Zitholele Consulting

Reg. No. 2000/000392/07

PO Box 6002 Halfway House 1685
South Africa
Building 1, Maxwell Office Park,
Magwa Crescent West,
cnr Allandale Road & Maxwell Drive,
Waterfall City, Midrand
Tel + (27) 11 207 2060
Fax + (27) 86 674 6121
E-mail : mail@zitholele.co.za

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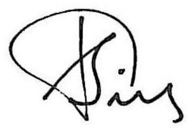
Approved	Project Director	S Pillay	02-09-2014	

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20-09-2012	1	N Rajasakran	Liner system revised. O&M info added.
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cnr Allandale Road & Maxwell Drive,
Waterfall City, Midrand
Tel + (27) 11 207 2060
Fax + (27) 86 674 6121
E-mail : mail@zitholele.co.za

CONCEPTUAL ENGINEERING DESIGN REPORT FOR THE EXTENSION OF THE ASH DISPOSAL FACILITY AT CAMDEN POWER STATION

Report No : 12670-REP-ENG-001-Conceptual Engineering Design Report

Submitted to:

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02 September 2014 12670

EXECUTIVE SUMMARY

The Camden Power Station is located approximately 15 km to South East of the town of Ermelo in the Mpumalanga province and has a production capacity of 1,600 MW. The first of its eight units was commissioned in 1967. Half of the station was mothballed in 1988 with the rest of the station following suit in 1990. Increase in the demand for electricity lead to a decision being taken in 2003 to re-commission the Camden Power Station. The first unit was re-commissioned in 2005. The existing Ash Disposal Facility (ADF) was adequate at that stage for future operation of the plant.

It was later estimated in an Eskom Report, Number 474-9565 dated March 2013, that the end of life of the existing ADF will be December 2016.

In June 2011 Eskom appointed Zitholele Consulting to conduct the EIA for the extension of the ADF at the Camden Power Station. This conceptual engineering report was undertaken to underpin the Environmental application. Three alternate sites were looked at during the EIA process which was evaluated at an engineering level.

The scope of work for the conceptual designs entailed the following:

- Spatial modelling to determine the footprint.
- Design and layout of a leachate/drainage system.
- Design of surface/stormwater diversion/collection systems.
- Liner design, including a leak detection system.
- Design of ash water return dam (AWRD).
- Layout for return water system.
- Layout of access roads.

The Phase I Geotechnical evaluation of the site revealed that Site 2 was not feasible due to the following site characteristics:

- It falls within the headwaters of a stream.
- Shallow groundwater seepage.
- Located on the geological contact between the dolerite and host sedimentary rocks. Fractures and joints are associated with this area.

The remaining sites were further evaluated. However, Site 3 was divided into two sites, 3A and 3B due to its topography and the watershed dividing the site equally. Conceptual designs were undertaken on these three sites.

The earthworks modelling of the site revealed that Site 1 is adequate for ash storage and is able to accommodate the entire 17 years production with a height restriction of 40 metres. Sites 3A and B could not achieve this individually and must be combined if this is to be achieved.

Sites 3A and B do not individually accommodate the ash production over the 17 years operation period and therefore cannot be compared directly to the cost of Site 1. However Sites 3A and 3B combined (Net Present Value Cost of R2.409 billion) can be compared directly with Site 1 (Net Present Value Cost of R1.972 billion) with regards to total lifecycle cost.

Site 1 is the preferred site as it can accommodate the full ash production for the 17 years ash production keeping within the 40 metres allowable height. The shape of the ADF will also facilitate the ease of operations. The combination of Sites 3A and 3B may be looked at only as a back-up to Site 1.

A Class C barrier is required in terms of the Waste Classification report. This liner system calls for a 300mm clay layer, as well as other layers (see Section 6.5.1). Testing will be conducted in August 2014 on the ADF footprint on Site 1 to determine the permeability of the in situ soils. If the permeability is less than 10^{-5}cm per second, then the in situ soils may be used instead of the 300mm thick clay layer, however the1.5mm thick HDPE liner must be increased to 2mm thick. Importation of clay is possible, however, may not be economically viable.

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LIST OF ACROYNYMS

ADF	Ash Disposal Facility
AWRD	Ash Water Return Dam
AWRR	Ash Water Return Reservoir
C-value or C_1	Run-off coefficient
CSY	Coal Stock Yard
DJP	De Jagers Pan
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
NB	Nominal Bore
NPV	Net Present Value
OHS	Occupational Health and Safety
PCD	Pollution Control Dam
RO	Reverse Osmosis
RP	Return Period
SANRAL	South African National Roads Agency Limited
SAR	South African Railways
WUL	Water Use Licence
WULA	Water Use Licence Application

DEFINITIONS

LIDAR	A remote sensing technology that measures distance by illuminating a target with a laser and analysing the reflected light

1 INTRODUCTION AND BACKGROUND

The Camden Power Station is located approximately 15 km to South East of the town of Ermelo in the Mpumalanga province and has a production capacity of 1,600 MW. The first of its eight units was commissioned in 1967.

Half of the station was mothballed in 1988 with the rest of the station following suit in 1990. Increase in the demand for electricity lead to a decision being taken in 2003 to re-commission the Camden Power Station. The first unit was re-commissioned in 2005.

As part of the re-commissioning process, Eskom commissioned a study to verify the stability of the existing ash facility to cope with the increase in ash production and disposal. The investigations concluded that the existing facility was suitable for re-commissioning. It was later estimated in an Eskom Report, Number 474-9565 dated March 2013, that the end of life of the existing ADF will be December 2016. The reduction in the life span of the existing ash disposal facility is due to the expected poor quality of coal supplied to station and hence the increase in the ash content. Further recent consultation with the operational staff at Camden Power Station indicated that the new ADF (Ash Disposal Facility) will be required from January 2017. This was the adopted in the design of the facility.

In June 2011 Eskom appointed Zitholele Consulting to conduct the EIA for the extension of the ADF at the Camden Power Station. This report documents the conceptual engineering design of the new facility to support the EIA application.

The scope of work for the conceptual designs will entail the following:

- Spatial modelling to determine the footprint.
- Design and layout of a leachate/drainage system.
- Design of surface/stormwater diversion/collection systems.
- Liner design, including a leak detection system.
- Design of ash water return dam (AWRD).
- Layout for return water system.
- Layout of access roads.

The current ADF is operated safely and therefore it is anticipated that the current method of operations will be retained. In the project initiation stage the design team met with the operational staff of the Power Station and established the following amongst others:

- The method of ash disposal, including method of mixing (i.e. is the slurry a combination of coarse and fly ash or are they pumped separately),

- The ratio of ash to water (consistency of slurry),
- Slurry density,
- Method of deposition, including number of discharge points,
- Number of compartments operated,
- Method of day wall construction,
- Preferred method of decant (i.e. via decant penstocks or barge pumps),
- Safe angle for the outer slope,
- Starter wall heights and slopes and
- Preferred rate of rise (m/year).

There is currently an existing AWRD as well as a natural pan (De Jagers Pan) being used as an AWRD. A new AWRD is proposed to comply with the latest legislation.

2 WASTE CLASSIFICATION

A classification of the ash produced at the Camden Power Station was undertaken by Jones and Wagener (Report No.: JW164/11/D116-Rev 5) in February 2014. Reference: Appendix A: Waste Classification Report.

3 BASIS OF DESIGN

3.1 Assumptions and Limitations

The following assumptions were made in developing the conceptual design:

- The remaining life of the power station for the New ADF was taken as 2017 to 2033.
- The existing method of mixing, transporting and placing of ash would be retained.
- The sizing of the new AWRD was based on the water balance.
- The use of De Jagers Pan as an AWRD is unacceptable under current legislation and hence a new AWRD is required.
- None of the options have taken into account the requirements for the closure of the existing ADF.
- As the current facility is operated safely operating methods are to be retained, it was assumed that for the conceptual designs no stability analysis or material testing is required.

- The requirements for clean and dirty water systems stipulated in Regulation 704 (Section 6) and Regulation 1560 of the National Water Act will be adhered to.
- The quality of the ash and hence the water to ash ratio will not change from what is currently being placed on the existing ADF.

3.2 Coal and Ash Characteristics

Based on previous studies on the existing ADF and literature the following coal and ash characteristics and design criteria were confirmed by Eskom:

Table 1: Coal and Ash Characteristics

Parameter	Unit	Value
Total coal burnt per year	Tonnes/year	5 400 000
Design moisture content in coal	%	6
Specific Gravity	N/A	2.1
Dry Density	kg/m^3	950
As received Ash Percentage of coal	%	28.4
Slurry Density	kg/m^3	1120
Ash to water ratio	N/A	1:5
Angle of friction	degrees	35

3.3 Grading

The fly ash varies from silty sand to silty clay using a triangular soil classification chart (US corps of Engineers). The grading curve exhibits a uniform particle size distribution. Crushed coarse bottom ash particle sizes ranges between 0.001 mm and 10 mm (Brackley et al, 1987). If not crushed, particles can be larger, possibly up 150 mm. These can be broken up during pumping and transportation.

3.4 Stability

The stability of the residue and embankment walls must be ensured throughout the design life of the facility. No stability analyses were carried out for this study. However based on studies such as Brackley et al (1987) and stability analysis of the existing facility, the ash will be stable with an outer slope of 1:3. This is however dependent on a well-managed pool and drainage system. The ADF will not be rehabilitated by “cut and fill” operations, but will only be rehabilitated by the placing of a 300 mm thick layer of topsoil and the planting of indigenous grasses on top of the ADF.

The compacted earth starter walls with a crest width of 5 m, inner slope of 1:3 and outer operational slope of 1:3 and closure slope of 1:3 is considered stable.

Similarly the anticipated height of 40 m for some of the options must be evaluated as part of the next phase in the Basic Design. A suitable and safe engineered wall and slope geometry must be determined.

The angle of friction of the ash at 20% moisture content and 950 kg/m^3 bulk density (simulating loosely placed Ash Dam conditions) is 35º and zero cohesion (Smith).

Pozzolanic properties of the ash can influence its strength.

3.5 Capacity Requirements

It was later estimated in an Eskom Report, Number 474-9565 dated March 2013, that the end of life of the existing ADF will be December 2016. As the power station is expected to be operational until the year 2033, a new facility would have to be constructed to provide disposal capacity for 19 years. However, looking at the current capacity of the current facility, it was determined by a later study in 2012 that the new facility will only be required from January 2017 until 2033.

The Camden Power Station burns on average 5,400,000 tons of coal annually. The ash content in the coal is taken as 28.4%. The dry density of the ash is taken as 950 kg/m^3. The table below reflects the ash production for the life of the New ADF. This includes a decommissioning period of 2 units per year over the last 3 years.

Table 2: Ash Production

YEAR	NO OF UNITS OPERATING	TOTAL COAL BURNT	ASH PERCENTAGE (AS RECEIVED)	ASH PRODUCTION (TON)	ASH PRODUCTION (M^3)	CUMULATIVE ASH PRODUCTION (M^3)
2017	8	5 400 000	28.40%	1 533 600	1 614 316	1 614 316
2018	8	5 400 000	28.40%	1 533 600	1 614 316	3 228 632
2019	8	5 400 000	28.40%	1 533 600	1 614 316	4 842 948
2020	8	5 400 000	28.40%	1 533 600	1 614 316	6 457 264
2021	8	5 400 000	28.40%	1 533 600	1 614 316	8 071 580
2022	8	5 400 000	28.40%	1 533 600	1 614 316	9 685 896
2023	8	5 400 000	28.40%	1 533 600	1 614 316	11 300 212
2024	8	5 400 000	28.40%	1 533 600	1 614 316	12 914 528
2025	8	5 400 000	28.40%	1 533 600	1 614 316	14 528 844
2026	8	5 400 000	28.40%	1 533 600	1 614 316	16 143 160
2027	8	5 400 000	28.40%	1 533 600	1 614 316	17 757 476
2028	8	5 400 000	28.40%	1 533 600	1 614 316	19 371 792
2029	8	5 400 000	28.40%	1 533 600	1 614 316	20 986 108
2030	8	5 400 000	28.40%	1 533 600	1 614 316	22 600 424
2031	6	4 050 001	28.40%	1 150 200	1 210 737	23 811 161
2032	4	2 700 000	28.40%	766 800	807 158	24 618 319
2033	2	1 350 000	28.40%	383 400	403 579	25 021 898

3.6 Water Supply for Ash disposal

Water from the existing Ash Water Return Reservoir (AWRR) will be utilised in creating the ash slurry that is required for pumping to the ADF. The water requirement will be the same for the existing operations as it is assumed that the ash production, and disposal thereof, will be the same.

3.7 Permeability

The permeability is largely dependent on the density of the ash on the facility. A value of 11.5 m/year for medium dense ash was assumed. This is the mean of 3 m/y (dense ash) to 20 m/year (loose ash) (Brackley et al, 1987) ($6.34*10^{-7}$ m/sec). This is required for calculating seepage from the pool to the leachate collection system.

3.8 Annual Rate of Rise

A preferred maximum rate of rise of 3.5 m/year (after the starter wall) was assumed for sizing the ADF. This is a manageable rate in terms of operating the facility using a cycled day wall construction method. Also, the 3.5 m/year rate of rise is below the accepted maximum for well drained disposal facilities.

4 SITE SELECTION AND OPTIONS ANALYSIS

4.1 Description of Existing Site Conditions

The site of the existing ADF is situated outside the north western boundary of the power station and covers a total area of 120 hectares.

The study area is in a summer rainfall area with the annual precipitation in the 650 to 900 mm range with January being statistically the highest rainfall month. The monthly averages of minimum daily temperatures vary from 1°C in July to 12°C in January. The monthly averages of maximum daily temperatures vary from 17°C in June and July to 26°C in January. Extreme temperatures of -8°C and 32°C have also been recorded. (Weather Bureau Station Number 04801704)

4.2 Site Selection Process

Four potential sites were identified initially using the following criteria:

- Ability to link into existing ash disposal facilities
- Must be within a 10 km radius from the existing disposal site and its associated facilities
- Had to have a minimum footprint area of 120 hectares

The four (4) sites were identified during a workshop with all relevant stakeholders. These four (4) sites were further evaluated using several "fatal flaw" identification criteria. Of the four sites, one was deemed to be fatally flawed and three were assessed further. This is discussed in detail in the Environmental Scoping Report. The proposed short listed sites are shown on Figure 4-1.

4.2.1 Description of Shortlisted Sites

The three (3) sites chosen above are shown on the attached Site Locality drawing. All three sites are in close proximity to the existing site and are subject to similar site conditions as documented in the previous section.

4.2.2 Site 1

This site is located immediately north of the existing ADF and approximately 2.8 km north-west of the Camden Power Station. Approximately 750 m to the east of the proposed site is the village of Camden. The total area chosen is 272 hectares with the terrain sloping in the northerly direction (away from De Jagers Pan) at 2.6%. Vegetation cover consists of typical Highveld grass. The site is currently not used for any activities.

4.2.3 Site 2

The second site is located approximately 1.2 km south of the Camden power Station and immediately south of the South African Railways (SAR) servitude. Coal stockpiles and water storage facilities are located to the north and northwest of this area. The total area potentially available for development is 291 hectares. Natural drainage over the site is split in the north easterly and south easterly directions at approximately 4%. The site is currently undeveloped and there are no visible farming activities.

The site is situated within the headwaters of a non-perennial north flowing stream that flows into the Witpuntspruit approximately 3 km to the north-east.

