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PLATREEF RESOURCES (PTY) LTD

Sustainability Evaluation of Alternative Landfill Sites

Submitted to:
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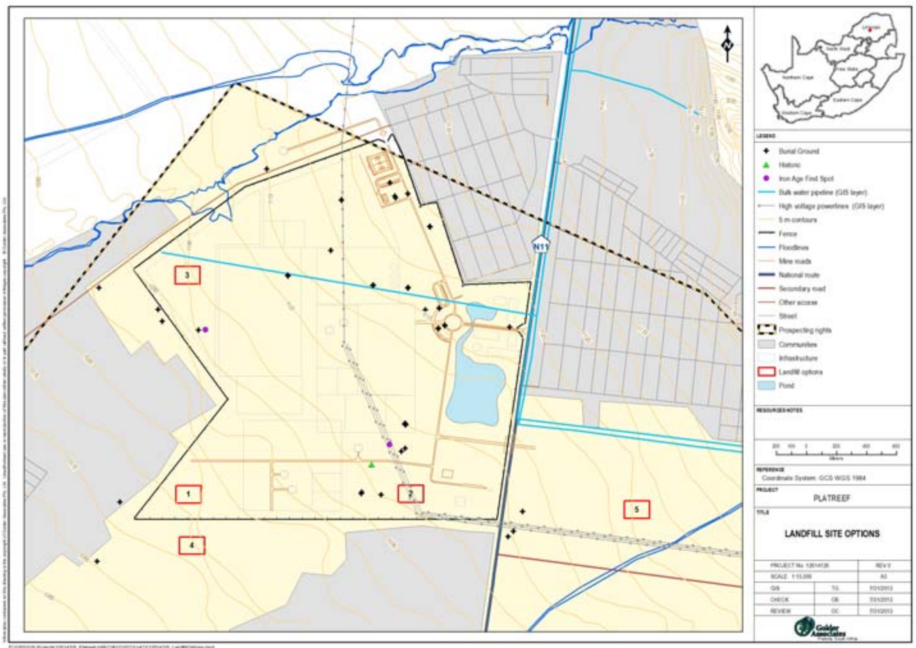

REPORT

Report Number: 12614156-12332-1

Distribution:

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1.0 INTRODUCTION

Platreef Resources (Pty) Ltd (Platreef) is currently undertaking an investigation to assess the feasibility of developing an underground platinum mine on the farms Turfspruit 241KR, Macalacaskop 243KR and Rietfontein 2KS in the Limpopo Province. Platreef holds prospecting rights for these farms which are located approximately 5 to 10 km North West of Mokopane.

Golder Associates Africa (Pty) Ltd (Golder) has been appointed to develop an Integrated Waste Management Plan (IWMP) and to undertake a Waste Management Licence Application process in terms of the National Environmental Management Waste Act, 2008 (Act 59 of 2008). The Integrated Waste Management Licence Application Report requires infrastructure engineering for, amongst other, a General Waste Landfill on site. This report will elaborate on the General Waste Landfill Site Selection since the landfill will be present for life of mine and will require closure at end of mine life.

1.1 Project background

Platreef Resources (Pty) Ltd engages in exploration and production of precious and base metals such as platinum and nickel. The company was established in 1988 and is based in Mokopane, South Africa. Platreef Resources (Pty) Ltd operates as a subsidiary of Ivanplats Limited, which holds a 90% interest in the Platreef Project. Itochu, together with ITC Platinum, holds an effective 10% indirect interest in the Platreef Project.

The Platreef Project includes a recently discovered underground deposit of thick PGE-nickel-copper-gold mineralisation, in the northern limb of the Bushveld Complex. PGE-nickel-copper-gold mineralisation in the northern limb is primarily hosted within the Platreef, a mineralised sequence which is traced more than 30 km along strike. The Platreef Project is situated in the southern sector of the Platreef on three contiguous properties, Turfspruit, Macalacaskop and Rietfontein. The northern most property, Turfspruit, is contiguous with and along strike from Anglo Platinum Limited's Mogalakwena group of properties and mining operations.

The Platreef Project Area is located in the Mogalakwena Local Municipality of the Waterberg District Municipal Area. The study and surrounding area is situated in the catchment area of the Mogalakwena River, in the upper end of the catchment in a broad SE – NW trending valley. The project area lies within a water scarce region.

The study area is peri-urban and lies to the north west of Mokopane and the main roads to Groblersbridge (N11) and Marken traverse the area. Extensive portions of the prospecting rights area are developed. The village of Ga-Magongwe is located in the northern boundary area on Turfspruit with Ga-Kgabadi in the west. Large parts of Macalacaskop are built up with the communities of Lekwlakala, Madika and Maroelereng. The Tshamahanzi village is situated on the boundary between the farms Turfspruit 241 KR and Rietfontein 2KS, and is the only village on the Rietfontein farm.

The mining lease area, described in Figure 1 as blue hatch area, will be under Platreef control with no access to external parties.

1.2 Timing and duration

Platreef has not yet commenced mining. The entire project is split into two phases. The first phase is the bulk shaft sinking or pre-operation phase which includes the mine and Process Plant construction phase which will commence in 2014 and continue for 6 years.

The operation phase of the project is to begin in 2020, in which mine-wide operations will commence. This phase of the project is expected to continue for 30 years or longer if new deposits are confirmed.

1.3 Stakeholders

Stakeholders include communities and settlements to the West, East and South, conservationists (due to wetlands in and around the site), and lease holders within the site and authorities.

