions; however, a conservative design approach assumes that a small percentage of annual rainfall will infiltrate into the landfill body and become collectable leachate.

8. PRELIMINARY LAYOUT PLAN

The Maletswai Landfill has been designed as a compact, engineered facility developed within a single footprint and a single final waste mass, but constructed and operated in four sequential vertical phases. Rather than developing four separate lateral cells, landfill development will proceed within one footprint, with airspace created through progressive vertical raising of the waste body over time.

The landfill is designed to an effective containment height of approximately 13 m, comprising 10 m of above-ground waste placement and 3 m of excavation below natural ground level. Each vertical phase is planned to provide approximately five years of disposal capacity, ensuring efficient use of available land while limiting the overall site footprint and associated environmental disturbance.

The footprint will be lined with a composite liner system (HDPE geomembrane underlain by either a Compacted Clay Liner (CCL) or Geosynthetic Clay Liner (GCL)). Each phase will incorporate leachate drainage pipes connected to sumps and a pumping system. Perimeter haul roads will provide access for compaction and waste placement, while a stormwater diversion channel will intercept upslope runoff and prevent ingress into the active cell.

Ancillary infrastructure, including the weighbridge, administrative buildings, offices, fencing, and leachate lagoons, will be located adjacent to the entrance area, separated from the waste footprint by a buffer zone. The facility will be progressively closed, with interim capping applied at the end of each vertical phase.