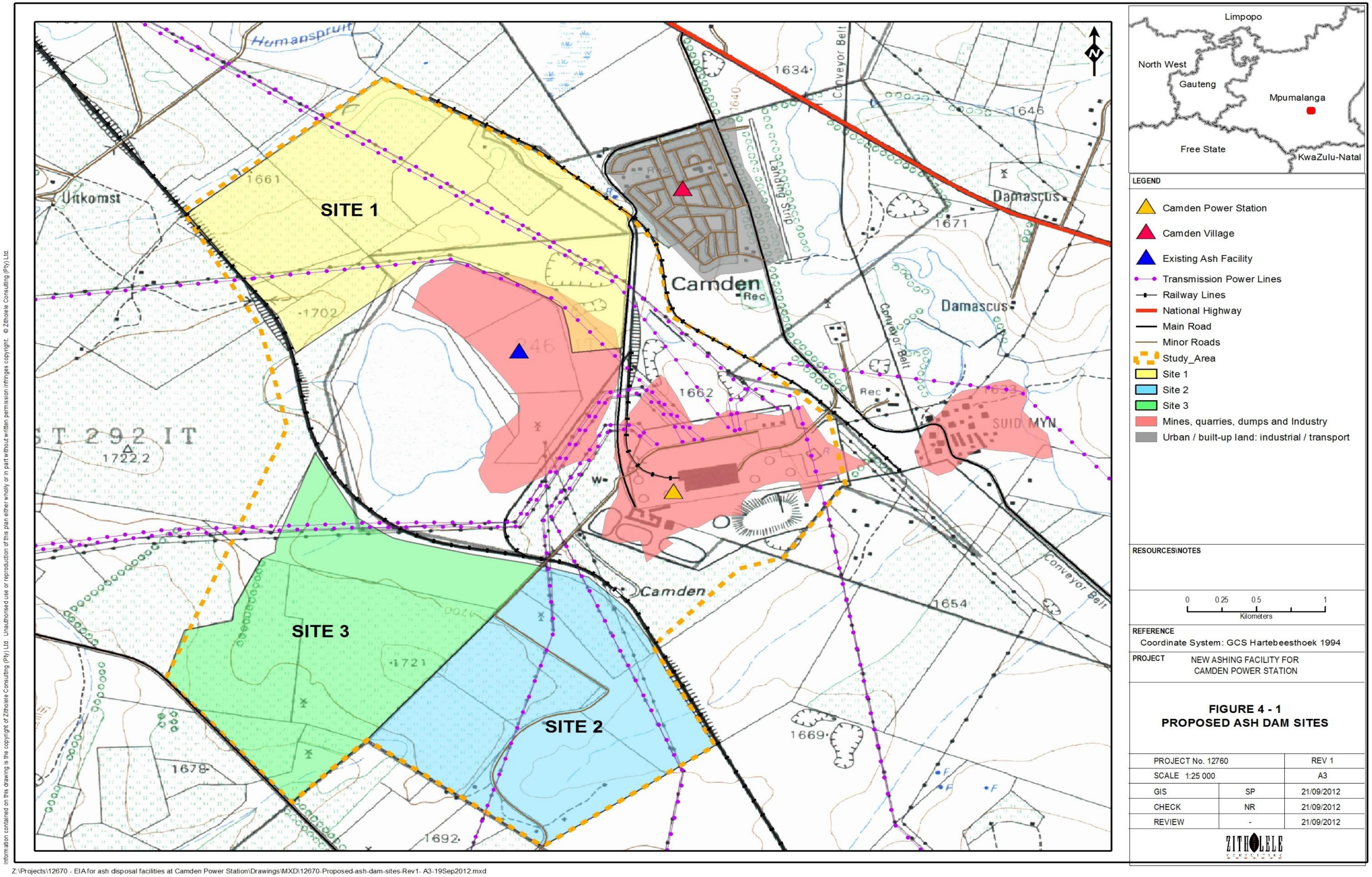

Figure 4-1: Proposed Ash Disposal Sites

4.2.4 Site 3

This site is located immediately south of De Jagers Pan and the SAR servitude, approximately 3 km south west of the Camden Power Station. The total area available for development is 322 hectares. A natural watershed divides the site, sloping in a north easterly direction towards De Jagers Pan and in a south easterly direction away from the Pan at a constant grade of 4%. Some form of agricultural activity is currently taking place at this site.

The eastern side of the site partially encroaches a drainage course of a small north easterly flowing non-perennial stream.

4.3 Engineering Geological Evaluation

An Engineering Geological Evaluation of the shortlisted sites was then commissioned. A report of the investigation and findings is attached as Appendix B.

The objectives of the evaluation were to determine the geotechnical and geological conditions that prevail beneath each of the three shortlisted sites and to provide an assessment of:

- the soil conditions at surface
- the nature and extent of near surface and outcropping strata
- existence of potential fatal flaws
- comment on any geotechnical problems that may impact upon the site selection
- recommendations for mitigation

A brief summary for each site is given below.

4.3.1 Site 1

The entire site appears to be underlain by inter bedded sandstone and siltstone of the Vryheid formation. No evidence of the presence of intruded sills and dykes were identified. Groundwater seepage was not observed on the site and no seepage was recorded in the test pits. The underlying soils consist of a shallow horizon of transported soils to an approximate depth of 500 mm which is overly ferruginised, jointed re-worked residual siltstone. Weathering is expected to extend to a depth of between 3 to 5 m.

4.3.2 Site 2

From the geological information available it is apparent that the site straddles the contact between the host sedimentary formations on the western side and an intruded dolerite sill to the east. The contact between the two geological lithologies is approximately along the perennial stream mentioned above. Due to the emplacement of the igneous material, the contact zone is typically fractured and differential weathering of the rock may result in deep residual soils occurring along the boundary. The underlying soils on the site consist of a shallow horizon transported silty and clayey soils to an approximate depth of between 500 mm and one metre, which is overly ferruginised, jointed re-worked residual siltstone. The depth of weathering is anticipated to extend to a depth of between 3 to 5 m.

Shallow ground water seepage was observed on the northern portion of the site and due to the topographic setting, significant seepage and surface run-off must be expected during periods of high rainfall.

4.3.3 Site 3

The geology of Site 3 is similar to Site 1. (Note that the numbering of the sites in the geotechnical report in Appendix B is not the same as the numbering in this conceptual engineering report) The entire site appears to be underlain by inter bedded sandstone and siltstone of the Vryheid formation. No evidence of the presence of intruded sills and dykes were identified. Groundwater seepage was not observed on the site and no seepage was recorded in the test pits. However, it is likely that the area may be subjected to seasonal seepage. The underlying soils consist of a shallow horizon of transported soils to an approximate depth of 500 mm to 10 000 mm, which is overly ferruginised, jointed re-worked residual siltstone. Weathering is anticipated to extend to a depth of between 3 to 5 m.

4.3.4 Geotechnical recommendations

On the basis of this evaluation, it was derived that Site 2 is not suitable for the intended development and should not be considered for further investigation. This is due to the following site characteristics:

- It falls within the headwaters of a stream
- Shallow groundwater seepage
- Located on the geological contact between the dolerite and host sedimentary rocks. Fractures and joints are associated with this area.

The remaining sites are both considered to be suitable for further evaluation. From a geological and geotechnical perspective, Site 1 is the preferred site.

5 WATER BALANCE

Conceptual engineering is undertaken at this stage to underpin the Environmental Assessments. The following structures have been conceptualised at this stage:

- Ash Disposal Facility (ADF);
- New Ash Water Return Dam (AWRD) and canals to contain the dirty water run-off;

The pollution control dam (PCD) as indicated above will need to be designed in compliance with Government Notice 704. More specifically, Clause 6 (d) of the regulation indicates that:

Design, construct, maintain and operate any dirty water system at the mine or activity so that it is not likely to spill into any clean water system more than once in 50 years.

In order to achieve the above, a continuous daily time step model needs to be set-up to simulate the duration as mentioned in the regulation in order to determine the performance of the proposed stormwater impoundment infrastructure under normal operating conditions. Following the finalisation of the model, the water balance may be derived for the facility once all proposed stormwater infrastructure has been determined.

5.1 Objectives

In order to understand the stormwater management system and the relevance of each of the proposed impoundment and conveyance structures, an integrated water balance needs to be consulted.

This also informs the design of any facility that needs to comply with Government Notice 704. Camden Power Station does not have an integrated water balance therefore a conceptual water balance is being proposed here for the stormwater management system.

5.2 Existing Stormwater Management System

The existing stormwater management is summarised in Figure 5-1 below and is described thereafter**.**

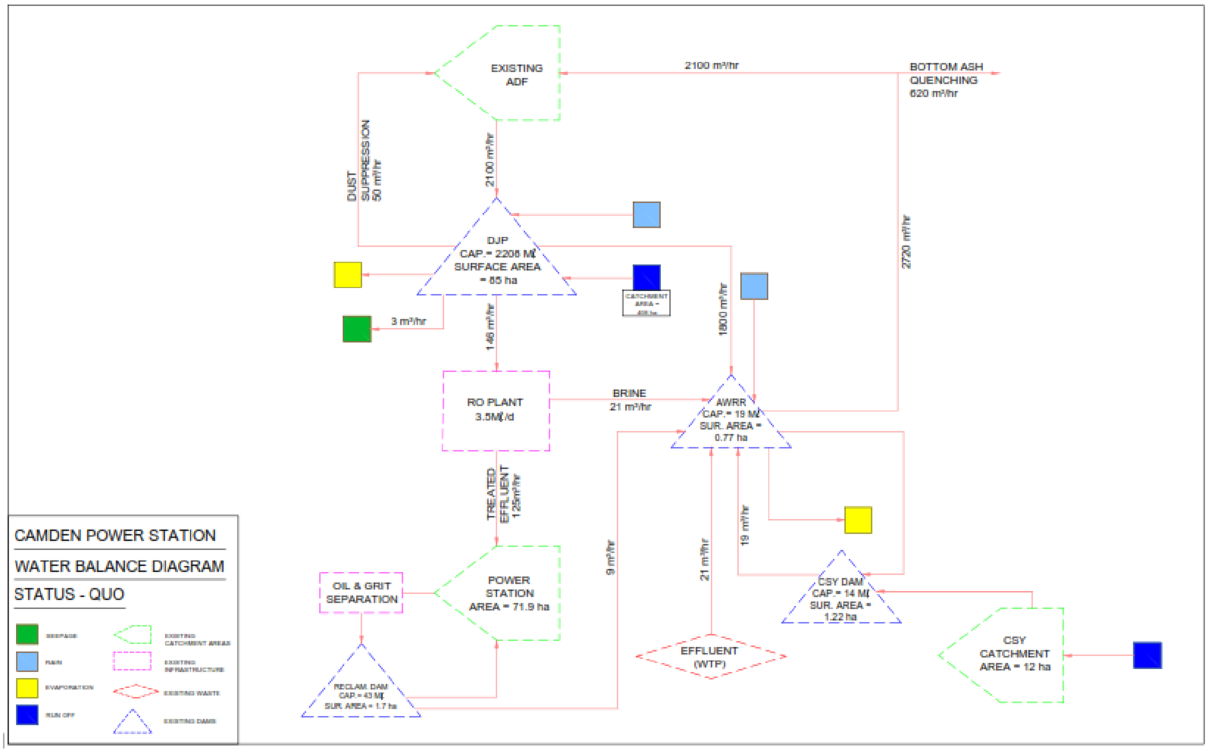

Figure 5-1: Stormwater System Diagram – Status Quo

5.2.1 De Jagers Pan (DJP)

De Jagers Pan (DJP) is a natural formed, low-level AWRD. DJP has a clean catchment area of approximately 408 hectares, including that of the existing ADF catchment. The surface area of DJP is approximately 85 hectares, as reported in the Camden Power Station water balance diagram. The capacity of DJP is 2 208 Mℓ at 2.5 metres.

Run-off from the surrounding catchment area, run-off from the existing ADF and direct rainfall is impounded in DJP. Dust suppression on to the existing ADF is done utilising water from DJP. Ash water is pumped to the AWRR (Ash Water Return Reservoir), located within the power station boundary, to be utilised as slurry water.

Seepage losses of 70 m^3/day from DJP have been taken into account in the water balance model.

5.2.2 Reverse Osmosis (RO) Plant

A RO Plant of 3.5 Mℓ/day capacity is situated at the southern side of the existing ADF. Brine water generated at the RO Plant reports to the AWRR at the power station. Treated water, from the RO Plant, reports to the power station to be utilised in the power station processes.

5.2.3 Ash Water Return Reservoir (AWRR)

The AWRR is a high-level dam within the power station, which acts as an intermediate reservoir to receive water pumped from DJP. The AWRR supplies water by means of gravity feed lines to the sluice water pumping system used to supply water at the correct flow and pressures for ashing and dusting activities.

Brine from the RO Plant, effluent from the Water Treatment Plant and stormwater flows from the Coal Stock Yard (CSY) catchment area report to the AWRR. Water from the Reclamation Dam can be pumped to the AWRR during emergency conditions.

The surface area of the dam is 0.77 hectares and it has a capacity of 19 Mℓ at 2.5 metres.

5.2.4 Power Station Terrace

The power station terrace is predominantly considered to be dirty with most of the impacted water coming from the process drains. The impacted water flows through an oil and grease separation process whereby the oil and grease is skimmed off the surface of the water and disposed of. The water then reports to the Reclamation Dam situated on the eastern side of the power station. During emergency conditions (spillage threats), water will be pumped from the reclamation dams to the AWRR.

5.3 Objectives of Proposed Stormwater Management System

The new system will need to manage the stormwater run-off from the New ADF. All dams proposed on this system will need to be in compliance with GN704. This will entail the following:

- Confine any unpolluted water to a clean water system, away from any dirty area;
- Design, construct, maintain and operate any clean water system so that it is unlikely to spill into any dirty water system more than once in 50 years;
- Collect the water arising within any dirty area, including seepage;
- Design, construct and maintain all stormwater systems in such a manner as to guarantee the serviceability of such conveyances for flows up to and including those arising as a result of the maximum flood with and average period of recurrence on once in 50 years;
- Design, construct, maintain and operate any dirty water system so that it is unlikely to spill into any clean water system more than once in 50 years.

In order to determine the optimum solution for stormwater management around the New ADF to meet the above objectives, the New AWRD must be sized by means of a detailed integrated Water Balance model.

5.4 Modelling Options & Assumptions

A fifty (50) year daily time-step model was built using a Microsoft Excel spreadsheet for the most optimum solution formulated.

5.4.1 Rainfall data

The model takes into consideration daily recorded rainfall closest to the site under investigation. An uninterrupted data set was purchased from the South African Weather Services for a period of 50 years. The rainfall data set consists of data obtained from the Welgelegen station (Station No. 0480170) in Ermelo, Mpumalanga.

Recorded data for Camden Power Station was used for the period between November 2006 and March 2014. The combined data set represents fifty (50) years of recorded rainfall.

The table below gives the statistics of the data set used.

Table 3: Recorded rainfall statistics

Recurrence Interval (1 in)	1 Day Rainfall Depth (De Emigratie)	1 Day Rainfall Depth Range (mm)	No. of Occurrences in Data Set
2	53	50 – 60	27
5	69	61 – 75	11
10	81	76 – 85	2
20	93	86 – 100	2
50	110	101 – 110	1

5.4.2 Operating flows

Table 4: Operating flows used in time-step model

Description of flow	Quality	m^3/hr	m^3/d	Mℓ/a
DJP to RO Plant	Dirty	146	3504	1279
RO Plant to AWRR	Dirty	21	504	184
Effluent from WTP to AWRR	Dirty	21	504	184
Stormwater CSY Dam to AWRR	Dirty	19	456	166
Reclamation Dam to AWRR	Dirty	9	216	79
Flow from AWRR	Dirty	2720	65280	23827
Flow from new AWRD to AWRR	Dirty	2100	50400	18396

5.4.3 Stormwater run-off calculations

The steps for calculation of stormwater run-off volumes for areas and dams are given below.

Step 1: Catchment areas are calculated for each dam.

Table 5: Catchment areas

Catchment	Hectares
De Jagers Pan	408
New AWRD	107

Step 2: The Run-off coefficient (C) for each catchment area is calculated. The C-values are calculated as per the South African National Road Agency SOC Ltd. (SANRAL) Drainage Manual. Table 3.7 in the manual provides a description of recommended values of C.

The recommended values are selected according to 3 characteristics of the catchment under consideration. They are namely:-

a) Surface slope classification
b) Permeability classification
c) Vegetation classification

A C-value for each characteristic is selected and the sum of which is the overall C-value, known as C_1, for a particular catchment. C_1 is then multiplied by adjustment factors for each return period, i.e. 2, 5, 10, 20, 50, 100 years. The return period for each storm event was determined using the rainfall depth and comparing it against the one day depth as contained in Table 3. Table 3.8 in the aforementioned Manual provides adjustment factors for the value of C_1.

