ANNEXURE N4:
GENERAL WASTE STUDY BY PASCO WASTE & ENVIRONMENTAL CONSULTING CC

Rössing Uranium Limited

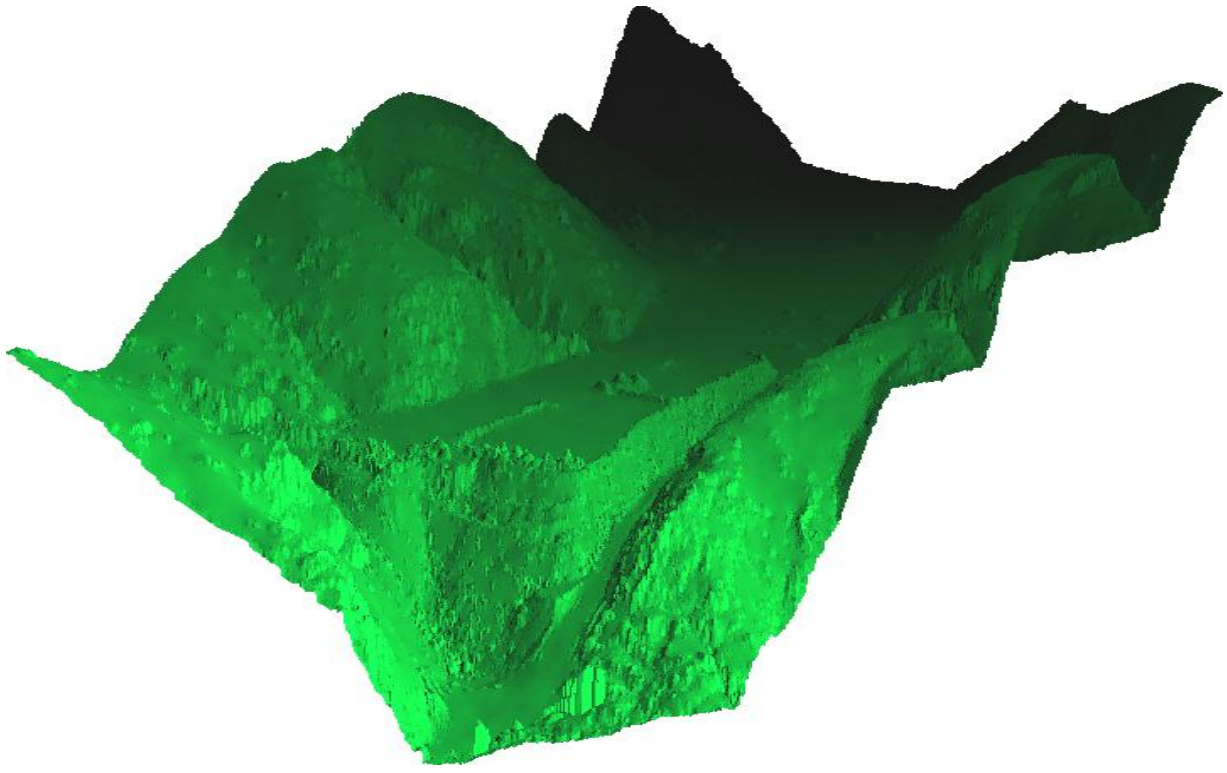
Rio Tinto
Rössing Uranium Limited
Private Bag 5005
Swakopmund
Namibia
Tel: +264 (64) 520 9111
Fax: +264 (64) 520 2556

Compiled by Pasco Waste & Environmental Consulting CC

For aurecon

GENERAL WASTE LANDFILL DISPOSAL FACILITY: Landfill Development & Operations and Maintenance Guidelines

November 2009



RIO TINTO RöSSING URANIUM

Operations and Maintenance Guidelines for the Rössing Uranium Mine's ($G:C:B^-$) landfill facility

OPERATIONS AND MAINTENANCE GUIDELINES

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List of Abbreviations

B^-	Water deficit climate, resulting in only sporadic leachate generation
B^+	Water surplus climate, resulting in significant leachate generation
BATNEEC	Best Available Technology Not Entailing Excessive Cost
BPEO	Best Practicable Environmental Option
C	Communal Landfill
CA	Competent Authority
CBO	Community Based Organisation
CQA	Construction Quality Assurance
CQC	Construction Quality Control
CR	Co-disposal Ratio
DEAT	Department of Environmental Affairs and Tourism
DOH	Department of Health
DWAF	Department of Water Affairs and Forestry
ECA	Environmental Conservation Act, 1989 (Act 73 of 1989)
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Regulations
FML	Flexible Membrane Liner
G	General Waste or Landfill for General Waste
GCL	Geomembrane Clay Liner
H	Hazardous Waste or Landfill for Hazardous Waste
H:h	Hazardous Waste Landfill that can receive wastes with hazard ratings of 3 and 4
H:H	Hazardous Waste Landfill that can receive wastes with hazard ratings of 1 and 2
HELP	Hydrological Evaluation of Landfill Performance
IAP	Interest and Affected Parties
IDSA	Integrated Disposal Site Authorisation
IEM	Integrated Environmental Management
IRD	Initial Rate of Deposition
L	Large Landfills
LDO	Land Development Objective
LEL	Lower Explosive Limit
M	Medium Landfill
MRD	Maximum Rate of Deposition
m/s	Metre per Second
NGO	Non Governmental Organisation
PI	Plasticity Index
RBDM	Risk-Based Decision Making
RoD	Record of Decision
S	Small Landfill
STP	Standard Temperature and Pressure
VOC	Volatile Organic Carbon

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Operations and Maintenance Guidelines for the Rössing Uranium Mine's (G:C:B$^-$) landfill facility

1 INTRODUCTION

This guideline sets out the general operation and maintenance procedures for the general[1] waste, communal (in size) and water deficit (in climatic conditions) **(G:C:B-)** landfill facility. General waste is a generic term for waste that, because of its composition and characteristics, does not pose a significant threat to public health or the environment if properly managed. Examples include domestic, commercial, certain industrial wastes and builders' rubble. General waste may have insignificant quantities of hazardous substances dispersed within it, for example, batteries, insecticides, weed-killers and medical waste discarded on domestic and commercial premises.

General waste may be disposed of on any authorised landfill.

For equipment that is supplied for use at the landfill the manufacturer's instructions should be consulted. These instructions should be included in this document once received. Unless otherwise stated, particular equipment specifications should take precedence over this document.

The layout of this document starts by listing the general landfilling principles that should be adopted especially as waste was only dumped in a predefined area and covered with dumprock and fine material. Very few specific procedures dealing with sanitary landfilling existed. Site conditions, site facilities and the site preparatory works are described next. Landfill cell construction and landfill operations are followed by site maintenance procedures. The guideline ends with sections on records and monitoring, final restoration and health and safety matters. **The document is therefore considered a "live" document that requires constant updates and modification as and when necessary.**

A Social and Environmental Management Plan (SEMP) which identifies the possible environmental impacts of the Landfill Facility, and the requisite measures to address these impacts, is included in Appendix F. This SEMP compliments the O & M manual and therefore forms part of the requirements for the operation and maintenance of the site.

[1] In some cases General waste is also referred to as Household waste.

2 GENERAL OPERATIONAL PROCEDURE

2.1 Introduction

The Rössing Uranium Mine (Mine) developed a landfill for the daily disposal of general household waste emanating from the mine.

All landfills in South Africa are governed by the Minimum Requirements[2] regulations and as such operators have to abide by the prescribed operational procedures when in operation. Due to Namibia not having completed the compilation of their regulations for landfill development as yet, the RSA Minimum Requirements are thus followed as a guideline for the operations of the waste disposal facilities. These regulations are considered in line with those developed by the World Bank for developing countries and are also in line with the regulations developed by the Botswana Government They are thus considered appropriate for the region.

2.2 Composition of Waste

The waste to be disposed of at the landfill will generally consist of the wood, plastic, paper, metal, textile, sand/stone and dust and which is generally considered general household waste. Figure 1 shows a typical breakdown of the waste stream encountered at the mine.

2.3 Landfilling Procedures

The following operational procedures should thus be adopted for the general household waste ($G:C:B^-$) landfill facility:

- All refuse should be deposited in layers
- No cell or fill lift is to exceed 600 mm in depth prior to being covered and should be built up in layers of 250 – 300mm and compacted
- All waste is to be covered at the end of the working day and no waste should be left uncovered for a period greater than 24 hours
- Waste is to be covered with a layer of crushed rock or used waste rock of minimum thickness 100mm preferably 150 mm
- Suitable screens or alternative measures should be provided to collect windblown refuse, paper and plastic

[2] Minimum Requirements for Waste Disposal by Landfill, second edition, 1998, Department water Affairs and Forestry, RSA.

- No waste is to be tipped into water

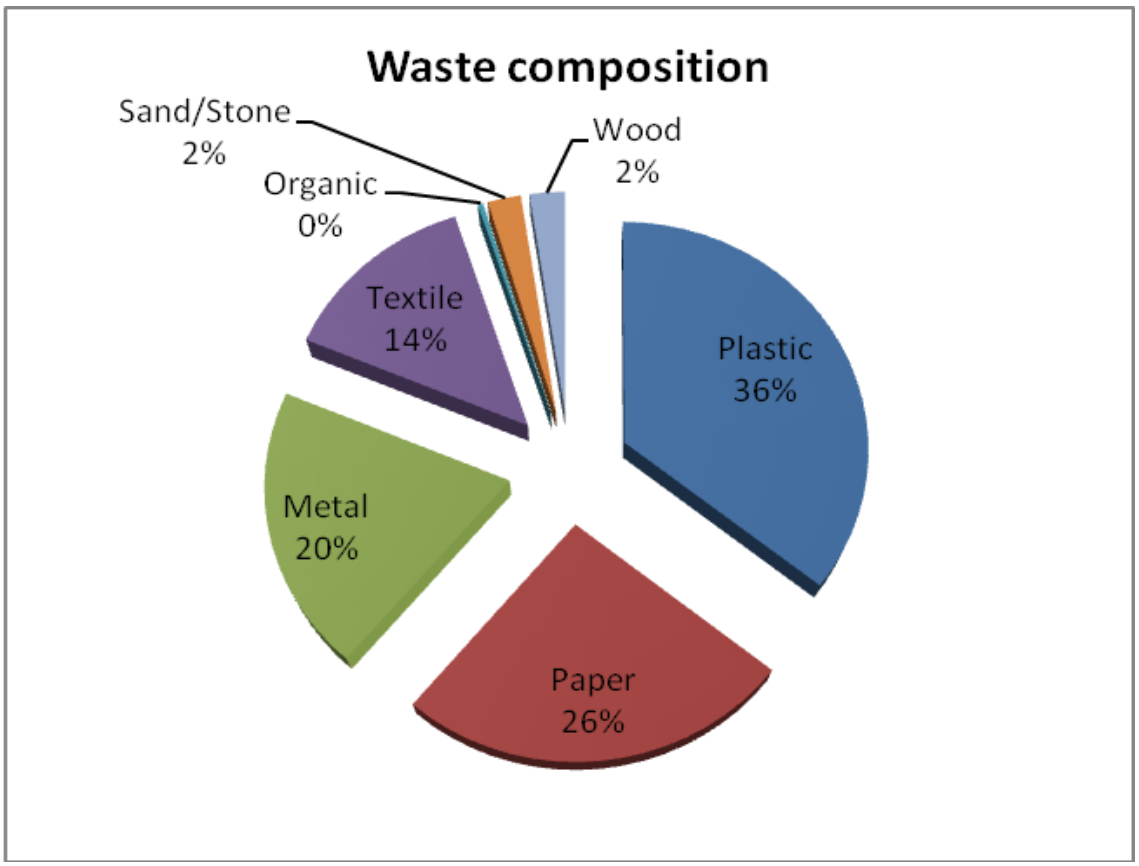


Figure 1: Typical composition breakdown of the waste stream at the Rössing Mine

* Source: Beco Institute for Sustainable Business

- Every precaution should be taken to prevent outbreak of fire. All fires are to be extinguished - burning waste should be exposed, spread and smothered and covered with cover material, soil or other non-combustible material. This should preferably not be done during high winds and water should not be used. The fire fighting services are always to be called immediately when a fire is detected as it could still be burning due to the presence of landfill-gas. Smoking on site should be forbidden.

- The site should be regularly inspected for vermin and appropriate measures taken to prevent infestation; all hollow containers should be flattened.

- All households hazardous material e.g. neon light bulbs, batteries and paints or detergents, should be placed in appropriate containers thus allowed for further processing by the Mine.

- Every deposit of waste must be kept tidy.

- All areas of the site outside the landfill should be kept free of litter. As a minimum, the site should be inspected every week to ensure that this is carried out.

- The access road to the site should also be kept free of litter and mud. Similar inspections to the above should be carried out.

- All drainage pipes and ditches should be kept in working order.

- All site roads should be maintained and potholes filled (Heavy wear and tear on collection vehicle tyres with a high incidence of punctures is a feature of landfill operations).

- The site fencing should be inspected and repaired on a regular basis by permanent on-site guarding.

- Monitoring for leachate and landfill gas should be undertaken and the results recorded in the site records.

- Members of the public should not be allowed on the site except for private contractors.

- A safety code of practice should be prepared and one member of each working shift should be trained in first aid. Safety apparatus such as ear, breathing and head as well as face and eye protection should be present on site. Safety clothing and shoes or boots are required. Showers and reasonable lodging should be provided for the landfill staff.

- Where provided, any breaches of the prepared liner in the landfill should be reported to the Site Supervisor immediately. In terms of the regulations this class of landfill should have a liner consisting of a layer of the natural material which is scarified and compacted i.e. a prepared surface.[3] Future expansions shall thus be provided with a prepared surface liner.

- No medical waste such as potentially hazardous waste containing sharp materials (needles, blades, contaminated glass etc) shall be disposed at the landfill.

- Although not anticipated animal carcasses should be buried on site and covered with lime should it be encountered.

[3] At present no prepared surface exists or existed under the landfill. This should be rectified in the future expansion.

3 SITE CONDITIONS

3.1 Location

The Mine's general household waste landfill site is located in a cross valley between Boulder Gorge and Dome Gorge within the mining rights area north of the open pit. The site is located in an area of high sensitivity in terms of the biodiversity, just off the water shed in the cross valley which eventually leads to Dome Gorge. The site is further located in an area with a low Heritage Significance Zoning.

3.2 Climatic conditions

The site level is approximately 538 m above sea level. Shade temperatures can range between 5.3ºC in the winter and 38.3ºC in the summer. Monthly temperature and rainfall statistics are given in Tables 1 and 2.

Table 1: Monthly climatic statistics for Rössing Uranium Mine

Month	AVERAGE RAINFALL mm	MAX DAILY TEMP °C	MIN DAILY TEMP °C	MEAN TEMP °C	EVAPORATION mm
January		34.6	14.3	21.9	
February		38.3	14.7	22.6	
March		35.5	11.4	25.4	
April		36.6	12.0	25.5	
May		33.6	10.5	20.4	
June		33.0	10.1	21.6	
July		32.0	5.3	18.3	
August		33.7	7.3	18.7	
September		36.8	8.0	20.5	
October		38.3	8.6	21.8	
November		38.3	11.2	21.8	
December		33.5	12.0	20.1	
Total	30mm/a	Figures used by mine		Total	2700mm/a

Table 2: Annual climatic statistics for Rössing Uranium Mine

Years	*Mean Annual Precipitation (mm)*	*Mean Annual Evaporation (mm)*	*No. of Rain Days*
1984	15.9	4401	6
1985	48.2	4401	8
1986	22.7	4401	6
1987	20.7	4401	5
1988	17.1	3964	8
1989	28.5	4818	9
1990	28.1	3150	12
1991	32.8	5572	15
1992	4.8	4502	1

1993	44.2	4401	18
1994	32.1	4401	14
1995	45.6	4401	17
1996	12.5	4401	6
Average	27.20	4401	10

(Source: Rössing Environmental Services)
(In line with Walvis Bay 1997 month-on-month figures with annual average of 4209mm)

On an annual basis the evaporation significantly exceeds the rainfall. It is thus not likely that leachate will be generated in significant quantities, during any month of the year. Flash floods do however occur where a great deal of the annual precipitation occurs over a short period during a single event. Where drainage systems are in place very little water will penetrate the waste as it would either run off the waste body surface which is covered and sloped or around the waste body or landfill in drainage channels. Where the waste itself is left exposed, the rainwater will naturally infiltrate the waste body of the landfill. Due to the high evaporation rate and periodic covering of the waste in layers at depth in the landfill the landfill is considered to have an inherent capacity to absorb more rainwater than presented through the annual precipitation.

A typical wind direction figure for the Mine is shown in Figure 4. The prevailing wind direction at Rössing for the last 2 year period is from the west (14% of the time), the west-southwest (13%) and the east-northeast (13%). This wind direction also dominates daytime and nighttime wind patterns. These wind components are characterized by low to moderate strong wind speeds. Wind speeds exceeding 5 m/s occurred for 5.4% of the time with the maximum recorded at 8.5 m/s. During the day the westerly and west-southwesterly winds were more dominant with a distinct decrease during nighttime from this direction. This information is of specific importance when controlling windblown litter.

Climatic conditions are of significance when dealing with the waste especially when it comes to the management of surface water and litter and dust. With virtually no rainfall, water management as part of the operations would therefore not be an issue. However, the lack thereof would require additional measures to be able to carry out dust suppression and addition water will have to be carted to site for this purpose.

On the other hand cognizance has to be taken of the wind direction and strengths to enable the curbing of windblown litter, possibly by means of litter screens, and the control of odours emanating from site.

3.3 Soil characteristics

The site is covered by Alluvial material and underlain by metamorphic rock. Further geological information can be obtained from the Geohydrological Report. The location of the borehole is shown below along with the coordinates of the site.

Table 3: Site Coordinate List

Corner peg	Latitude (Southing)	Longitude (Easting)
A	22º 28,110’	15º 3,246’
B	22º 28,136’	15º 3,269’
C	22º 28,036’	15º 3,335’
D	22º 28,072’	15º 3,371’

Station	Latitude	Longitude
Site Centre	22º 28,100’	15º 3,300’
LF2 (Borehole)	22º 28,026’	15º 3,370’