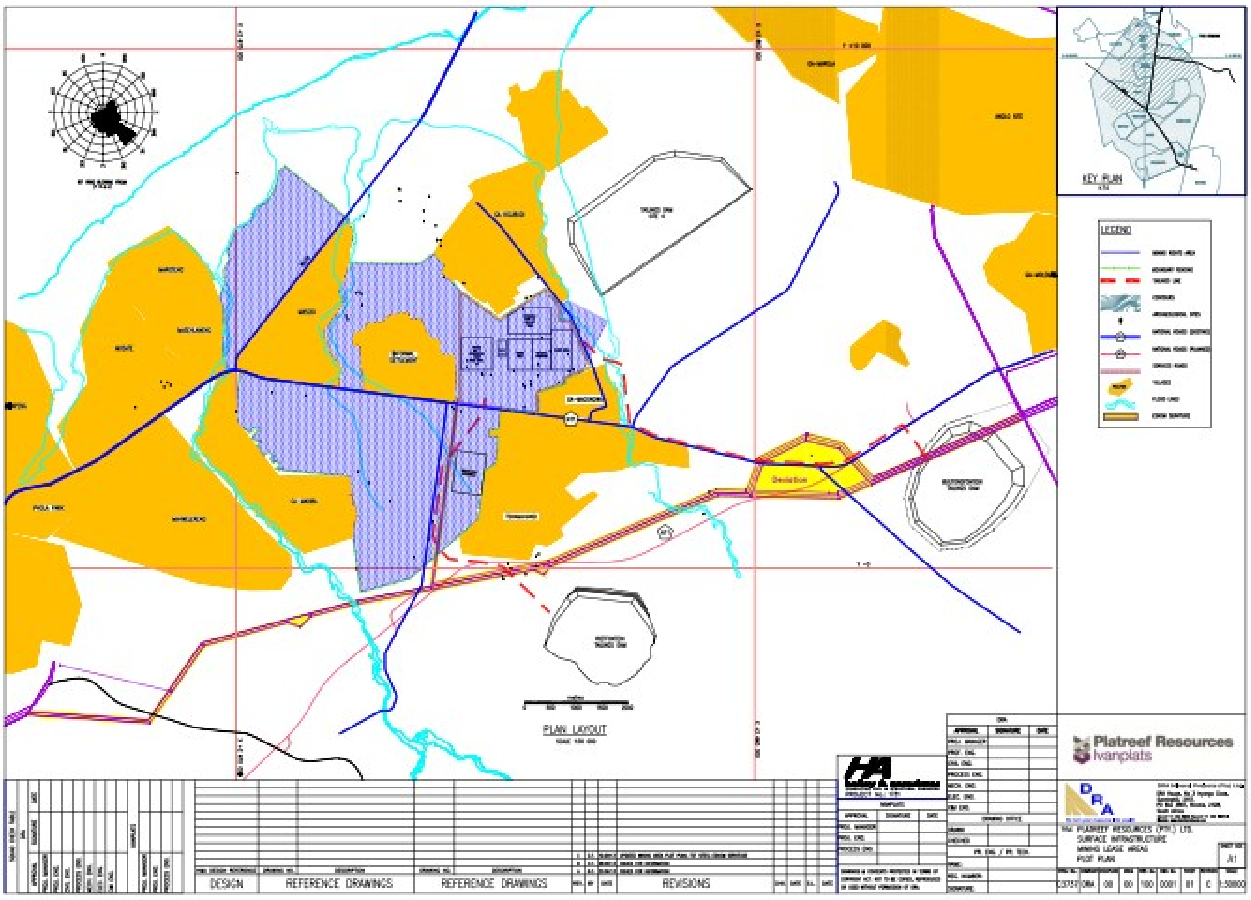

Figure 1: Mine Lease Area

1.4 Objectives

The Alternative Strategies and Scenarios report developed by Golder for Platreef Resources elaborates the facility waste streams for life of mine including the basis for assumptions and develops strategies for each waste stream. Within that process, the sizing of a General Waste Landfill is developed and recommendation made for Platreef Resources to develop a purpose built and operated landfill. The objective of this report is to perform the selection of a site for a General Waste Landfill for Platreef Mine.

This report aims to prepare an evaluation framework based on a range of sustainability criteria that align with the Region's environmental, social, economic goals as well as technical criteria which impact those goals and to evaluate the performance of each of five preliminary General Waste Landfill site options against these criteria in order to make recommendation on a specific location.

2.0 METHODOLOGY

The study methodology is based on the concept of sustainability, which requires a multi-variate decision making process, i.e., environmental, social, economic and, in this case including technical considerations.

The first step requires a first order estimate of the landfill capacity requirement and footprint for the landfill operation. This footprint is applied to the selected set of potential/on- and off-site locations.

Golder then applies their globally developed, proprietary sustainability assessment tool, GoldSET in the South African context using fully site specific criteria developed for the specific application of this landfill site selection to develop the recommendation for location. The process is designed to generate a list of options and to then evaluate the sustainability of each option in terms of the environment, economy, social acceptability and technical advantage. A set of parameters is developed to represent concerns under each category, in order to provide a comprehensive picture of the relative strengths and weaknesses of each option. Ranking of impact and weighting for each parameter are then developed before the program is used to calculate a total valuation of each option for comparative selection. One major outcome will be to compare on- and off-site locations generally, to indicate whether additional off-site locations might be valuable to assess.

The steps employed to reach the recommendation are discussed below.

2.1 Basis of Design for General Waste Landfill

The general waste landfill design is based on the Alternative Strategies and Scenarios report developed by Golder for Platreef Resources in which an inventory of mine wastes was produced (Refer to Appendix C) and the results of a landfill capacity model were used to present an economic landfill trade off. The landfill trade-off analysis determined that there were significant economic advantages to an on-site landfill based on simple economic calculation based on current operating costs. Furthermore, the trade-off analysis suggested that an off-site landfill presented risks associated with potential municipal management issues, security and liability which could easily be expected to result in increased capital cost and increases in operating cost over time.

However, off-site landfill locations (i.e. not within, but near the mine shaft and plant area) were retained in the current evaluation to verify that preliminary conclusion, rather than eliminating them as fatally flawed.

2.2 Sizing of the General Waste Landfill

Table 1 below reflects the calculated landfill cell dimensions and areas in pre-production and at five year increments during the operation phase.

Table 1: General Waste Landfill Cell Dimensions

	Pre-Production	**Operation**					
Cell No.	1	2	3	4	5	6	7
Cell Life	0-6 years	7-11 years	12-16 years	17-21 years	22-26 years	27-31 years	32-36 years
Square Cell Dimension	40	55	70	80	90	95	100
Landfill Area (15 m Height), m^2	1 600	3 025	4 900	6 400	8 100	9 025	10 000

As a result, an area of 17 500 m^2 was allotted for general waste landfill development to include provision for supporting infrastructure and setbacks.

2.3 General Waste Landfill site option selection

Five site options for a general waste facility have been selected. Figure 4 below depicts the site locations; these options are summarised in the sections to follow.

2.3.1 Option 1: On-site SW corner

This location has been designated as a General Waste area, and provides a total space of 14.25 Ha. The design recommendation for this site is a 15 m total height, 12 m of which is above ground. The air space requirement for the full life-span of the mine requires a waste cell footprint of 100 m × 100 m which, with added space for infrastructure, results in an estimated space requirement of 1.75 Ha. There is hence more than sufficient space at the location to accommodate the general waste landfill. Figure 2 below is a photograph of the general area where option 1 would be located.

The lined landfill cell will have limited cover material stockpile, and will be developed in phases. Leachate collection and treatment is included. Studies must still be conducted to determine if the site requires stand-alone utilities and facilities such as administration buildings, workshop, power, water and leachate treatment or if the integrated waste management system will share such utilities with the rest of the plant. The leachate management and treatment for this site will be simplified since it will be within an integrated waste management area.

Figure 2: Option 1: General Area SW Corner

2.3.2 Option 2: On-site NW corner

This area has been designated as a Plant Construction Laydown area and Waste Rock Dump area. This means that the use of this area will be highly constrained during the shaft sinking and mine construction phases. The 1:100 flood line also impinges nearby this area, although the site berm does not cross the flood line. Since the facility is designed in cells, i.e., as a small waste facility which will be expanded, the landfill can co-exist with the Plant Construction area usage and the available area is sufficient for the facility. Figure 3 presents a photograph of the general area where option 2 would be located.

As with the previous landfill, this will be a lined facility with limited cover material stockpile, developed in phases, and including leachate collection and treatment. Stand-alone utilities and facilities such as administration, power and water will have to be provided for separately at a high cost since this facility area is too distant to share such utilities with the main site, particularly with the other elements of an integrated waste management area.