Table 6: C values calculated according to catchment characteristics

Catchment	Area (m²)	Surface Slope Classification	Cs	Permeability Classification	Cp	Vegetation Classification	Cv	C1
DJP	408 0000	Flat Areas (3-10%)	0.08	Semi-permeable	0.16	Grasslands	0.21	0.45
New AWRD	107 0000	Hilly (10 – 30%)	0.16	Impermeable	0.26	No vegetation	0.28	0.70

Table 7: C values obtained from adjustment factors

RP (Return Period)	DJP	NEW AWRD
0	0.00	0.00
1	0.23	0.35
2	0.23	0.35

5	0.25	0.39
10	0.27	0.42
20	0.30	0.47
50	0.37	0.58
100	0.45	0.70

5.5 <u>Step 3</u>: Rainfall, catchment area and C-values are multiplied to obtain a volume of run-off for each area and dam. Future Stormwater Scenario Option Modelled

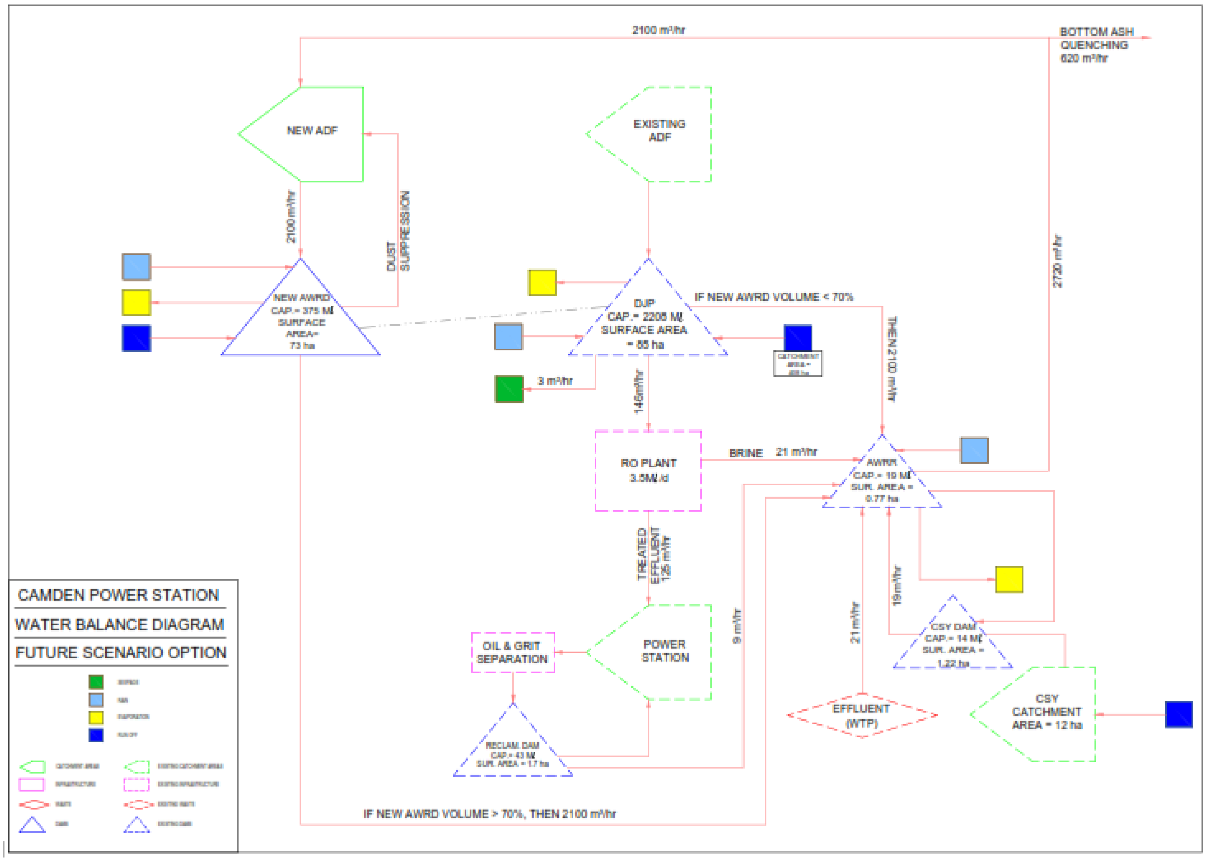

Figure 5-2: Future Stormwater Scenario Option

5.5.1 Summary of Future Stormwater Scenario Option

- Existing ADF to be rehabilitated;
- The amount of water that is abstracted from the AWRR is 2 720 m^3/h;
- The amount of water used for bottom ash quenching is 620 m^3/h. This loss has been considered in the water balance model;
- The amount of water in the slurry that reports to the ADF is 2 100 m^3/h;
- The amount of water returning to the New AWRD is 2 100 m^3/h;
- The amount of water from the new AWRD to AWRR is 2100 m^3/h; This flow cannot be reduced due to the required AWRD capacity becoming too large and therefore uneconomical;

- The interstitial water is not lost through the ash body but takes some time to go through the leachate collection system. This was not included as a loss in the system;
- The link between the New AWRD and De Jagers Pan was included such that the New AWRD operates at + 70% volume whilst De Jager's is being drained.

5.6 Modelling Results

Table 8: Spills Summary – Future Stormwater Scenario Option

Future Stormwater Scenario Option	
Volume (m^3)	**No. of Spills**
250 000	22
275 000	17
300 000	2
325 000	2
350 000	2
375 000	2
385 000	1

The proposed size of the new AWRD is 385 Mℓ, as according to the Water Balance Model.

5.7 Proposed Infrastructure

The proposed infrastructure is detailed below. Layout drawings of the proposed infrastructure for the options modelled as well as the preferred option are attached to the appendices.

5.7.1 New AWRD

One additional AWRD is proposed. The performance (dam levels) for the fifty (50) year simulation period is shown on the respective graphs below for the new AWRD and existing DJP.

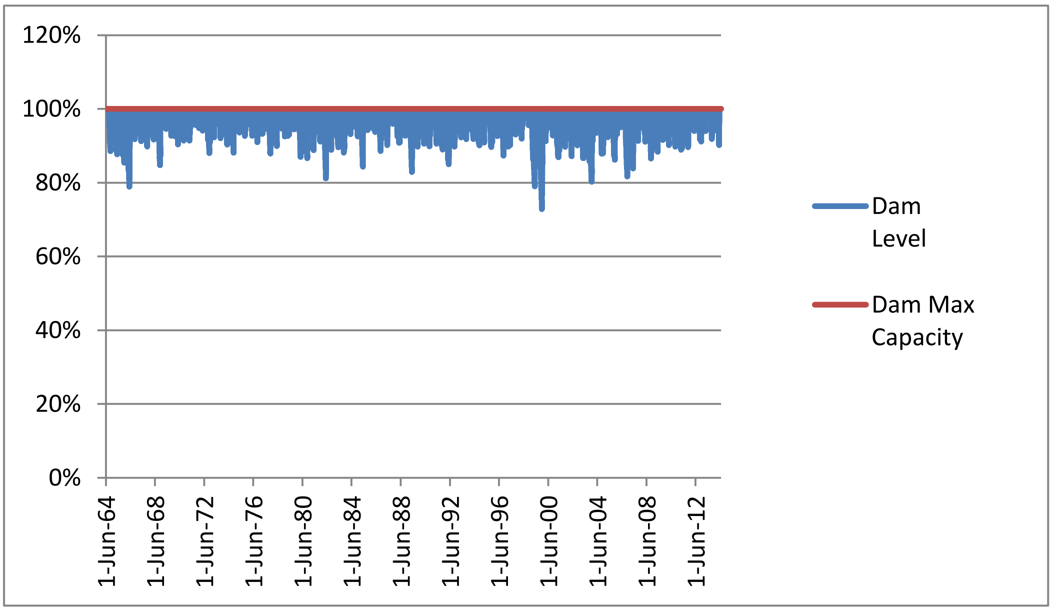

Figure 5-3: Proposed New AWRD Levels for Simulation Period

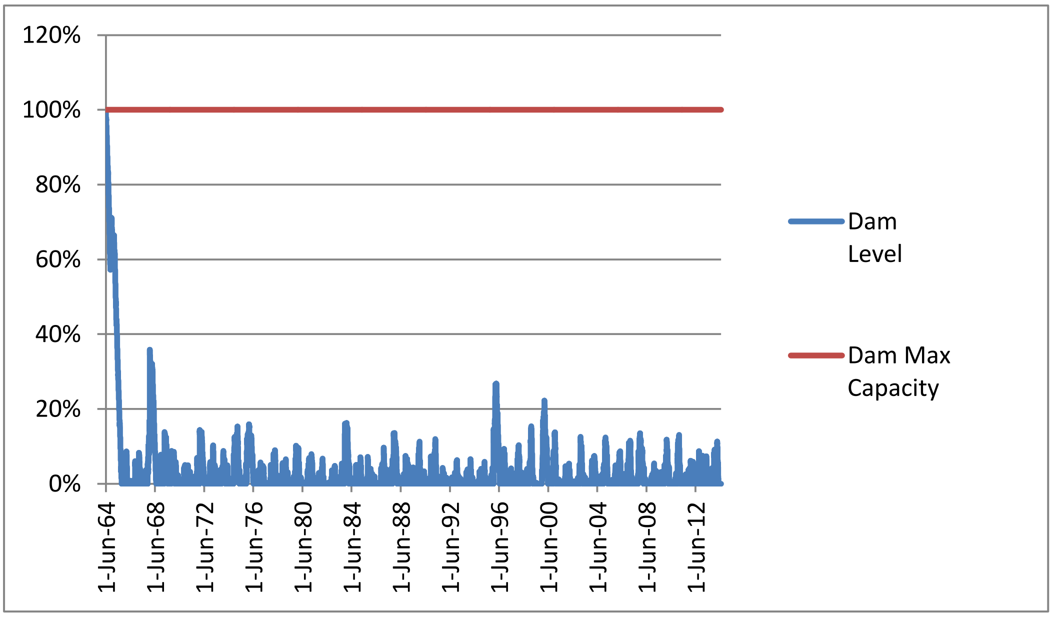

Figure 5-4: DJP Levels for Simulation Period

5.7.2 Conveyance infrastructure (pumps, pipelines and channels)

The proposed operational philosophy around stormwater management will involve the construction of new infrastructure. Apart from the New AWRD as mentioned in the previous sections of this report, conveyance infrastructure will be required for the following reason:

- Dust suppression from storage reservoir to area not covered by the beach of the ADF;

5.8 Operational Requirements

In sizing the proposed infrastructure, several assumptions were made for the operational philosophy surrounding the ADF and its infrastructure, as stated in previous sections of this report. These assumptions need to be realised during operation in order to ensure the performance of the new infrastructure.

5.8.1 Maintaining Silt Traps

The storage capacity of the proposed AWRD does not assume a continuous influx of silt into it as it is equipped with a silt trap. If these silt traps are not maintained as per their design requirements, the performance of the dams will be compromised. The silt traps will be finalised during detailed design and the operations thereof need to be communicated to the power station operators.

5.9 Raw water for construction purposes

The volume of water of which Camden is licenced to abstract from the Usutu government scheme is a maximum of 23.86 million m^3 per year. Camden Power Station abstracts 17.71 million m^3 per year of raw water for its process. A volume of 360 000 m^3 per year is abstracted for the Usutu Mine and Army Base situated within close proximity to the power station. This leaves a surplus of 10.79 million m^3 per year.

A high level calculation to determine the amount of raw water required during the construction phase has yielded a value of 980 000 m^3 per year. Therefore, the surplus volume for abstraction of 5.79 million m^3 per year will be sufficient to cater for raw water abstraction volumes, during the construction phase.

5.10 Way forward for Stormwater Management

The link between the New AWRD and DJP was introduced to draw down the water level of DJP in preparation for the rehabilitation of DJP after closure of Camden Power Station. This has resulted in a large volume New AWRD Dam size of 385 Mℓ. It is recommended that a Water Use Licence Application (WULA) be made for the water uses as described in this report.

6 CONCEPTUAL DESIGN

6.1 Site Access and Roads

The site will be accessed via extensions to the existing roads. An access road exists on the eastern side of the existing ADF and a road leads to the AWRD (to the west of it). The roads are gravel and are in fair condition. It is proposed to link the new roads to the existing roads. A 5 m step-in is proposed on the ADF for vehicular access. A gravel base with a stabilised wearing course is proposed for the site access roads. All accesses to the new facility will be fully secured by means of 1.8 m high diamond mesh fencing.

6.2 Site Services

The contractor's camp will be located within the site. Provision will be made by the contractor for potable water supply, sewage collection and electricity.

6.3 Ash Disposal

The six (6) existing 300NB slurry pipelines to the existing ADF will be replaced with six (6) 350NB pipelines. Two (2) additional 350NB pipelines will also be installed parallel to the six (6) existing pipelines. Eight (8) new 350NB slurry pipelines will be connected to the new pipelines on the existing pipeline route and installed on a new pipeline route to the northeast of the existing ADF towards the New ADF on Site 1.

The ash slurry is pumped from the power station via a booster pump station situated at chainage 3000m from the power station to a central distribution point situated at a high point on the southern perimeter of the New ADF. From the distribution point the fly ash and the coarse ash are channelled through various open trenches and allowed to gravitate into the appropriate paddocks.

The ash disposal deposition method will be the same for each option. There will be a single point of discharge. The single point of discharge for Site 1 will be at the highest point on the southern side of the New ADF. The slurry will be channelled to the respective day walls and night walls.

Initial deposition needs to be contained using a starter earth wall for each compartment. This initial deposition area is thus very small and grows as the compartment basin fills. Due to the small area the rate of rise is high initially. The ash does not have enough time to consolidate and gain sufficient strength to support itself. The starter wall is thus built to a height where the rate of rise is 3.5 m/year. A single point day wall method is required once the starter wall height is reached.

Deposition using the day wall channels in a cycle around the entire perimeter of each compartment allows the walls to be built in a stable way and enables proper pool and freeboard control.

Cycled deposition using the day wall channels allows for the slurry to be deposited in thin layers, which are then allowed to dry out and consolidate. A specified cycle time is allowed between the layers which is dependent on the geometry of the deposit and consolidation parameters. The deposit thus gains sufficient strength and rises continuously. A maximum increase of 3.5 m in height over a year period for a well-drained facility was accepted for this study.

Water will be decanted from the pool using penstocks. Up to two temporary penstock inlets per compartment in the initial phases will be required. A permanent penstock, central to each compartment will then be installed and operated for the life of the facility.

In developing these options various operational aspects were assumed which help reduce risks associated with the operation of the ADF and reduce potential environmental impacts. These include, inter alia:

- The pool will be operated at a minimum level; i.e. water will not be stored on the ADF except during major storm events, in which case the water will be decanted as quickly as the penstock will safely allow. The minimum freeboard after a 1 in 100 year storm event shall be 500 mm in accordance with SABS 0286. The minimum freeboard under normal operating conditions shall be 1 500 mm. If water is stored on the dam the ADF will need to be licensed as a water dam with the dam safety office according to regulation 1560 of the National Water Act (1998).
- More than one compartment allows flexibility in terms of deposition if a compartment requires maintenance.

A penstock consists of a vertical decant tower and an inclined horizontal conduit. The penstock's function is to remove the free water from the top surface of the ADF, thereby recovering the water for re-use in the next cycle of ash disposal. The penstock has been designed to decant all the water from the ash disposal operations and is also capable of removing the storm water from a 1 in 50 year 24 hour storm in 96 hours off the facility with one penstock functioning, or 48 hours with two penstocks functioning.

Penstocks are a very important part of an ADF operation but are notoriously unreliable. For this reason most slimes dams have two penstocks. Should a penstock fail and need replacement, ash disposal could continue without disruption using the other penstock. There are currently two penstocks on either side of the dividing wall of the ADF. Theoretical calculations show that the concrete penstock rings can safely carry the forces resulting from an ash height of 24 m. Floating penstocks will be provided beyond heights of 24 m.

In order to reduce the risk of cavity formation in the future, it is important to double wrap the vertical sections of the penstock decant tower with a Grade A4 geotextile once the rings have been placed.

6.4 Pipelines and Pump Stations

6.4.1 Slurry pipelines

Currently six (6) 300NB slurry pipelines leave the existing ash sumps located on the power station terrace to the existing ADF. The six (6) existing 300NB pipelines will be replaced with six (6) 350NB pipelines. Two (2) additional 350NB steel pipelines will be installed parallel to the six (6) replaced pipelines from the existing ash sumps to the take-off point to the New ADF. The pipelines will be extended from the existing pipeline route to the new facility by 350NB steel pipelines. Eight (8) pipelines are required in total, with four (4) operational at any given time. The pipelines will convey 950 m^3/hr each. All pipelines will be installed above surface and fixed to concrete plinths. A booster pump station, accommodating eight (8) pumps and having an estimated footprint area of 100 m^2, will be constructed at chainage position 3000m from the power station. The length of the new pipelines is approximately 3.0 km each. The two (2) new steel pipelines constructed parallel to the six (6) existing pipelines from the ash sumps to the take-off (T-off) point is approximately 1.5km in length each.

6.4.2 Ash water return pipelines

The existing return water pipeline from De Jagers Pan will need to remain in place after the existing facility has reached its design capacity. This will be required in order to manage stormwater that either runs off the contaminated terrain and side slopes of the facility or any stormwater that recharges through the facility before it is capped. New return water pipelines, four (4) in total, will need to be constructed from the new AWRD back to the existing AWRR at the power station. New 600 mm NB steel pipelines, approximately 4.8 km long each, is proposed for the ash water return pipeline. The pipeline will be installed above surface and fixed to concrete plinths. A total combined flow of 2100 m^3/hr will be conveyed by these pipelines to the existing AWRR located on the power station terrace. The pumps for these pipelines will be located within a new pump station located adjacent to the new AWRD and will be able to accommodate seven (7) pumps, four (4) duty and two (2) standby. A mini electrical sub-station will also be accommodated adjacent to the pump station. Both the pump station and the mini sub-station will cover a footprint area of approximately 100 m^2.

The set of pipelines will have five (5) metre wide access roads on either side for its entire length. This will facilitate maintenance of the pipelines. These roads will also serve as the access roads to the New ADF and to the new AWRD.