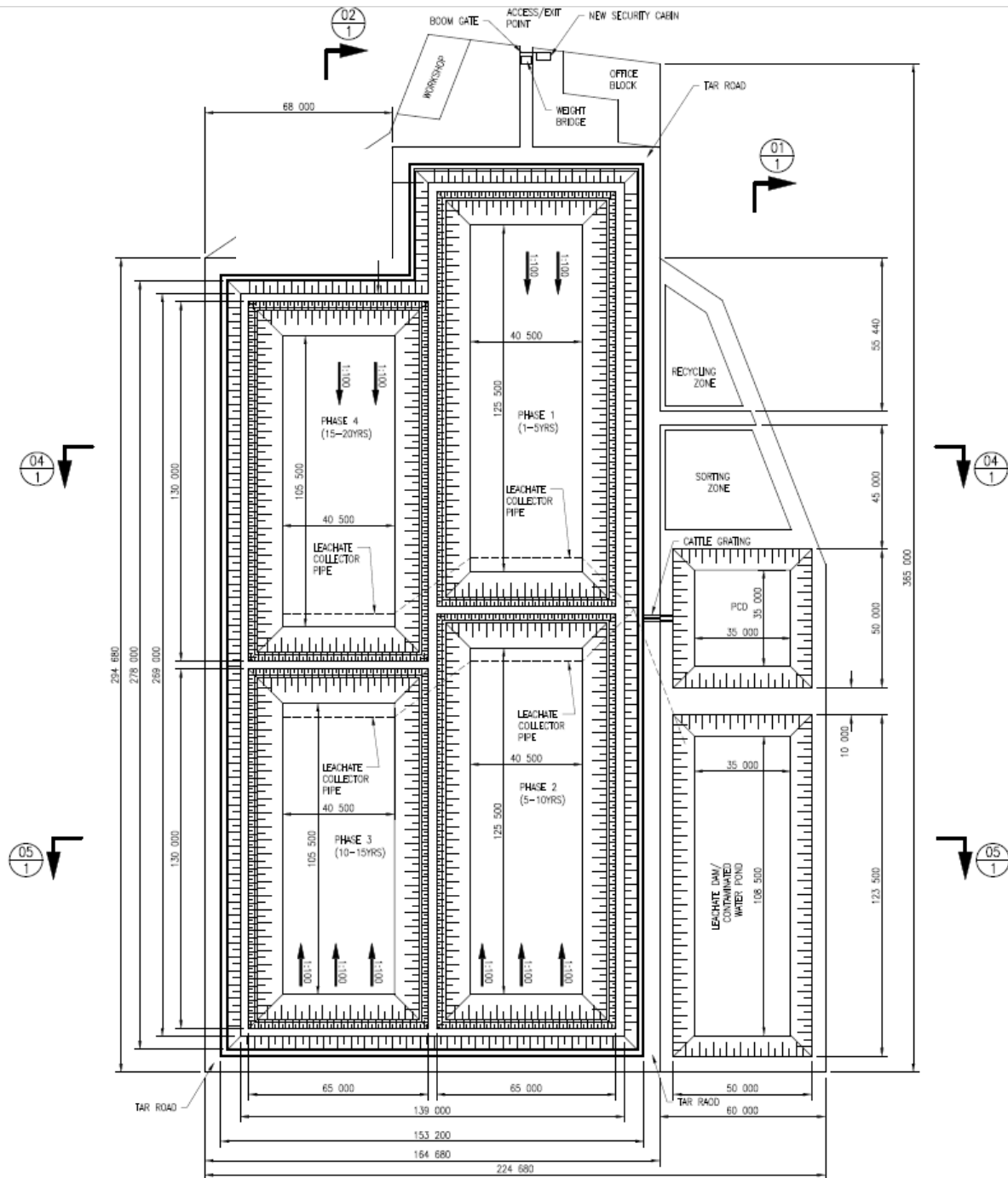


Figure 7: Proposed preliminary layout plan

8.1 Landfill Design Philosophy

8.1.1 General Approach

The design adopts a phased vertical development strategy within a single landfill footprint. This ensures that the facility is developed incrementally, with each 5-year vertical phase constructed, filled, and temporarily capped before the next lift is developed. This approach minimizes the exposed tipping area, reduces rainfall infiltration, and allows for early environmental protection through progressive rehabilitation.

8.1.2 Capping of Existing Waste Cells

The existing Aliwal North landfill, once decommissioned, will be closed and capped using a final cover system consisting of compacted clay or GCL, a geomembrane, a drainage layer, and a vegetative soil cover. This intervention will reduce infiltration, improve environmental compliance, and allow for integration of the old site into the new facility's operational framework.

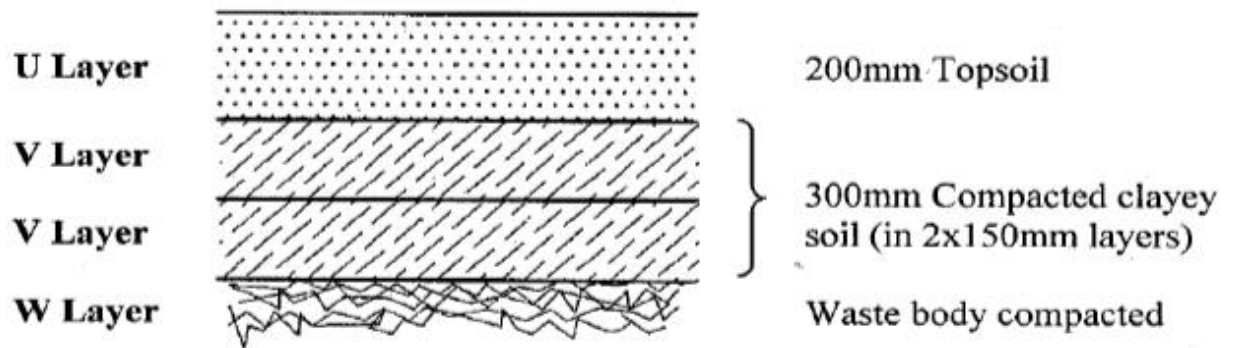


Figure 8: Proposed Capping Layer

8.1.3 Landfill Gas Generation and Management

Landfill gas (LFG) is generated through the anaerobic biodegradation of organic waste within the landfill body, producing primarily methane (CH_4) and carbon dioxide (CO_2), with trace quantities of volatile organic compounds and hydrogen sulphide (IPCC, 2006). The rate and quantity of gas generation vary throughout the landfill's lifespan and are influenced by several factors including

waste type, waste depth, moisture content, degree of compaction, pH, temperature, and time since deposition (EPA, 2003). Due to these interacting variables, accurate prediction of gas quantities carries a high level of uncertainty and must be refined through ongoing field monitoring and data evaluation during landfill operation (DWAF, 1998).