Figure 2: Locality Plan

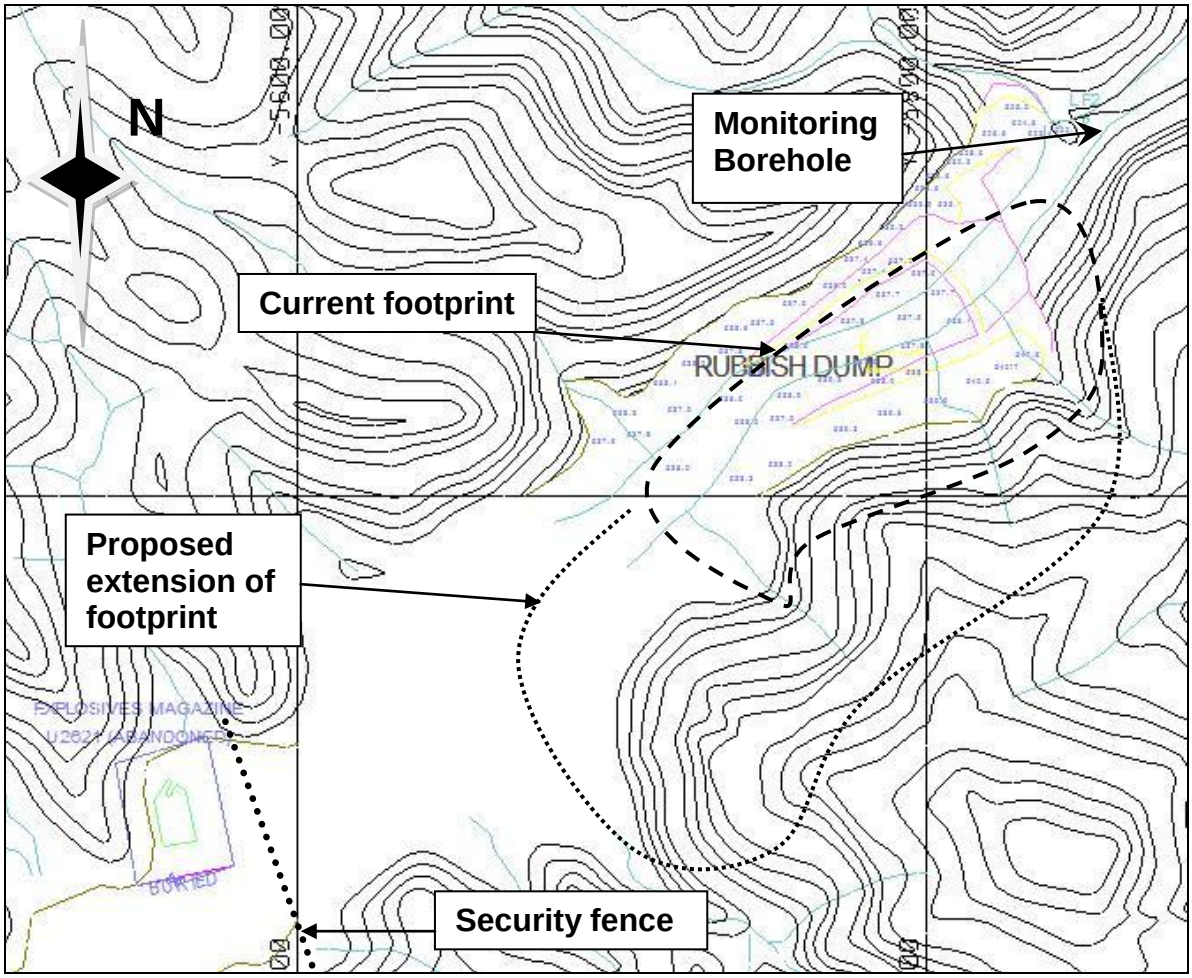
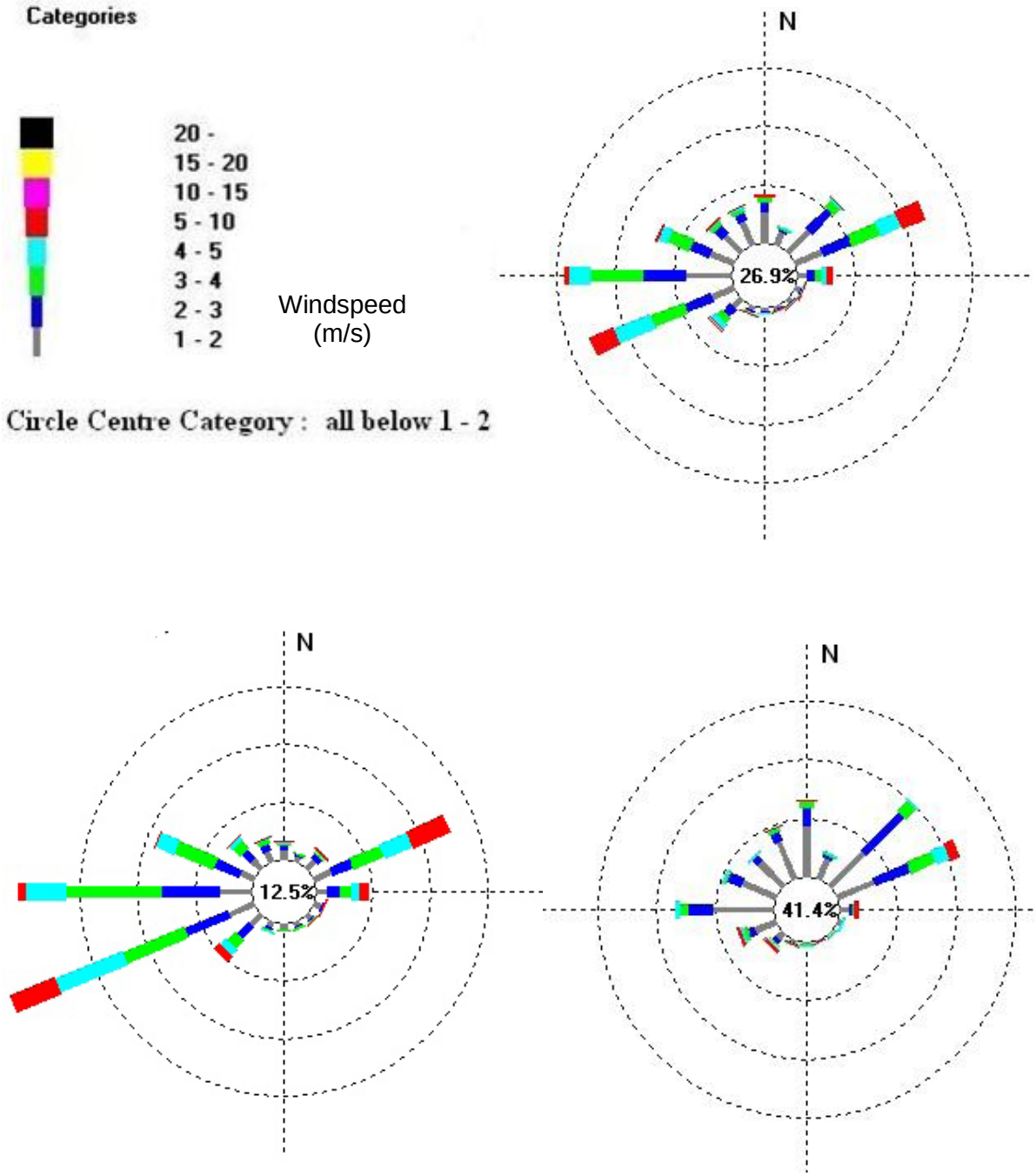


Figure 3: Basic survey layout of the disposal site.

Topographical Survey of Site: (Detailed plan to be provided when construction starts)



Day-time **Night-time**

* Source: Airshed Planning Professionals (Pty) Ltd - Air quality impact assessment for the proposed expansion project for Rössing Uranium mine in Namibia: Phase 1, December 2007

Figure 4: Typical Wind Rose for Rössing Mine.

The proposed detailed site layout drawing (Fig 5) is to be replaced with the final engineering drawings before implementation.

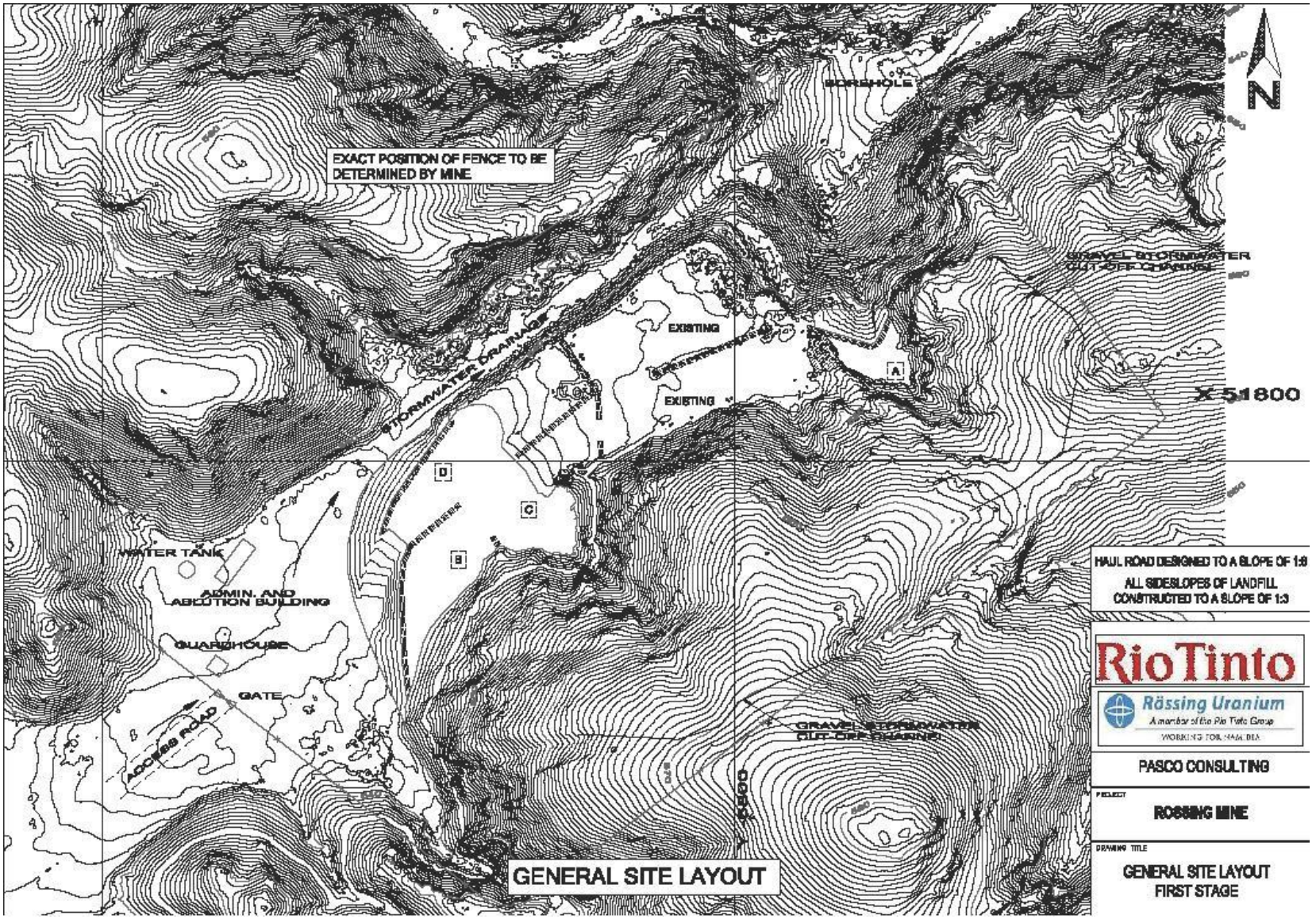


Figure 5: Detailed site layout

4 OVERALL PLAN AND PHASING

4.1 Planning Options

The current landfill is located in a valley linking Dome Gorge and Boulder Gorge. The location of the site is midway between the water shed of the valley and the Dome Gorge floodplain. Ideally the landfill should have been located close to the water shed or as close as possible to it. This option would have allowed virtually the entire valley and tributaries as potential airspace provided filling was done taking cognisance of the drainage pathways and done through a methodical process.

The entire valley offers close to 1 000 000 m^3 of available landfill airspace[4] provided it is utilised in a specific order of filling (see Fig 6). However, with the proposed expansion programme of the mine this would most likely not be required. However, a localised area at the top end of this large valley forming part of the large landfill could offer another option for the short term with available airspace of approximately 200 000 m^3. Filling of the adjacent valleys would offer between 150 000 and 200 000m^3. This can only be executed provided management of the entire valley is considered.

However, as a first option (Option 1) for expansion of the current landfill, consideration should be given to increasing the footprint of the existing landfill from approximately 120m x 60m to 200 x 100m up the slope of the hills measured horizontally (see Fig 3).

A Mega landfill option would also be considered by expanding the landfill across the entire valley starting at the water shed (see Fig 7). Other options could be considered up the various sub-valleys provided sufficient access could be established to the top of the areas under consideration. The underlying principle would be to ensure integrity of the potential water course until it is filled and the surface water flow is dealt with in a different way.

A second short term option (Option 2) would be to fill the entrance to the suggested Mega landfill to create a smaller landfill (see Fig 7).

4.2 Drainage pathways

One of the main principles of locating a new landfill is to consider the surface water flow pathways. It is clear that due to normal rainfall there is no likelihood of any surface flow occurring down the landfill valley. However, extreme floods do occur and as such pathways are to be ensured.

[4] Landfill airspace is defined by the volume created between the bottom and top barrier systems (landfill liner surface and landfill cap surface). The top or final surface of the landfill is defined by the finally accepted landform.

It appears that some form of subsurface drainage pathway could have been formed in the valley beneath the current landfill allowing for infiltration flow beneath the landfill and as such operating as a large subsurface drainage system.

For ease of reference the valley past the landfill along the northern side is called the gully and the open area upstream (south west) of the gully is called the upstream valley (grey on the attached figure). The blue circle and straight lines (see Fig 6) depict the proposed drainage pathway to be prepared with either concrete or other low permeability material.

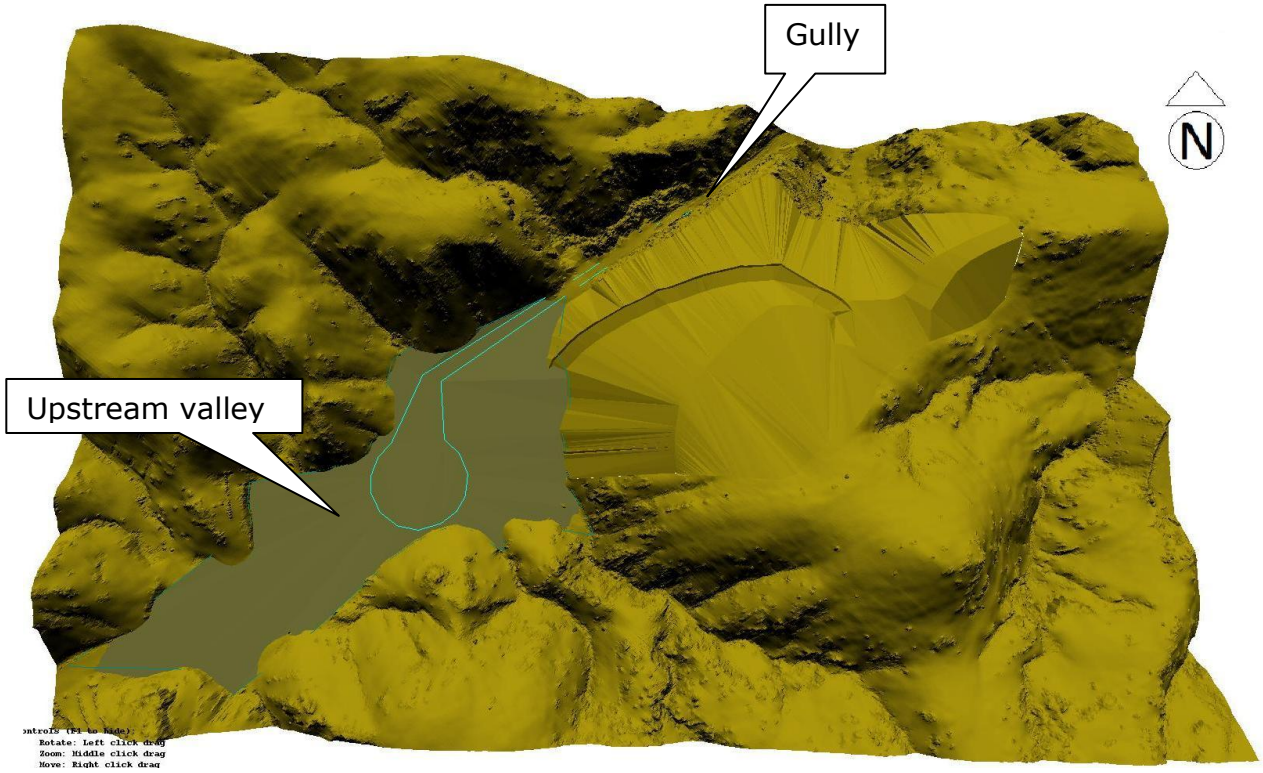


Figure 6: Drainage Valley to the North of the Site

As a result of the gully being partially filled by landfill spillage, the natural drainage path of the larger valley has been obscured. Even though it appears open, the survey shows that there are undulating sections thus offering no general drainage slope. The upstream valley area has a low area (more or less in the middle) of more than 2,5m lower than the entrance to the gully (i.e. leaving an incline from the valley to the gully). In general therefore the upstream valley area has to be filled and sloped and the gully has to be cut and sloped to ensure a general slope of at least 1% down the entire grand valley area to allow for stormwater flow. With the coarse and sandy material a 2% slope would be required to ensure proper stormwater flow.

Figure 6 shows the proposed future landfill landform along with the extent of fill in the valley area to ensure that there is a general 1% slope (already

nominal) for stormwater to drain past the landfill down the gully. At the same time the gully also has to be cut to ensure the undulations are flattened and also sloped. This would require at least 1m cut in some places

The cut and fill required to ensure an overall sloped drainage path at nominal slope is estimated at 26000m³ of fill and 1000m³ of cut. Generally a cut to fill balance would have been ideal. However in this case there is no space in the gully to excavate safely by cutting the gully deeper and still ensuring 1:3 slopes on the landfill outer face, unless a portion of the mountain is blasted away on the opposite side (from the landfill) of the gully which could offer more stable slopes. This will however have to be investigated in more detail.

As no clayey material is available on the mine that could be used to cover the fill to ensure an impervious layer for water to flow from the filled valley area through the gully northwards, an option is to cast a wide concrete surfaced channel in this section . This could however be a problem where bulldozers are used which could damage the concrete. Investigating the blasting of the opposite mountain face in the gully area and then to lower the gully floor may be a cheaper solution than the extensive fill and sealing of the water flow pathway.

The access pathway to the north of the landfill down to the borehole is considered an open flow-path and will allow clear access to the valley below the landfill where the monitoring borehole is located. It is therefore recommended that this area be kept open and not used as an expansion option for the current landfill.

4.3 Long term development option

A long term landfill development option is to fill the entire valley as shown in fig 7 to form a mega landfill. Should the entire valley including the sub valleys be used, as a "mega landfill", subsurface drainage systems will then have to be formed in these sub valleys. This is done by developing "ribs" using stone fill in the gullies, covered with a layer of soil to form the base drainage system of the individual landfill cells within the mega landfill.

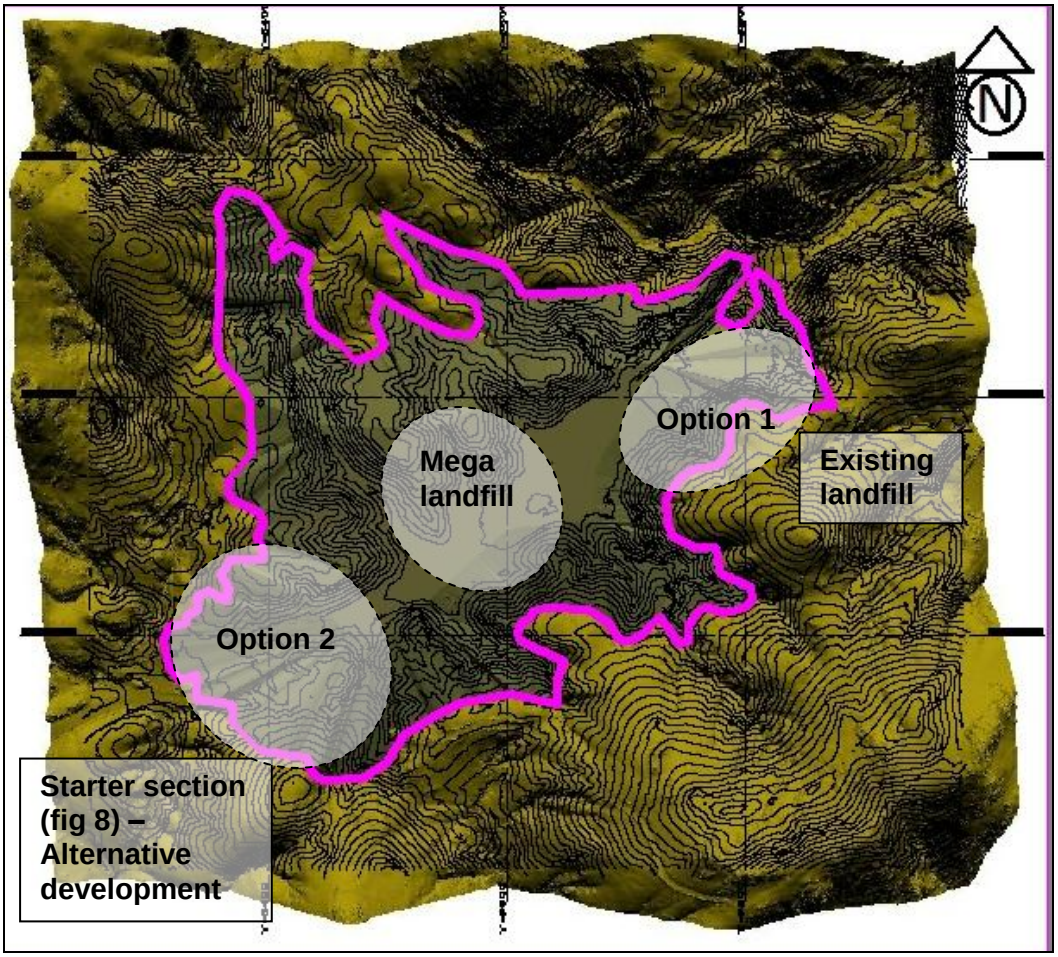


Figure 7: Layout of "Mega landfill" covering the entire valley.

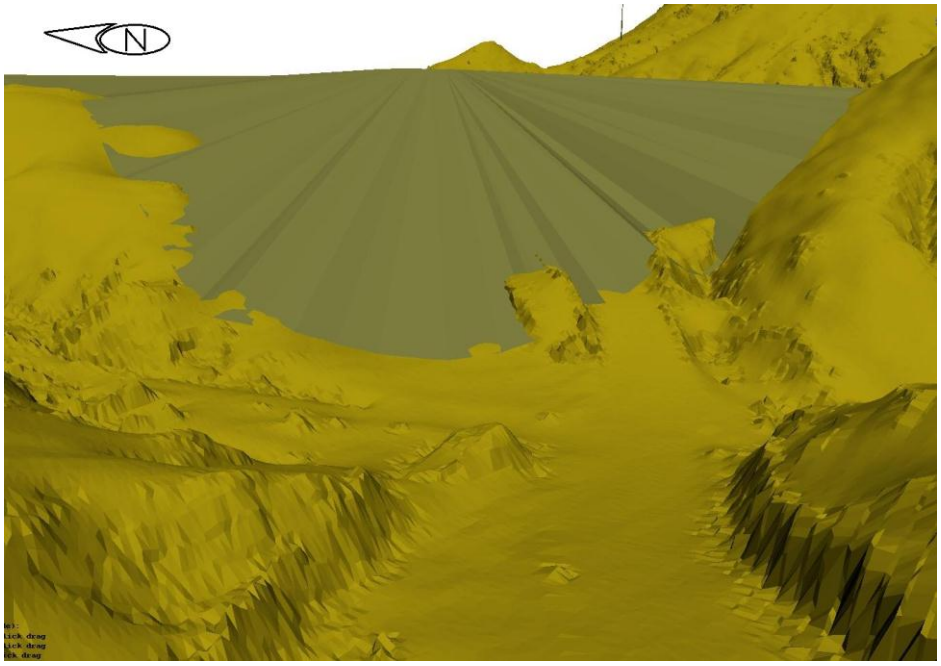


Figure 8: Typical south western elevation of Option 2.
(At water shed of the Mega landfill looking north eastwards down the valley.)