6.5 Liner System

6.5.1 Liner Design

It should be noted that wet ash disposal is not a new solution for ash disposal and Eskom has developed this technology for a number of their power stations between 1960 and 1980 however, but the requirements for lining of the ash disposal facilities is new. This poses new challenges to the operating methods of ash disposal facilities. With the introduction of a liner system the management of compartments becomes critical, as it will not be practical to line the entire facility on initiation as the risk of liner damage will be high. The liner may be protected with the placing of a layer of material on top of it or by constructing temporary roads on top of the liner. This will however be finalised during the detail design phase.

The number and sequencing of the liner construction will have to be discussed and agreed with the operational staff and Eskom's technical managers/engineers as this impacts the cash flow of the project. The phasing of the construction of the liner will be dependent on the rate of rise and the growing footprint area required for the New ADF.

The interaction between the liner and the ash also needs to be investigated (both chemically and structurally). The Waste Classification report, attached to the appendices, proposes a typical Class C barrier as per the DEA's regulations.

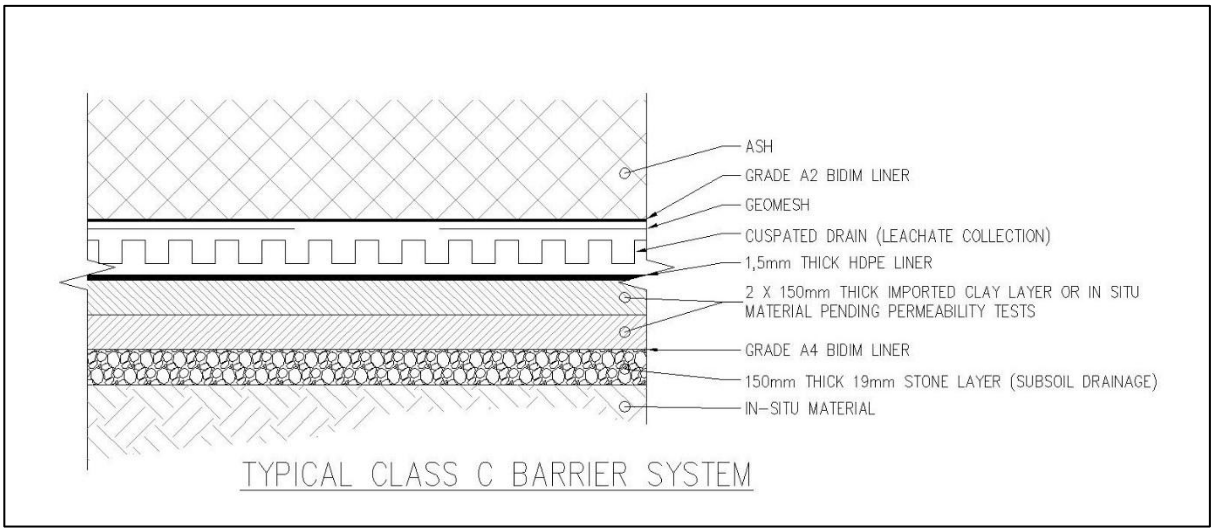

Figure 6-1: Class C Landfill Barrier System

An HDPE sheet is used for the geomembrane indicated in the figure above. The thickness of the HDPE sheet is indicated in the figure. River sand is proposed to be used for the cushion layer. Grade A4 bidim is proposed for the geotextile layer.

The liner system also calls for a 300mm clay layer. Testing will be conducted in August 2014 on the ADF footprint on Site 1 to determine the permeability of the compacted in situ soils. DWA have indicated that if the permeability is less than 10^{-5}cm per second then the in situ soils may be used instead of the clay layer, however the 1.5mm thick HDPE liner must be increased to 2mm thick. Importation of clay is possible however may not be economically viable.

6.5.2 Starter wall

The starter wall for the New ADF must be constructed to a height where the average annual rate of rise is less than 3.5m per year. A graph showing the rate of rise versus the year for Site 1 is presented in the figure below:

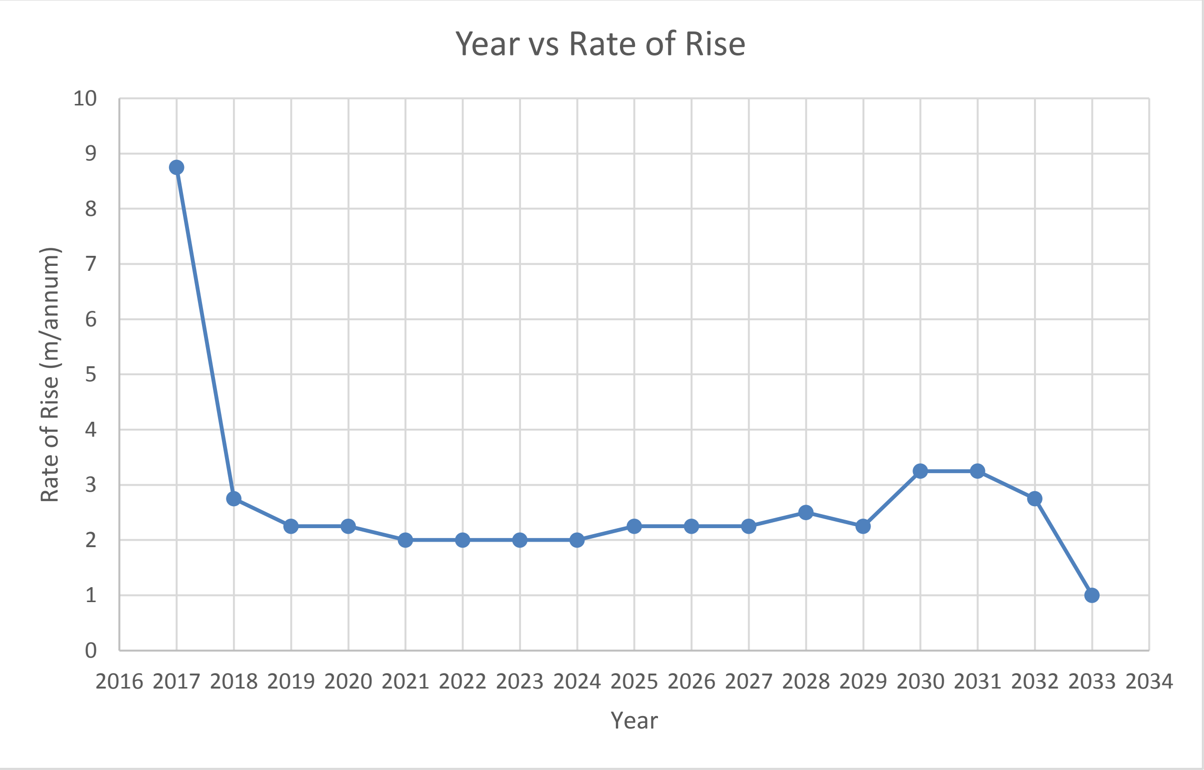

Figure 6-2: Site 1 Years versus Rate of Rise

Figure 6-2: Site 1 Years versus Rate of Rise shows how the Rate of Rise will increase in 2029 from 2.2 m/year to 3.2 m/year, but then due to the unit decommissioning period over the last 3 years, the Rate of Rise will actually decrease. It was calculated that the annual rate of rise will decrease to below 3.5 m per year after 1 year and 11 months. The required height of the starter wall is 11.25 m. The starter wall has a top width of 5m, 1 in 3 side slopes and will have a volume of approximately 364 000 m^3.

6.5.3 Liner installation

The total footprint area of the New ADF on Site 1 is approximately 99 ha. The construction of the liner may be phased to a certain extent taking into account the rate of growth of the footprint area of the New ADF. The footprint area required for the first year of ash disposal will be approximately 54.2 ha, which is more than half of the total footprint area. This is indicated by the red contours in the figure below. The entire site must be lined before the fifth year of ash disposal commences. The New ADF will reach a level of 1 688 m AMSL and a total height of 16.25 m above the toe of the starter wall in the beginning of the fifth year of ash disposal.

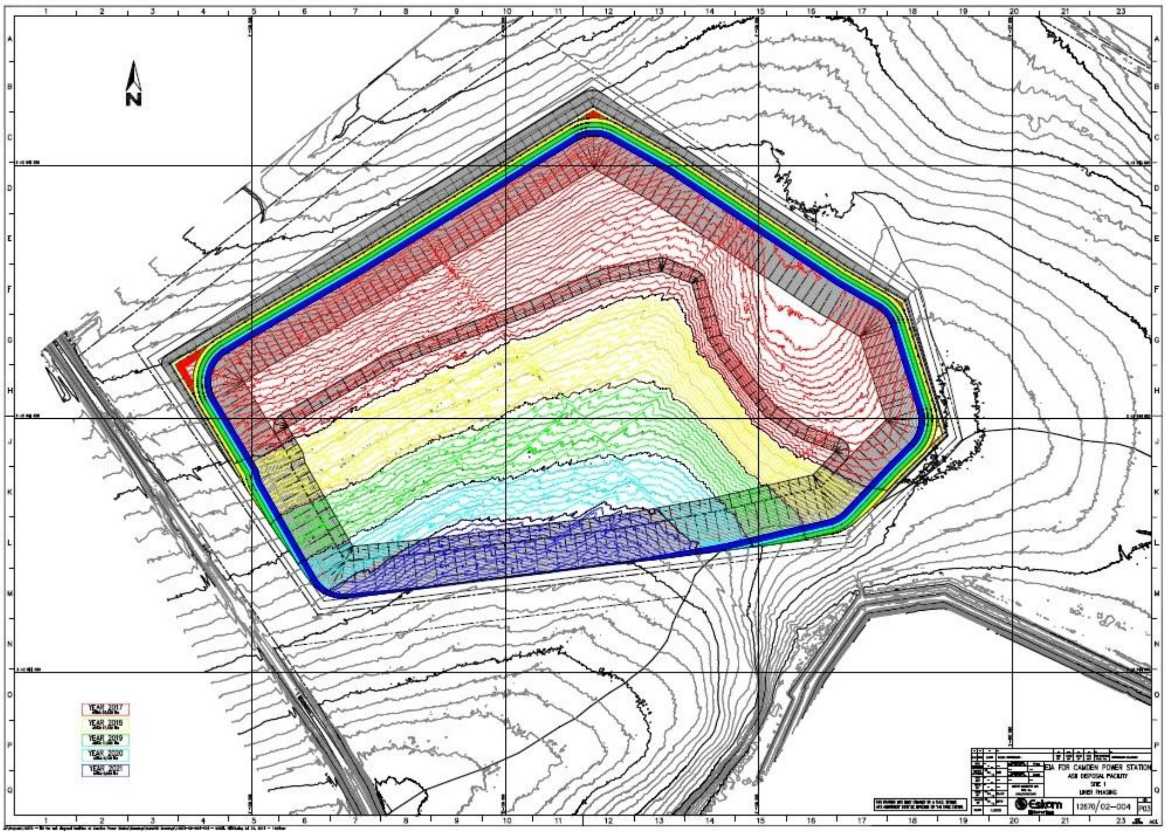

Figure 6-3: Lining requirements for the first five (5) years of ash disposal

6.6 STORMWATER MANAGEMENT PHILOSOPHY

6.6.1 Stormwater Management System

The New ADF and the New AWRD may not be located within the 1 in 100 year floodline or within a 100m distance of a watercourse in accordance with Section 4 of Government Notice 704. The 1 in 100 year floodlines were determined for Site 1 and the new facilities were positioned outside the 1 in 100 year floodlines. This is discussed in detail under Section 6.6.2.

Clean water and dirty water will be separated for the New ADF and the New AWRD. Clean water will be discharged into the environment, while dirty water will be contained, silt will be removed and then the dirty water will be recycled and re-used for slurry make up water at the Camden Power Station. This is all in accordance with Government Notice 704. Clean water diversion channels will be provided around the New ADF and the New AWRD to prevent clean water from entering the dirty water system. Clean water diversion channels are however not required all around the new facilities, but just where clean water will gravitate naturally towards the dirty areas. In other areas clean water will naturally gravitate away from the dirty areas. The clean water diversion channels will be lined to prevent ingress into the groundwater below the New ADF. The design of the clean water diversion channels are discussed in more detail in Section 6.6.3.

Dirty water diversion channels (or solution trenches) will completely surround the New ADF to prevent dirty water from polluting the environment. Dirty surface water runoff, leachate and overflow from the pool on top of the New ADF will all report to the dirty water diversion channels. The dirty water will gravitate along the lined dirty water channels to the silt traps at the inlet into the New AWRD. After silt has settled out, the dirty water will flow into the lined New AWRD, therefore contained and prevented from polluting the environment. The New AWRD is sized not to spill more than once in 50 years as discussed in Section 5. The dirty water will then be pumped from the New AWRD back to the existing AWRR to be re-used as ash slurry water at the Camden Power Station. The design of the dirty water diversion channels are discussed in more detail in Section 6.6.4. The leachate collection system of the New ADF is discussed in detail in Section 0.

6.6.2 1 in 100 Year Floodlines

6.6.2.1 General

The 1 in 100 year floodlines before and after development have to be determined in support of the Water Use Licence Application. This section provides the methodology used in determining the 1 in 100 year floodlines. The 1 in 100 year floodlines were only determined for the preferred site, namely Site 1.

6.6.2.2 Methodology

A LIDAR topographical survey of the candidate sites for the New ADF was done as part of this conceptual engineering design. (LIDAR is a remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light.) Contours with 0.5m intervals were generated from the topographical survey. A Watercourse was identified on the 1 in 50 000 topographical map. The surface area of the catchment was determined as well as the ground cover, the average slopes and distances of overland flow and the average slopes of watercourses. The delineation of the catchment for Site 1 is shown in Figure 6-4.

6.6.2.3 Flood Hydrology

The *Rational Method* as described in the document *Drainage Manual, Sixth Edition (2013)* as published by SANRAL (South African National Roads Agency Limited) was used to determine the magnitude of the 1 in 100 year floods.

The peak flow rate is calculated with the following formula:

$$Q = \frac{CiA}{3.6}$$

Where Q = peak flow (m^3/s)

c = run-off coefficient (dimensionless)

i = average rainfall intensity over the catchment (mm/hour)

A = effective area of catchment (km^2)

3.6 = conversion factor

Daily rainfall data from 1952 to 2001 was obtained from the Department of Water and Sanitation for the meteorological station located at Ermelo (Number C1E002), which is located approximately 19km north west of Eskom Camden Power Station. The Mean Annual Precipitation (MAP) at this station was calculated to be 719 mm/year.

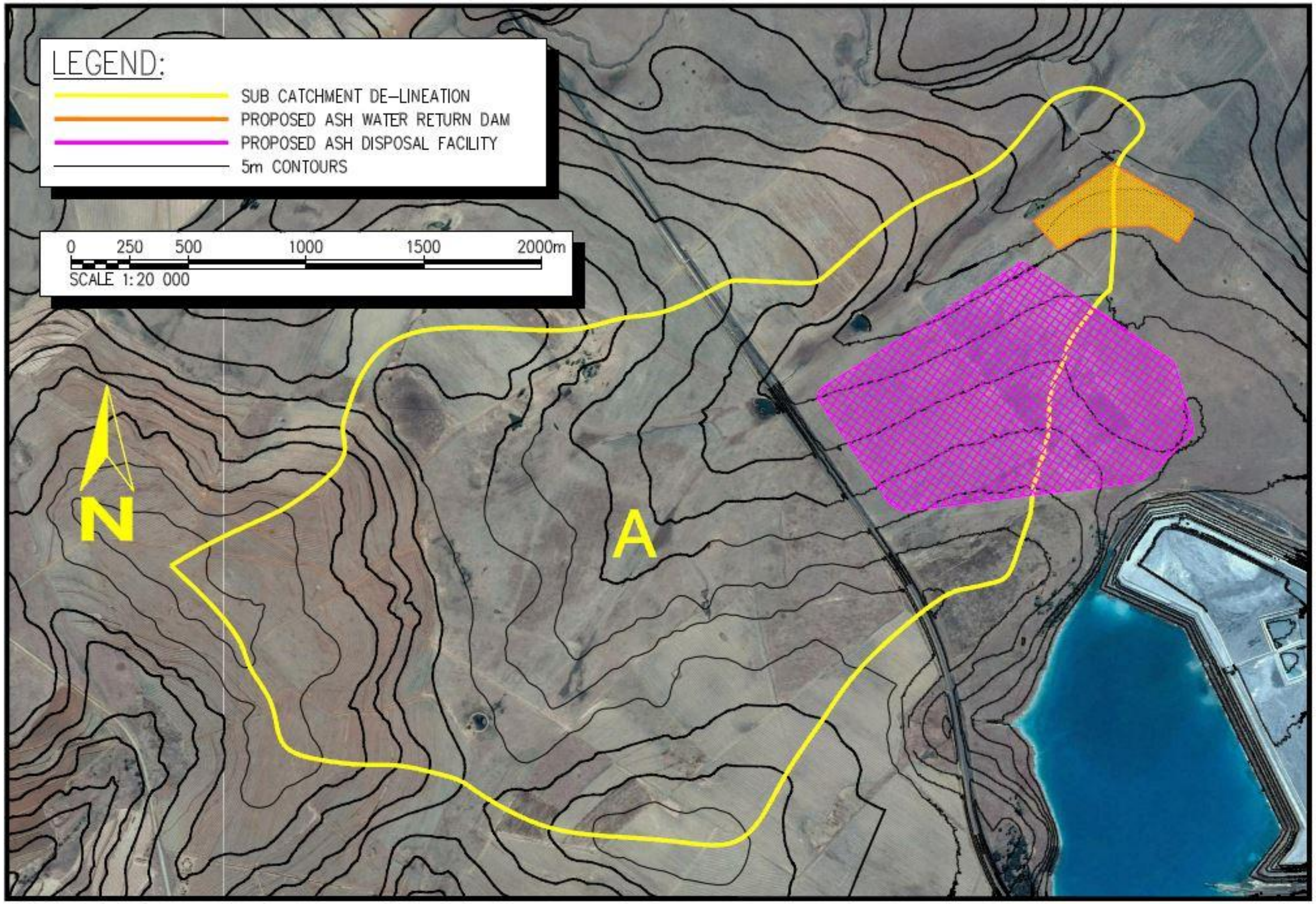

Figure 6-4: Delineation of Catchment for Site 1

The Time of Concentration was determined for the catchment in accordance with the following formulas. Refer to *Drainage Manual, Sixth Edition (2013):*

For overland flow:

$$T_{C1} = 0.604\left(\frac{rL}{S^{0.5}}\right)^{0.467}$$

Where T_c = time of concentration (hours)

r = roughness coefficient = 0.4 for medium grass cover

L = length of the catchment from the boundary to where the flood needs to be recorded (km)

S = slope of the catchment (m/m)

For defined water courses:

$$T_{c2} = \left(\frac{0.87L^2}{1000S_{av}}\right)^{0.385}$$

Where T_c = time of concentration (hours)

r = roughness coefficient = 0.4 for medium grass cover

L = length of the watercourse from the boundary to where the flood needs to be recorded (km)

S = average slope of the catchment (m/m)

The total time of concentration is the sum of the time of concentration for overland flow plus the time of concentration for watercourse flow, namely T_{c1} plus $T_{c2.}$

The storm duration is taken as the total time of concentration. The rainfall intensity is determined from Figure 3.8 in the *Drainage Manual*, Sixth Edition (2013) as published by SANRAL.