Figure 3: Option 2: On-site NW Corner

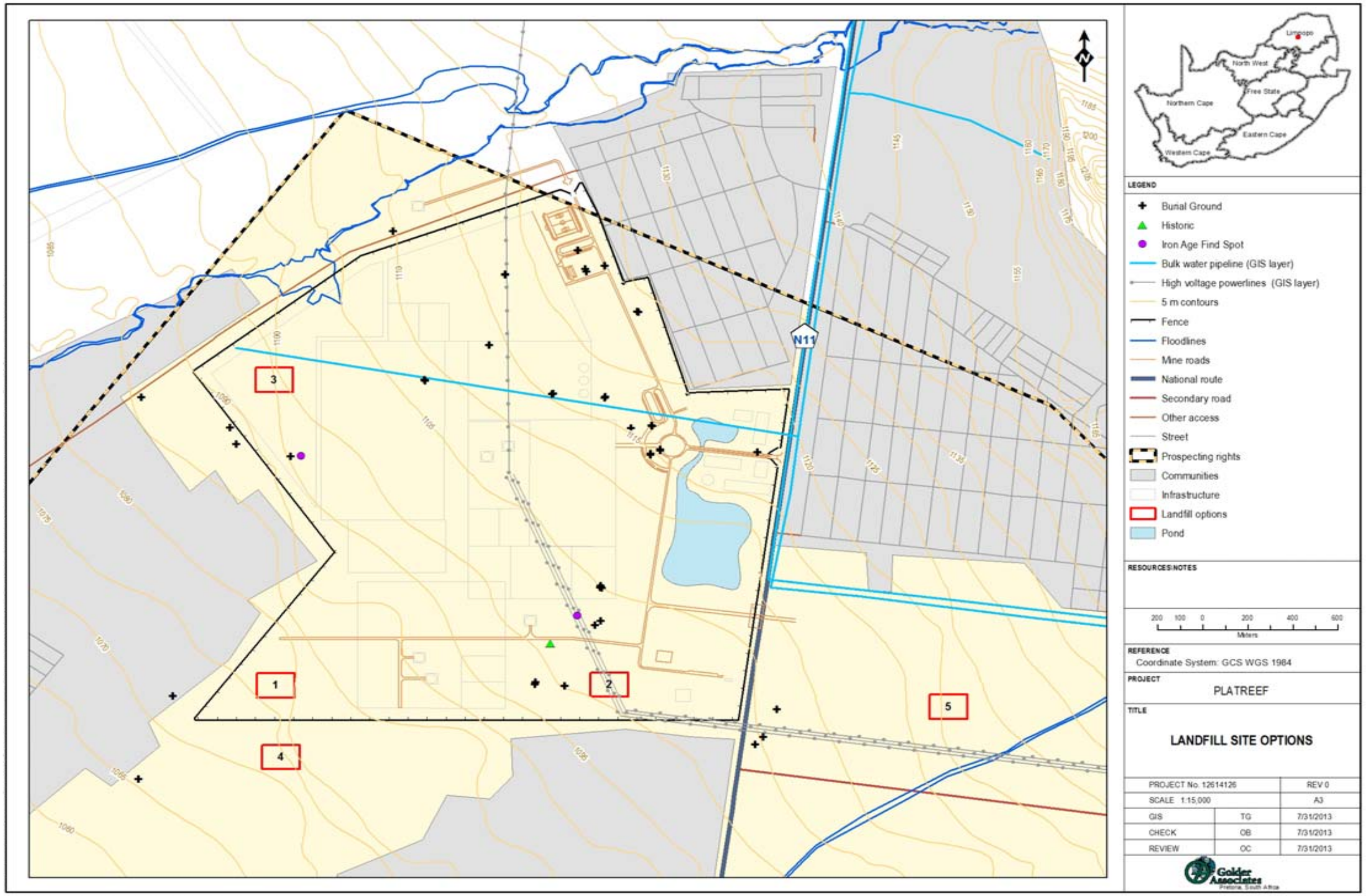

Figure 4: General Waste Landfill Site Selection Options Layout

2.3.3 Option 3: On-site SE corner

Although there is sufficient space in this area for a landfill site, this area is close to the entrance to the site and visible from the N1, the main highway passing the site. This means that this landfill, which will be higher than the berm surrounding the site, will be quite conspicuous and its use may be highly constrained. Furthermore, this site is separated from the planned waste management area. A large sub-station planned for the location raises safety concerns. Figure 5 presents a photograph of the general area where option 3 would be located.

This waste facility will be 15 m high. If it is to be flattened due to visibility, the available area will become constrained. As with the other facilities, this landfill will be lined, with limited cover material stockpile, developed in phases, and will include leachate collection and treatment. Utilities and facilities such as administration, power and water will have to be provided for separately at a high cost.

Figure 5: Option 3: On-site SE Corner

2.3.4 Option 4: Off-site South of SW end

This location is just outside the General Waste area and also just outside the current site contained by a berm.

This landfill can be designed with different heights depending on the size of the area of land leased, but the design recommendation is 15 m total height, 12 m of which is above ground. Air space requirement is similar to Option A, with a waste cell footprint of 100 m × 100 m only, and a total footprint of 1.75 Ha when infrastructure is included. Again, this landfill will be lined with limited cover material stockpile, developed in phases, with leachate collection and treatment. Utilities and facilities will be shared with the rest of the mine and integrated waste management site. Figure 2 presents a photograph of the general area where option 4 would be located since it is proximate to the location of option 1.

An added advantage of this option is that leachate can be managed easily within an integrated waste management area, and this site will be part of that area, albeit expanded beyond the current mine site. There are serious concerns regarding unofficial settlements already encroaching on the site and the difficulties in expanding the land lease may be insurmountable.

2.3.5 Option 5: Off-site West of site entrance

This area is situated just outside the Mine Main Gate and will not be protected by the site berm. As with Option 1 and Option 4, this landfill site will be 15 m high, 12 m of which will be above ground, it will have a footprint of 100 m × 100 m and take up a total area of 1.75 Ha. Figure 6 presents a photograph of the general area where option 5 would be located.

It will be a lined landfill with limited cover material stockpile, developed in phases, with leachate collection and treatment. Separate utilities such as administration buildings and water supply will be required for this site. Closure and rehabilitation of an off-site facility is an added cost that may also result in legal issues and costs. An off-site landfill is subject to incursion from waste pirates, which poses serious health and safety issues but also potential liability issues to the mine. Incursion of residences in the proximity of an off-site landfill will be difficult to prevent and is considered to add further potential liability.

It has been determined that further resource is located in the vicinity and this option is considered fatally flawed since its presence at the surface will bar development of subsurface resource, termed resource sterilization.

Figure 6: Option 5: Off-site SW Corner

2.4 Fatal flaw analysis

Initial screening of the options includes a fatal flaw analysis. The fatal flaw analysis asks the following questions:

- Are the objectives met?
- Is it technically feasible?
- Are timing and duration constraints met?
- Is it financially feasible?
- Are the risks associated with it acceptable?
- Is the option qualified?
- Is there justification for the option?

It was found that each of the on-site options produced a positive answer for all of these questions and thus proceeded on to the next phase in the landfill site selection procedure. Off-site options were not considered economically feasible as determined in the Alternative Strategies Report landfill trade-off analysis. With respect to risks associated with off-site landfill, and potentially with respect to meeting timing and duration constraints, off-site options are considered border line at best but, as described above have been retained so that the evaluation process will provide comparison with on-site options. The outcome will further advise the mine in case other off-site options are proposed at a later date.

2.5 Development of Multi-Criteria Analysis Framework

The decision-making method employed by GoldSET is an approach to assess options based on multiple decision criteria or objectives. This approach allows the systematic comparison of options based on multiple evaluation criteria that may be grouped together into environmental, social, economic and technical dimensions. While subjectivity (or professional judgement) is always inherent in decision-making, GoldSET provides a method where subjectivity is minimised, the decision process is traceable and the results can be explained to stakeholders. This decision-making method is further enhanced by the formulation of goals which direct the selection to the Option which best fulfils the goals set by the professional, and thus leads to lower risks and greater opportunities.

As mentioned previously, four dimensions are considered in this decision making process: environmental, economic, social and technical. Within each of these dimensions, multiple criteria are set up, which allows the user to score each Option based on these criteria. Further to this, each of these criteria has different levels of importance, which gives them different weightings. All of this together allows the most important attributes and goals to stand out. Also, as many criteria as desired may be used with inputs from multiple specialists, which reduces the subjectivity of the decisions.