Fig 8 shows the start of the "Mega" landfill or the smaller Option 2 development at the watershed just past the local water course crossing. This starter section may also offer landfill airspace in the short term as opposed to expansion of the existing landfill. The option 2 could provide approximately 200 000m^3 of additional landfill airspace.

4.4 Landfill Area

The present landfill covers approximately 50% of the proposed site. The remainder of the 50% is utilised to separate some materials for recycling purposes. The proposed landfill expansion (Option 1) will cover approximately 75% of the total proposed new landfill site area allowing for the facilities and other activities to be developed in the remaining 25%. These facilities would include surface drainage structures and amenities such as an ablution block, guardhouse and other shelters. The available site area is approximately 3 to 4ha.

As haulage of excavated materials is ongoing at the mine (part of the routine activities) no cover material is required to be stockpiled at the landfill site. However it is understood that little fine grained material is available and has to be specifically provided for. Material is thus brought to site on an as and when required basis for cover purposes.

4.5 Void Space Available

The present and final contours of the site are shown in figure 11 and Appendix J. The site will be filled generally to approximately 20m above the valley floor and current landfill surface level. The total volume of the void space available is estimated at 100 000 m^3, which (according to Table 4 and discussion in Appendix A) is forecast to be sufficient at a disposal rate of 12 to 15 m^3/d or approximately 365m^3/m to meet the needs of the Mine until the year 2027. Contrary to typical landfill practices the site will not be excavated to gain cover material. The proposed landfill will be extended on top of and adjacent to the existing landfill and will thus be an extension of the existing landfill. Cover material will be obtained from the mining operations.

4.6 Waste Cover Material

Due to the use of coarse material (particles way in excess of 75mm) as cover material, it leads to over covering of waste and thus over utilization of the airspace.

A sampling exercise in June, July and August 2009 of material (rock and tailings) utilised to cover waste showed that approximately 400m^3 of cover material was used to cover 987 ton of waste over this period (see

Appendix A). This equates to 133m^3 of cover material for 329 ton of waste per month. Should the waste in the landfill be compacted to a density of 1 t/m^3 (which is possible considering the size of equipment and material used) then a cover to waste ratio of approximately 1:3,5 is currently applied which is in excess of what is required and will lead to a wastage of available airspace . Earlier reports show that the waste is compacted to 369m^3 (factor 2+ down from between 738 and 880m^3 of loose waste) which is thus considered realistic. The tables as shown in this document are therefore based on the monthly disposal volume of 369m^3 when calculating the airspace requirements. The assumed cover to waste ratio of 1:4 is also considered realistic.

Although large boulders are visible on the side slopes and to some extent in the bunds it is not clear how much of these boulders end up in the cover material especially with the final surface appearing smooth consisting of finer material. However there appears to be sound practice applied with the covering of waste with some improvement and saving in airspace to be made by limiting the large size material. Typically a landfill would be operated with a cover to waste ratio of between 1:4 and 1:6.

4.7 Phasing

The proposed landfill expansion can be development in a number of stages as shown on the Landfill Development Sequencing plans - Stages 1 through 8. Each stage will need to be re-assessed in terms of surface and subsurface drainage, haul road design and all other aspects pertaining to accepted landfill design prior to the commencement of the landfilling operations.

The concept is to fill the site in phases so that areas can be completed and returned to a vegetated state or other rehabilitated state as soon as possible after filling has been completed. Stage 1 is described in Section 6. The airspaces in the first four stages will be arranged to correspond to the volume required for at least a 5 year filling cycle per phase. The volumes are shown in Table 4.

Table 4: Volumes or Airspace Requirements

Phase	Years	Airspace *req'd* @ 1.0 t/m^3 [m^3]	Cumulative Total Airspace [m^3]
1	2009 – 2014	33 000	22 000
2	2015 – 2020	33 500	66 500
3	2021 – 2025	33 500	100 000

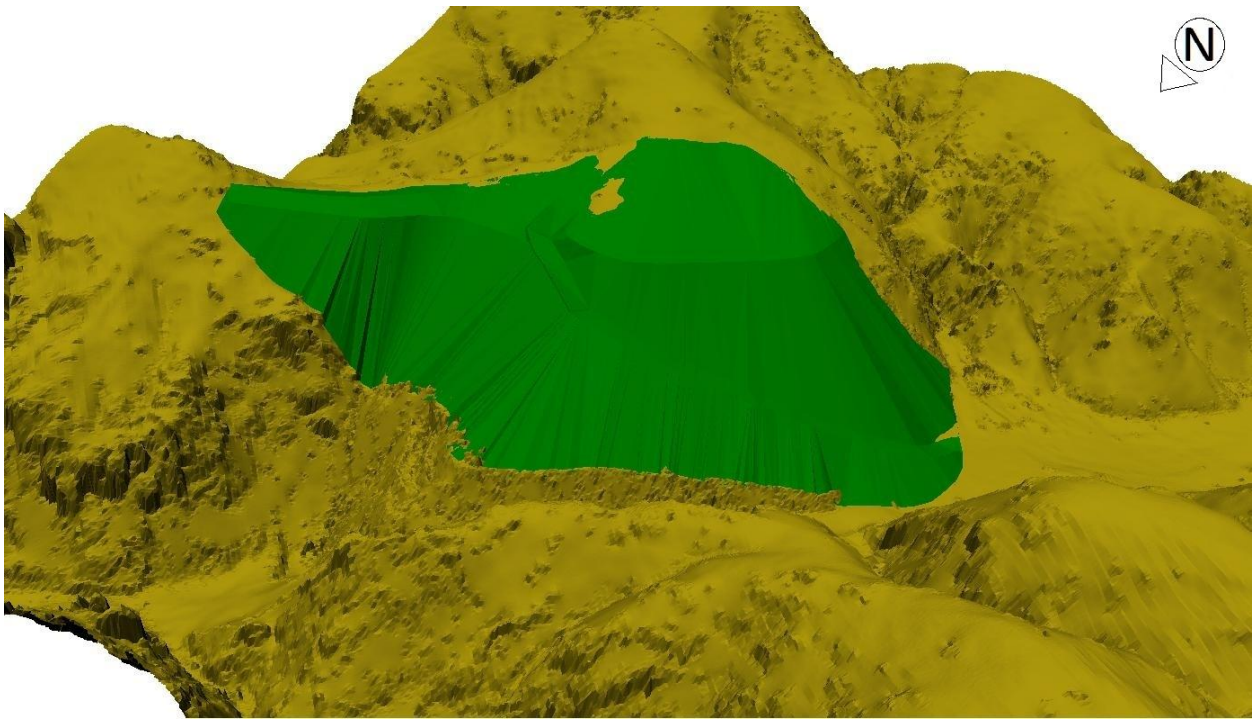


Figure 9: Final landform (north western view)

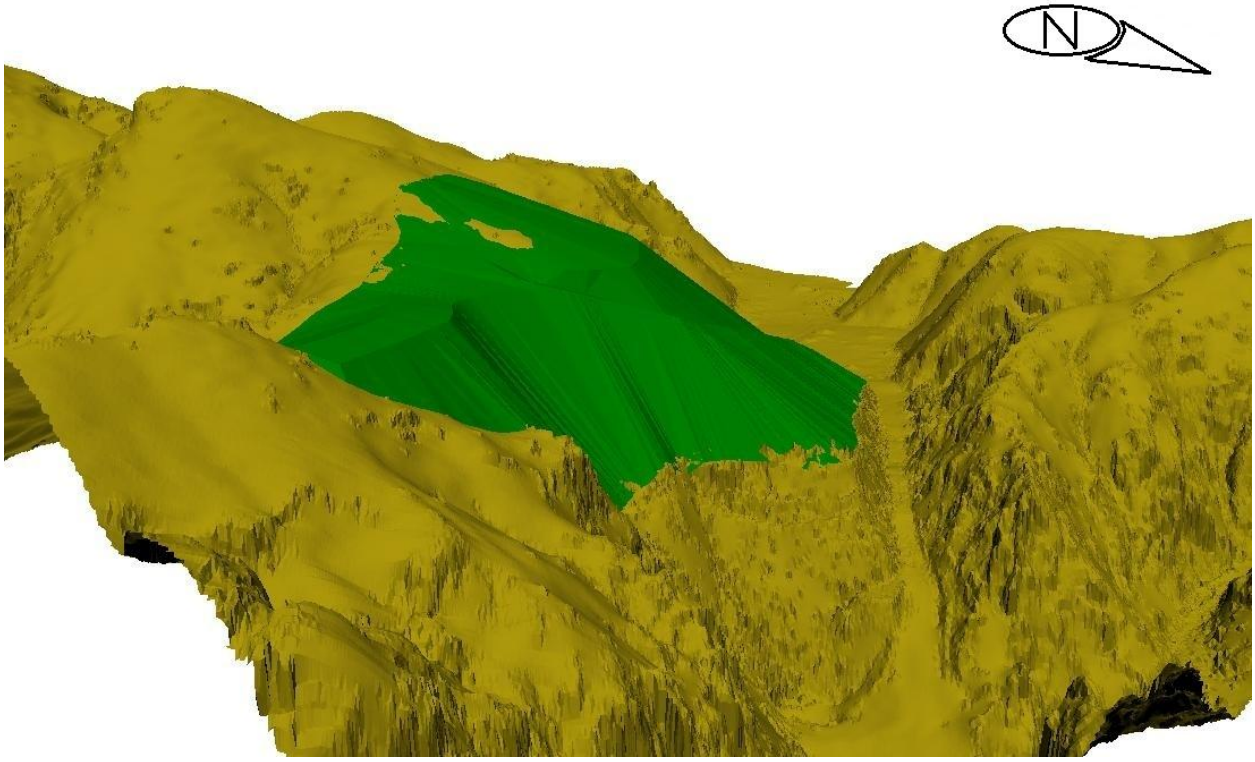


Figure 10: Final landform (northern eastern view)

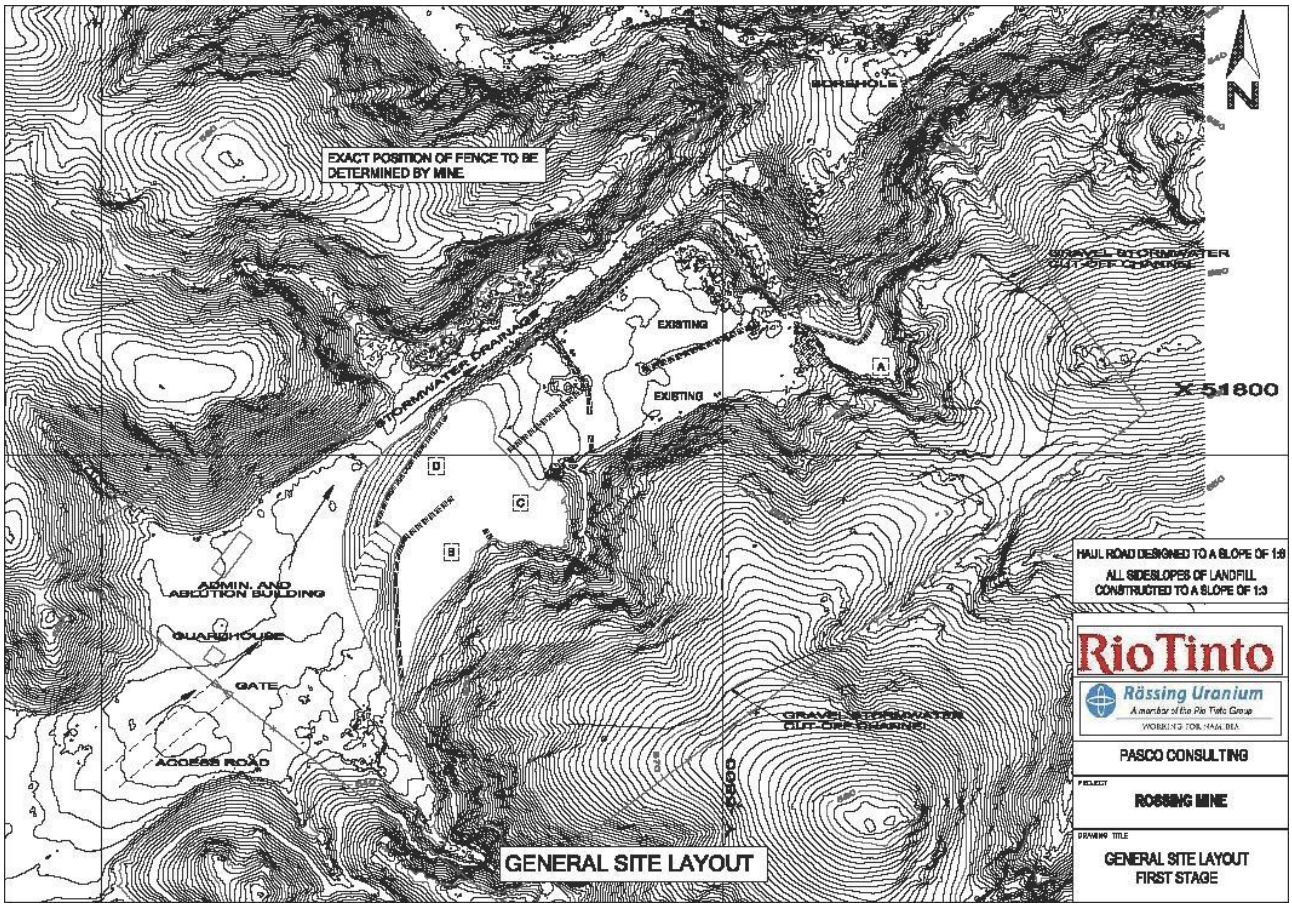


Figure 11: First Stage Cell Development

4.8 Annual intake of Waste

The annual intake of waste has been estimated as shown in Table 5. This estimated quantity would need refining once the site is operational and the actual intake details of the waste are recorded.

Table 5: Annual Quantities of Waste

Year	Number	Annual waste disposed (compacted to 2x volume reduction) (m³)	Annual volume consumed including cover (m³)	Remaining Airspace (m³)
			Start volume	100000
2009	1	4428	5535	94465
2010	2	4428	5535	88930
2011	3	4428	5535	83395
2012	4	4428	5535	77860
2013	5	4428	5535	72325
2014	6	4428	5535	66790
2015	7	4428	5535	61255
2016	8	4428	5535	55720
2017	9	4428	5535	50185

2018	10	4428	5535	44650
2019	11	4428	5535	39115
2020	12	4428	5535	33580
2021	13	4428	5535	28045
2022	14	4428	5535	22510
2023	15	4428	5535	16975
2024	16	4428	5535	11440
2025	17	4428	5535	5905
2026	**18**	**4428**	**5535**	**370**
2027	19	4428	5535	depleted
2028	20	4428	5535	
2029		4428	5535	

* Based on 369m^3 per month as per BECO report and a cover to waste ratio of 1:4

The proposed design for the landfill (Option 1) would offer a site with airspace capacity of approximately 100 000m^3 to last the next 18 years provided a maximum cover to waste ratio of 1:4 is used. The latter represents waste 600mm deep covered with a 150mm layer of soil.

4.9 Cell Arrangements

The initial cell arrangements are shown on the overall site layout, Figure 4. The sequence of filling the cells is shown on Figure 3. Details of cell construction after the initial cells have been filled are given in Section 7. Cells will be filled sequentially. It is envisaged in the design that a layered filling pattern will be adopted, see Section 8.

4.10 Number of Site Personnel

The proposed minimum number of site personnel to run the site is five as detailed in Table 6. Due to the size of operations the site does not have to be manned 24 hours per day.

Table 6: Site Personnel

Position	**Nr.**
Site supervisor	1
TLB/FEL operator	1
Water tanker operator	1
Labourers / Litter pickers	2
TOTAL	5
Medium term	
Bull dozer	1

4.11 Equipment Provided

The equipment provided to operate the site is listed below. (Operating manuals and Specifications will be appended to this document once the

equipment has been purchased if not already available). Some of the equipment and facilities don't necessary have to be available on site but be close-by as typical on the mine.

- **Personnel Equipment Required**
  - Ear muffs
  - Dust masks
  - Head protection
  - Eye Protection
  - Safety boots/Wellington boots
  - Overalls
  - Shower equipment
  - Reasonable shelters (as described in 5.2 below)
  - Safety gloves.

- **Mobile Equipment**
  - Tractor-loader-backhoe (TLB)
  - Water cart and spray bar (bowser)
  - Tipper truck
  - Utility vehicle for landfill management

  As waste collection improves and should the waste volume increase a bulldozer suited for waste management will have to be procured to assist in the landfill operations.

- **Fixed and Other Equipment:**
  - Mobile litter screens
  - Diesel Fuel Storage Tank

4.12 Site Operating Hours

The site will be open from Monday to Saturday during the following hours:

7 a.m. to 4 p.m.

The site will remain operational for a further hour**, to 5 p.m. to allow tidying up and the final part of the daily covering of the waste.**

The first waste load will arrive at about 9 a.m. and the last load at about 4 p.m. Before and after these loads, site preparation and closing operations must be done.

5 SITE FACILITIES

5.1 General

The following facilities are to be constructed on the site and are shown in Figure 13:

- Guard house
- Water supply tank
- Fencing and security boom

5.2 Guard house, Mobile Shelter

The guardhouse kiosk also acts as the reception point. A mobile shelter near the work face is to be provided by the contractor for use by personnel that will require it. The shelter will act as a rudimentary sun/rain cover and will be in addition to the permanent gatehouse shelter.

5.3 Office and toilet

A shower, toilet and hand wash basin is included in the guardhouse toilet building.

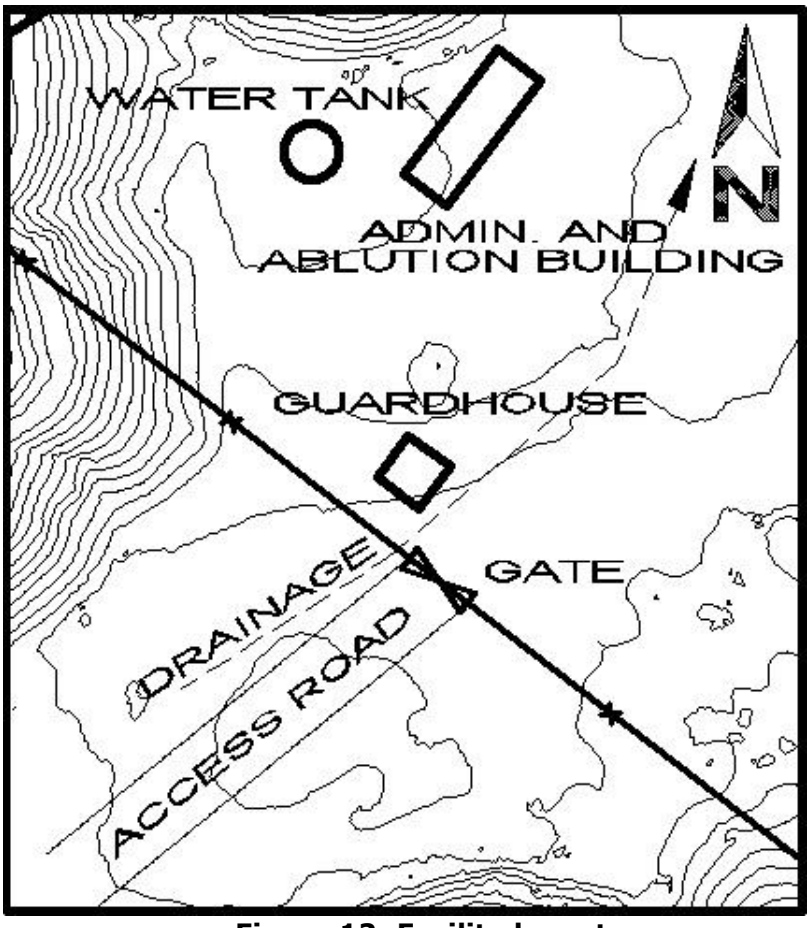


Figure 12: Facility layout

5.4 Covered Bay for Landfill Equipment & Diesel Storage Tank

As the landfill facility is located in a remote area with very little anticipated activity on and around the site it is considered much safer to house any mobile equipment or fuel at the main offices until such time full time security can be justified.

5.5 Lighting

No site lighting has been provided for the facilities areas as it considered not warranted.

5.6 Site Information Boards

A notice board is to be positioned inside the entrance gates. Traffic and other relevant signs to assist with site movements are to be placed around the site in accordance with good engineering practice.

5.7 Haul Roads

The one haul road provided on the site is indicated on Figure 13. Waste vehicles will generally enter the site and travel to the disposal area along this haul road. They will return via the same route.

Cover material will be carted from the mine stockpiles to the cell via access road.