The Run-off coefficient (c) for the catchment must now be calculated.

The recommended values are selected according to 3 characteristics of the catchment under consideration, namely:-

a) Surface slope classification

b) Permeability classification

c) Vegetation classification

The run-off coefficients with regard to surface slope classification are presented in Table 9:.

Table 9: Run-off Coefficients with regard to Surface Slope Classifications:

Description	**Run-off coefficient (c_s) for rural areas with an MAP between 600 and 900mm/year**
Steep areas (slopes > 30%)	0.03
Hilly (10 to 30%)	0.08
Flat areas (3 to 10%)	0.16
Vleis and pans (slopes < 3%)	0.26

The run-off coefficients with regard to permeability are presented in Table 10.

Table 10: Run-off coefficients with regard to Permeability

Description	**Run-off coefficient (c_p) for rural areas with an MAP between 600 and 900mm/year**
Very permeable	0.04
Permeable	0.08
Semi-impermeable	0.16

Impermeable	0.26

The run-off coefficients with regard to vegetation classification are presented in Table 11.

Table 11: Run-off coefficient with regard to Vegetation

Description	**Run-off coefficient (c_v) for rural areas with an MAP between 600 and 900mm/year**
Thick bush and plantation	0.04
Light bush and farmlands	0.11
Grasslands	0.21
No vegetation	0.28

The overall c-value for a catchment, also known as the c_1 is the sum of the c-values for the three characteristics, as shown by the following equation:

$$c_1 = c_s + c_p + c_v$$

Where c_1 = Overall run-off coefficient for a catchment

c_s = Run-off coefficient with regard to slope

c_p = Run-off coefficient with regard to permeability

c_v = Run-off coefficient with regard to vegetation

The overall run-off coefficient c_1 is multiplied by an adjustment factor with regard to the return period, as presented in Table 12.

Table 12: Adjustment Factors for c1 with regard to Return Period:

Return Period (years)	2	5	10	20	50	100
Factor (F_t) for steep and impermeable	0.75	0.80	0.85	0.90	0.95	1.00

catchments						
Factor (F_t) for flat and permeable catchments	0.50	0.55	0.60	0.67	0.83	1.00

The magnitude of the 1 in 100 year flood can now be determined for exact locations within watercourse. .

The resulting c-values are presented in Table 13.

Table 13: Resulting c-values

Description	c-value
c_s	0.26
c_p	0.12
c_v	0.16
c1	0.54

The results of the hydrology calculations are presented in Table 14.

Table 14: Results of Hydrology Calculations

Description	Catchment Area (ha)	Critical Storm Duration (hrs)	i (mm/hours)	c1-value	Maximum 1 in 100 Year Flood (m^3/s)
Catchment before development	672.3	1.0	120	0.54	121.0
Catchment after development	552.3	1.0	120	0.54	99.4

6.6.2.4 Hydraulic Simulation

The 0.5m interval contours were obtained from the topographical survey. The software *Autodesk Civil3D 2013* was used to extract longitudinal sections of the watercourse. Cross sections were also extracted at intervals of approximately 300m. The length of typical cross sections was approximately 1.3km.

The geometry was imported into the software *HEC-RAS*, a backwater model, which was developed by the United States Army Corps of Engineers.

A Manning's "n" hydraulic roughness value of 0.040 was assumed for all sections, which corresponds to natural straight watercourses without deep pools.

Information with regard to downstream culverts and bridges were measured on site. The culverts were entered into the backwater model. Two culverts were identified that affect the watercourse next to Site 1, namely under the existing Richards Bay railway line to the south west of Site 1 and under a decommissioned railway line to the north east of Site 1.

Normal water flow depths were assumed for the upstream position and downstream position of the river section. Normal flow depth here means the calculated water depth for a certain roughness, a certain flow and a certain longitudinal slope. The software does the hydraulic calculations for each cross section. The output from the software are flow depths, flow velocities, cross sectional area, wetted perimeter etc.

The water levels, or flood lines is an output from the hydraulic model. The flood lines were imported back for presentation into an *AutoCAD* drawing.

6.6.2.5 Results

The resulting post-development 1 in 100 year floodlines are shown in Figure 6-5.

The New ADF and the New AWRD were placed outside of the 1 in 100 year floodlines. The post development floodlines will be slightly narrower due to a reduction in the catchment area.

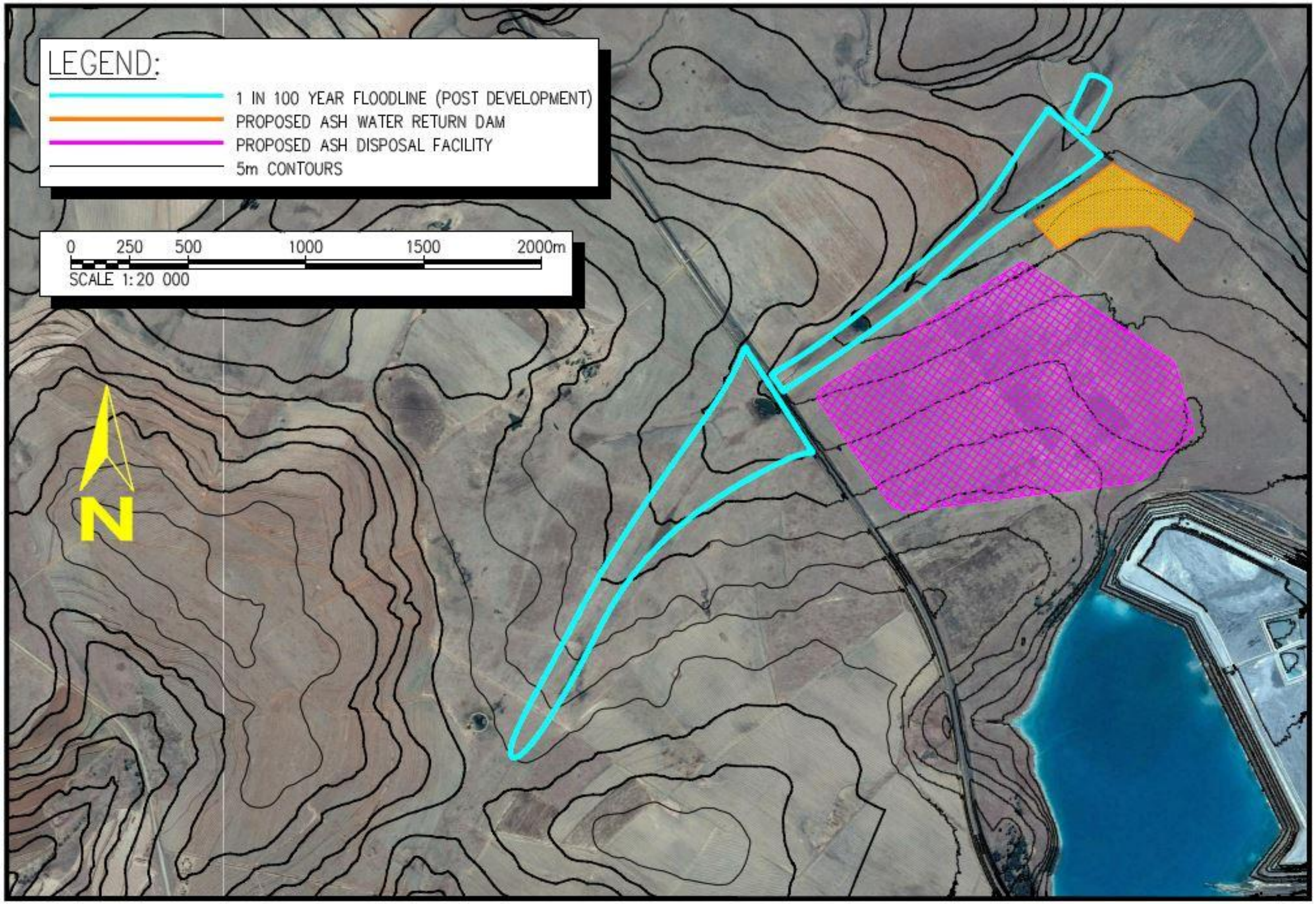

Figure 6-5: Resulting Post-Development 1 in 100 year Floodlines

6.6.3 Clean Water Diversion Channels

An upstream lined channel shall be constructed to divert clean water around the proposed facility and discharge into the natural environment. The channel will be sized to accommodate the 1 in 100 year storm event. Each site is positioned such that the area between the natural watershed and the proposed facility that is not impacted by ash is a minimum. The proposed sizes of the trapezoidal channels, with side slopes of 3:2 (h:v) and base width of 1 m, required are listed in the table below. The clean water diversion channels for Site 1 are shown on Drawing Number 12670-02-002. Reference: Appendix C: Conceptual Engineering Drawings:

Table 15: Sizing of Clean Water Diversion Trench

Site	Channel ID	"Clean" Area (ha)	Flow Rate (m^3/s)	Channel Length (m)	Slope (%)	Channel Height (mm)	Channel Top Width (mm)
1	1	15.8	2.4	450	0.78	500	2500
1	2	5.6	0.833	623	1.18	260	1800
1	3	6.0	0.9	295	0.78	300	1900
1	4	6.0	0.9	306	0.76	300	1900
1	5	23.4	3.5	590	2.00	480	2400
3A	1	13.1	10.1	1700	3.69	700	3100
3B	1	28.2	11.4	1800	4.71	700	3100
3B	2	27.5	10.4	1200	3.92	700	3100

The channels will be concrete lined in order to facilitate cleaning. The slope of the channels for Sites 3A and B are marginally steeper than that of Site 1.

6.6.4 Dirty Water Diversion Channels

Dirty water run-off generated off the side slopes will drain into a suitably sized "solution trench" running around the facility. These trenches will be designed to receive and convey run-off generated after a 100 year storm event. The solution trenches will also receive discharge from the leachate collection system and this flow will also be required to be included in its sizing. Conceptual sizes of the trapezoidal channels, with side slopes of 3:2 (h:v) and base width of 1 m, required are listed in the table below. The dirty water diversion channels for Site 1 are shown on Drawing Number 12670-02-002. Reference: Appendix C: Conceptual Engineering Drawings:

Table 16: Sizing of Solution Trenches

Site No	Channel ID	Flow Rate (m^3/s)	Channel Length (m)	Channel Slope (%)	Channel Height (mm)	Channel Top Width (mm)
1	A	33	450	0.78	1800	6400
1	B	33	590	2.00	1500	5500
1	C	33	1,021	0.59	1900	6700
1	D	33	623	1.18	1600	5800
1	E	33	295	0.78	1800	6400
1	F	33	306	0.76	1800	6400
1	G	33	753	1.11	1600	5800
3A	A	6.3	1,700	5.51	500	2,500
3A	B	13.7	800	3.92	800	3,400
3A	C	5.9	580	4.83	500	2,500
3A	D	3.4	730	1.60	500	2,500
3B	A	7.5	1,300	3.80	600	2,800
3B	B	2.6	400	2.21	400	2,200
3B	C	6.6	700	2.94	600	2,800
3B	D	16.9	1,150	3.64	900	3,700
3B	E	22.9	570	4.26	1,000	4,000
3B	F	10.5	350	3.99	700	3,100

6.6.5 Leachate Collection and Management

The leachate collection system will comprise of a toe drain as well as a main drain system. A leachate collection system will be designed such that a maximum leachate head of 300 mm will be maintained over the liner system. The leachate will be drained to the solution trench, discussed below, which ultimately discharges to the New AWRD.

The leachate collection system will be designed using a 160mm geopipe covered with 19mm stone wrapped with Grade A4 bidim. This will be located above the liner system. The permeability, as discussed in a previous section, varies between 3 to 20 m per year. Based on this, a conservative drainage rate of 5mm/h was assumed in order to determine spacing of the geopipe for the leachate collection system. Conceptual flows draining to the new AWRD via the solution trenches indicated in the previous section is indicated in the table below:

Table 17: Leachate Flow Rates

Site No	Max Area for Leachate (ha)	Flow Rate (m^3/s)
1	99	1.4
3A	101	1.4
3B	92	1.3

6.6.6 New AWRD

All run-off generated within the footprint area of the facility will be captured in the new AWRD. Although Government Notice 704 (GN704) stipulates that the AWRD shall be sized to accommodate the 50 year 24 hour storm event, this is based on the assumption that the AWRD is empty prior to this storm event. However, this is rarely the case and a more realistic approach should be adopted. It is Best Practice to undertake continuous modelling (a daily time step model) of the system in order to ascertain a more realistic capacity of the dam. This method takes into account the operating philosophy of the facility as well any abstractions from the dam including evaporation. This method was only applied for Site 1, which is the preferred site. For the other sites (3A and 3B) the assumption was made that the New AWRD will be 25% full prior to the 1 in 50 year storm event. The table below gives the proposed sizes of the AWRD for each of the proposed options for this method which complies with the requirements of GN704.

Table 18: Sizing of New AWRD

Site No	"Contaminated" Area (ha)	Crest Height (mamsl)	AWRD Size (m^3)
1	99.0	1669.00	385,000
3A	162.3	1669.80	153,400
3B	214.5	1682.55	180,600

Stormwater captured at the ADF pool level will be conveyed to the New AWRD via penstocks. The penstocks and the discharge pipes will be designed such that the flow is attenuated at the pool level and drained over a 24 hour period (with two penstock inlets in operation) to the New AWRD.

Two silt traps will be installed to remove silt from the decanted water before it enters the lined New AWRD. The amount of silt in the water will need to be determined and will provide input into the detailed sizing and cleaning frequency of the silt trap.

The position of the New AWRD for Site 1 is shown on the drawings. Reference: Appendix C: Conceptual Engineering Drawings. A well prepared and compacted base is essential for the liner. The liner requirement for the New AWRD is the same standard as for the ash facility, except it will not have leachate collection drains. The liner design is discussed in the previous sections.

A provisional position for the New AWRD is shown on the General Arrangement drawing in the appendices. Refinement to fit within the property boundary and accommodate the silt trap at the inflow section will form part of the next design phase.

The New AWRD will have two (2) equal compartments to facilitate maintenance. The size of each compartment will be equal to half of the total volume of the new AWRD.

6.7 Construction Methods and Sequencing

The deposition method will be the same for each option. Initial deposition needs to be contained using a starter earth wall for each compartment. This initial deposition area is thus small and grows as the compartment basin fills. Due to the small area the rate of rise is high initially. The ash does not have enough time to consolidate and gain sufficient strength to support itself. The starter wall is thus built to a height where the rate of rise is 3.5 m/year. A transition from open end deposition to a single point discharge day wall method is required once the starter wall height is reached. Cycled deposition using the day wall channels allows for the slurry to be deposited in thin layers, which is then allowed to dry out and consolidate. A specified cycle time is allowed between the layers which is dependent on the geometry of the deposit and consolidation parameters. The deposit thus gains sufficient strength and rises continuously. A maximum increase of 3.5 m in height over a year period was accepted for this study.