This approach makes the decision criteria explicit and can facilitate cooperation among multiple stakeholders during the decision-making process. Results of the evaluation can be expressed in multiple levels of detail, by dimension, goals or evaluation criteria. However, GoldSET does not make the decision and is only the tool which will aid the decision-maker by setting the options out systematically so that the benefits and implications can easily be seen.

For the purpose of the landfill site selection, Golder built a specific site selection framework for landfill sites using GoldSET. This framework was based on environmental, technology and sustainability issues and values applicable to the area. The following sections describe how this framework was set up for the landfill site selection specifically.

2.6 Determining Goals and Evaluation Criteria

The general structure proposed for the multi-criteria framework can be described by a hierarchical structure composed of three layers: Dimensions, goals and criteria. The dimensions are used to compare options on four key factors which show the overall performance of a landfill option. Goals are defined to reflect how the various options address main concerns by stakeholders, and criteria are questions or conditions which assess the ability and extent to which the options achieve the goals previously defined.

2.6.1 Dimensions

The specific dimensions were chosen since they make up the various sustainability measures of a system or facility. The technical dimension takes into account factors which influence technical performance, such as complexity, adaptability and performance uncertainty. The economic dimension assesses various factors which affect costs and revenues throughout the project life-cycle. The environmental dimension considers benefits of and impacts on air, water quality, climate change, energy consumption, etc. Lastly, the social dimension considers the impact of the option on local communities and other stakeholders. This includes the well-being of the community, public acceptance as well as resource use.

2.6.2 Goals

The purpose of this intermediate step between dimension definition and evaluation criteria development is to identify the main drivers in each of the four dimensions. It provides direction to the criteria developer to identify criteria which should be used as well as the relative importance of each criterion.

Goals were identified based on environmental, economic and social goals and ideals of the general area, legislation, and professional opinion in Golder's waste management sector.

2.6.3 Criteria

It is necessary to divide the sustainability dimensions into measurable criteria to allow for meaningful analysis. Evaluation criteria were thus selected to align with the goals selected for the landfill site. Each of these criteria has an explanatory description to avoid confusion and/or miscommunication as to the issue being addressed or the meaning of the score which may be given to the criterion.

Individual criteria with their definitions are shown in Section 3.1.

2.7 Criteria Scoring

A common scoring scale was used for all of the criteria in order to be able to compare these options without bias. The scoring scale used was from 1 to 100%. All of the criteria in this site selection procedure were qualitative criteria and were thus scored according to their degree of performance with respect to the criteria, with 100% being the best performance and 0% being the worst performance.

The list of final criteria with their respective scoring schemes is shown in Section 3.2.

2.8 Dimension weighting

Weighting factors for each dimension reflect the degree of importance of each dimension within the overall sustainability evaluation of each option. The base case weighs each dimension equally at 25%.

2.9 Calculating GoldSET Outputs

The criteria were assigned and scored for each option through an in-depth literature review, input of experts and through stakeholder engagement results. These scores were then entered into GoldSET waste management module for analysis and generation of overall scores and rankings.

GoldSET calculates a final score for each option as well as total percentage scores for each of the four dimensions (environmental, social, economic and technical). It represents these scores in a graphical form which is easy to understand and interpret. The higher the percentage score for a specific dimension, the better the option is at minimising adverse impacts and maximising positive impacts.

In addition to this, GoldSET is also able to display the results in greater detail to see how each option performed for all of the criteria.

3.0 EVALUATION AND RESULTS

The fatal flaw analysis revealed that all of the on-site options are capable of fulfilling all the requirements, and will thus be feasible options. Off-site options are retained so that the GoldSET evaluation either supports, is neutral towards or somewhat contradicts the earlier conclusion with respect to off-site general waste landfill locations. It therefore still remains to complete the process to choose one of these options as the most viable option above the other options but also to examine off-site versus on-site locations in terms of the results.

3.1 Criteria and scoring schemes

The following sections depict the various criteria, their detailed definitions and their respective scoring schemes. These criteria are shown separately for each dimension.

3.1.1 Environmental

Eleven environmental criteria were considered, as shown in Table 2.

Table 2: Environmental Dimension - List of Selected Criteria

Goal/ Theme	Criteria	Description	Scoring Scheme	Reference
Air Quality	Air quality	Wind: Prevailing wind direction and dust impact on the facilities. Potential dust generation from the project facilities that may impact the adjacent residents. Proximity to communities/ households/buildings	0 = Prevalent wind direction 500 m, 25 = Prevalent wind direction and within 1 km, 50 = Other direction and within 500 m, 75 = Other direction and within 1 km, 100 = Further than 1 km (any direction).	Eskom SPOT Building Count, 2009 release. Eskom ESI-GIS, and Current mapped communities
Community Wellbeing	Noise	Proximity to communities	0 = within 400 m, 25 = within 400 - 600 m, 50 = within 600 - 800 m, 75 = within 800 – 1 000 m, 100 = greater than 1 km.	Eskom SPOT Building Count, 2009 release. Eskom ESI-GIS, and Current mapped communities
Ecological Integrity (impact of the system)	Terrestrial Ecology	Threatened Ecosystems	0 = Critically endangered, 33 = Endangered, 66 = Vulnerable, 100 = Least threatened (transformed land).	Threatened ecosystems (SA Ecosystem THR Remaining Extent: The first national list of threatened terrestrial ecosystems for South Africa was gazetted on 9 December 2011 (National Environmental Management: Biodiversity Act: National list of ecosystems
Water Quality	Groundwater	Sensitivity to contamination: The incremental impact of the facility on the groundwater resource. The presence of local water bearing aquifers.	0 = No go, 33 = High sensitivity to GW contamination, 66 = Medium sensitivity to GW contamination, 100 = Low sensitivity to GW contamination.	Date sources: 1:50 000 topography map and existing groundwater reports for Platreef

Goal/ Theme	Criteria	Description	Scoring Scheme	Reference
Visual Impact	Visual	Visibility to sensitive viewers (proximity to communities/ households/buildings/roads)	0 = within 400 m, 25 = within 400 - 600 m, 50 = within 600 - 800 m, 75 = within 800 – 1 000 m, 100 = greater than 1 km.	Eskom SPOT Building Count, 2009 release. Eskom ESI-GIS, and Current mapped communities
Effect on Traditional Land Use	Soils	Alternative use value of land to be used for landfill	0 = Very high potential arable land, 20 = High potential arable land, 40 = Moderate potential arable land, 60 = Non-arable, grazing, woodland or wildlife, 80 = Wilderness, 100 = Disturbed land (brownfields site).	Schoeman, JL, van der Walt, M, Monnik, KA, Thackrah, A, Malherbe, J and Le Roux, RE. (2002). Development and application of a land capability classification system for South Africa. ARC-ISCW Report no GW/A/2000/57.
Archaeological site, cultural or heritage asset	Heritage	Presence of cultural heritage sites, graves, etc.	0 = < 200 m from graves, 25 = 200 – 400 m from graves, 50 = 400 - 600 m from graves, 75 = 600 - 800 m from graves, 100 = > 800 m from graves.	Van Riet, W, Claassen, P, van Rensburg, J, van Viegen, T and du Plessis, L. (1997). Environmental Potential Atlas for South Africa. Published by van Schaik, Pretoria, and Preliminary heritage survey results
Water management	Surface water	Presence/impact from footprint (proximity to floodlines/distance to watercourse)	0 = within 32 m of watercourse/floodline, 50 = 32 - 500 m from water course/floodline, 100 = More than 500 m.	1:50 000 topography map
Adverse Impact to Natural Environment	Terrestrial ecology	Biodiversity	0 = Protected, 20 = Irreplaceable, 40 = Highly significant, 60 = Important/ necessary, 80 = Least concern, 100 = No natural habitat remaining.	Mpumalanga Parks Board (2006). Mpumalanga Biodiversity Conservation Plan (MBCP) Terrestrial Biodiversity Assessment. Details in: Ferrar AA & Lotter MC (2007). Mpumalanga Biodiversity Conservation Plan Handbook. Mpumalanga Tourism & Parks Agency, Nel