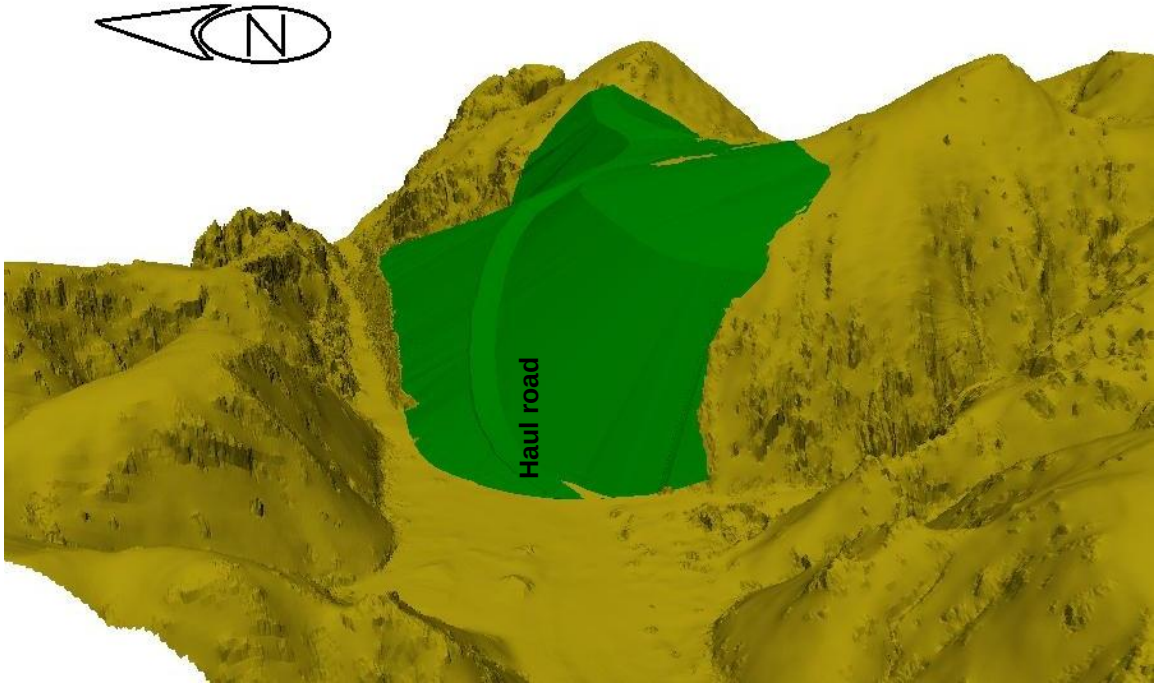


Figure 13: Haul road onto the landfill

5.8 Access Roads

The access road to the site is as shown on Fig. 14

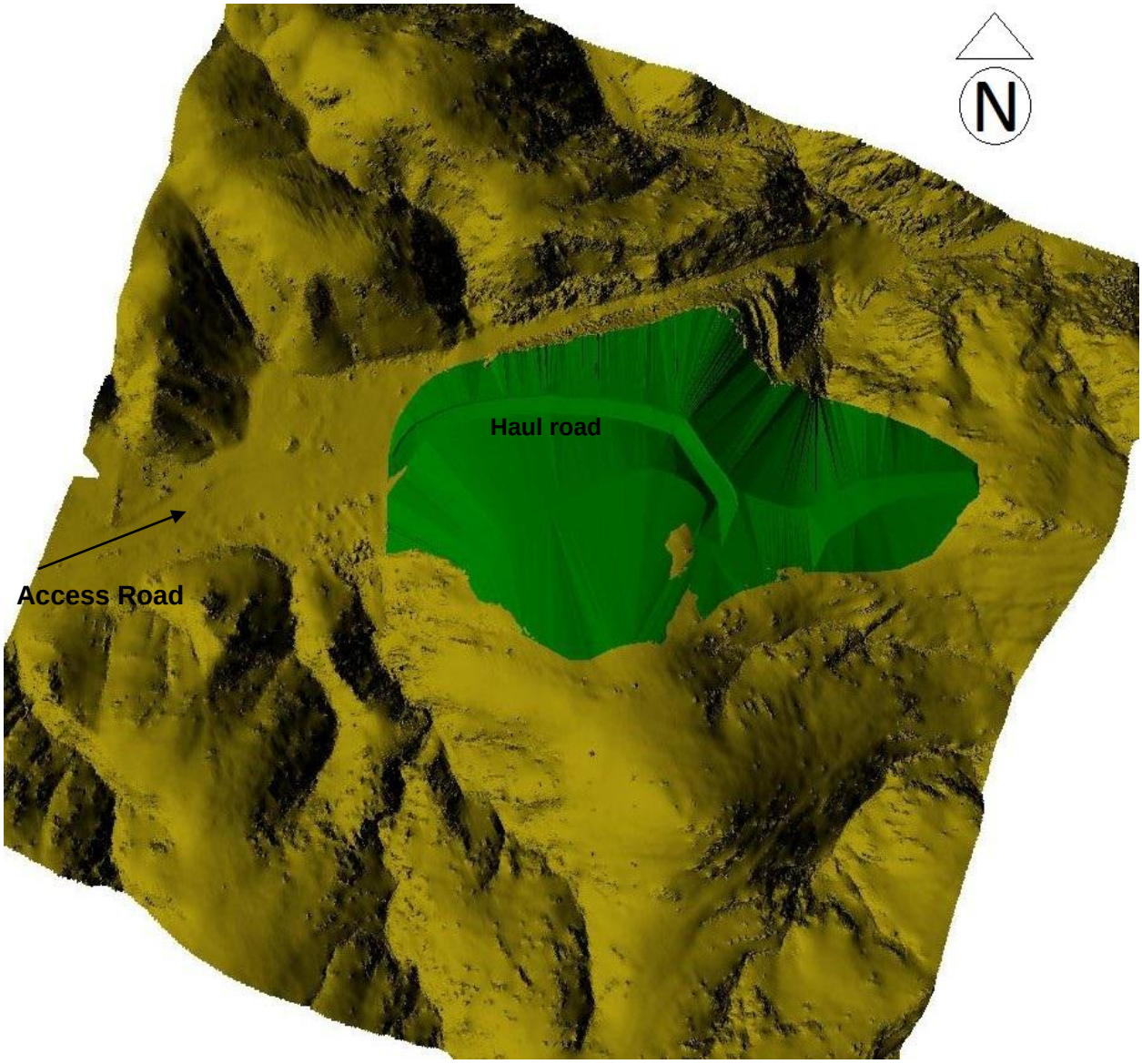


Figure 14: Access Road to the Landfill Site

A typical cross section of the access road is shown in Fig 15. Although the access road partly exists large sections has to be reconstructed and or upgraded.

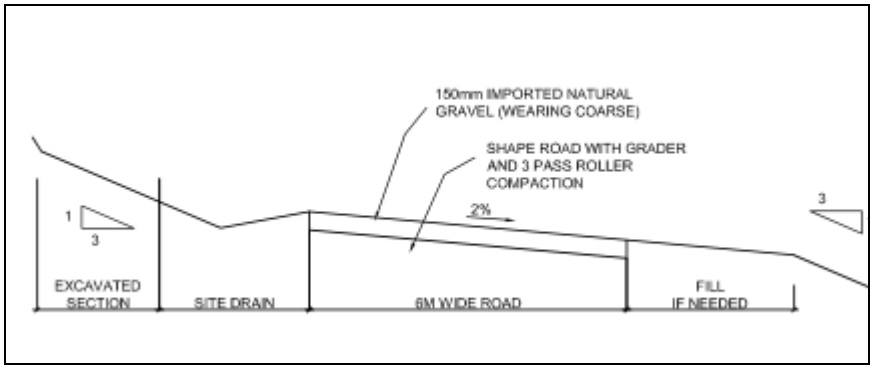


Figure 15: Typical gravel road cross section

6 SITE PREPARATORY WORK

6.1 General

A plan showing the constructed landfill prior to the commencement of filling is shown in Figure 5. Once the first phase of the site has been prepared to receive waste, the following engineering works will have been completed.

6.2 Surface Water Cut-off Drain

A surface water cut-off drain has been constructed around the working area on the eastern side of the site. This drain discharges to the water course/stream, which leaves the south-eastern and north east boundaries of the site. For future phases, the surface water drainage works should be extended as the site develops, to avoid pollution, as no surface water from the higher lying areas to the east should come into contact with the waste.

6.3 Subsurface Drains

No subsurface water was encountered during the site investigation nor is it evident on site. However, a small valley to the east of the site is to be closed as part of the landfill operations. The valley will be treated as a sub-surface drain and as such filled with rock and cover with a layer of soil as the landfill progresses. This subsurface drain will then tie in with the main "sub-surface" drain in the main valley.

6.4 Site Lining

As per the Minimum Requirements for a Communal and Small landfill only a reworked in-situ material liner is required as a base lining or barrier to prevent potential leachate entering the groundwater. Such a liner thus consists of one 150mm thick in-situ base preparation layer (natural soil). As stated in Section 2.2 no liner was prepared for the earlier landfill development at the mine. The proposal is however to construct a base preparation layer for the Rössing General Waste landfill as described above.

6.5 Monitoring Borehole

A monitoring borehole LF2 was sunk north of the site during the site investigation phase and is shown on the survey layout. Monitoring details are discussed in Section 14.

6.6 Site Roads

The site roads have been extended to the working area (see Figure 15). Further roads for access to lifts 3 onwards are shown on the stage drawings in appendix J. Road construction information is given in Section 9.

6.7 Site Security

A security fence has been erected around the full perimeter of the site. The main access gates have been positioned where the access road enters the site.

6.8 Greens Disposal Area

Certain waste types that will be brought to the landfill are very suitable for producing compost, which could be enhanced by the co-disposal of the wastewater treatment sludge. The process is furthermore of a technical nature when considering that temperature, moisture content, rotation time of the compost windrows thus formed and along with drainage of the site, the process has to be monitored and controlled.

Of particular importance is the necessity to provide proper drainage structures such as channels, a cut-off drain and a sump to collect and drain the contaminated water and collect the solids before the fluids enter the drainage pipes that will lead to the contaminate water ponds. This is of importance as no contaminated water must be able to impact on the groundwater.

Yard trimmings brought to the site have to be chipped and will also act as a bulking agent for the wastewater treatment sludge to be co-composted. Once this has been done windrows from the potential compost must be formed over a perforated pipe (which is to provide aeration via a compressor located at one end) and a temperature of approximately 65°C has to be maintained in the windrow. A moisture content of approximately 55% is ideal for composting. The turning of the windrows will be dictated by the required temperature and moisture content and to aid in its aeration.

It is strongly recommended at this early stage of the landfill facility that composting only be considered once the landfill is operational and a good understanding of the waste and composting market has been achieved.

It must be borne in mind that compost that is made on site can be used as part of the cover material on the landfill when doing the final capping.

7 LANDFILL OPERATION - CELL CONSTRUCTION AND SEQUENCING

7.1 Cell Construction

7.1.1 Cell construction and bund formation should be within the capabilities of the site operating staff, using the equipment and plant proposed for normal operations. The initial cells have been constructed as part of the site preparatory works. Details of bund construction are given in Figure 16. The figure shows a lift by lift filling profile for the early phase of the landfilling operation. The bund walls are developed by end tipping loads of coarse gravel material adjacent to one another. Smaller bunds are proposed to enable optimum use of the available airspace. The bund walls must be compacted while leveling out and shaped. Figure 16 shows a minimum option. Larger bund walls could however be constructed using trucks to end-tip the course material while driving on top of the bund at the same time compacting the material. Larger bunds will also consume available landfill airspace faster than the smaller bunds. Critical parameters are the outside slope of 1:3 not to be exceeded (not made steeper) and the waste to be covered regularly.

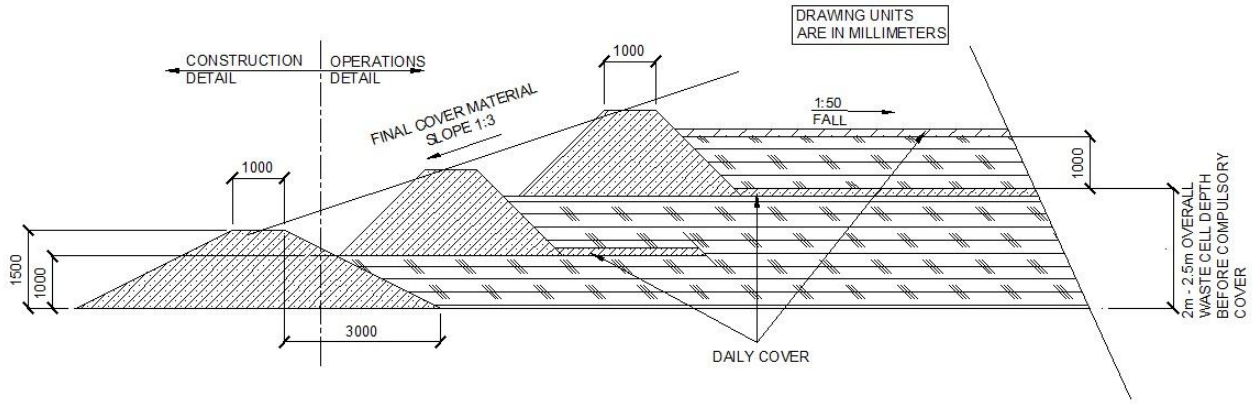


Figure 16: Typical Minimum External Bund Construction

7.1.2 The cell size between the bunds has been determined to allow say two vehicles to back up to the working face at the same time, and for the site to be divided into a convenient number of bays. The size of the cells can be varied to suit actual waste inputs and seasonal variations as determined by actual working practice.

7.1.3 Additional perimeter bunds should be constructed using basic construction methods. These details are given in Appendix C. The use of a tipper truck on an occasional basis when the perimeter bunds are being formed may be advantageous as larger quantities of soil can be moved around the site.

7.1.4 For internal bunds forming daily cell walls, the material used should be taken from the site spoil stockpile. The walls should be 1,5 m high with 1 vertical to 1,5 horizontal sides.

7.1.5 As work progresses across the site it may be possible to reuse some of the intermediate bund material as daily cover to maximise the available void space. Alternatively, the central core of the bunds can be formed using incoming refuse. Where builders' rubble comes into the site, this material can also be used for bund construction or daily cover of refuse. Extreme caution should be taken not to damage the liner or preparation layer when constructing the bunds, using building rubble, during the first lift.

7.1.6 When the cell has been filled to its full 1,5m depth above ground level, the remaining half meter of the intermediate and perimeter (Lift 2 onwards) cell bunds should be removed and spread over the waste as cover.

7.2 Development Sequencing

7.2.1 The sequencing of the landfill development have been designed in stages to represent 2m lifts across the entire landfill surface area at the same time ensuring that all areas are accessible (see Appendix J). The waste is then also deposited on the high ground and thus not in any potential rain runoff. Run off from stage 1 e.g. discharges away from the waste body around the cell to the north.

7.2.2 Stage 1(representing the first 2m of fill) is to be landfilled with waste to its maximum practicable height before commencing with landfill in subsequent stages. This will be determined by vehicle accessibility and by the containment of surface runoff from the waste body within stage 1. Prior to reaching the top of the perimeter bund, a new perimeter bund must be constructed as per detail on Stage 1 drawing. (Refer also to Figure 16).

7.2.3 Similarly stage 2 (representing the next 2m of fill) is to be landfilled with waste to its maximum practicable height before commencing with landfill in stage 3.

7.2.4 Care must be taken to limit the noise created at working face. Scheduling the stockpiling of the cover material during a time when the off loading of the collected waste is not taking place, which is generally before 9 a.m, should aid in minimising the noise. The compaction of the waste and the spreading of the cover material can then take place. The spreading of the cover material should also be arranged when the disposal vehicles are off site.

8 LANDFILLING OPERATIONS - WORKING FACE PRACTICE

The pre-forming of cells has been discussed in the previous section. This section discusses the method of landfilling.

8.1 Vehicle Movements

Vehicles entering the site will be directed to the operating cell. The truck will enter the cell and be directed to the offloading area. The preformed cell width should be sufficiently wide so as to allow three vehicles to offload simultaneously. The truck will back up to the working area, taking due care and attention, and discharge its load. The site personnel will assist in dislodging any waste that is hung up in the vehicle body. Once empty the vehicle will leave the cell. Vehicle movements are shown in Figure 17.

8.2 TLB Operations

The compactor (at this stage a TLB/FEL) will spread the waste over the short distance of the area being filled, driving backwards and forwards over the waste between two and six times depending on the type of waste being compacted. The waste should be built up in shallow layers, no more than 250 - 300 mm deep at a time, so that compaction is maximised. The daily work area should be kept to a minimum in order to conserve cover material. The optimum slope of the waste should be 1 in 12. The cell geometry is shown in Figure 18 and the landfilling layers in Figure 19.

At all times care should be taken to avoid accidents involving collection vehicles and site personnel. If private collection contractors are allowed on site they should stay in their vehicles. Personnel should keep away from the compactor due to the possibility of flying objects shot out by the rubber or steel wheels.

8.3 Difficult Wastes

- **Categories**

  Certain wastes require special care when landfilling. These wastes may be categorized as follows:

  - bulky crushable items: furniture, white goods (cookers, refrigerators, washing machines and other appliances)
  - car bodies, engines, sheet and metal sections, tyres
  - tree stumps, boulders, other large items
  - wire and other similar material

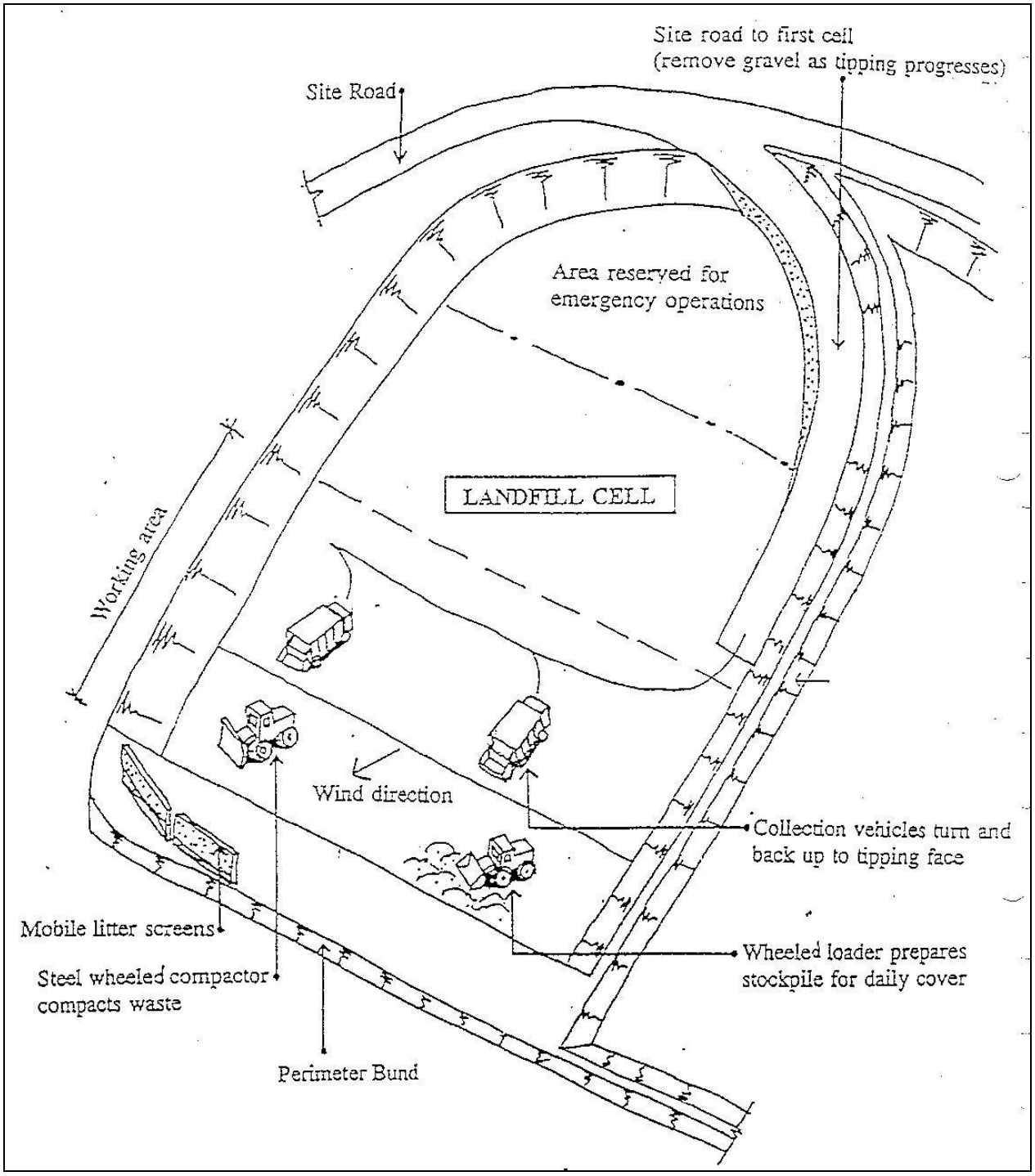


Figure 17: Typical Vehicle Movements

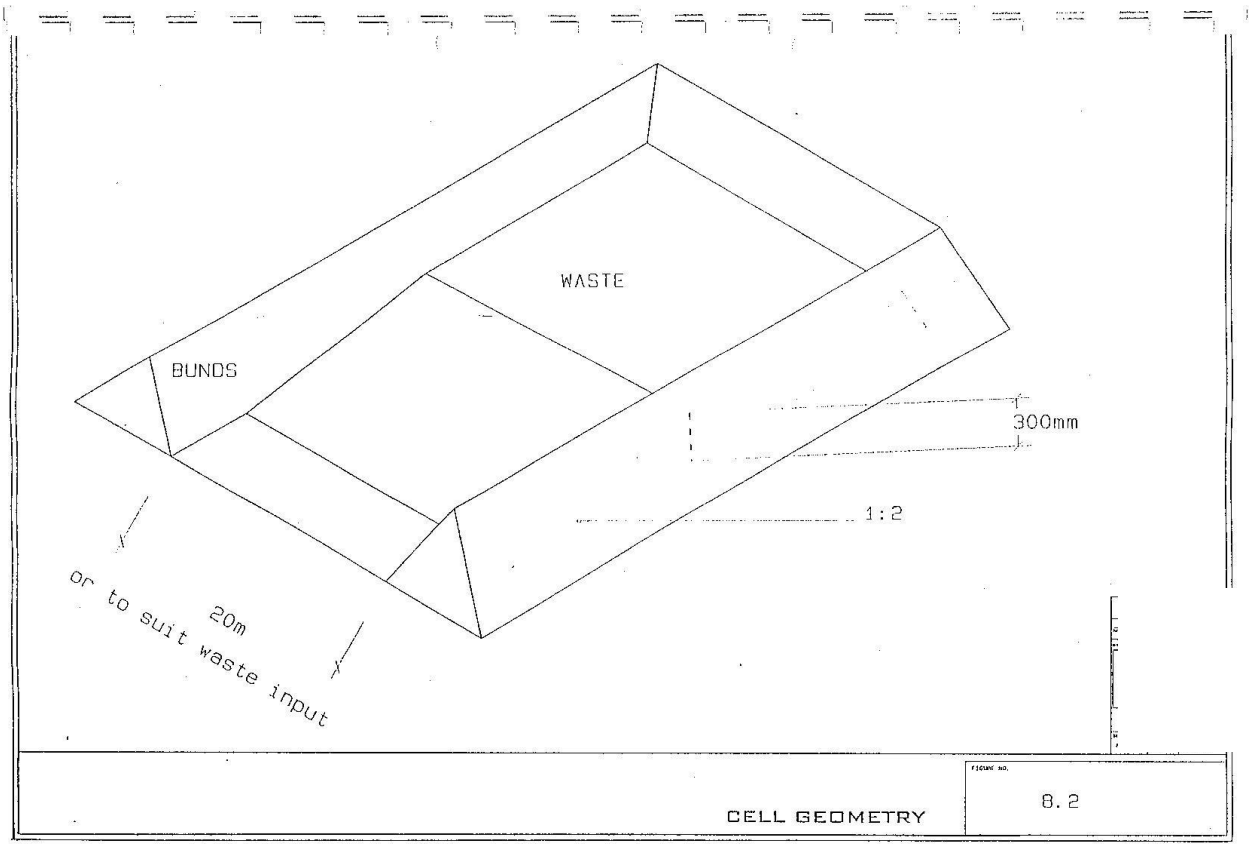


Figure 18: Typical Cell Geometry

- condemned food, dead animals, offal, odourous matter
- drums and containers
- mud, sludge's, dust, light weight and fluffy material, waste oil
- permitted chemical waste

Regulations may be in force prohibiting some of the above wastes from being deposited. These regulations should be consulted and respected. As a general guide the wastes described in Appendix D should not be landfilled.