The water management on the ADF will be as described in Section 6.3.

6.8 Capacity Modelling for Selected Sites

Three sites were short listed after the initial workshop which was further subjected to a geotechnical assessment. Two of the sites were deemed feasible for further consideration following this assessment. One of the sites was eliminated due to underlying dolorites and fractures which compromised the bearing capacity of the proposed ADF footprint.

The proposed ADF shall have an overall capacity of 25.0 million m^3 for an operational period from 2017 to 2033 (17 years). A maximum height of 40 m has been adopted for the modelling exercise. A step height of 8 m vertical and 24 m horizontal with a benching (roadway) of 5 m was used. All side slopes were taken as 1 in 3. The 5m wide horizontal roadways together with the 1 in 3 slopes gives an overall slope of 1 in 3.5.

An area-height method was used to model the capacity for the ADF options. This includes the capacity within the compartment basin and the volume above this as the facility crest plan area diminishes. In order to evaluate the three options the height of the starter walls (and the respective earth volumes) was determined (from the height at which the average annual rate of rise is less than 3.5 m per year). Thereafter the volume that can be contained at a maximum height of 40 m on each site was determined. The capacity is based on 1 in 3.5 overall side slopes and a preferred maximum rate of rise of 3.5 m/year for a well-drained facility.

The stage curve for each option is given below. The stage curve does not take into account the shape of the beach and this should be considered during the preliminary design phase of this project.

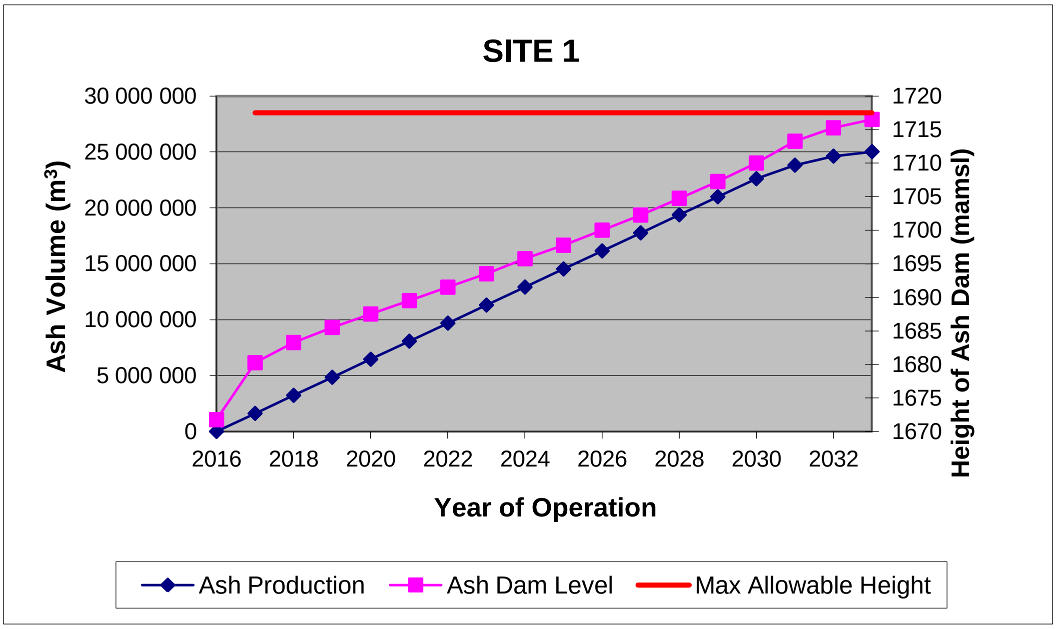

Figure 6-6: ADF Stage Curve for Site 1

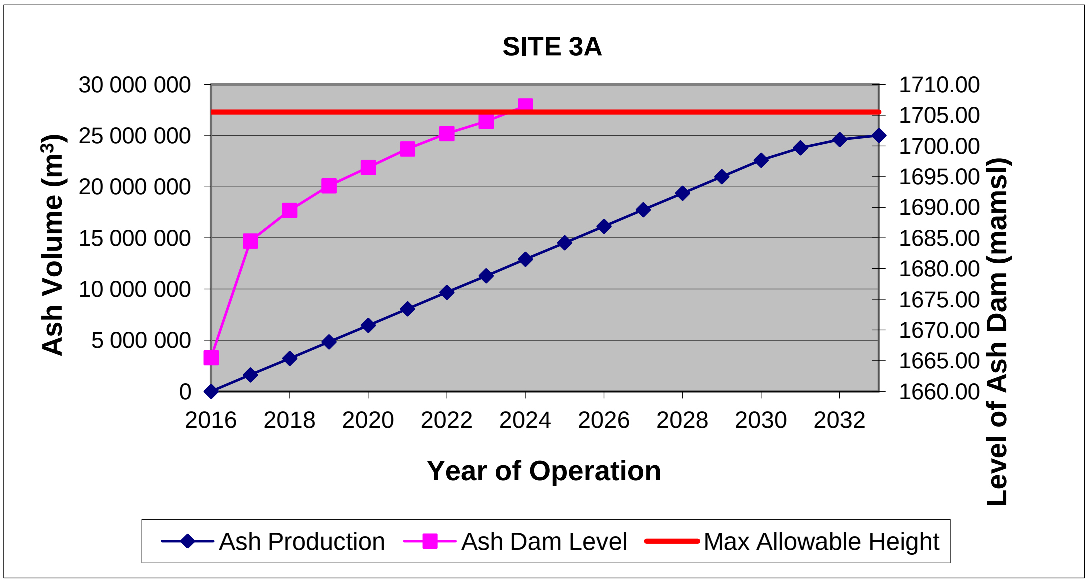

Figure 6-7: ADF Stage Curve for Site 3A

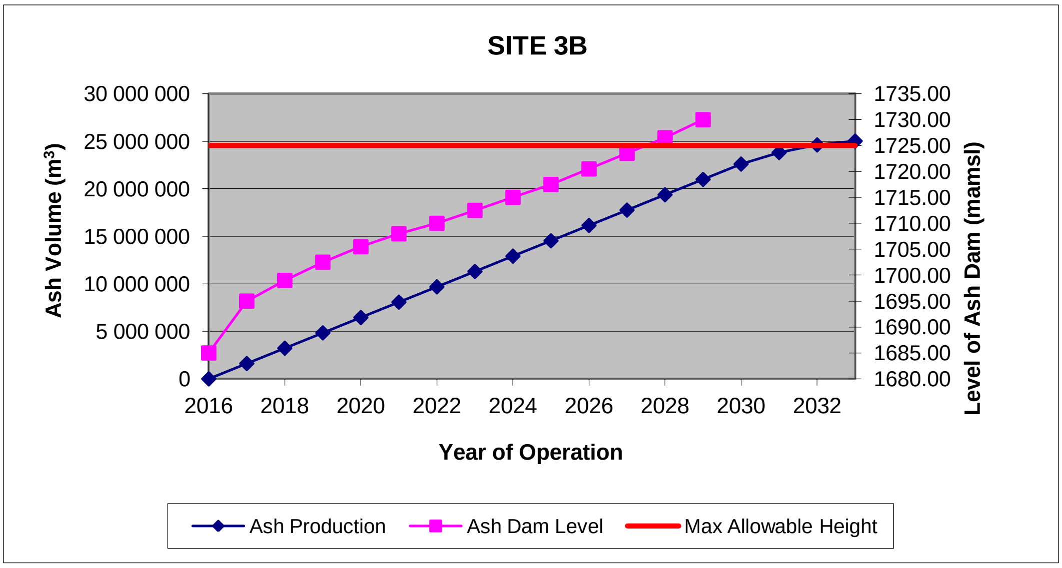

Figure 6-8: ADF Stage Curve for Site 3B

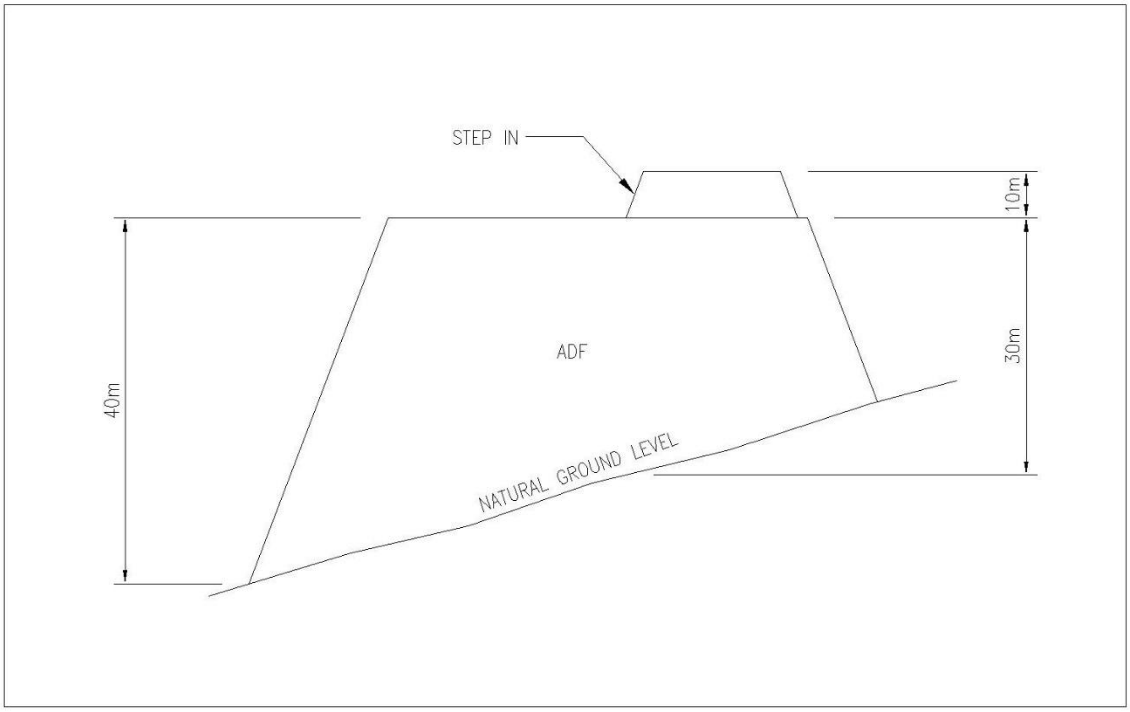

Figure 6-9: Sketch of Step-In and Height Restriction

The modelling indicates that only Site 1 is capable of achieving the height restrictions within the available footprint. A 8m high step-in is however required on approximately half of the ADF while still observing the 40 m maximum height restriction to achieve the required volume. This is indicated in Figure 6-9: Sketch of Step-In and Height Restriction

Sites 3 A and B cannot accommodate the ash production over 17 years without significantly going over a maximum allowable height of 40 m. The model was run for Sites 3A and B up to a maximum height of 48 m and 56 m respectively. In both cases the total ash production could not be achieved, even at these heights, so the model was terminated without achieving the total required ash storage.

6.9 Relocation of services

The preferred site, Site 1, was revisited in order to determine services that may need to be relocated. There were no pipelines visible on the footprint of the site and the roads were restricted to informal tracks. This will not need relocation. No electrical transmission lines need relocation either.

Pipelines, roads and channels need to pass underneath existing transmission lines. Cross sections of these crossings, also indicating clearances, are shown on the Conceptual Engineering Drawings included in Appendix C. The drawings will be presented to Eskom's Transmission and Distribution department for their approval.

7 OPERATION AND MAINTENANCE PLAN

7.1 Introduction

This Operations Manual is to be used for the correct and cost efficient operation and maintenance of the ash disposal facility/ies at Camden Power Station. For purposes of this report, the site referred to is Site 1, the preferred site for the ash facility.

The Operations Manual is intended to inform and guide Camden's ADF operations and maintenance personnel on the requirements for the operation and maintenance of the ash facility. The design philosophies are described to assist the Operator to understand the reasons for having to carry out certain actions.

The Operations Manual first describes the philosophy of the design of the various components of the ADF and then details the requirements for the operation and maintenance of the various components. It also details the requirements for monitoring of the ADF and AWRDs, maintenance procedures, rehabilitation of the facilities and environmental considerations. Lastly the legal and safety aspects relevant to the ADF are summarized.

7.2 Code requirements in terms of SABS 0286

SABS 0286 is the code of practice that regulates deposition practices of all mine residues in South Africa. This code has been introduced after the Merriespruit disaster where many people lost their life during the failure of a gold tailings dam. The code clearly defines accountabilities for the safe operation of a tailings facility. The ash disposal facility/ies at Camden power station will be operated in accordance with the SABS 0286. All references in the code to The Owner or The Mine Manager shall be read to mean The Power Station Manager. The following points from the code are highlighted for ease of reference:

7.2.1 Management

Refer to Clause 6 in the code.

A management framework, based on the ISO 14000 system shall be followed and will include the following components:

- Policy making
- Operation
- Setting of objectives
- Operation

- Conformance assessment
- Management review
- On-going improvement

7.2.2 Operational phase appointments

Refer to Clause 5.2.6 in the code.

The Power Station Manager shall appoint a manager to manage the ash disposal operation. This person is referred to as the Project Manager in the Operation and Maintenance Manual. The Project Manager is to appoint an appropriately qualified professional person (the Professional Engineer) to advise on the structural stability of the ADF and a second appropriately experienced person (the Contractor) to operate this facility.

The Professional Engineer is an appropriately qualified and experienced professional civil engineer in the field of mine residue deposits, who is registered with the Engineering Council of South Africa as a professional engineer or technologist.

7.2.3 Facility audit

Refer to Clause 6.4.4.6 of the code.

Audits are to be performed annually by a professional engineer for all facilities with a high hazard classification.

7.2.4 Hazard classification (See clause 7.4 of the code)

Refer to Clause 7.4 of the code.

An ADF can be given a hazard classification based on the criteria stipulated in SABS Code No 0286. The zone of influence is defined as the zone which will be affected by a failure of the tailings facility. This code provides the following three criteria to be used in determining the zone of influence for any wet tailings facility:

- A distance of 5H (H=height of the ADF at the point of consideration) upstream of the ash deposit or the distance where the natural ground reaches H/2 above the toe of the facility (whichever is the lesser).
- A distance of 10H on sides parallel to the slope of the ground.
- A distance of 100H on the downstream face of the facility.

The hazard classification is based on a number of criteria and is based on the table below:

Table 19: Hazard Classification

Workers	Property (Millions)	Depth to underground mine workings	Classification
<10	0-R2	>200	LOW
11-100	R2-R20	50 m -200 m	MEDIUM
>100	>R20	<50 m	HIGH

Please note the workers on the ADF are to be excluded from the total number of workers in the table above. The property includes only third party property and Eskom property should therefore not be included in the final analysis. The zone of influence, in the event of a failure, is to the north east of the site due to the topography of the site. There are between 1 and 10 residents in the zone of influence. There are less than 10 workers in the zone of influence. There is no underground mine established below the ADF. Based on this, the preferred ash disposal site at Camden, Site 1, will be classified as a **low hazard** facility.

Site 3B is considered **high risk** as it is located in close proximity and upslope of a major railway line. In the event that a facility located in this site fails, the result will be damages in excess of R20 million.

Site 3A is considered **medium risk** as it is located in close proximity and upslope of an arterial road. In the event that a facility located in this site fails, the result will be damages will be in between R2 million and R20 million.

7.2.5 Operating manual

Refer to Clause 10.4.5 of the code.

The operating manual is to be produced by a professional engineer for medium and high hazard residue deposits. The manual should address the following areas:

- Process circuit
- Water management plan
- Method of operation
- Environmental monitoring and auditing
- Safety surveillance

- Emergency response

- Decommissioning phase

7.3 Operation of the ADF

7.3.1 Commencement of operations

The main objectives during the initial disposal of ash shall be:

- To cover all of the main and ancillary filter drains with a layer of coarse ash without wash disposal away the top layer of the filter drains.

- To raise the day wall as quickly as possible.

- To train the operations staff to build the ADF in a controlled and safe manner.

7.3.1.1 Starter walls

To enable ash to be placed and contained within the required boundaries of the day wall, starter walls must be built. These are made by taking earth from the surrounding area and forming an earth wall against which ash can be placed. Refer to Figure 7-1and Figure 7-2.