Goal/ Theme	Criteria	Description	Scoring Scheme	Reference
	Wetlands	Area within proposed landfill footprint characterised as wetlands	0 = Less than 100 m, 20 = 100 – 200 m, 40 = 200 – 300 m, 60 = 300 – 400 m, 80 = 400 – 500 m, 100 = >500 m.	Nel, JL, Murray, KM, Maherry, AM, Petersen, CP, Roux, DJ, Driver, A, Hill, L, van Deventer, H, Funke, N, Swartz, ER, Smith-Adoa, LB, Mbona, N, Downsborough, L and Nienaber, S. (2011). Technical Report for the National Freshwater Ecosystem Priority Areas
Engineering Parameter - Land	Sustainability	Use of Natural Resources. GHG development, energy consumption	0 = unsustainable practices, 100 = sustainable resource use.	Golder

3.1.2 Social

Twelve social criteria have been selected, as shown in Table 3.

Table 3: Social Dimension - List of Selected Criteria

Goal/Theme	Criteria	Description	Scoring Scheme	Reference
Health & Safety	Public Safety	Evaluates the potential negative impacts of the project on public (residents, transients) safety.	0 = Potential significant impacts on the community, 50 = Moderate potential impact on the community, 100 = No anticipated impact on the community.	GRI-G3 (SO1), FIDIC (SO-8, SO-11)
Impact on Community	Use for the Public	Value of end land use for the public, after closure.	0 = No possible benefits from the property, 50 = Some restrictions for use, 100 = No restrictions for use.	GRI-G3 (EC8), FIDIC (EC-01, SO-12)

Goal/Theme	Criteria	Description	Scoring Scheme	Reference
Corporate Image	Public Acceptance	Assesses the positive impact that the project's interaction with the public could have on corporate image, particularly when society is sensitive to issues surrounding the project.	0 = Negative effect on image, 50 = Status quo, 100 = Positive effect on image.	GRI-G3 (PR5); ORR (SDED)
Community Economic Growth	Economic Advantages for the Local Community	Assesses the spin-off benefits to the local community resulting from the implementation of the option.	0 = None, 50 = Some, 100 = High.	GRI-G3 (EC6), FIDIC (EC-01)
Impact on the Landscape	Impact on the Landscape	Impacts of the landscape (aesthetic value) resulting from the implementation of the options.	0 = Long-term significant negative effects, 33 = Long-term moderate negative effects, 66 = Short-term negative effects, 100 = No impacts.	Golder
Landowner proximity	Proximity	Not situated on commercially farmed land (except sugar cane)	0 = < 200 m from agricultural activities, 25 = 200 – 400 m from agricultural activities, 50 = 400 – 600 m from agricultural activities, 75 = 600 – 800 m from agricultural activities, 100 = > 800 m from agricultural activities.	Dept. of Agriculture
Additional financial risks and opportunities	Social	Economic Advantage to local Community	0 = economic exclusion of locals, 33 = jobs provided to some community members, 66 = jobs and business opportunities provided to locals, 100 = jobs and business opportunities provided to communities on a large scale.	Golder

Goal/Theme	Criteria	Description	Scoring Scheme	Reference
Land tenure	Land use	Alteration to existing beneficial land uses	0 = irrigation, 33 = commercial dry land, 66 = other agriculture, 100 = mines/disturbed areas.	Van den Berg EC, Plarre C., van den Berg, HM and Thompson, MW. 2008. The South African National Land Cover 2000. Agricultural Research Council-Institute for Soil, Climate and Water. Pretoria. (report number GW/A/2008/86).
Visual aspects	Aesthetics	Landscape/Aesthetic appearance	0 = significant visual impacts, 50 = some visual impacts, 100 = negligible visual impacts.	Golder
Waste Management	Public acceptance	Rural Dwellings in site; dwellings per hectare	0 = perceived as negative impact on locals, 50 = perceived as neutral impact on locals, 100 = perceived as positive impact on locals.	DRA, Aerial survey, EIA survey
Additional Land Requirements	Potential Relocation/ Restriction to Accessing Property	In case of people being affected (access roads, landfill site)	0 = extensive relocation or access restriction required, 50 = some relocation or access restriction required, 100 = No relocation or access restriction required.	Golder
	Land ownership	The need for land acquisition	0 = outside mine lease area, 50 = within mine lease area on prime agricultural land, 100 = within mine lease area on disturbed land.	Golder

3.1.3 Economic

The economic criteria selected are shown below in Table 4.

Table 4: Economic Dimension - List of Selected Criteria

Goal/Theme	Criteria	Description	Scoring Scheme	Reference
Competitiveness	Capital Cost	Capital cost	0 = Extremely expensive, 33 = Quite expensive, 66 = Affordable, 100 = Very affordable.	As the method of construction is similar, Golder reflected on capital cost risk
	Operating Cost	Operating cost	0 = Extremely expensive, 33 = Quite expensive, 66 = Affordable, 100 = Very affordable.	As the method of operation is similar, Golder reflected on operational cost risk
	Closure Cost	Closure cost	0 = Extremely expensive, 33 = Quite expensive, 66 = Affordable, 100 = Very affordable.	Golder
	Distribution of Cost Over Time	Distribution of Cost Over Time	0 = Very bad, 33 = Bad, 66 = Good, 100 = Very good.	Golder
	Materials Recovery	5 bin system recommended on site.	0 = No potential for recovery, 33 = Some potential, 66 = Good potential, 100 = Very good potential.	Golder

Goal/Theme	Criteria	Description	Scoring Scheme	Reference
Technology	Overall Project Level of Confidence	Assesses the level of technological uncertainty associated with the success of the option in achieving the overall objectives. Managing technological uncertainty requires an assessment of previous experience with the technique. Appropriate measures can be recommended to reduce uncertainty related to performance.	0 = Significant uncertainty associated with technology (groundbreaking technology; no proven track record in full-scale applications), 50 = Some uncertainty remains with technology (no proven track record in specific site conditions), 100 = Marginal or no uncertainty with .technology (previous successful experience in specific site conditions).	Golder
Legal Aspect	Complexity of permitting process	Servitudes, landownership, transferability to new owner, number of exemptions/licenses/ supporting specialist studies required	0 = highly complex process, 50 = permitting required but not complex, 100 = permitting not required.	Golder
	Proximity	Not within 2 km of formal or informal human settlement; or settled traditional authority areas. Not within a metropolitan planning constraint, e.g. C-Plan (Gauteng) Not within 3 km of airport or 500 m from aerodrome runway/airfields	0 = > 200 m of settlement, 25 = 200 – 400 m of settlement, 50 = 400 – 600 m of settlement, 75 = 600 – 800 m of settlement, 100 = > 800 m of settlement.	Dept. of Water Affairs Settlements; Digby Wells; Metropolitan Municipality; Dept. of Water Affairs
	Rezoning of land use	Required or not	0 = required, 100 = not required.	Golder
Costs	CAPEX	Borrow material needed, land purchases, cost of relocating and compensation of communities, etc. Cost function to be applied.	0 = Major Additional CAPEX Requirement, 33 = Risk of major additional CAPEX, 66 = Minor additional CAPEX, 100 = Equivalent or better than baseline SW corner inside Project.	Golder
	OPEX	The distance of the site from waste generation, cost of operating and maintaining the facility, etc. Cost function to be applied.	0 = Major OPEX additional cost, 33 = Risk of major OPEX additional, 66 = Minor OPEX additional.	Golder

Goal/Theme	Criteria	Description	Scoring Scheme	Reference
		Financial Recoveries over life cycle. Vulnerability to Climate Change. Liabilities over life cycle. Potential Litigation. Operation and Performance of Activities. Value of End Land Use. Distance to surfaced main road.	100 = Equivalent or better SW corner inside site.	