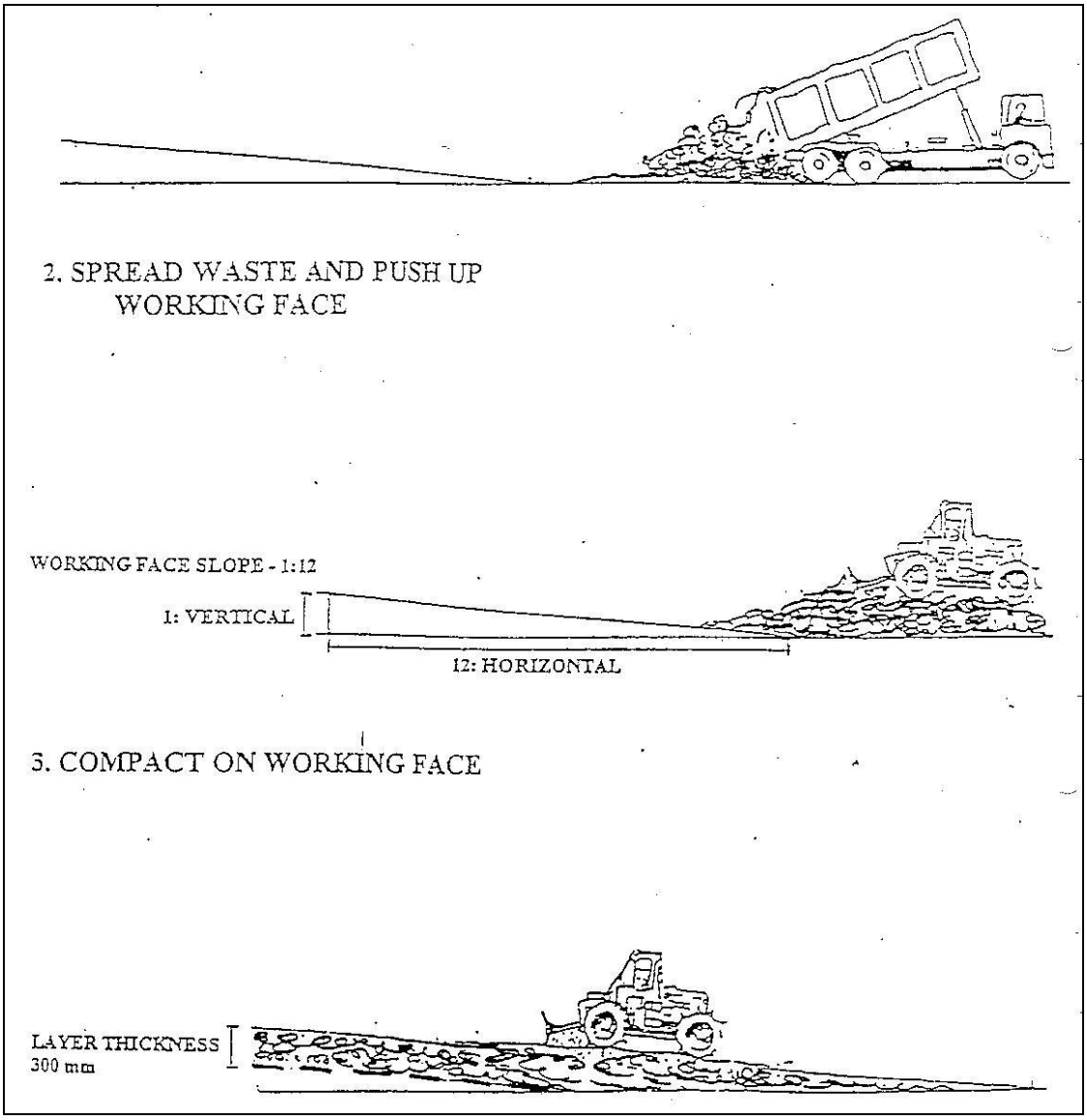


Figure 19: Landfilling Layers

- **Methods of placing**
  The main options for dealing with any of the permitted difficult types of waste is either to locate them near one of the inner cell dividing walls or to ensure that they are covered as soon as possible after arrival at the site. Particular methods that should be followed are as follows:

  - Hollow items should be crushed

  - Fridge and freezers should have their coolant removed and recycled as the gas used depletes the ozone layer. If stored in public access areas their doors should be removed (children have been known to suffocate whilst playing and hiding in discarded units).

- Tyres should be cut up as they have a tendency to rise to the surface if left intact (see new **RSA Tyre Regulations**)

- When not forming compost the sludge from the wastewater treatment ponds, when de-sludging, should be co-disposed with the general waste in the landfill by digging a long 2m trench and once the sludge is disposed of in the trench, it should be filled with waste and cover material.

- **Safety**
  Generally all difficult types of waste should not be located near the outer side, base or surface of the landfill, a buffer of at least 5 m of other waste should be provided between the difficult waste and the boundary of the fill. With all these types of materials extreme care must be taken to ensure that the waste is deposited in a safe manner. The general rule is to locate difficult (dangerous) wastes in such a way that it could be retrieved at a later stage when other techniques of waste handling are available locally.

8.4 Covering Waste

The most important aspect of solid waste disposal is the daily covering of waste

During the working day the TLB/FEL will be stockpiling cover material adjacent to the working area. This material will be used to spread over the day's waste input. The daily waste covering will form a sub-cell within the main cell. The layer should be kept as thin as possible to conserve material and void space. Typically a layer approximately 250 - 300 mm should be deposited. Under certain circumstances, for example if any builders waste or sub-soil is brought to the site, it may be possible to use this material as part of the daily cover. The criteria for use as cover is that it should be inert, for example soil, sub-soil, sand, clay, bricks, broken concrete, hard-core or a mixture of these materials.

When a cell is filled to the full height and it is anticipated that some time will elapse before a further layer is built on the waste, the top surface of the cell should be covered with an intermediate layer of cover 300mm thick. Some of this layer can be removed and reused as daily cover immediately prior to commencement of filling of the next layer.

8.5 Wet Weather Disposal

Under certain weather conditions, during exceptional storms for example, it may not be possible to use the normal cell being filled. A cell near the entrance of each lift should be designated for use during these conditions. The cell shall operate on a surface, which is of course material and well drained, such as builders' rubble or mine blast material.

Notwithstanding the above, the bottom of the working face floor area should at all times be shaped to ensure drainage of stormwater away from the working area.

Certain abnormally high amounts of waste may be directed to the site, for example debris from natural disasters. Under these circumstances the advice of the senior management should be taken with respect to the method of disposal.

9 LANDFILLING OPERATIONS - ANCILLARY OPERATIONS

9.1 Landfill Gas

As the landfill and waste to be received is anticipated to be very dry with no or limited moisture, no landfill gas is expected at the landfill facility.

Caution: Accumulations of Landfill gas can be extremely dangerous. Concentrations higher than 5% can result in fires or even explosions. Furthermore landfill gas can cause suffocation and possibly poisoning. Extreme care should therefore be taken when entering / working in enclosed confinements such as manholes, rooms close to the landfill, etc.

9.2 Leachate Management - Water Balance

- Analyses of the climatic water balance for this region show that no significant leachate is expected at the landfill facilities.

- When the rain falls on the waste a certain amount is absorbed into the waste mass. When this absorptive capacity (field capacity) is reached the excess liquid percolates through the waste becoming leachate. This liquid is a source of pollution. Leachate is brown or black in colour and has a high chemical and biochemical oxygen demand. Before discharging to a watercourse it should be treated to an acceptable standard.

Caution: Leachate can be infectious and/or toxic. Extreme care should therefore be taken when working with Leachate to minimise contact with skin. Protective equipment such as rubber gloves and boots should be worn.

- **Typical water balance calculations are contained in Appendix E.**

9.3 Site Roads

From time to time it will be necessary to extend the site haul road(s) to obtain access to successive lifts. The road(s) should be at least 5 m wide and made of either stone or crushed aggregate or selected hard-core (crushed rock, broken bricks or concrete) delivered to the site as part of the waste input. Site roads should be maintained and kept in good order to minimise damage to the refuse vehicles.

9.4 Site Drainage

All drainage structures such as manholes, inlet/outlet structures, channels etc. should be inspected to ensure functionality at all times. Attention should be given to control erosion.

10 SITE MAINTENANCE & GENERAL ENVIRONMENTAL CONSIDERATIONS

10.1 Site Maintenance

The site should be kept clean and tidy at all times. Part of the duties of the site staff should be regular site maintenance activities. The following items should be regularly inspected, once a week for example, and problems reported so that repairs can be undertaken:

- Site fencing and security gates.
- Access road.
- Buildings.
- Fixed equipment.

10.2 Environmental Evaluation

An environmental evaluation was undertaken prior to the design of the site, the findings and recommendations of this evaluation are contained in Appendix F. The Environmental Management Plan that addresses the environmental impacts is contained in Appendix G.

10.3 Litter, Mud and Dust

- With the cell method, the landfilling activity is undertaken in a protected area as the cell walls help to minimise the effect the wind has on the placed refuse. However, when the site is operational it will become apparent that under certain wind conditions light waste, paper, plastic film etc. will be lifted from the working area. Under these circumstances the mobile litter fencing should be positioned to trap the waste. These fences should be cleaned at the end of each working day.

- Similarly, waste will be dropped on and around the access and site roads by badly laden vehicles. Litter may also become lodged in parts of the boundary fence and surrounding vegetation. This litter should also be removed on a daily basis.

- Dust may also become a nuisance. A bowser (water tanker with ground spray bar) should be issued so that the site roads can be damped down to suppress dust generation.

10.4 Bird Control

Birds, particularly gulls, crows or vultures can be a problem at landfill sites. They are undesirable as they pick up and deposit unwanted remnants, which may be obnoxious, on the surrounding area. The bird problem will be minimised by good working practice, keeping the working area to a minimum and covering the waste at the end of each working day.

10.5 Pest Control

If the recommendations for landfilling are followed problems with infestations of flies and rats should be minimised. Covering of the waste is the most important requirement. Should vermin infestation occur the public health department should be contacted and pesticides applied. Personnel need to be trained in pesticide application and protective clothing should be worn. The rodent control officer should be contacted should these pests become a nuisance.

10.6 Odours

- The characteristic landfill odour is generated by the decomposition of putrescible (decomposable food and vegetable) matter. Odours are minimised by covering waste. It has been found that tipping waste into standing water increases the possibility of odour generation; therefore depositing waste into water should not be practised and thus avoided. Due to limited food or vegetable waste being present on site very little chance exists for odours to develop.

- If it becomes necessary to prevent odours leaving the site, the following actions may be taken for the sake of reducing the nuisance created:
  - spreading hydrated lime over newly filled or saturated wastes;
  - or in the long term, flaring of landfill gas.

10.7 Fires

- Waste materials should not be burnt. The natural degradation within the landfill will reduce the volume of organic material. The following should also be noted in particular:

  - Burning plastics is an environmental hazard.

- Any hot or burning waste that arrives on the site should not be deposited with the waste. It should be allowed to burn out and cool before being deposited.
- Smoking of cigarettes should not be permitted at the working area.
- If any fire occurs the Fire Service should be called.

- If safe to do so the waste on fire should be isolated before the Fire Service arrives and covered with earth or cover material to smother the flames. Fire extinguishers may be used on small fires.

- The personnel should be trained in procedures to be adopted if a fire is noticed on the site. Local Fire Services should be consulted on the best procedures to be adopted.

10.8 Existing Vegetation

All existing vegetation should be retained as far as possible to help control soil erosion, to regulate catchment outflow, to provide visual screening and to buffer noise emissions from disposal operations. It is envisaged that the Environmental Department should be involved to attend to any site cultivation work such as planting of trees around the site as screening mechanism.

11 EQUIPMENT MAINTENANCE

11.1 Manufacturer's Instructions

All site equipment should be maintained in accordance with the manufacturer's instructions. Copies of the equipment instruction booklets should be available on site for reference.

11.2 Daily Inspection

- At the commencement of each working day a walk around check should be undertaken. Points to check are shown in Figure 20. In addition to this check, a daily and weekly maintenance check should be carried out. Points to check are itemised below. All checking operations of equipment should be carried out on level ground with all hydraulic equipment at its lowest level.

- **Typical Operators Maintenance Schedule - Loading Shovel (FEL)**

(For guidance only, refer to manufacturer's instruction book and schedule as necessary)

THINK and ACT SAFELY at all times. If in doubt ASK.

Lower all raised equipment before carrying out any checks or servicing.

Daily Tasks:

- ***Check - before starting engine:***
  Radiator coolant level
  Engine oil level
  Fuel level
  Precleaner (Dust filter)

- ***Check - with engine at low idle:***
  Engine oil level
  Hydraulic oil level
  Transmission oil level
  Bevel gear and steering clutch oil level

- ***Walk around check (see Figure 20) and report any defects***

- ***Grease*** ***Grease Points***

  Bucket lift arms *4*

  Bucket pivots *6*

Weekly Tasks:

- ***Check -***

  Batteries

  Fan belt tension and condition

  Final drive oil level

- ***Grease*** ***Grease points***

  Bucket linkage 18

  Track frame outer bearing 2

  Fan pulley bearing 1

  Steering pedals 5

  Governor control 1

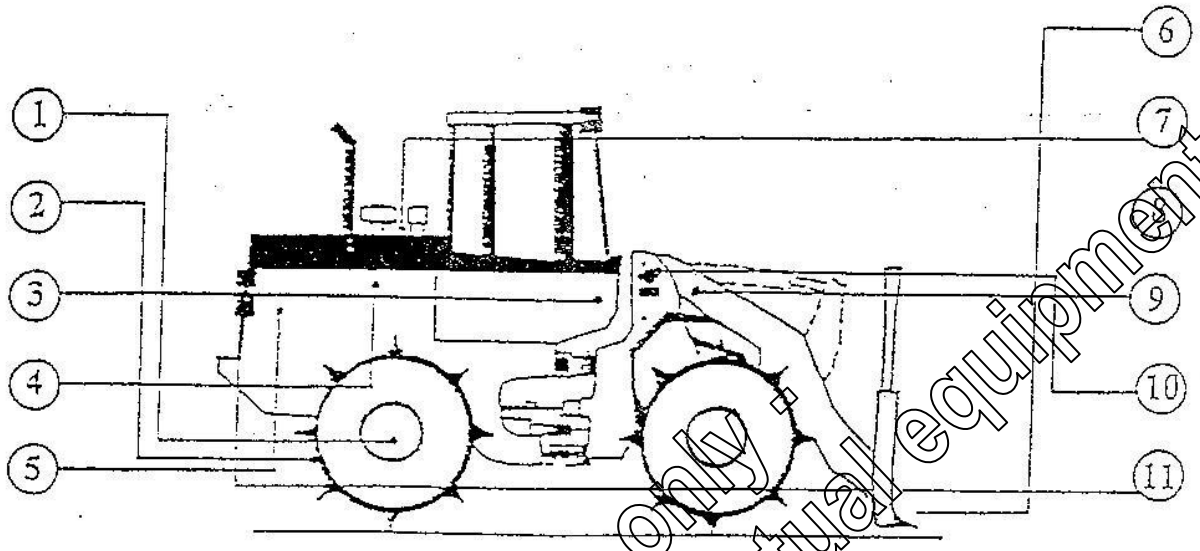
- Oil

- Bucket positioned

- Drain sediment from fuel tank if necessary

11.3 Equipment Cleaning

At the end of each week all equipment should be cleaned. In particular windows, rear view mirrors and lights should be kept clean at all times.



WALK AROUND CHECK

1. HUBS - wear
2. WHEELS - loose, missing teeth
3. GAUGES - functioning, damage
4. ENGINE - oil, fuel, leaks
5. COOLING SYSTEM - leaks, worn hoses, litter, dirt build up
6. BLADE - general wear, linkage
7. GUARDS - damage, loose bolts
8. STEERING LINKAGE - wear, leaks
9. HYDRAULICS - leaks, worn hoses
10. LIGHTS - functioning, damage
11. REVERSING WARNING DEVICE - functioning

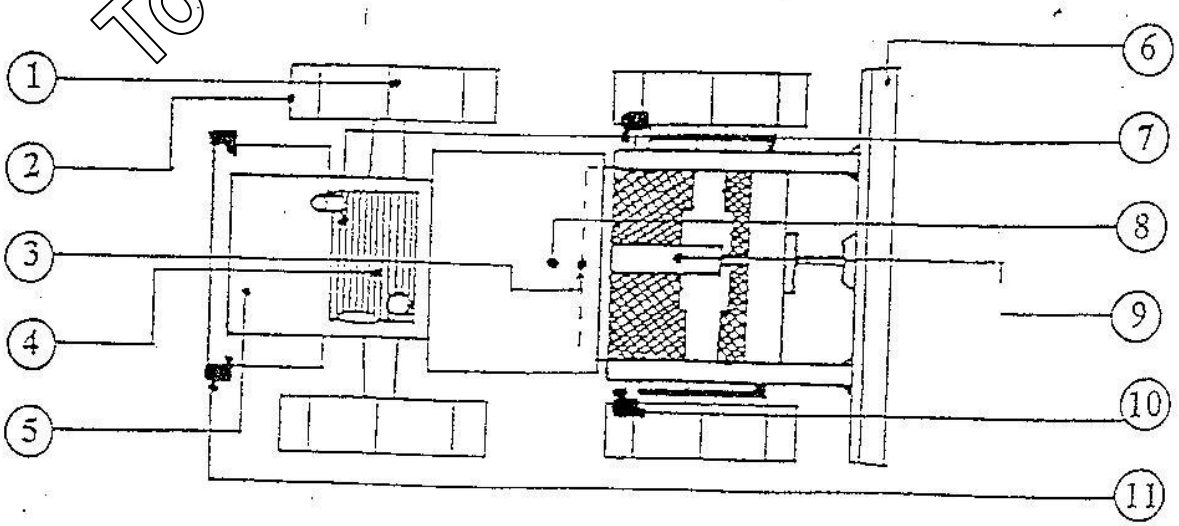


Figure 20: Equipment Walk-around Checks

12 RECORDS AND MONITORING

The EMP included in Appendix G details the monitoring requirements for operation of the site and must therefore be read in conjunction with this section.

12.1 During operation of landfill site

- **Waste input records**

Daily records of the waste entering the site should be kept. Where a weighbridge is not present tallies or estimate of truck loads could be taken or made. Table 7 shows details of how the records should typically be kept. A daily summation of the amounts of different categories of wastes should be kept, together with monthly and yearly totals. This information is important for amongst other things the future planning and design of the landfill can be made more accurate.

Table 7: Daily Waste Input Records

Vehicle no	Time	Wastes		Weigh in	Weigh out (tare weight)	Amount delivered	
		Source*	Type**			Solid waste	Cover material
					TOTAL		

General household waste Landfill Facility Date:

Signature ……..