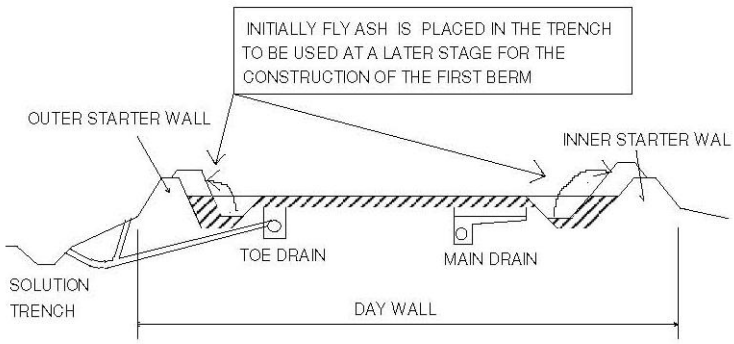

Figure 7-1: Construction of first ash berms

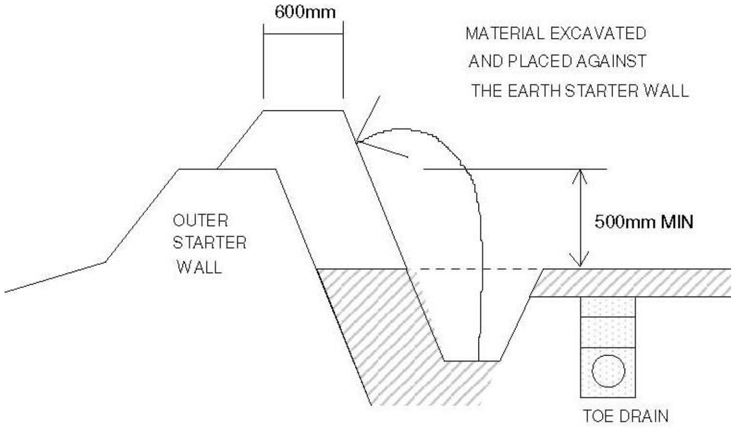

Figure 7-2: Construction of first berm and step

7.3.1.2 The initial covering of the main filter drain:

The initial method of covering the main and toe drains with ash is very important. The prime objective in covering these filter drains is to ensure they are covered with coarse ash to prevent the top layer of the filter drain from being eroded by the initial slurry flow.

7.3.1.3 Initial deposition of fly ash on the day wall

The prime objective in the initial deposition of fly ash on the day wall is to ensure that the day wall rises rapidly in the early stages so that a freeboard of at least 1 m above the night paddock is achieved and maintained. The freeboard must also not be less than 500mm above the 1:100 yr. maximum flood level (See Figure 7-3). The 1:100 year. maximum flood level will be between 0.85 m and 1.75 m above the pool level. The actual rise in pool level is a function of the pool area. The Contractor may assume that the pool will rise by one metre under current conditions. The pool level must therefore be maintained at a level, which is at least 1.5 m below the lowest point plus the shape and slope of the area which surrounds the pool (See inside the day wall).

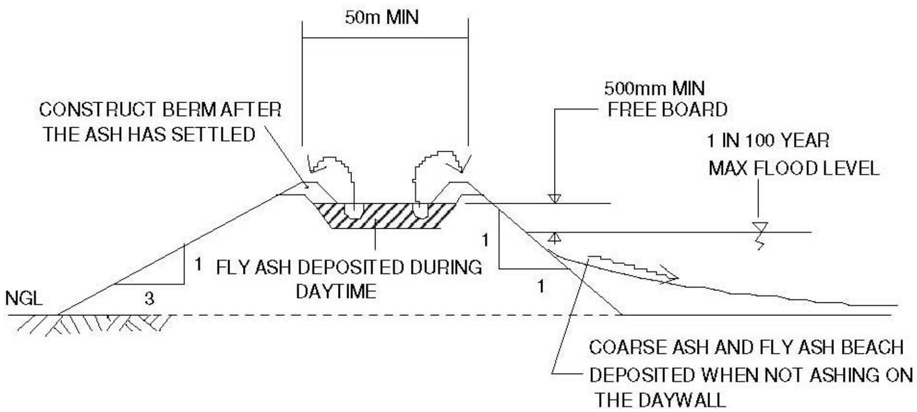

Figure 7-3: Wall building method

The day wall must be built using fly ash only. The small berms that have to be built to provide capacity for the next deposition of slurry shall be built with ash that is just dry enough to work with. This criterion will ensure that the pozzolanic action (cementing action) available in the fly ash takes place, thus reducing the future erodability of the side slope of the facility by both wind and water. If the ash is too dry, the chemical bonding will not take place and the wall will be much weaker and more permeable. Sludge from the power station may not be mixed with fly ash that is intended for use in day wall construction.

A competent backactor machine operator will be able to build 250 m of these berms in 8 hours. Compaction with a small vibratory roller will improve the pozzolanic bonding and reduce the permeability of the sides of the ADF thereby reducing its erodability. The crest width of the small berms shall not be more than 600 mm, as wider steps are unnecessary and increase the cost of running the backactor per tonne of ash deposited considerably. Wider steps require more labour and also result in greater wear on the vibratory roller. The optimum height of the step is a function of the size of the vibratory roller and the type of ash, and has to be determined on site. The berm must however be at least 500mm above the final level of the placed ash to allow for sufficient freeboard during high intensity storm conditions.

7.3.1.4 Initial wall building

The prime objective of the initial wall building is to create sufficient freeboard and to build the walls in the correct place and in the correct way. Freeboard is the term used to describe the height difference between the maximum operating level of fluid in a structure and the overtopping level for that structure. Freeboard on an ADF is defined as the difference in level between the night paddock and the day wall. The minimum freeboard required by law on slime dams is 0.5 m above the high water level of the dam after a 1:100 year 24hr storm. However, there are potential benefits if the freeboard is more than 0.5 m, since far more storage will be available in the case of a labour strike, machinery breakdowns or a major storm. The actual rise in the water level during a major storm depends on a number of factors such as the run-off coefficient of the top surface and the ratio of the catchment area to that of the pool area. The water level can rise between 450mm and 750mm depending on the circumstances mentioned above. See Figure 7.3 and the more detailed explanation in the previous section. It is essential that the wall building grow above the main starter wall quickly to create this required freeboard.

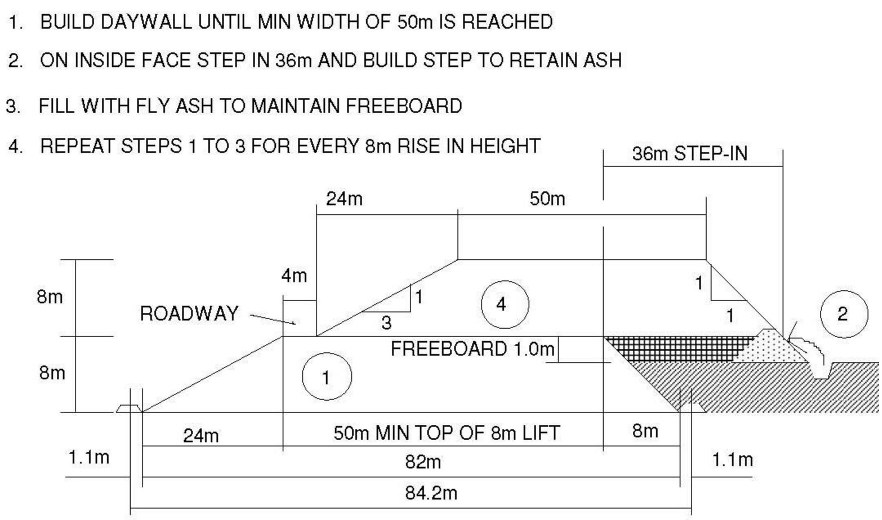

Figure 7-4: Day wall step-in process

The toe of the day wall must always tie in with the starter wall to ensure that the ash covers the toe drain and that the capacity of the ADF is maximized. Thus the steps of the ADF will not necessarily be constructed parallel to the starter wall but will bend outwards to meet the outer starter wall at the same elevation. The day wall berms or steps shall be constructed with ash that is just workable (not so wet that it cannot be worked with and not so dry that the bonded/hardened ash has to be broken) to ensure that pozzolanic and chemical bonding takes place. If the ash used for berm construction is too dry or has to be broken, the berms or steps will be susceptible to erosion and piping. The compaction of the steps with a vibratory roller will increase the density of the ash and enhance the resistance to erosion and piping.

Generally the steps should be constructed in such a way that the side of the ADF has a slope of 1 in 3 (1 metre rise for 3 metre step in), but with additional provision for access roads. The minimum width of the day wall is 50m and it must be stepped in when the minimum width has been reached.

Cross sections of the proposed facility are shown on the conceptual engineering drawings attached to the appendices.

7.3.2 Normal operation of the ADF

In any wall building operation it is essential to ensure that:

- The correct wall building procedures are being followed
- Adequate access for operation and rehabilitation is provided

- Planning and preparation for the step-in's are carried out timeously
- The total amount of wall building is optimized

7.3.2.1 Wall building

The correct wall building procedures as mentioned above should be used. As the ADF grows the day wall width will reduce to the point where there will be too much slurry to handle on the day wall. At this point it will then be necessary to step in the day wall. Typical sections showing how the step-ins will occur are shown on the conceptual engineering drawings attached to Appendix C.

Initially the day wall is 82 m wide. Generally the day wall step-in occurs where the day wall width has reduced to 50 m. The step in creates a new width of 87 m, including an allowance for a 5 m wide road.

The procedure for forming the step-ins is as follows:

1. On the inside face of the day wall step-in 36m and build up berm to a level at least 0.5m above the level of the day wall.
2. On outside face of the day wall step-in 4m for road access.
3. Fill with fly ash in separate lifts and maintain freeboard until width of day wall has reduced to 50m once again.
4. Repeat steps 1, 2, and 3 for each 8m rise in height.

This procedure will ensure that there is always sufficient capacity for daytime slurry operations and allow adequate access onto the facility.

The number of walls built to control and guide ash flow shall be kept to a minimum as the cost of operating the facility is almost directly proportional to the cost of wall building.

The 5m roadways as described above shall be covered with ferricrete gravel to reduce dust blow-off. They shall also be sloped inwards (towards the facility) with a drainage channel or take down chute leading the water down to the next roadway as shown in Figure 7-5: Roadway detail. This will reduce the amount of water running down the slopes and thereby minimize soil erosion.

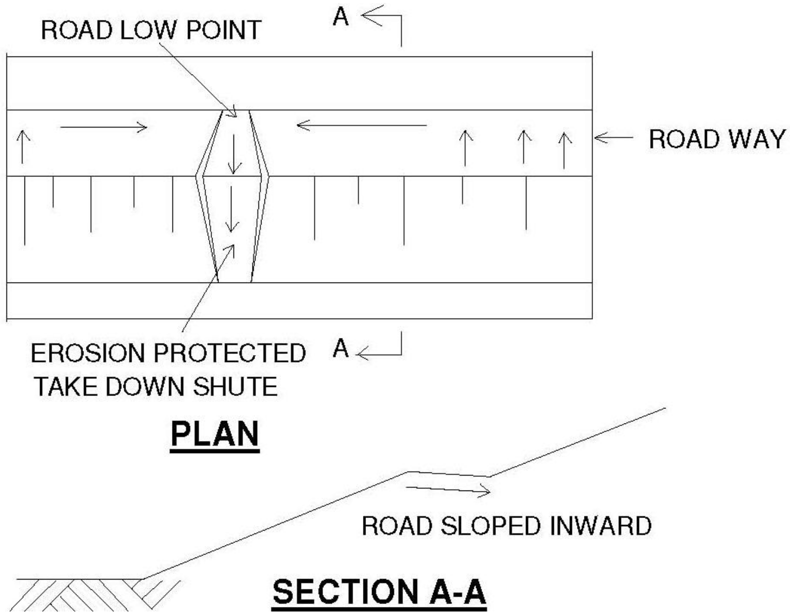

Figure 7-5: Roadway detail

7.3.2.2 Construction specification for the day wall, night-wall and innerwall sections

1. The station has four ash delivery cycles. Fine ash is transported daily at 7 am and 7 pm and coarse ash at 3 am and 3 pm. Camden’s ash consists of 80% fine and 20% coarse ash.

2. The perimeter wall of the ADF is divided into two sections. The first section is called the day wall and runs along the outer perimeter of the facility. The day wall has a minimum width of 50 m and is used for transporting only fine ash slurry and only during daylight hours. Only fine ash from the 7 am ash disposal cycle is therefore transported along the day wall. The second section is called the night wall and runs between the day wall and the inside of the facility. The night wall channels all the ash from both coarse ash cycles and the 7 pm fine ash cycle. The day wall therefore transports 40% and the night wall 60% of the station’s total ash production. The rate of rise will be the same for both walls provided that the night wall has a width equal to 1.5 times that of the day wall. The day wall should always be 250 mm above the night wall to further reduce the risk of an ash spillage during night hours. See Figure 7-6 below:

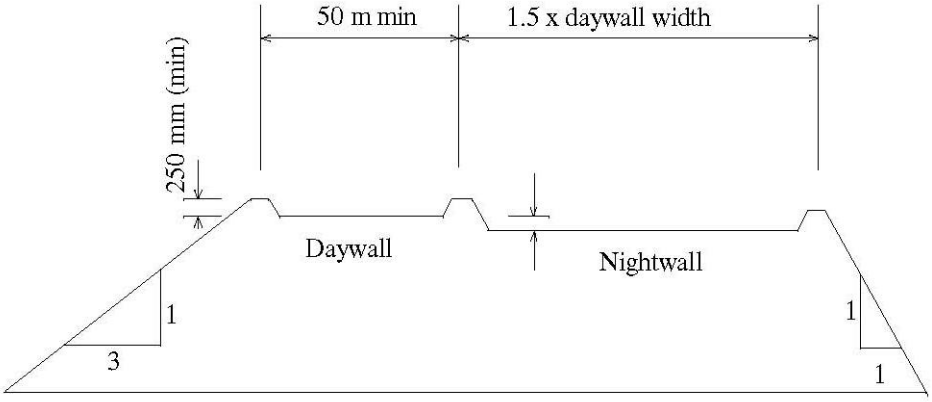

Figure 7-6: Day wall and nightfall construction

3. The floors of both the day wall and the night wall are constructed to slope towards the inside of the facility. This will force the rainwater to drain along the inner berm thus avoiding any risk of erosion of the outer berm during a major storm.

4. All berms are constructed from relatively fresh ash that has been deposited a maximum of fourteen days prior to their utilisation. Ash at an age of more than fourteen days is too dry and must first be wetted up through at least two ash disposal cycles before being used in constructing the new berm.

5. Material for all berms is excavated at least one metre inward from the toe of the new berm.

6. Berms are compacted with the excavator bucket in layers not exceeding 200 mm. The Project Manager may specify a different compaction specification in areas where the standard method of compaction fails to achieve the required results.

7. The side slope for all berms will be at least 1:1 except for the outside slope of the outer day wall berm which will be at least 1:3.

8. The crest width of every berm will be at least 1 m for all the straight sections of the day wall.

9. The crest width will be increased to 2 m where the berm changes direction by more than 10 degrees. The transition distance from a 1 m crest width to a 2 m width will be at least 15m. The crest width will remain at 2 m for at least 10 m before being reduced back to 1 m over another transition distance of at least 15 m.

10. Any erosion of the berms will be repaired as soon as possible and no ash will be transported along a channel where the crest width of any of its berms has been eroded by more than 30% of the original width.

11. The freeboard of the berms shall be at least 250 mm above the ash level in the channel at all times.

12. An innerwall acts as a division wall between different pool areas inside the facility. The innerwall has a minimum width of 30 m and is used for transporting both coarse and fine ash slurry to various positions on the facility.

13. Berms for the innerwall have the same dimensions as the berms for the night wall.

14. The ash slurry gravitates from a high point (distribution point) on the south side of the ADF along various distribution channels towards starting points on the day wall, the night wall or the innerwall.

15. The ash slurry further gravitates along the day/night or innerwall sections to a deposition point from where the ash is allowed to flow into the facility and to beach towards the penstock intake structure.

16. A beach slope of approximately 1:500 along the centre lines of the day/night and innerwalls will ensure a continuous capability to gravitate ash along these routes.

17. Ash slurry will be channelled in such a way that the extreme fine portion of the fine ash be deposited away from the highest section of the facility. The low point in the channel should therefore never coincide with the high point on the ADF.

18. The rate of rise for the day/night and innerwalls shall not exceed 6 m per annum. (The maximum permissible rate of rise for the dam as a whole is 4 m per annum)

19. The level difference between adjacent ash transport channels may vary between a minimum of 250 mm and a maximum of 1000 mm. The level difference at the transition between the night wall and the inside of the dam shall not exceed 3.5 m.

20. The Contractor may on occasion want to reduce the growth rate on the day wall section and can achieve this by channelling all the ash along the adjacent channel(s) for short periods of time.

7.3.2.3 Control of the pool on top of the ADF

The prime objective in the control of the pool on top of the ADF is to ensure that the pool is kept local to the decant tower inlet, and to ensure that the minimum freeboard of the maximum level of the water after a 1:100 year 24hr storm plus at least 0.5 m is maintained at all times. During severe rainfall periods the size of the pool could increase considerably but should be reduced as quickly as the penstocks and AWRD will allow. The excess stormwater must however be managed in such a way as to maximize the evaporation from the ADF and to reduce the amount of surplus water in the AWR dam.