Models such as the IPCC first-order decay model and USEPA LandGEM can be applied to estimate gas generation potential at the design stage. These estimates should later be validated through gas sampling, pumping trials, and subsurface investigations once waste placement commences (USEPA, 2005). A number of approaches exist for estimating LFG production, including rule-of-thumb methods, field pumping tests, and computer-based modelling.

According to the EPA Landfill Site Design Guide (Gregory et al., 1991; EPA, 2003), as a rule of thumb, every ton of degradable waste can produce approximately 6 m³ of landfill gas per year for up to ten years after deposition, under typical conditions. Under optimum conditions with high moisture content, one ton of degradable waste can theoretically generate 400–500 m³ of landfill gas, although practical yields are much lower—often 200 m³ or less per wet ton of municipal waste.

A comprehensive survey of 262 landfill sites conducted by Gregory et al. (1991) reported an average cumulative landfill gas yield of 146 m³/t (wet waste), of which approximately 70% could be recovered for utilization, equating to an achievable yield of about 102 m³/t over the life of a landfill. However, in semi-arid regions such as Maletswai, the actual gas yield is typically less than 10% of these values, owing to limited waste moisture and a negative climatic water balance (DWAF, 1998; Jones & Wagener, 2010).

Based on these findings and applying the IPCC (2006) methodology for the Maletswai site, the theoretical methane generation potential is approximately 270,000 m³ CH₄ per year, but due to the semi-arid climate and small operational scale, the effective gas generation rate is expected to range between 27,000 m³ and 54,000 m³ per year. This equates to about 37–75 m³/day of

methane, confirming that active extraction, flaring, or energy recovery systems are not technically or economically warranted.

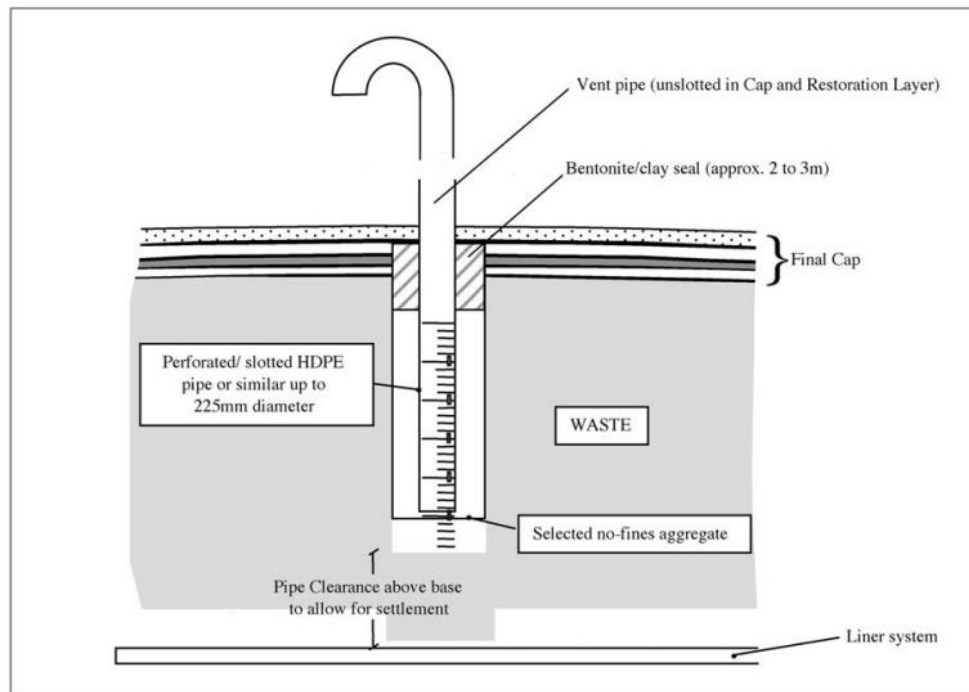


Figure 9: Passive gas control system to atmosphere (EPA, 2003)

The recommended management approach is passive gas control figure 7, allowing natural venting through the working face during early operations. As final cover systems are installed based on figure 6, gas venting infrastructure comprising vertical vent pipes connected to subsurface perforated collection trenches will be implemented to prevent gas build-up. To enhance passive ventilation, “whirly bird” ventilators may be installed on selected vents. These low-cost systems use wind-driven rotation to draw gases upward while carbon or biofilters remove odorous compounds before release (Koerner & Koerner, 2012).