3.1.4 Technical

The technical criteria are shown below in Table 5.

Table 5: Technical Dimension - List of Selected Criteria

Goal/Theme	Criteria	Description	Scoring Scheme	Reference
Technology	Feed characteristic dependency	Applicability of the technology for materials with different mineralogy, PSD, bitumen content, clay content and solid content	0 = Severe restrictions may be applied, 50 = Minor restrictions may be applied, 100 = Applicable for any feed.	Golder
Stack & Dam Stability	Landfill Stability - Design Complexity	Slope angle; liquefaction; consolidation; under-drainage	0 = Extremely complex, 33 = Complex, 66 = Somewhat simple, 100 = Simple.	Golder
Dewatering & Transport	Transportation - Cost & Complexity	Reduced Transport distance & addition of destinations for waste/ complexity	0 = Extreme transport & complexity, 50 = Separate areas but distance same, 100 = Common Area.	Golder
	Impact to Other Processes	Waste transport impact on the mine operations.	0 = Major negative impacts, 33 = Some impacts, 66 = Minimal impacts,. 100 = No expected impact.	Golder

Goal/Theme	Criteria	Description	Scoring Scheme	Reference
Capacity	Landfill Capacity - Design Complexity	Slope angle; footprint and land take; consolidation; leachate management and related infrastructure	0 = Extremely complex, 33 = Complex, 66 = Somewhat simple, 100 = Simple.	Golder
	Capacity - Reliability	Placement density; consolidation; emergency storage	0 = Extremely unreliable, 33 = Somewhat unreliable, 66 = Reliable, 100 = Extremely reliable.	Golder
Cover System	Cover System - Design Complexity	Control of infiltration; trafficability; dust control; re-vegetation etc.	0 = Extremely complex, 33 = Complex, 66 = Somewhat simple, 100 = Simple.	Golder
	Cover System - Reliability / Flexibility	Ease of construction; long-term integrity	0 = Extremely unreliable, 33 = Somewhat unreliable, 66 = Reliable, 100 = Extremely reliable.	Golder
Reliability	Landfill System - Reliability	Ease of operations; Risk of failure: - number and complexity of remote operations; staffing, power supply; water management	0 = Extremely unreliable, 33 = Somewhat unreliable, 66 = Reliable, 100 = Extremely reliable.	Golder
Costs	Bulk services	Electrical, water supply requirement/complexity	0 = Expensive requirement to access Municipal Services or Intersection, 33 = Permit required to supply services from mine site but high cost, 66 = Permit required to supply services but low cost, 100 = Integral with planned mine site services.	Golder; DRA

Goal/Theme	Criteria	Description	Scoring Scheme	Reference
Waste Management	Security	Remote/within Mine security area	0 = outside mine lease area, 50 = inside mine lease area but not aligned with current waste management site, 100 = Integral to planned waste management site.	Golder
Engineering Parameter - Land	Collection systems	Waste Transfer distances	0 = outside mine lease area, 50 = inside mine lease area but not aligned with current waste management site, 100 = Integral to planned waste management site.	Golder
	Access: Contractors	Consider potential end-users	0 = outside mine lease area, 50 = inside mine lease area but not aligned with current waste management site, 100 = Integral to planned waste management site.	Golder
	Geotechnical	Safety factor / undermining, etc.	0 = Undermining may influence licencing, 100 = Undermining will not influence licencing.	Golder; DRA
	Options for waste facilities	Proximity & Area/for alternatives for waste sites to accommodate evolving waste strategy	0 = outside mine lease area, 50 = inside mine lease area but not aligned with current waste management site, 100 = Integral to planned waste management site.	Golder
	Operations	Standalone entity for 3rd Party management; Independence of operations	0 = outside mine lease area, 50 = inside mine lease area but not aligned with current waste management site, 100 = Integral to planned waste management site.	Golder

Goal/Theme	Criteria	Description	Scoring Scheme	Reference
	Closure liability	Proximity	0 = outside mine lease area, 50 = inside mine lease area but not aligned with current waste management site, 100 = Integral to planned waste management site.	Golder
	Access: Disposal	Roads/rail	0 = Expensive requirement to develop off site roads, 33 = Permit cost only for offsite roads with minimal roadwork, 66 = Roadwork only on mine site, 100 = Planned roadwork integral with planned mine site layout.	Golder
	Topographic	Slope steepness <= 20%	0 = non-compliant/infeasible, 50 = amendment required, 100 = No relevance.	Golder GIS
	Geology/ Pedology	Not in immediate proximity to dolomites, dolerite dykes and sills, faults, structures, outcrops, sand dunes (200 m buffer)	0 = In proximity, 50 = 200 m buffer, 100 = No relevance.	Golder GIS

3.2 Results and Conclusions

The options were evaluated according to the criteria in Section 3.1. The individual scorings are appended to this document, as well as the weightings of each criterion.

The results from the evaluation of the options are presented in Figure 7 and can be summarised as follows:

- Building on-site in the South West corner of the site (i.e. Option 1) is the most advantageous solution in terms of all four of the dimensions;
- The most technically feasible solution by far is Option 1, since this option has more than sufficient available land, and has waste infrastructure and waste management already in place in that area. It does not require additional infrastructure or complicated waste transportation systems in order to function properly;
- The most economically feasible solution is also Option 1, since this landfill site is within the general waste management area and does not require new facilities and utilities to be built to support this landfill. Infrastructure used for the rest of the plant can thus also be used for this landfill;
- All on-site options have similar social scoring, which shows that the choice of landfill site within the mine site does not affect the surroundings, since it is within an impacted area. On-site is preferable to landfill sites taking up public or private grounds outside of the mine, which have not been impacted, and which would destroy the aesthetic nature of the area and cause environmental pollution. There are also serious concerns regarding incursion onto and residential encroachment near an off-site landfill; and
- The two sites which score the highest in terms of environmental impacts are the sites which are situated away from wetlands and other water catchments. These two sites are Option 1 and Option 4.

The outcomes with respect to on-site versus off-site landfills support the conclusion that resulted from economic analysis alone, where off-site landfill operation cost was found to be prohibitive.

Looking at all the dimensions, Option 1 proves itself to be the most desirable solution on all accounts, since it is situated within easy access of site infrastructure and waste management, is within an impacted area, and is out of sight of public view from, for example, the N1.

Execution of a sensitivity analysis was considered, but deemed unnecessary since Option 1 performs the highest for each of the dimensions and the weightings of the dimensions will thus not affect the final choice.

The results obtained from this evaluation are presented in the figure below where total area accruing to Option 1 reflects its higher performance.