Instructions:
[To be completed for each vehicle each time it makes a delivery]

* R = Residential C = Commercial
I = Industrial A = Agricultural
Other codes as appropriate
**H = Household
B = Bulky waste - Furniture, Refrigerators, etc.
D = Demolition / construction
T = Tyres

- **Daily Activity Summary**

A daily activity summary showing the amount of waste landfilled, the daily cover used and machine and man hours, should be completed by the site supervisor. Details to be recorded are shown in Table 8. Where a weighbridge is not available volumes (m^3) should be stated.

Table 8: Daily Activity Summary

Date	Solid waste		Cover Material				Man hours	Machine hours		Site Hours
	Loads	Tonnes/ volumes	Begin 20000 m^3	Received	Used	Remain		Use	Down	
1st										
2nd										
3rd										
etc.										
TOTAL										

Rössing Landfill Facility Month Year

Date	Operator	Man hours	Vehicle Identity	Machine hours		Site hours
				Use	Down	
1st						
2nd						
3rd						
etc.						
TOTAL						

Signature ……..

Instructions:

[To be completed by the site supervisor at the end of each day. The record of cover material should be in either tonnes or cubic metres. Today's beginning material equals yesterday's remaining. The cover material on site at the end of the construction of phase 1 is approximately 20 000 m^3 but is to be confirmed.]

- **Filling**

The rate of filling of the site should be monitored by surveying the site at three monthly intervals to determine the rate of airspace utilisation especially

as in some cases excessive cover material is used leading to the depletion of valuable airspace.

- **Settlement**

Areas of the site that have reached the final level and have been finally covered should be monitored for settlement (see final restoration section for the method of construction). A suggested settlement monitoring programme is given in Table 9 below.

Table 9: Settlement Monitoring Guideline

Activity	Interval
General inspection of covered areas, looking for obvious depressions, cracks, and pools of water.	Weekly
More **rigorous inspection** of landfill, looking for smaller cracks and depressions.	Monthly
Checking of level of survey benchmarks on landfill cover using survey equipment.	Annual

To minimise settlement, it is necessary that good, uniform compaction of waste is achieved.

- **Surface Water**

The surface water monitoring points should be established in the valley North and North-East of the landfill. These points should be marked and numbered and displayed on a site drawing for future reference.

- **Performance Evaluation**

From time to time the operations will be audited by senior management or an outside agency to check and ensure compliance with the requirements of the EMP (refer Appendix G). Typically the list of items that should be examined is shown in Table 10 in checklist form.

Table 10: Performance Evaluation

		Compliant (satisfactory)	Non compliant/ (Not satisfactory)	Remarks
1	General method of working in accordance with plan and specification			
2	Site security			
3	Condition of site roads			
4	Control of tipping area width of face			

5	Compaction and formation of layers to specified depth			
6	Depth of primary cover			
7	Primary cover completed each day			
8	Measures for handling difficult waste			
9	Litter control			
10	General site tidiness			
11	Arrangements for bad weather or emergency working			
12	Employee's amenities			
13	Fire precautions			
14	Pest control measures			
15	General Remarks			
	Etc.			

12.2 Post-closure monitoring

All potential subsidence, possible gas and water monitoring should continue into the post-closure phase.

13 FINAL RESTORATION AND DECOMMISSIONING

13.1 General

Upon completion of the first stage, tipping will proceed to the first cell of the second stage. At this point the final restoration of the cover to the first stage can be commenced albeit in isolated areas.

The final cover proposed for the landfill will consist of a 300 mm thick crushed rock layer to be stockpiled on the site to be spread over the surface or as directed by the environmental officer when required.

Completed areas of the site will be left fallow as an open area.

The final contours envisaged for the site for Stage 1 and all subsequent Stages are shown in Appendix J.

Upon the facility's decommissioning, notice should be given that the site has been used for solid waste disposal. This notice should be posted on site and recorded on all legal descriptions to avoid its premature use for purposes other than open space. At such time that the site is certified to be safe for built structures and human occupation (probably 50 to 100 years after closure), the cautionary notices and use prohibitions can be waived.

14 HEALTH AND SAFETY

14.1 General

Health and safety matters are the responsibility of all members of the staff. A safety officer should be appointed to ensure that safe procedures are being adopted. The safety officer may be the site supervisor of his/her immediate superior. A safety plan should be compiled and displayed for all staff to follow. The safety plan should cover the following topics:

- No smoking on the site
- Awareness of vehicle movements particularly on or near the working face
- Protective clothing requirements
- Keeping the site clear of mud and rubbish
- Dust suppression
- Ensuring that vehicles at the working area have a firm riding surface
- Ensuring the stability of permanent and temporary embankments
- Fire prevention and control procedures
- First aid and accident procedures
- Any other applicable working regulations
- Dangers of landfill gas and leachate

It will be necessary to train both the supervisors and operatives in safety matters.

14.2 Protective Clothing

The following protective clothing should be provided for each site operative:

- Overalls
- Heavy duty boots
- Gloves
- Goggles
- Dust masks

14.3 Training

Various training schemes are available to site operating and supervisory staff. Operator training normally takes place on site, whereas supervisor training may take place at training institutes. The need for training has been identified and included elsewhere in the project.

14.4 Emergency Procedures

Suitable training of personnel, along with well-planned emergency procedures, is imperative right from the outset of the operation of the landfill.

Because it is impossible to anticipate and formalise every emergency and because emergencies are, by nature, unpredictable, a decision flow chart defining only broad emergency strategies should be readily available to all site personnel. This flow chart should incorporate a set of trigger and completion parameters, i.e. a set of parameters that will trigger and end an emergency procedure respectively. Possible example emergency scenarios should be displayed along with the flow chart and a list of actions and information common to all emergencies should be provided. This list would include detail like:

- Names of persons involved in dealing with and the name of the person in control of an emergency
- Emergency contacts (fire, police, ambulance, telephone number of any responsible person not on site)
- Flow of information (who should be notified and when)

It is important to accumulate and maintain a database of extraordinary events occurring on site which may be linked to emergency occurrences. These events must in turn be matched with other circumstances (e.g. weather conditions, site operations etc.). A statistically valid pattern can then be sought to help with the forecasting and prevention of similar emergencies.

15 SUMMARY - LANDFILL SITE SPECIFICATIONS

A summary of landfill operations has already been given as Section 2 - General operating procedures. This last section will take the form of a specification. For reference the section in the manual referring to the particular subject is shown in brackets.

GENERAL HOUSEHOLD WASTE LANDFILL SITE SPECIFICATIONS

1	Name of site:	Rössing Landfill Facility
2	Address and telephone number:	Rössing Uranium Mine – Namibia
3	Location Co-ordinates:	To be determined as the site was set out and located based on a local system

Corner peg	Latitude (Southing)	Longitude (Easting)
A	22º 28,110’	15º 3,246’
B	22º 28,136’	15º 3,269’
C	22º 28,036’	15º 3,335’
D	22º 28,072’	15º 3,371’

4	Intended After use:	Open Space (Section 13)
5	Maximum ground water level:	No significant groundwater present on site. All engineering works above ground water table. (Section 3 and Appendix B)
6	Site stormwater drainage:	Perimeter drain around site (Section 6)
7	Water protection measures:	Engineered insitu liner with perimeter bund up to 1,5 metres high. Liner comprises reworked 150-mm thick natural gravel material. (Section 6)
8	Boundary Fencing:	Post and diamond mesh fencing 1.8 m high with barbed wire on top. Double entry gates to same specification. (Section 6)
9	Site security arrangements:	Vehicle gates and entry guardhouse. Site manned part time. (Sections 4 and 5)
10	Site information boards:	Entry sign as follows: Rössing Uranium Mine General Household Waste Landfill Facility

		Hours of Opening: 7 a.m. to 4 p.m. All visitors to report to guardhouse [*An emergency telephone Waste Management Department's number*.] Other notice boards to suit traffic movements - to public road's standard (Section 5)
11	Fixed installations:	Guardhouse Toilet (Section 5)
12	Landfilling plan:	1 Volume of space available 100 000 m^3 2 Approximate daily intake of solid waste: 2008 – 9 to 12 tonnes 2012 – 9 to 12 tonnes 2017 – 9 to 12 tonnes 2022 – 9 to 12 tonnes 3 Direction of working: Phases arranged in an east to west configuration. See Figure 2 4 Maximum width of working face: 20 metres 5 Bad-weather or emergency working areas: Adjacent to site haul road, dependent upon cell in use 6 Number of layers and depth of layer after initial consolidation: 4 & 600 mm 7 Thickness of daily cover: 150mm 8 Thickness of primary cover: 300mm 9 Thickness of final cover: 600 mm (Sections 4, 8 and 15)
13	Types of waste excluded such as hazardous and toxic waste:	Certain hazardous wastes as directed by procedures JK65/PRD/003 and regulating authority (Section 8 and Appendix D)
14	Litter screens:	Mobile Litter screens provided (Sections 4 and 10)
15	Fire-fighting arrangements:	Localised fires by isolation and smothering. Fire Services to be called in all fire events (Section 10)
16	Pest control measures:	Waste to be covered each working day Infestations to be controlled by pest control

		officer (Section 10)
17	Final restoration:	Site capped with material engineered to the same specification as the site lining, then sub-soiled, top soiled. (Section 15)
18	Special instructions:	No vegetation other than areas used for site operational purposes to be removed. Avoid all construction and operational activities where Indigenous plant species grow (Section 10 and Appendix F)

REFERENCES

1. Minimum requirements for Waste Disposal by Landfill, South African Department of Water Affairs and Forestry, 2nd edition, 1998.

2. Diaz, Luis F, et. al., CalRecovery Inc. "Solid Waste Management for Economically Developing Countries", ISWA October 1996.

3. Tchobanoglous George, et. al., University of California, Davis, "Integrated Solid Waste Management, Engineering Principles and Management Issues", 1993. ISBN 0-07-112865-4.

4. Beco Institute for Sustainable Business, "Waste Characterisation and Risk Evaluation at Rossing Uranium Limited", November 2007.

5. Airshed Planning Professionals (Pty) Ltd, "Air quality impact assessment for the proposed expansion project for Rössing Uranium mine in Namibia: Phase 1, December 2007.

6. Jarrod Ball & Associates, "Development of a New Disposal Site for Walvis Bay", October 1998.

APPENDIX A

WASTE QUANTITIES AND VOID SPACE REQUIREMENTS

Appendix A

This appendix elaborates on the waste quantities and void space requirements (Section 2) by way of comparison and to verify the waste deposition quantities.

Waste generation and airspace utilisation

As directed in the terms of reference, the landfill is to be designed to accommodate the full waste stream deposited for the next 20 year design life starting March 2009 lasting until 2028. The above figures form the basis for determining the landfill airspace requirements for the 20-year design period. It is thus estimated that a total of some 88 000 tonnes of waste will be deposited over the 20 years design life.

Using an in situ landfill density of 800 kg/m^3 (lower than recommended) and a volumetric cover to waste ratio of 1:6 (typically where limited cover material is applied), the estimated total airspace required would thus be 110 000 m^3. This would require approximately 22 000m^3 of cover material for a proper sanitary landfill operation.

Year	Number	Annual waste disposed (m^3)	Annual volume consumed including cover (m^3)	Remaining Airspace (m^3)
			Start volume	100000
2009	1	4428	5535	94465
2010	2	4428	5535	88930
2011	3	4428	5535	83395
2012	4	4428	5535	77860
2013	5	4428	5535	72325
2014	6	4428	5535	66790
2015	7	4428	5535	61255
2016	8	4428	5535	55720
2017	9	4428	5535	50185
2018	10	4428	5535	44650
2019	11	4428	5535	39115
2020	12	4428	5535	33580
2021	13	4428	5535	28045
2022	14	4428	5535	22510
2023	15	4428	5535	16975
2024	16	4428	5535	11440
2025	17	4428	5535	5905
2026	**18**	**4428**	**5535**	**370**
2027	19	4428	5535	depleted
2028	20	4428	5535	
2029		4428	5535	

Recent records of cover material used during June to August 2009 provided by the Mine show the following:

Month	General waste mass (kg)	Rock material (m^3)	Tailing sand (m^3)
June	375585		
July	434157	192	110
August	177450	50	44
Total	**987192**	**400**	

Cover material thus utilised was approximately 400m^3 in 3 months. Waste disposed over the same period was 987192kg or approximately 329t/m or 11t/d.

The airspace utilisation would thus be improved upon when the waste is compacted o a higher density such 1t/m^3 and the cover to was ratio is increase to 1:4. With the dry waste and climatic conditions a cover ration of 1:6 would suffice.

APPENDIX B

Geotechnical Information

Appendix B

A detailed geotechnical and geohydrological investigation was carried out on the site. The report on the findings of this investigation is included in the Appendix B

Some general notes are highlighted here under.

Soil Stability

Cut Slopes

Due to the insitu rock formation in the vicinity of the proposed landfill site, it is expected that cut surfaces with slopes of up to 45 degrees or 1 vertical to 1 horizontal would remain stable, provided the cuts are situated above the water table.

To reduce slope erosion by surface waters, it is considered expedient to place cut-off drains at the top of permanent cut slopes, so that rain water can be channelled away from them. For slopes maintained for short periods of time, the drain may be considered unnecessary.

Embankments

Although no specific testing was conducted to ascertain stability of recompacted material, it is anticipated that instu material used to form embankments will be stable if compacted in layers of maximum thickness 150 mm to 93% mod. AASHTO density. Embankments slopes constructed at slopes of 1 vertical to 2 horizontal are considered reasonable for fill with coarse rocky material. However final slopes on the landfill should be in the order of 1 vertical to 3 horizontal.

It is considered likely that embankments will be susceptible to erosion, and consequently will need to be periodically maintained. Compaction of the insitu material will reduce permeabilities, depending on compaction achieved.

APPENDIX C

Perimeter Bund Specification

Appendix C - Perimeter Bund Construction

C1 The perimeter bunds should be constructed from engineered fill selected for uniformity from the stockpile. The bunds are required to stand until either the next phase of development or the construction of the final cover, soon after the next phase is commenced. The profile of the bund has been chosen as 1 vertical to 3 horizontal on the outside face and 1 vertical to 2 horizontal on the inside face. A steeper slope on the inside face is acceptable as the waste supports this slope. The shape of the perimeter bund is shown on Figure 15

C2 The portion of the bund will be set out using pegs. The base area will first be pegged out in the correct position as shown on the layout drawings of the landform. Simple triangular planks set up at 1 in 3 and 1 in 2 can assist in forming the battered slope.

C3 It is anticipated that the perimeter bunds will be constructed by using the track type loader. It will excavate material from the stockpile and spread it out in layer about 150 mm thick. To compact the layer the track type loader should run over the material 8 times, making sure that the whole surface has been given the compaction treatment.

C4 The next layer will follow, and so on until the 2 metre height of the bund has been reached. The addition of water may be desirable to aid compaction. The water bowser for damping down the site roads may be used for this purpose. Compaction density tests can be carried out to determine the optimum moisture content and to experiment with the number of passes of the track loader to achieve the best results.

C5 It may be that the track loader is fully occupied in the daily covering of the waste, in which case the perimeter bunds may be constructed by the private contractor using mining equipment.

APPENDIX D

Wastes that should not be Landfilled

Appendix D

Government Gazette RSA, 7 September 2001

LIST OF HAZARDOUS OR TOXIC MATERIAL WHICH MAY NOT BE DISPOSED OF ON A GENERAL DISPOSAL SITE.

1. Waste where specific control has been established in terms of the Nuclear Energy Act, 1993 (Act 131 of 1993).
2. Waste types controlled in terms of the Minerals Act, 1991 (act 50 of 1991) and the Electricity Act, 1987 (Act 41 of 1987), unless written permission has been obtained from the Regional Director.
3. Waste which is defined, according to the Minimum Requirements, as an extreme hazard or Hazard Group 1 (HG1); High hazard or Hazard Group 2 (HG2); moderate hazard or Hazard Group 3 (HG3) and low hazard or Hazard Group 4 (HG4), unless an application for delisting has been successfully submitted to the regional Director and written approval was obtained from the Regional Director for the disposal of the waste on the Site.
4. Flammable wastes, with a closed cup flash point less than 61°C.
5. Corrosive substances, as defined and described in the Minimum Requirements as Class 8 (1998 edition: page 6-8, Diagram III).
6. Oxidising substances and organic peroxides, as defined and described in the Minimum Requirements as Class 5 (1998 edition: page 6-8, Diagram III)
7. Any waste with a substance which is a Group A and /or Group B carcinogen/mutagen. Group A carcinogens/mutagens have been proven in humans, both clinical and epidermiological. Group B carcinogens/mutagens have been proven without a doubt in laboratory animals.
8. Any waste with a substance at a concentration greater than 1% where the substance is a Group C and/or Group D carcinogen/mutagen. Group C carcinogens/mutagens have shown limited evidence in animals. Group D carcinogen/mutagen – the available data is inadequate and doubtful.
9. Any infectious waste, unless it has been incinerated in 800°C or higher for at least 1 second. Infectious waste is waste which is generated during the diagnosis, treatment or immunisation of humans or animals; in the research pertaining to this; in the manufacturing or testing of biological agents including blood, blood products and contaminated blood products, cultures,

pathological wastes, sharps, human and animal anatomical waste and isolation waste that contain or may contain infectious substances.

10. All materials which falls in Class 1 (explosives), Class 2 (compressed gasses) and Class 7 (radioactive materials), as defined and described in the Minimum Requirements.
11. Any waste with a pH less than 6 or greater than 12.
12. Any waste which is difficult to analyse and classify.
13. Any complexes of heavy metal cations, paint and paint sludge, or laboratory chemicals.

As a general guide the wastes described as follows should not be landfilled:

- Waste with high percentages of volatile organic content
- Waste with high percentages of aromatic, halogenated and non-halogenated compounds
- Wastes with high percentages of metals, especially arsenic, cadmium, lead, mercury and selenium
- Wastes with a high percentage of cyanide and sulphide
- Powdery hazardous waste that may cause dust problems in and around the landfill
- Large amounts of waste with very low shear strength that may preclude settlement particularly on the final lifts, near the surface (for example sewage sludge with a high moisture content)
- Waste with high percentages of liquid that may generate too much leachate (for example tankers of liquid waste)

It should be understood that any recommendation of specific acceptable concentration levels of hazardous materials is not viable because of the fairly unregulated manner in which waste enters a landfill and in which a landfill is operated. The wastes mentioned above are permissible on the landfill site but in amounts which are not potentially harmful. In this regard, it will be necessary for a Hazard Rating System, perhaps according to the United States EPA's methodology, to be drawn up. The South African Minimum Requirements series could also act as an excellent guideline.

Wastes, which should, under no circumstances, be allowed onto the site in any form, are:

- Strong Acids and Alkalis (these should be diluted to a pH of 8-9)
- PCB's
- Explosive materials
- Compressed gases
- Radioactive material.

As per RSA Minimum Requirements Class 7, Radioactive wastes, are covered by the Atomic Energy Act, 1967, (Act 90 of 1967) and the Hazardous Substances Act, 1973 (Act 15 of 1973); their disposal in a landfill is PROHIBITED.

Only those radioactive wastes defined as "inactive", i.e., with a specific activity less than 100 becquerels per g (Bq/g) and total activity less than 4 kBq (0.1uCi), may be disposed as waste in terms of the RSA regulations. Becquerel is a measurement of decay and measures all radioactivity (alpha, beta and gamma rays) of a waste body.

In terms of Rossing's procedures on disposal of contaminated items, JK65/PRD/003, no contaminated waste shall be disposed or dumped on the domestic waste disposal site (Landfill Site). This would then include items such as radioactive waste. As stated this procedure deals with the redundant items that are contaminated and are to be disposed of at the Tailings Impoundment according to the following contamination criteria;

Total of fixed and non-fixed radioactivity	> 0.4 Bq/cm^2 (averaged over 300 cm^2)	Tailings Impoundment

The latter would then be in line with the RSA Dept Minerals and Energy (Radioactive waste management policy(draft)) to dispose of such waste in deep impoundments or deep earth burial and covering.

In summary therefore:

- contaminated waste less than 100 becquerels per g (Bq/g) and total activity less than 4 kBq (0.1uCi), may be disposed as waste in a hazardous waste landfill..
- contaminated waste more than 100 becquerels per g (Bq/g) or > 0.4 Bq/cm2 (averaged over 300 cm2) will have to be disposed in the tailings impoundment for now and as such cannot be disposed in any landfill.

APPENDIX E

Water Balance Calculations

Climatic Water Balance			
[name]		Lat	
Station		Long	
Elevation m		MAP 30 mm	

Six months		Site classification	
(Ranked Wettest)	Precipitation	Evaporation	B+/-
Period			

For the wettest years the site is considered "dry". No significant leachate is expected to occur and the site is classified as B^-.

APPENDIX F

Environmental Evaluation

Appendix F

ENVIRONMENTAL EVALUATION

Summary of Impacts and mitigation

Recommendations listed below incorporate the management actions identified in this report. The aim is to mitigate potential negative impacts arising from the construction and operational phases and, where possible, optimise the benefits. The management and monitoring plan that will follow on from this report, will take these recommendations further by adding specific actions and suggested targets and guidelines for their implementation.