Routine gas monitoring will form part of the environmental management program. Quarterly sampling will be undertaken from perimeter wells and vent pipes to verify methane and carbon dioxide concentrations and to ensure compliance with the National Environmental Management: Air Quality Act (Act No. 39 of 2004) and the 2024 National Norms and Standards for Disposal of Waste to Landfill (DFFE, 2024).

In conclusion, the Maletswai Landfill is expected to generate low volumes of landfill gas due to its small size, dry climatic setting, and reduced organic fraction. Passive venting, supported by simple mechanical ventilators and odour filtration, provides a safe, cost-effective, and environmentally compliant solution for landfill gas management (2024).

8.1.4 Phase 1 Development

Phase 1 figure 5 proposed layout will comprise the first 5-year vertical lift within the designated footprint, reaching an effective filling height of approximately 3–4 m. This phase will be constructed immediately after licensing, with all supporting infrastructure (weighbridge, access road, leachate lagoon, stormwater system, and staff facilities) established concurrently. Phase 1 will provide 15 000 m³ of airspace, sufficient for the first five years of operation.

8.1.5 Long-term Development Plan

Subsequent phases will be developed upward in 5-year increments, progressively raising the landfill height to the final 13 m design limit by Year 20. Each completed phase will be capped with an interim cover to limit infiltration and nuisance, while leachate management systems will remain active across all phases. The final closure will include a composite capping system with geomembrane and vegetation, returning the site to a stable and rehabilitated landform. The design also provides flexibility, allowing for potential vertical extension or transfer of waste to regional facilities beyond the 20-year planning horizon.

8.2 Supporting Infrastructure and Services

8.2.1 Site Access and Roads

The landfill will be accessed via an upgraded gravel access road designed for 20–25 tons compactor and haul trucks, with appropriate drainage and erosion control. Internal roads will run along the perimeter of the footprint and provide all-weather access to the active tipping face, constructed from compacted gravel with a wearing course. Roads will be 6 m wide with adequate turning radii for compaction and haulage equipment. Stormwater side drains will be provided to prevent ponding and minimize maintenance requirements.

8.2.2. Weighbridge Facility

A weighbridge and control office will be located at the site entrance to record all incoming waste loads, supporting billing, municipal reporting, and compliance with the National Waste Information Regulations. The weighbridge system will include electronic record-keeping, ensuring accurate monitoring of waste inflows and available airspace utilization.

8.2.3. Laboratory and Testing Facilities

A small on-site laboratory will be established for quality control of construction materials such as clay liners and cover soils, including routine compaction, density, and moisture testing. Limited leachate quality tests may also be conducted. More complex chemical analyses of leachate and groundwater will be outsourced to accredited laboratories.

8.2.4 Perimeter Security (Fencing)

The site will be enclosed by a 2.4 m high steel palisade or chain-link fence topped with barbed wire, with a controlled access gate at the entrance. Security will include guard facilities and lighting to prevent unauthorised access, illegal dumping, or scavenging.

8.2.5 Water Supply

Water for dust suppression, wheel washing, cover soil conditioning, and construction activities will be supplied via a borehole or municipal reticulation connection. On-site storage tanks will ensure a continuous supply. A separate water supply will be provided for potable use in administrative and staff facilities.

8.2.6 Electricity Provision

Electricity will be supplied by a connection to the municipal distribution grid. Power will serve the weighbridge, leachate pumping systems, offices, and security installations. A standby diesel generator will provide backup to ensure uninterrupted operation of critical systems during load shedding or power outages.