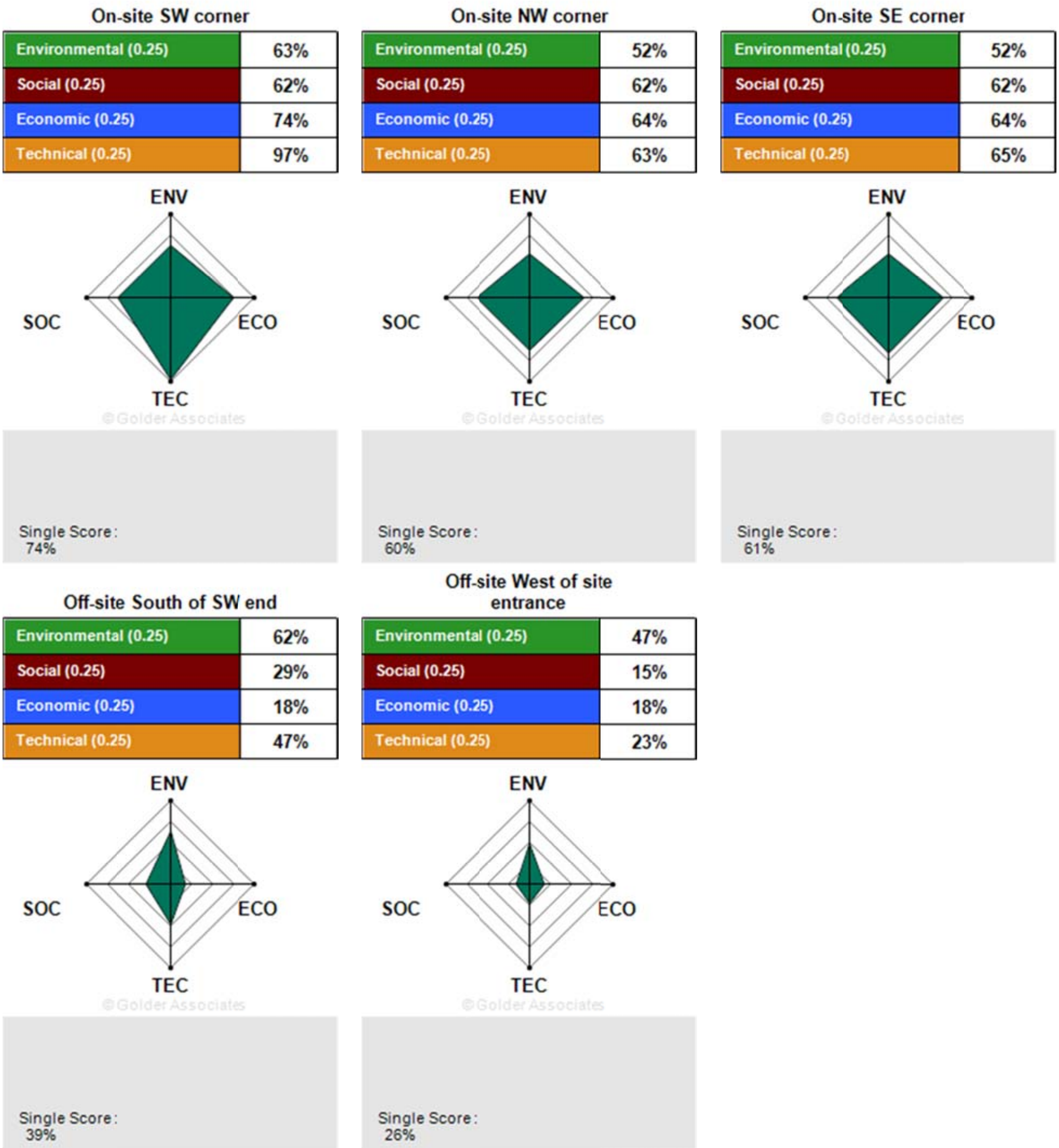

Figure 7: GoldSET Results per Dimension

4.0 STUDY LIMITATIONS

This report has been prepared for the exclusive use of Platreef Resources (Pty) Ltd. All studies done and interpretations made are specific to this project and cannot be used for any other project.

Unless otherwise stated, these interpretations have been made as per the scope of work and assumptions that have been described in the report. Also, as is the nature of qualitative assessments, the interpretations may be subject to the opinion of the person conducting the evaluation to a degree. Golder shall thus not be held responsible for any damages and losses resulting from the use of the information and/or output from GoldSET.

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https://afpws.golder.com/sites/12614126amecdevelopiwmpplatreef/reports/12614126-12332-1_rep_landfill_site_selection_final_20sep13.docx

APPENDIX A

Criteria Evaluation

The evaluation of options is presented per dimension in the tables below. Scores have been assigned for each applicable indicator.

Table 6: Environmental Dimension – Evaluation of Criteria

CRITERIA	On-site SW corner	On-site NW corner	On-site SE corner	Off-site South of SW end	Off-site West of site entrance
Air quality	100	100	100	100	25
Noise	0	0	0	25	50
Terrestrial Ecology	66	66	66	66	66
Groundwater	66	66	66	66	66
Visual	0	0	0	25	50
Soils	40	40	40	40	40
Heritage	50	0	50	50	75
Surface water	100	100	50	100	50
Terrestrial ecology	80	80	80	80	40
Wetlands	100	100	100	100	40
Sustainability	100	0	0	0	0

Table 7: Social Dimension - Evaluation of Criteria

CRITERIA	On-site SW corner	On-site NW corner	On-site SE corner	Off-site South of SW end	Off-site West of site entrance
Public Safety	50	50	50	0	0
Use for the Public	50	50	50	50	0
Public Acceptance	50	50	50	50	0
Economic Advantages for the Local Community	0	0	0	0	0
Impact on the Landscape	66	66	66	66	33
Proximity	100	100	100	25	25
Social	33	33	33	33	33
Land use	100	100	100	33	33
Aesthetics	50	50	50	50	0
Public acceptance	50	50	50	0	0

CRITERIA	On-site SW corner	On-site NW corner	On-site SE corner	Off-site South of SW end	Off-site West of site entrance
Potential Relocation/ Restriction to Accessing Pr	100	100	100	50	50
Land ownership	100	100	100	0	0

Table 8: Economic Dimension - Evaluation of Criteria

CRITERIA	On-site SW corner	On-site NW corner	On-site SE corner	Off-site South of SW end	Off-site West of site entrance
Capital Cost	66	66	66	33	33
Operating Cost	33	66	66	33	33
Closure Cost	66	66	66	33	33
Distribution of Cost Over Time	66	66	66	33	33
Materials Recovery	66	66	66	33	33
Overall Project Level of Confidence	100	100	100	50	50
Complexity of permitting process	50	50	50	0	0
Proximity	75	75	75	0	0
Rezoning of land use	100	100	100	0	0
CAPEX	100	33	33	0	0
OPEX	100	33	33	0	0

Table 9: Technical Dimension - Evaluation of Criteria

CRITERIA	On-site SW corner	On-site NW corner	On-site SE corner	Off-site South of SW end	Off-site West of site entrance
Feed characteristic dependency	100	50	50	0	0
Landfill Stability - Design Complexity	100	66	66	33	0
Transportation - Cost & Complexity	100	50	50	0	0

CRITERIA	On-site SW corner	On-site NW corner	On-site SE corner	Off-site South of SW end	Off-site West of site entrance
Impact to Other Processes	100	100	100	100	100
Landfill Capacity - Design Complexity	100	100	100	66	66
Capacity - Reliability	100	100	66	66	66
Cover System - Design Complexity	100	100	100	66	66
Cover System - Reliability/ Flexibility	66	100	100	33	33
Landfill System - Reliability	100	66	66	66	33
Bulk services	100	66	66	33	0
Security	100	50	50	50	0
Collection systems	100	50	50	50	0
Access: Contractors	100	50	50	50	0
Geotechnical	100	0	100	100	100
Options for waste facilities	100	50	50	50	0
Operations	100	50	50	50	0
Closure liability	100	50	50	50	0
Access: Disposal	100	66	66	33	33
Topographic	50	50	50	50	50
Geology/ Pedology	100	100	100	0	0

APPENDIX B

Criteria Weighting with Justification

The weighting of criteria is presented per dimension, in the tables below.