	Impact during Planning			
	IMPACT	**ASSESSMENT WITHOUT MITIGATION**	**ASSESSMENT WITH MITIGATION**	**DISCUSSION**
	Expectations	Impact is very low	No impact	Community participation is required
	Community attitudes and concerns	Impact is very low	No impact	Site is approved by Stakeholders. Community must be informed
	Limitations resulting from topographical and geo-technical conditions	Impact is moderate	No impact	Slopes, flow paths and barrier systems can be addressed during planning
	Limitations resulting from health issues	Impact is low	No impact	Environmental health can partially be addressed during planning.
	Fauna, Flora and Habitats	Impact is very low	Impact is very low	Habitat has been disturbed

Impact during Construction				
	IMPACT ON LAND			
	Change to landform	Impact is low	Impact remains low	Excavations will alter the landform temporarily during construction.
	Soil contamination by oil, fuel, etc.	Impact is very low	No impact	Preventative measures to be provided.
	Landscape disfigurement as a result of cut and fills	Impact is low	Impact is low	Final landform to be aesthetically pleasing and environmentally sound
	Alteration & compaction of original soil	Impact is very low	No impact	Compacted soil to be ripped and fertility improved
	Increased rate of erosion	Impact is very low	No impact	Preventative measures to be provided.
	IMPACT ON WATER			
	Change to drainage system	Impact is very low	No impact	Engineered drainage courses will blend in with surrounding system.
	Surface water contamination	Impact is very low	No impact	Preventative measures to be taken.
	Possible ground water contamination	Impact is very low	No impact	Preventative measures to be taken.
	Change to subsurface water movement	No impact	No impact	Impact if any to be addressed during planning
	IMPACT ON AIR			
	Air pollution due to dust, smoke and odours	Impact is very low	No impact	The impact is during construction and operations. No people stay in the area. The impact is thus negligible.

	IMPACT	**ASSESSMENT WITHOUT MITIGATION**	**ASSESSMENT WITH MITIGATION**	**DISCUSSION**
	Air and noise pollution from vehicle operation	Impact is very low	No impact	Few people stay in the area. The impact is negligible.
	IMPACT ON BIOLOGICAL SYSTEMS			

	Destruction wildlife habitat	No impact	No impact	Vegetation will be re-established where present
	Loss of cover	No impact	No impact	Impact is temporary
	Invader plant introduction	No impact	No impact	Impact is temporary
	IMPACT ON SOCIO-ECONOMIC ENVIRONMENT			
	Perceptions	No impact	No impact	Set up participation programme where required
	Increased traffic and potential for accidents	Very low impact	Very low impact	Provide temporary access or deviations
	Noise and vibrations	No impact	No impact	Impact is short term. No people live close to the site.
	Visual impact	No impact	No impact	Short term. No people live close by.
	Influx of temporary workers	No impact	No impact	Employ local labour

IMPACT DURING OPERATIONAL PHASE				
THE BIO-PHYSICAL ENVIRONMENT				
	Pollution of ground and surface water	Very low impact	Very low impact	Monitoring must take place
	Incidences of veld fires	No impact	No impact	Barren surroundings will prevent veld fires
	Siltation of streams due to exposed surfaces	Very low impact	Very low impact	No streams nearby
SOCIO-ECONOMIC ENVIRONMENT				
	Visual impact	No impact	No impact	Visual impact will be limited to litter blown from the site.
	Roadside littering	No impact	No impact	Minimise windblown materials from vehicles.
	Accidents due to increased traffic	No impact	No impact	Volume of waste is small and access road to be improved
	Job creation	No impact	No impact	Recruit local labour as far as possible especially on recycling of materials
	Level of service provision to surrounding communities	No impact	No impact	Existing service to be continuously improved. No mitigation will be required
	Land use conflicts	No impact	No impact	After-use will return land to original use. Inform communities
	Conflicts between vehicle, pedestrian & bicycle traffic	No impact	No impact	Design of access road to eliminate conflict.
	Odours due to bad operational practices	No impact	No impact	Monitor operations through community participation
	Fires	No impact	No impact	Enforce appropriate management practices.
	Health hazards to litter pickers on the landfill	No impact	No impact	Enforce access control.

	Danger to health & safety of workers, children & animals.	No impact	No impact	Enforce access control.

Recommendations relating to Construction and Operation

- In order to prevent habitat destruction, the area of construction and operation should be confined to the smallest possible space and well-defined access roads established.

- To prevent unauthorised access, a security fence with a lockable gate must be erected around the operating area of the site, and general mine security staff to be aware of the need to secure the site.

- Waste material should be separated at source, thereby facilitating the effective management of lightweight materials at the landfill site.

- Implement management actions to mitigate the visual impact of windblown materials carried from the proposed waste disposal site, including daily cover of the waste, the use of moveable litter screens and regular clean-ups in and around the site.

- Implement management actions to mitigate odours generated by waste materials, such as daily cover and not disposing of waste under wet conditions.

- Implement management actions to reduce occupational health and safety risks at the waste disposal site, including the provision and use of the required personal protective equipment and improvements to the current emergency response plan.

- Manage and control vectors of disease through compaction and application of daily cover.

- Regularly monitor the new system to ensure that it is working efficiently.

APPENDIX G

Environmental Management Plan

Appendix G

SITE WATER MANAGEMENT PROGRAMME

Due to the geology and topography of the site and the stated High Risks the site exhibits towards surface water and ground water sources the following site water management programme is recommended.

Surface water (where found to be present) and groundwater monitoring needs to be carried out in terms of quality assessment and frequency of analysis on the following basis:

a – annually
s - six monthly or bi-annually

Determinant	**Surface water / Groundwater (if present)**			
pH	s		s	
Electrical Conductivity (EC)	s		s	
Chemical Oxygen Demand (COD)	s		s	
Ammonia (NH_3 – N)	s		s	
Alkalinity (Total Alkalinity)	s		s	
Chloride		s		s
Nitrate (NO_3 – N)		s		s
Potassium (K)	s		s	
Alkali earth metals (Na)		s		s
Total Dissolved Solids (TDS)	s		s	
Fluoride (F)	a		a	
Magnesium (Mg)		a		a
Calcium (Ca)	a		a	
Sodium (Na)	a		a	
Sulphate (SO_4)	a		a	
Heavy metals (Zn,Ni,Cd,Cu,Cr,Pb,As)	a		a	

In addition other determinands to be monitored dependent upon regulations in force.

BASELINE INFORMATION ON WATER QUALITY

Chemical analyses of ground water samples collected during the site investigation in [*date*]

Groundwater

The groundwater sample obtained from borehole **LF 2** was subjected to the performance of chemical electro- chemical and contamination tests for the determination of:

- **pH**
- **Conductivity**
- **Total Dissolved Solids (TDS)**
- **Suspended Solids (SS)**
- **Sodium (Na)**
- **Potassium (K)**
- **Calcium (Ca)**
- **Iron (Fe)**
- **Chloride (Cl)**
- **Sulphate (SO_4)**
- **Nitrate (as NO_3-N)**
- **Ammonia (as NH_3-N)**
- **Total alkalinity (as $CaCO_3$)**
- **Chemical Oxygen Demand (COD)**

The results of these tests are presented in **Table I.**

Table I - CHEMICAL ANALYSIS OF GROUND WATER TAKEN FROM THE GENERAL HOUSEHOLD WASTE LANDFILL SITE

PARAMETER	SAMPLE (LF2)	SAMPLE
pH		
Conductivity (mS/m)		
Total Dissolved Solids (SS) mg/l		
Sodium (Na) mg/l		
Potassium (K) mg/l		
Calcium (Ca) mg/l		
Sulphate (SO_4) mg/l		
Total Harness (as $CaCO_3$)		
Total Alkalinity (as $CaCO_3$)		
Chloride (Cl) mg/l		
Chemical Oxygen Demand (COD) mg/l		
Nitrate (NO3 – N) mg/ℓ		
Magnesium mg/ℓ		
Fluoride (F) mg/ℓ		
Cadmium (Cd) mg/ℓ		
Chromium (total) mg/ℓ		
Lead (Pb- total) mg/ℓ		
Manganese (Mn) mg/ℓ		
Mercury (Hg) mg/ℓ		
Chromium $^{6+}$ (Cr^{6+}) mg/ℓ		
Cyanide (Cn) mg/ℓ		
Nickel (Ni) mg/ℓ		
Boron (B) mg/ℓ		
Silica (SiO2) mg/ℓ		
Phenols mg/ℓ		
SAR meg/ℓ		
Total Coliforms (TC counts/100ml)		
Faecal Coliforms (FC counts/100ml)		

Notes on finding:

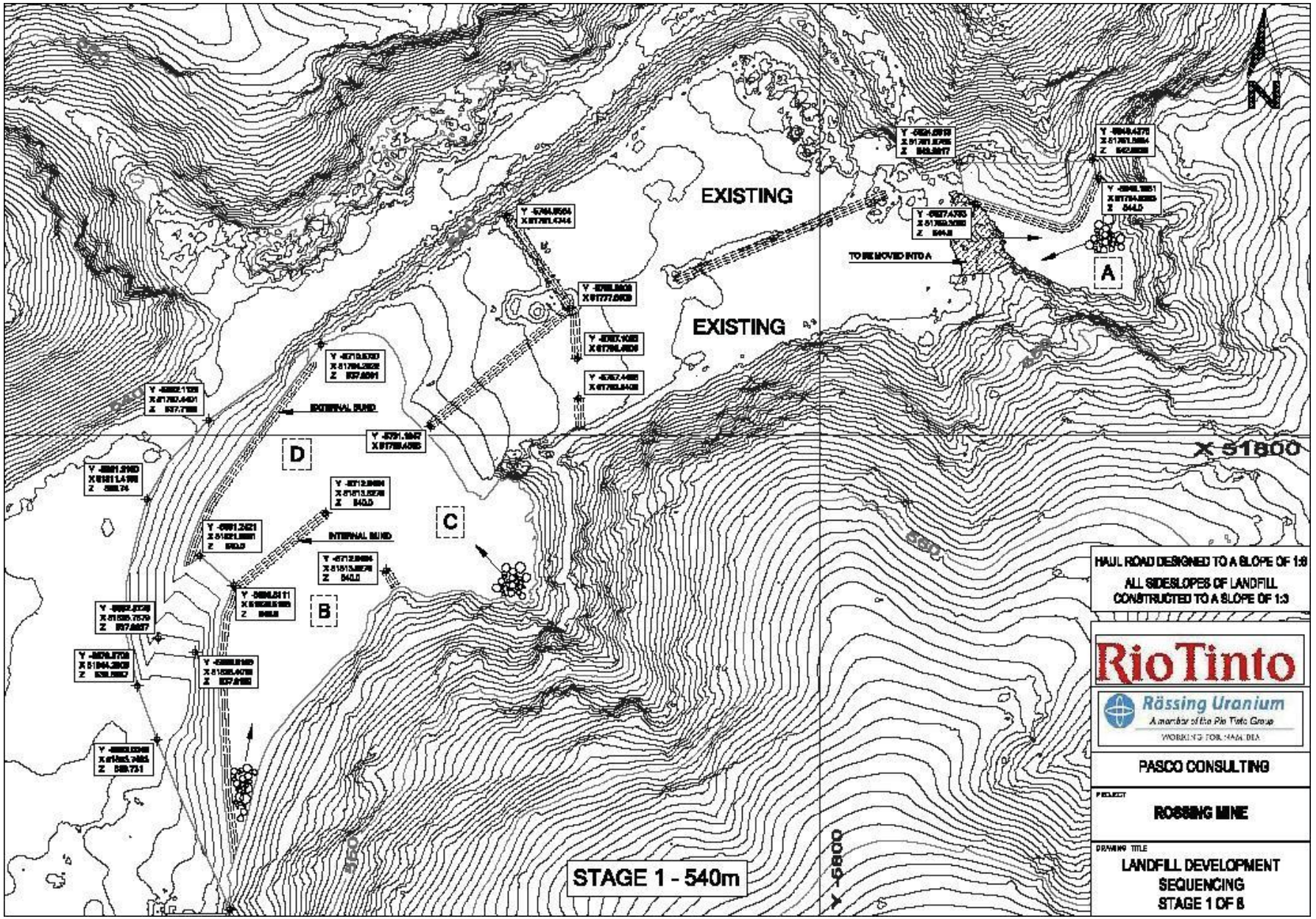
The water from the boreholes should not be used for consumption purposes on site.

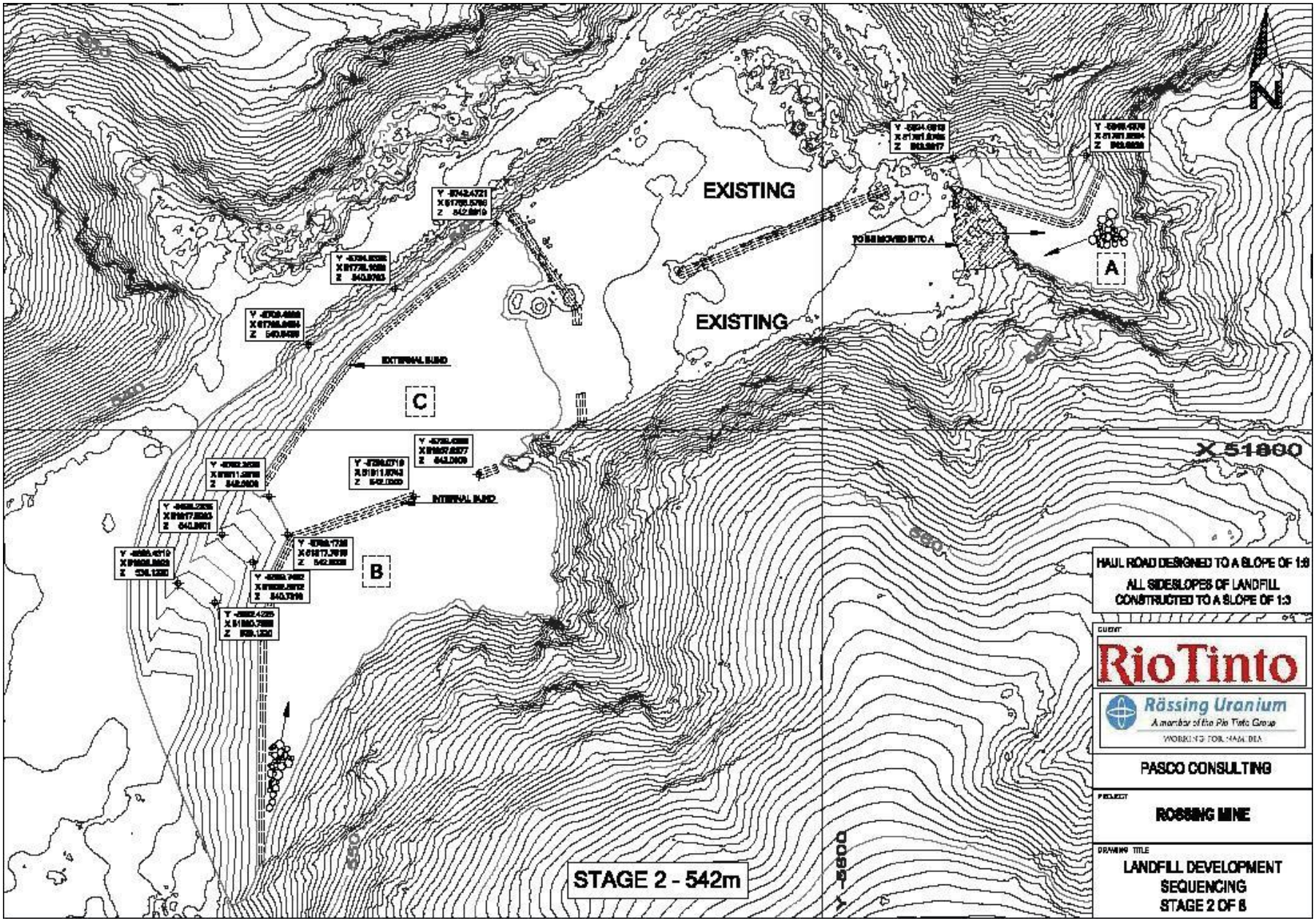
APPENDIX H

Equipment Operating and Maintenance Manuals

APPENDIX I

Landfill development plans


N
EXISTING
EXISTING
TO BE MOVED INTO A
A
INTERNAL BUND
D
C
INTERNAL BUND
B
X 51800
HAUL ROAD DESIGNED TO A SLOPE OF 1:8
ALL SIDESLOPES OF LANDFILL CONSTRUCTED TO A SLOPE OF 1:3
RioTinto
Rössing Uranium
A member of the Rio Tinto Group
PASCO CONSULTING
PROJECT
ROSSING MINE
DRAWING TITLE
LANDFILL DEVELOPMENT SEQUENCING STAGE 1 OF 8
STAGE 1 - 540m
Y 6800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INTERNAL BUND
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Y 15800
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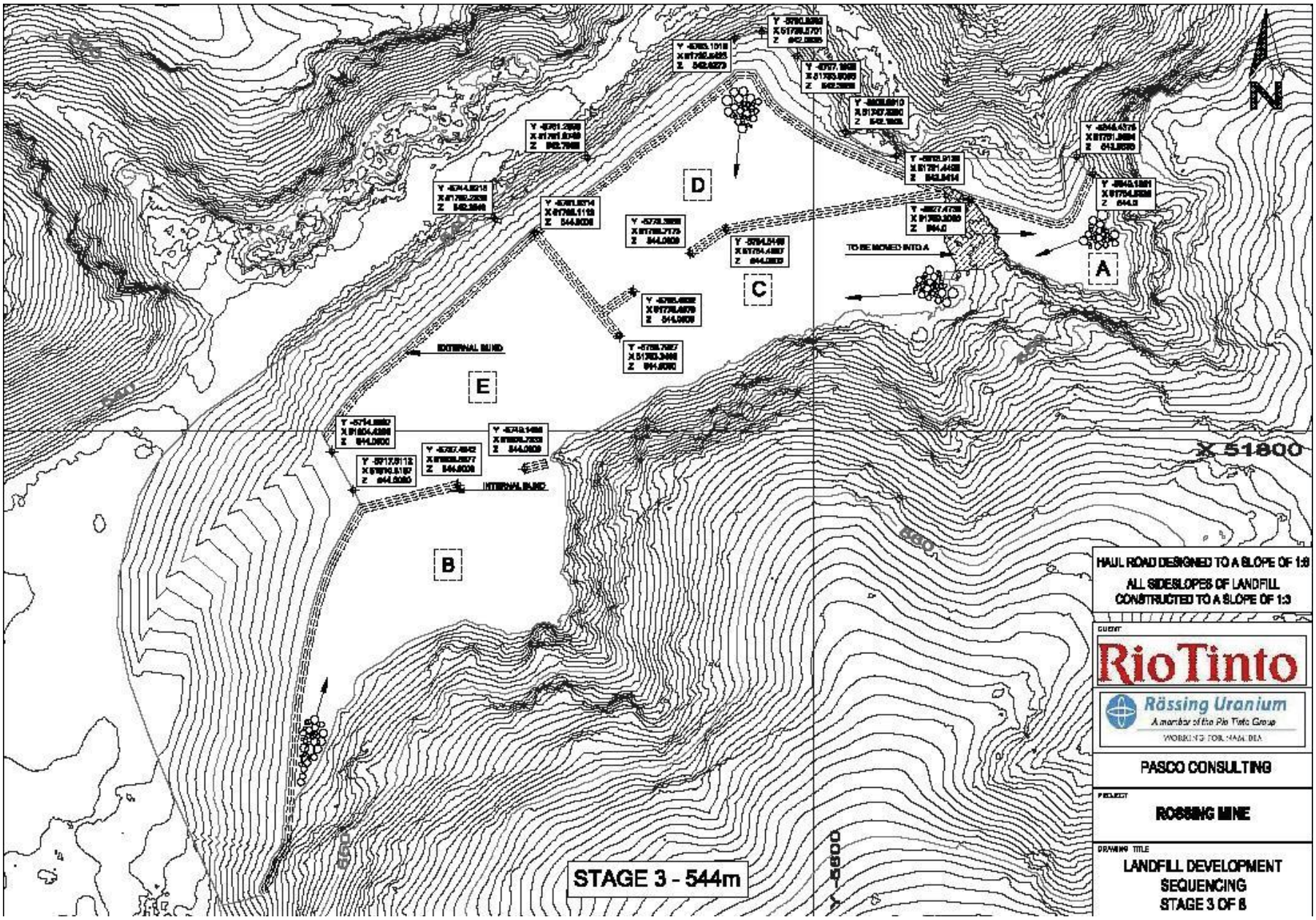
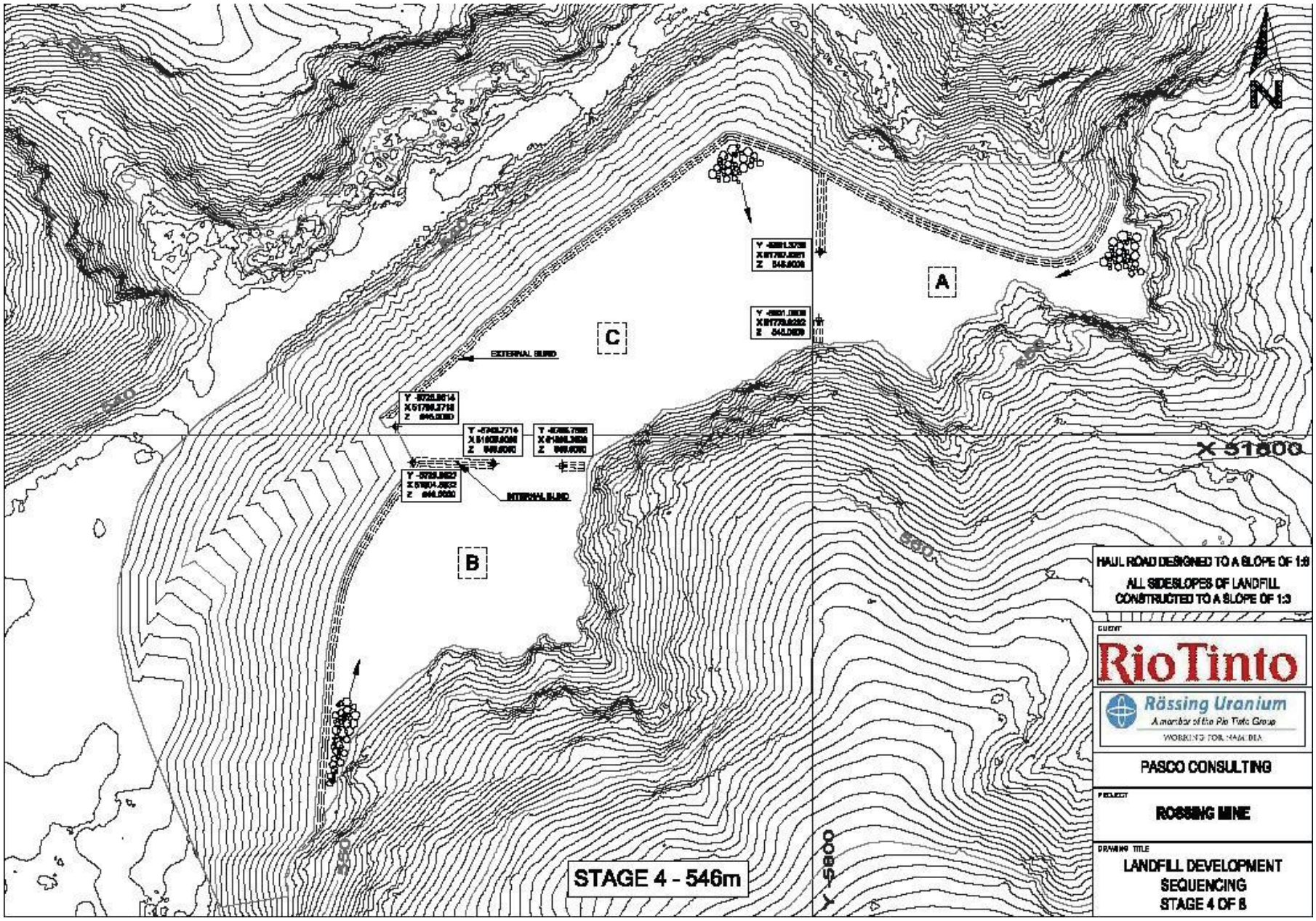
5300
5250
N
HAUL ROAD DESIGNED TO A SLOPE OF 1:9
ALL SIDESLOPES OF LANDFILL
CONSTRUCTED TO A SLOPE OF 1:3
CLIENT
RioTinto
Rössing Uranium
A member of the Rio Tinto Group
WORKING FOR NAMIBIA
PASCO CONSULTING
PROJECT
ROSSING MINE
DRAWING TITLE
LANDFILL DEVELOPMENT
SEQUENCING
STAGE 2 OF 8
STAGE 2 - 542m