8.2.7 Staff and Administrative Facilities

Administrative and support facilities will include a control office, staff ablution block, waste area, changing rooms, and a small meeting room. These will be located near the entrance for easy access and oversight of incoming vehicles and operations. The layout will be designed to separate staff areas from the active landfill footprint for safety.

8.2.8 Plant and Equipment Maintenance

A dedicated maintenance yard and workshop will be provided for daily servicing of landfill equipment such as compactors, dozers, and loaders. A fuel storage facility, compliant with SANS standards, will be established for refueling operations. Parking bays and a washing area will be included to ensure plant readiness and minimize breakdown

9. OPERATIONAL STRATEGY

9.1 Overview

The operational strategy for the Maletswai Landfill is designed to ensure that the facility is managed in compliance with the National Environmental Management: Waste Act (Act 59 of 2008) and the 2024 Norms and Standards for Disposal of Waste to Landfill. Operations will focus on minimizing environmental impacts, maintaining health and safety, and extending landfill life through best-practice waste placement, monitoring, and progressive rehabilitation.

9.2 Access Control

Access to the site will be strictly controlled. A single gated entry point with a weighbridge, security office, and guard presence will regulate incoming vehicles. Only authorised waste collection vehicles and contractors will be permitted. A visitors' logbook and vehicle checks will be maintained to prevent illegal dumping and ensure waste loads meet acceptance criteria.

9.3 Waste Control and Monitoring

9.3.1 Waste Pickers and Informal Reclaimers

Waste picking will not be permitted on active disposal cells due to safety risks. Recycling initiatives will be formalized at a dedicated Materials Recovery Facility (MRF), where reclaimers can operate under municipal management.

9.3.2 Acceptance Criteria

Only general waste consistent with the site's permit classification of Class B will be accepted. Hazardous, infectious, or industrial waste requiring special treatment will be prohibited. Random load inspections will ensure compliance.

9.3.3 Record Keeping

All waste entering the site will be weighed and recorded. Records will include vehicle ID, origin, waste type, and tonnage. This information will feed into the South African Waste Information System (SAWIS) and annual reporting to the regulator.

9.3.4 Auditing Requirements

Quarterly internal audits and annual external audits will verify compliance with licence conditions. These audits will review operational records, monitoring data, and environmental management practices.

9.3.5 Gas Monitoring Systems

Although climatic conditions suggest limited gas generation, perimeter gas monitoring wells will be installed to detect methane and carbon dioxide migration. Monitoring will be conducted quarterly, with results included in compliance reports.

9.4 Water Quality Monitoring Program

9.4.1 Baseline Conditions

Baseline water quality will be established prior to operation through sampling of groundwater, surface water, and leachate.

9.4.2 Surface Water Monitoring

Upstream and downstream points along nearby drainage lines will be sampled bi-annually for pH, EC, nitrates, and heavy metals.

9.4.3 Groundwater Monitoring

At least three boreholes (one upgradient, two downgradient) will be monitored quarterly. Parameters will include major ions, heavy metals, and microbiological indicators.

9.4.4 Leachate and Contaminated Water Monitoring

Leachate volumes will be measured daily, with quarterly laboratory analysis for chemical composition. Any contaminated runoff from the site will be managed through lined stormwater ponds.

9.4.5 Reporting Requirements

All water quality results will be compiled into a bi-annual monitoring report submitted to the Department of Forestry, Fisheries and the Environment (DFFE) and shared with the Walter Sisulu Municipality Council.

9.4.6 Recycling Initiatives

The landfill will integrate recycling by establishing a small-scale MRF near the entrance. Materials such as plastics, cardboard, glass, and metals will be separated and diverted from landfill disposal. Partnerships with local cooperatives will enhance job creation while reducing landfill airspace demand.

9.5 Waste Deposition Operations

9.5.1 Cell Operation Procedures

Waste will be placed in thin layers (≤ 0.5 m) and compacted using landfill compactors to achieve high density (0.8 t/m^3). The working face will be minimized to reduce windblown litter and infiltration.