Table 10: Environmental Dimension - Weighting

Goal/Theme	Criteria	Criteria Weight	Justification
Air Quality	Air quality	3	Potentially high impact
Community Wellbeing	Noise	3	Potentially high impact
Ecological Integrity (impact of the system)	Terrestrial Ecology	3	Potentially high impact
Water Quality	Groundwater	3	Potentially high impact
Visual Impact	Visual	3	Potentially high impact
Effect on Traditional Land Use	Soils	2	Moderate impact
Archaeological site, cultural or heritage asset	Heritage	3	Potentially high impact
Water management	Surface water	3	Potentially high impact
Adverse Impact to Natural Environment	Terrestrial ecology	3	Potentially high impact
	Wetlands	3	Potentially high impact
Engineering Parameter - Land	Sustainability	2	Moderate impact

Table 11: Social Dimension - Weighting

Goal/Theme	Criteria	Criteria Weight	Justification
Health & Safety	Public Safety	3	
Impact on Community	Use for the Public	2	Moderate impact
Corporate Image	Public Acceptance	2	Moderate impact
Community Economic Growth	Economic Advantages for the Local Community	3	Potentially high impact
Impact on the Landscape	Impact on the Landscape	3	Potentially high impact
landowner proximity	Proximity	3	Potentially high impact
Additional financial risks and opportunities	Social	2	Moderate impact
Land tenure	Land use	2	Moderate impact
Visual aspects	Aesthetics	3	Potentially high impact
Waste Management	Public acceptance	3	Potentially high impact
Additional Land Requirements	Potential Relocation/ Restriction to Accessing Pr	3	Potentially high impact
	Land ownership	2	Moderate impact

Table 12: Economic Dimension - Weighting

Goal/Theme	Criteria	Criteria Weight	Justification
Competitiveness	Capital Cost	3	Potentially high impact
	Operating Cost	3	Potentially high impact
	Closure Cost	3	Potentially high impact
	Distribution of Cost Over Time	2	Moderate impact
	Materials Recovery	3	Potentially high impact
Technology	Overall Project Level of Confidence	2	Moderate impact
Legal Aspect	Complexity of permitting process	3	Potentially high impact
	Proximity	3	Potentially high impact
	Rezoning of land use	3	Potentially high impact
Costs	CAPEX	3	Potentially high impact
	OPEX	3	Potentially high impact

Table 13: Technical Dimension - Weighting

Goal/Theme	Criteria	Criteria Weight	Justification
Technology	Feed characteristic dependency	1	Low impact
Stack & Dam Stability	Landfill Stability - Design Complexity	1	Low impact
Dewatering & Transport	Transportation - Cost & Complexity	3	Potentially high impact
	Impact to Other Processes	2	Moderate impact
Capacity	Landfill Capacity - Design Complexity	1	Low impact
	Capacity - Reliability	3	Potentially high impact
Cover System	Cover System - Design Complexity	1	Low impact
	Cover System - Reliability/Flexibility	1	Low impact
Reliability	Landfill System - Reliability	3	Potentially high impact
Costs	Bulk services	2	Moderate impact
Waste Management	Security	3	Potentially high impact
Engineering Parameter - Land	Collection systems	3	Potentially high impact
	Access: Contractors	3	Potentially high impact

Goal/Theme	Criteria	Criteria Weight	Justification
	Geotechnical	2	Moderate impact
	Options for waste facilities	3	Potentially high impact
	Operations	3	Potentially high impact
	Closure liability	3	Potentially high impact
	Access: Disposal	3	Potentially high impact
	Topographic	2	Moderate impact
	Geology/Pedology	3	Potentially high impact

APPENDIX C

Inventory of Mine Waste for 4 Mtpa

Waste Type	Source	Classification	Estimated Quantity	Waste Management Facility/Solution
Shaft Area				
Explosive contaminated waste, and explosives packaging	Blasting areas	Hazardous	17 tpa	Engineered detonating yard
Waste rock	Shaft excavations/mine development	Could vary from general to hazardous, but in terms of the required design standards it could be reasonably accepted that non-hazardous designs supported by Source Pathway Receptor Modelling would suffice for authorisation applications	1780 000 tons total from bulk mine shaft sinking phase. 360 000 tpa from Year 1 onwards	Re-use options will be explored in part, and unusable portions to be disposed on on-site waste rock dump
Concentrator				
Explosive bags	Concentrator stores	Hazardous	4.7 tpa	Take back agreement/on-site or off-site disposal
Dry reagent Bags from flotation unit	Concentrator stores	Hazardous	21 tpa	Take-back agreement/re-use
Lab waste	Laboratory	Hazardous	73 tpa	On-site/off-site H:H disposal
Tailings and residue from water treatment plant	Concentrator process	Hazardous	3.81 million tpa (dry)	On-site tailings disposal facility
Sewage Treatment Plant				
Domestic wastewater	Ablutions facilities and change houses	Bio-hazardous	164 ML/a at peak construction phase population to 50 ML/a in operation	On-site sewage treatment plant (STP), with potential re-use of sewage effluent
Sewage residue (sludge and screenings)	STP in shaft area	Bio-hazardous	21 tpa at peak construction phase population to 6.3 tpa in operation	Composting/ Incineration/ On-site/off-site disposal facility

Waste Type	Source	Classification	Estimated Quantity	Waste Management Facility/Solution
Incinerator ash	Incinerator (e.g. sewage screenings, and possible sewage sludge and medical waste)	Hazardous, depending on waste classification	4.4 tpa	On-site/off-site H:H disposal (N/A)
Medical Centre				
General medical waste (including sanitary waste)	Medical station in the shaft area	Hazardous	8.7 tpa	Destruction On-site/off-site H:H disposal
Mine-Wide				
Domestic waste	Mine wide bins and storage facilities	General	1 240 tpa	Separation (for recycling) On-site/off-site landfill
Packaging	New equipment & consumables brought on site	General	17 000 tpa	Recycling
Office waste	Offices in shaft and concentrator areas	General	1.04 tpa	Recycling and take-back agreement
Electronic waste	Offices	Hazardous	31 tpa	Recycling On-site/off-site H:H disposal
Wood and garden waste	transport and storage crates in stores	General	Approx. 1 300 tpa	Recycling Donate to community Composting
Rubber (Tyres and conveyor belts)	Vehicle and Equipment maintenance	General	51 tpa	Recycling On-site re-use applications
Scrap metal/steel (ferrous and non-ferrous)	Equipment and vehicle maintenance workshops	Ranging from general to hazardous	2 600 tpa	Recycling
Used oil and grease	Equipment and vehicle maintenance workshops	Hazardous	22 tpa	Recycling On-site or off-site H:H disposal
Oil contaminated PPE/Rags	Mine wide	Hazardous	33 tpa	On-site or off-site H:H disposal or Incineration

Waste Type	Source	Classification	Estimated Quantity	Waste Management Facility/Solution
Hydrocarbon contaminated soil	Mine wide, mostly at workshops	Hazardous	20 tpa	Spillage prevention plan Bioremediation, Thermal Desorption, On-site/off-site H:H disposal
Used paint	Stores	Hazardous	40 m^3/a	Reduction Donate to community Take-back agreement
Used Batteries (Lead acid from mining vehicles and small NiCd from offices)	Workshops and designated bins mine wide	Hazardous	2.3 tpa	Take back agreement Recycling On-site/off-site H:H disposal
Crushed fluorescent tubes (traces of Hg)	Mine wide lighting, stored at designated hazardous storage area at shaft	Hazardous	1.1 tpa	Avoidance/ reduction Recycling On-site/off-site H:H disposal

APPENDIX D

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