N
A
B
C
D
E
TO BE MOVED INTO A
EXTERNAL BUND
INTERNAL BUND
X 51800
Y 5800
5850
5900
HAUL ROAD DESIGNED TO A SLOPE OF 1:8
ALL SIDESLOPES OF LANDFILL CONSTRUCTED TO A SLOPE OF 1:3
RioTinto
Rössing Uranium
A member of the Rio Tinto Group
PASCO CONSULTING
ROSSING MINE
LANDFILL DEVELOPMENT SEQUENCING STAGE 3 OF 8
STAGE 3 - 544m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A
B
C
EXTERNAL BUND
INTERNAL BUND
X 51800
Y 5800
HAUL ROAD DESIGNED TO A SLOPE OF 1:8
ALL SIDESLOPES OF LANDFILL CONSTRUCTED TO A SLOPE OF 1:3
CLIENT
RioTinto
Rössing Uranium
A member of the Rio Tinto Group
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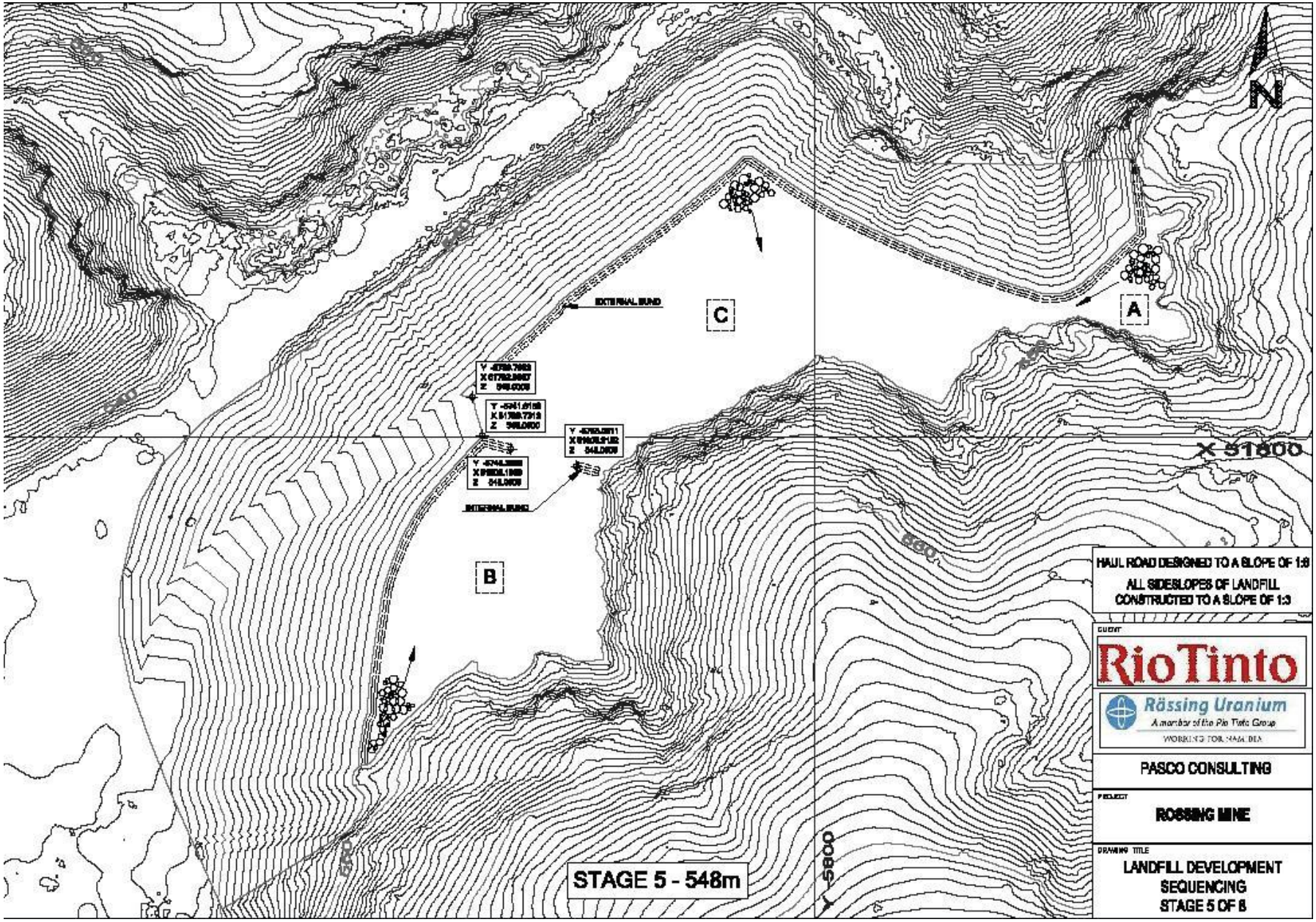
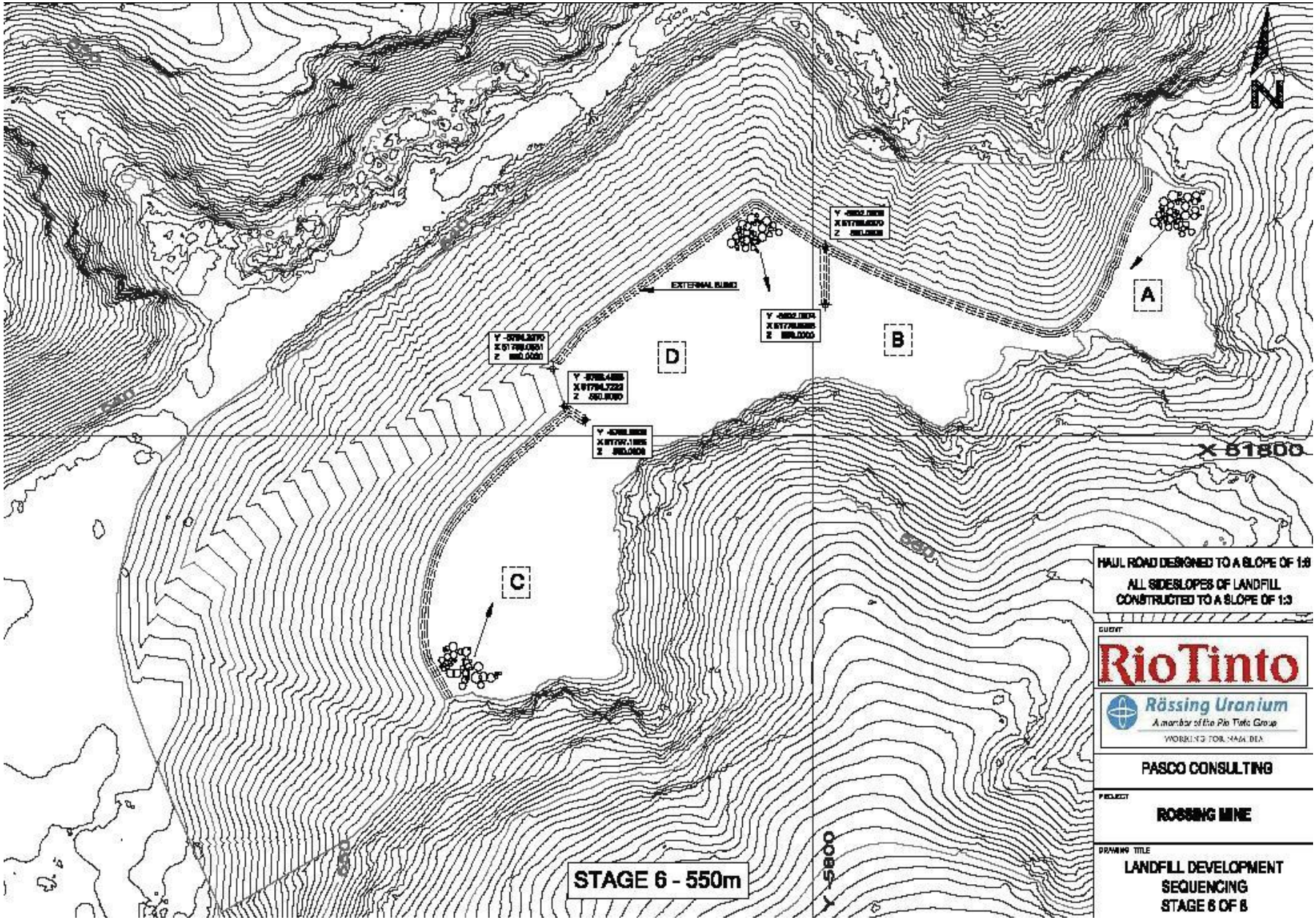
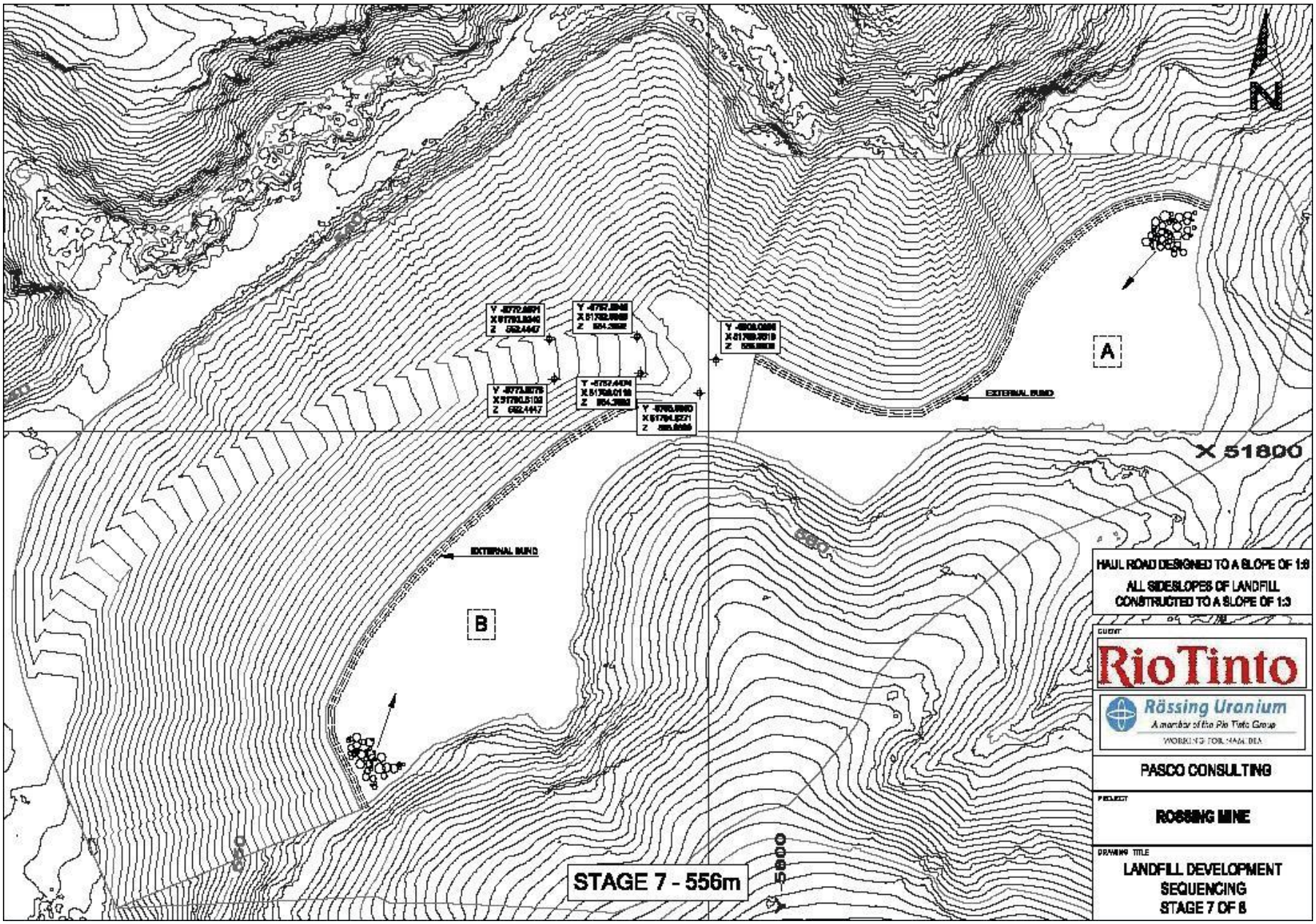
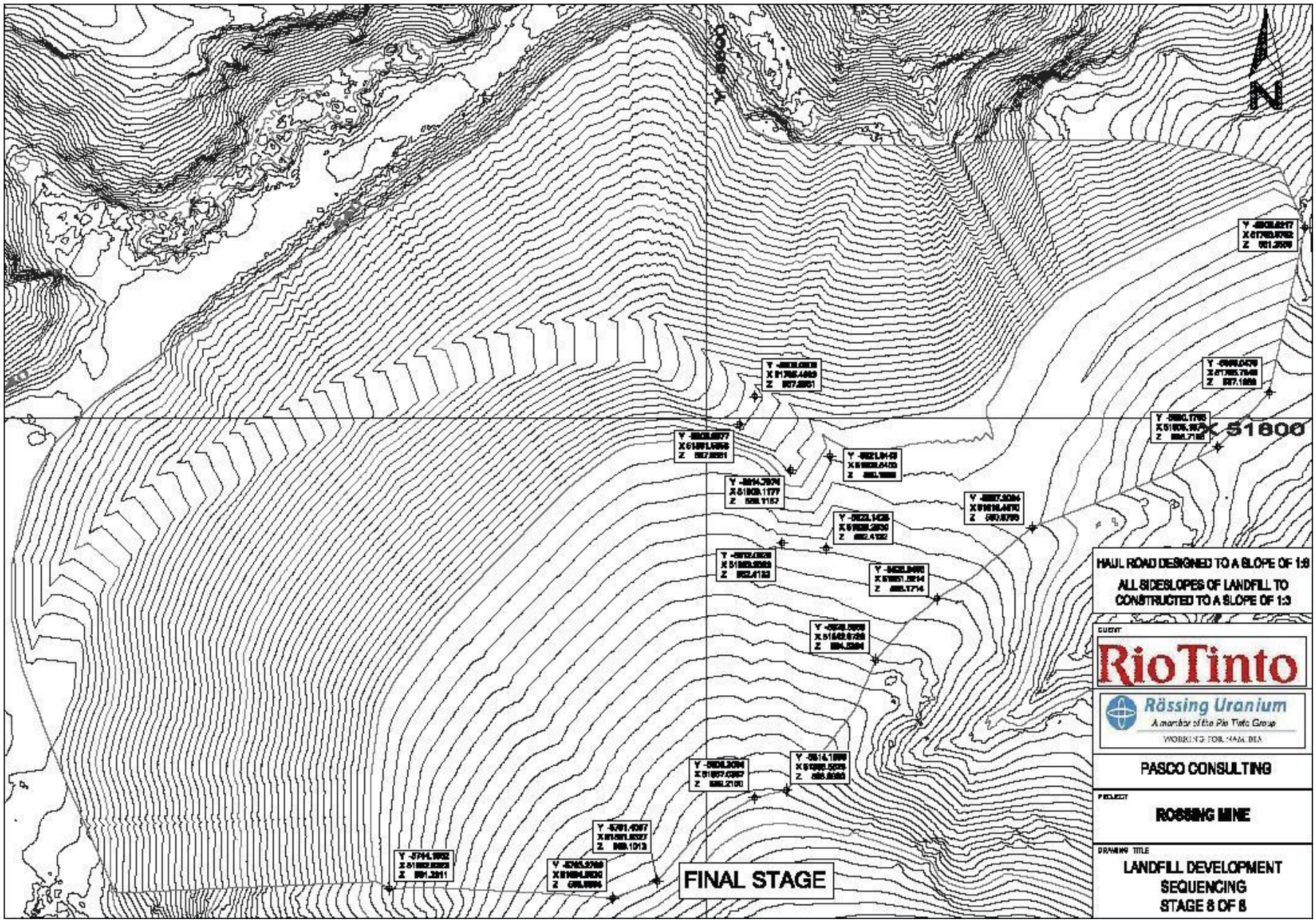
PASCO CONSULTING
PROJECT
ROSSING MINE
DRAWING TITLE
LANDFILL DEVELOPMENT SEQUENCING STAGE 4 OF 8
STAGE 4 - 546m


N
A
B
C
EXTERNAL BUND
INTERNAL BUND
X 51800
5900
5850
5800
HAUL ROAD DESIGNED TO A SLOPE OF 1:8
ALL SIDESLOPES OF LANDFILL CONSTRUCTED TO A SLOPE OF 1:3
CLIENT
RioTinto
Rössing Uranium
A member of the Rio Tinto Group
WORKING FOR NAMIBIA
PASCO CONSULTING
PROJECT
ROSSING MINE
DRAWING TITLE
LANDFILL DEVELOPMENT SEQUENCING
STAGE 5 OF 8
STAGE 5 - 548m


N
A
B
C
D
EXTERNAL BUND
X 61800
Y 5800
STAGE 6 - 550m
HAUL ROAD DESIGNED TO A SLOPE OF 1:9
ALL SIDESLOPES OF LANDFILL CONSTRUCTED TO A SLOPE OF 1:3
CLIENT
RioTinto
Rössing Uranium
A member of the Rio Tinto Group
WORKING FOR NAMIBIA
PASCO CONSULTING
PROJECT
ROSSING MINE
DRAWING TITLE
LANDFILL DEVELOPMENT SEQUENCING STAGE 6 OF 8


N
A
B
EXTERNAL BUND
EXTERNAL BUND
X 51800
STAGE 7 - 556m
HAUL ROAD DESIGNED TO A SLOPE OF 1:9
ALL SIDESLOPES OF LANDFILL
CONSTRUCTED TO A SLOPE OF 1:3
CLIENT
RioTinto
Rössing Uranium
A member of the Rio Tinto Group
PASCO CONSULTING
PROJECT
ROSSING MINE
DRAWING TITLE
LANDFILL DEVELOPMENT
SEQUENCING
STAGE 7 OF 8


N
X 51800
HAUL ROAD DESIGNED TO A SLOPE OF 1:8
ALL SIDESLOPES OF LANDFILL TO CONSTRUCTED TO A SLOPE OF 1:3
RioTinto
Rössing Uranium
A member of the Rio Tinto Group
PASCO CONSULTING
ROSSING MINE
LANDFILL DEVELOPMENT SEQUENCING STAGE 8 OF 8
FINAL STAGE

APPENDIX J

As Built Drawings