9.5.2 Daily and Intermediate Cover

A minimum of 150 mm of soil cover will be applied daily, and 300 mm of intermediate cover will be placed on inactive areas to limit smell, vermin, and fire risk.

9.5.3 Wet Weather Operating Cell

A dedicated wet weather cell with graveled access and all-weather surfacing will be prepared for use during heavy rainfall, ensuring uninterrupted operations.

9.5.4 Site Drainage and Run-off Control

Stormwater diversion berms and cut-off drains will be constructed around active cells to prevent surface water ingress. Collected runoff will be channeled to lined attenuation ponds before controlled discharge.

9.6 Resource Requirements

9.6.1 Plant and Machinery

Essential equipment includes a landfill compactor, bulldozer, front-end loader, and water cart for dust suppression. Leachate pumping equipment and tankers will also be maintained.

9.6.2 Staffing Requirements

The site will be managed by a Landfill Supervisor, supported by machine operators, weighbridge clerks, environmental monitoring staff, and security personnel. Training in occupational health, waste handling, and emergency response will be mandatory.

9.6.3 Nuisance Control (Noise, Dust, Odor, Vermin)

Dust will be controlled with water carts and vegetative cover on inactive areas. Odors will be reduced by rapid covering of waste. Litter fences will capture windblown debris, and vector control measures (trapping and baiting) will be applied. Operating hours will be limited to daylight to reduce noise impacts on nearby communities.

9.6.4 Implementation Schedule

Phase 1 infrastructure and the first cell will be constructed immediately after licensing, with operations commencing within 12 months. Cells will be filled sequentially at five-year intervals, with monitoring and rehabilitation implemented progressively.

9.6.5 Rehabilitation Program

Rehabilitation will be progressive, with final cover applied to each cell upon completion. The final cap will consist of a compacted clay or GCL layer, geomembrane, drainage layer, and vegetative soil cover. Vegetation will stabilize slopes and integrate the site into the surrounding landscape.

9.6.6 Closure Plan

Closure will involve decommissioning infrastructure, final capping of all cells, groundwater monitoring for a minimum of five years, and conversion of the site into a controlled green

space. The plan will be refined closer to the end of life to incorporate updated regulatory requirements and available technologies.

9.7 Discussion

The operational strategy for Maletswai Landfill demonstrates a balance between engineering practicality, environmental protection, and socio-economic benefits. With structured access control, careful monitoring, and phased development, the site can operate safely for its 20-year design life. Recycling initiatives and progressive rehabilitation will further enhance sustainability, while continuous auditing and reporting will ensure compliance with the regulatory framework.

10 CONCLUSION & RECOMMENDATION

The preliminary design for the licensing of a new landfill site in Maletswai, Eastern Cape, is an important response to the growing waste management needs area. The existing landfill, primarily used for domestic waste disposal, has reached its airspace capacity, and it is in the process of closure. Additionally, due to the current poor waste management practices, such as burning, not covering the waste, which are practiced at the landfill site, they are outdated and environmentally unsafe.

The proposed landfill design considers legislative requirements and strives to optimize waste management operations, ensuring compliance with environmental regulations. The proposed landfill is classified as a Class B Liner Landfill Site and "G: S: B-" based on waste type, size, and potential climatic water balance. It falls into the "Small" size class with a calculated Maximum Rate of Deposition (MRD) of 66.1 tons per day. The landfill's calculated airspace capacity and lifespan are estimated, with approximately 20 years of operational life anticipated.

The design incorporates liner and capping systems, considering the absence of natural clay capping material, and relies on geosynthetic clay liners (GCLs). The final capping of the landfill will involve topsoil planted with local vegetation. Effective leachate management is emphasized, with a system of perforated pipes and layers for leachate collection, valves, and emergency

overflow mechanisms. Continuous monitoring and sampling of leachate are crucial for quality assessment.

Surface water management strategies are in place to prevent surface water ingress, erosion, and on-site flooding, including stormwater cut-off trenches. In conclusion, the proposed new landfill site aligns with environmental regulations, addresses waste disposal needs, and is designed for long-term viability, considering factors such as infrastructure, future growth, and environmental impact mitigation.

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