Legislation (The Water Act - Act 54 of 1956 and Regulation R287 / 4989 / 20.2.1976) requires the minimum storage capacity of the system to be based on the normal operating water plus the average monthly rainfall less the gross mean monthly evaporation plus 1:100 year 24hr storm capacity plus 0,5 meter dry freeboard. Day walls shall be constructed in such a way that the ADF will always have sufficient capacity for normal ash disposal operations plus the average monthly rainfall less the gross mean monthly evaporation plus a 1:100 year 24hr storm plus at least 0.5 m of dry freeboard at the lowest point on the day wall.

7.3.2.4 Penstocks

Penstock rings are placed one on top of each other to form the decant tower as the level of the ash rises. They are also used to control the amount of water being drawn off the facility. Before the end of each day additional penstock rings must be placed on the decant tower to prevent water and ash being drawn into the decant tower during the night. In the morning the rings must be removed in order to enable water to be drawn off the facility. It must be borne in mind that, unless unavoidable; no water should be drawn off the pool while slurry is being run into the night paddock.

After severe storms it might be necessary to draw water off the facility while slurrying into the inner paddock but this occurrence should be the exception rather than the rule. The water level over the penstock ring should never be more than 160 mm as this will cause pressure surges in the pipe which could dislodge the penstock rings. Excess storm water must be decanted from the ADF within 4 to 5 days.

The pool level may rise between 450mm and 750mm during a 1:100 year storm event. The true value depends on the pool area and the beaching slope close to the penstock. The Contractor must keep enough penstock rings in stock to cater for at least 1 500 mm rise in the pool level

The outside of the decant tower is to be double wrapped using a geotextile to prevent piping of the fine ash particles through the joints between successive rings. Failure to do this can cause cavity formation which could lead to a penstock failure.

Decommissioning of the penstock must be carried out once it is no longer needed. This involves grouting up the decant tower by lowering a plug down to the bottom of the tower and then pouring a sand cement grout down to fill the tower.

It is extremely dangerous to place or remove penstock rings without a safety belt. A number of fatalities have occurred specifically in the area of the decant tower at various disposal facilities. The safety harness shall be attached to the catwalk column or balustrade, and shall always be worn when working in the vicinity of the penstock inlets.

7.3.2.5 Stormwater management

Management of stormwater on the ash disposal facilities is a critical part of the operation of the facility. Poor management of water on the facility could result in the failure of the impoundment. The volume of stormwater retained on the ADF must be kept to a minimum at all times. Excess stormwater must be drained from the facility within 2 to 3 days.

7.3.2.6 Solution trench

A regular monthly inspection of the solution trench shall be carried out to determine whether the trench has become choked by sediment or vegetation, or has been seriously eroded. Any damage shall be repaired as soon as possible. Grass and weeds growing through the concrete joints of the concrete lining shall be removed as soon as possible. Any trench crossings shall not encroach into the trench where the flow can be obstructed. Any seepage of water through the soil into the trench shall be noted, recording both the approximate flow rate and the location. The Project Manager must be notified of any such events. Any increase in the wetted area and/or flow from the toe of the ash facility is to be treated as an early indication that the filter drains are malfunctioning.

7.3.2.7 Stormwater diversion canal

The storm water diversion canal shall be checked fortnightly during the rainy season and also after severe storms. Erosion damage shall be repaired as soon as possible and logs, reeds and other large obstacles shall be removed. Grass and weeds growing through the concrete joints of the concrete lining shall be removed as soon as possible. Any canal crossings shall not encroach into the canal where the flow can be obstructed

7.3.2.8 Grass and reed cutting

The Contractor shall cut all grass vegetation once a year at the end of the growing season. Grass vegetation on the entire ash disposal area, enclosed by the storm water diversion canal on the south and the perimeter road elsewhere, shall be cut at this frequency. Reeds at the silt traps and AWR dam are to be cut at the same frequency.

7.3.2.9 Roads

Roads must be maintained according to the original design and construction specification. This includes cross slopes, road bed and wearing surface material, layer thickness and compaction of the layers. The roads must be kept in a condition acceptable to the Project Manager at all times. Ponding of water on the road surface after a rainstorm shall not be permitted.

7.3.2.10 Walkway to penstock

Figure 7-7 below shows the recommended walkway construction for access to the penstock decant tower. The structure must be able to carry the load from several people carrying penstock rings. It must also be able to support the horizontal forces on handrails for balustrades as set out in the SANS 10160 loading code. This will ensure adequate support for the safety harnesses worn by personnel when adding or removing penstock rings.

The walkway platform will have to be raised regularly to ensure that the platform is never less than 0,5 m above the pool. In addition, the minimum height above the pool shall be such that adequate access will remain possible after a major rainstorm.

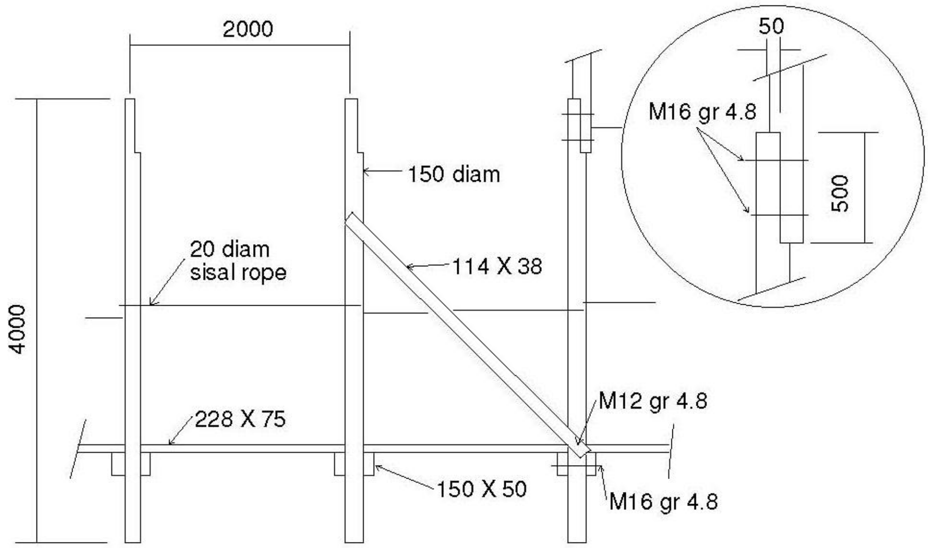

Figure 7-7: Typical walkway elevation

Timber used for the walkway is to be kept in good repair at all times. A walkway constructed from structural steel may also be used, but a timer structure is usually easier to raise and is therefore preferred.

7.3.2.11 Piezometers

Piezometers are necessary on an ADF in order to monitor the position of the water table within the wall of the facility. It is perhaps more economical to install the piezometers during the early stages of the facility and to extend them as the facility rises, rather than to drill holes and install them at a later stage. The piezometers will also tend to be far more reliable if installed in the early stages of the facility. Piezometers shall be read on a monthly basis.

The Contractor shall determine a safe phreatic surface and compare the readings against this. The Project Manager is to be provided with a set of all piezometer readings. Any increased risk due to a rising phreatic surface, shall be communicated immediately to the Project Manager and the professional engineer responsible for the facility.

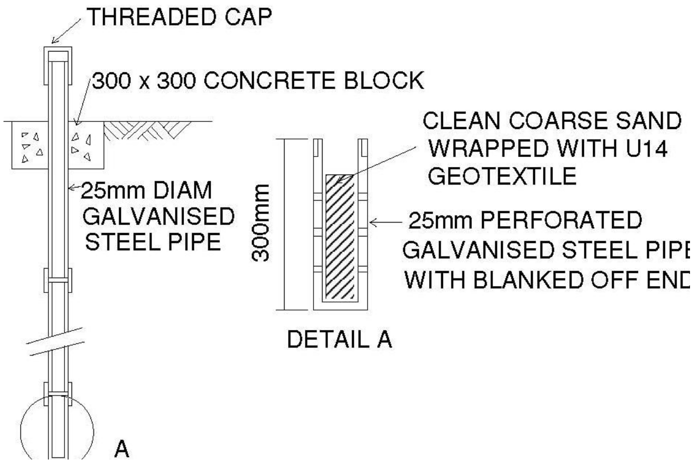

Figure 7-8: Typical piezometer detail

Figure 7-8 shows some typical details for the installation of a piezometer. The 300 mm square by 300mm deep concrete block is only to be installed after the wall has reached the final level at this specific position. Galvanized steel pipe sections are also only required for the top 3 metres of the piezometer, the remaining sections may consist of PVC piping provided that suitable couplings between the two types of material are available. This is to reduce the risk of damaging the piezometer during the normal operation of the facility. Special caution shall also be exercised when top soil for rehabilitation is placed in the vicinity of a piezometer. The piezometer tip, shown in detail A, can also be a proprietary porous ceramic or plastic tip. The augured hole for the piezometer is to be thoroughly washed with water until the water flowing from the hole is clear prior to installing the piezometer. The following installation procedure is recommended:

- Lower the porous tip into position, about 200 mm from the bottom of the hole.
- Pour a sand mixture down the hole until the tip is covered to a depth of 300 mm. The sand shall have a D10 of between 0.1mm and 0.7 mm.
- Seal off the sand layer using bentonite
- Seal the remainder of the hole by pouring course ash grout down the hole.

7.3.2.12 Rainfall

Measurement of rainfall at the ADF is essential as there often appears to be local differences in rainfall between the power station terrace and area of the ADF. The Contractor shall record all the rain falling on this area. The Project Manager must agree to the position(s) for the rain gauges. Rainfall figures will help in the correlation of the changes in level of the water table in the area of the ADF and in the rise in the pool level. This will assist in confirming the run-off factor of 0.8 currently being used for the facility.

7.3.2.13 ADF office

The Contractor shall maintain the facility to the satisfaction of the Project Manager.

7.3.3 Water management

Camden is actively trying to reduce the water consumption on the power station. Ash disposal operations have a significant impact on water consumption. Various actions to reduce water consumption have been identified and will be implemented as soon as possible. The Contractor is responsible to operate the ADF in such a manner that will minimize the water consumption by the ash disposal operations. The Contractor shall focus on the following areas of operation in order to reduce water usage on the facility:

7.3.3.1 Flushing of ash delivery lines.

The main objective is to reduce water usage per ash disposal cycle. Flushing shall only continue until the lines are cleared from ash. The Contractor telephonically notifies the relevant person in the station as soon as all ash has been cleared from the ash delivery lines and only clear water is being pumped into the distribution box on the ADF. This message is to be communicated after every ash deposition cycle. The Contractor notifies the Project Manager in the event that water continues to be pumped to the distribution point after the station has been notified that the lines are clear.

7.3.3.2 Drainage channels.

The Contractor must ensure that all drainage channels are kept clean from dirt, plant growth and any other items that can obstruct the free flow of water in these channels

7.3.4 Emergency procedure

The following situations are to be treated as emergency situations and the Contractor must deal with these in accordance with the relevant sections of the O&M Manual.

7.3.4.1 Inadequate freeboard

The Contractor immediately informs the Project Manager and the Responsible Professional Engineer when the level difference between the lowest point on the day wall and the decant pool level is less than 1.5 m.

7.3.4.2 Inadequate distance between the edge of the pool and the facility wall.

The Contractor immediately informs the Project Manager and the Responsible Professional Engineer when the pool moves closer than 200 m from the edge of the facility crest.

7.3.4.3 Inadequate storage capacity in the AWR-dam

The Contractor immediately informs the Project Manager and the Responsible Professional Engineer when the water level in the AWRD exceeds the design top water level before freeboard.

7.3.4.4 Polluted water spillage

The Contractor immediately informs the Project Manager and the Environmentalist on the station of any incident where polluted water from the ADF is spilled into the environment.

7.3.4.5 Penstock failure

The Contractor immediately informs the Project Manager when a penstock fails.

7.3.4.6 Slope failure

The Contractor immediately informs the Project Manager and the Responsible Professional Engineer when a slope failure occurs on the facility.

7.4 Operation of silt traps and AWRD

7.4.1 AWRD

The prime objectives of the operation of the AWRD is:

- To prevent spillage of polluted water into the natural environment, by containing water from the ADF.
- To have sufficient storage capacity for stormwater run-off generated from the impacted areas, from large storms.
- To minimize the need for make-up water for ash disposal at the station by having sufficient water in the AWRD

The storage capacity of the AWRD is discussed in the Conceptual Design of the facility, Section 5 of this report. The dam level is controlled by pumping ash water back to the AWRR. The Contractor shall at all times liaise closely with the operating staff from Camden power station to ensure that the water balance in the station, the stability requirements of the ADF and Eskom's zero effluent discharge philosophy are all adhered to. The Contractor should assist as far as possible with the level control of the AWRD by letting more water off the ADF when the level in the AWR dam drops below 500mm or by retaining more water on the facility when the level exceeds the design top water level before freeboard. The safety and the stability of the ADF will always take preference to any level control issues.

7.5 Monitoring and maintenance requirements

7.5.1 ADF Monitoring

The Contractor checks and presents in a format that is acceptable to the Project Manager the status of the following items on a monthly basis:

Pool

- Closest position of the pool to the day wall.
- The area of the pool.

Penstocks

- Verticality of the rings forming the decant tower.
- Presence of the geofabric wrapping around the decant towers.
- Flow depth at the crest of the decant tower.

Catwalk

- Availability and use of safety harness.
- Minimum height of the platform above the pool level.
- Structural integrity of the platform and handrails.

Day wall

- Age of the ash that is being used in day wall construction.
- Days of day wall ash disposal currently available.
- Total freeboard between day wall and the pool level.
- External and internal slope.
- Presence of any wet spots on the outer slope.
- Slope alignment maintained?

Road at step-ins.

- Is the road sloping inward?
- Is adequate drainage provided on the side slopes?

Ash facility perimeter access road.

- Properly graded to the required cross fall gradient?
- All water drained off the road surface after a rain storm?
- Road surface wearing course still intact?
- Structural layers still intact

Filter drain outlets

- Are the drains still functioning?
- Is the water from the drains clear or is ash silt present?
- Is chemical scaling occurring at the outlets?
- Is there any damage to the pipe or drainage system?

Solution trench

- Is the trench clear of any obstacles?
- Are the trench bottom and sides well maintained?
- Is all growth between expansion joints removed?

Stormwater diversion canals

- Is the canal clear of any obstacles?
- Are all growth between expansion joints removed?
- Have they been installed in the areas required?
- Are those already installed, in good working order?

- Have the water table levels been recorded?
- Is the current phreatic surface within acceptable safety limits?

Barrier fence

- Is the fence still intact?
- Is unauthorized entrance prevented?

7.5.2 Piezometers

Readings are to be taken at monthly intervals. Weekly readings are to be taken when the phreatic surface has risen to a level that represents a high risk situation. A pool less than 200 metres from the outer crest of the day wall, is to be considered as a high risk situation and weekly readings will also be applicable in this instance.

7.5.3 AWRD monitoring

The Contractor checks and presents in a format that is acceptable to the Project Manager the status of the following items on a monthly basis:

Water storage capacity

- The current water level.
- Check with Camden personnel that all the pumps are operational.
- Silt levels in the dam (annually).
- Is adequate storage capacity available for the maximum anticipated rainfall?

AWRD wall

- Any wet spots on the downstream slope?
- Any sign of erosion on the internal or external slopes?
- Any cracks along the crest?
- Any signs of settlement or movement.
- Are any shrubs or trees growing on the wall?

Downstream pollution

- Has any polluted water spilled into the environment?
- If so, was the Project Manager notified immediately thereafter of the volume and the reason for the spill?

7.5.4 Silt trap monitoring

The Contractor checks and presents in a format that is acceptable to the Project Manager the status of the following items on a monthly basis:

Retention storage capacity

- Water depth at the decant tower
- Silt levels in the dam.
- Is adequate retention storage capacity available to satisfy the de-silting requirements?

Dam wall

- Any wet spots on the downstream slope?
- Are both spillways in a good and functional condition?
- Any signs of piping between the horizontal penstock section and the dam wall?
- Any sign of erosion on the internal or external slopes?
- Any cracks along the crest?
- Any signs of settlement or movement?
- Are any shrubs or trees growing on the wall?

7.5.5 Groundwater monitoring

A system of groundwater monitoring points is proposed to be installed. The responsibility for the monitoring of the water quality will remain with the environmental section of the power station. The monitoring frequency is currently three monthly on the existing facility, but will be increased when a deterioration in the pollution levels is being detected. The changes in the monitoring programme will also be informed by the station's Water Use Licence (WUL) requirements.

7.5.6 ADF Contour Survey

An aerial survey of the ADF area shall be carried out every two years. A contour plan with contours at 2m intervals and a digital file with the X, Y and Z coordinates of every survey point are to be produced after every aerial survey. In addition to the aerial survey, a representative number of spot levels are to be taken every six months to assess the rate of rise of the various wall areas. A number of survey beacons are to be constructed at strategic positions to serve as benchmark levels from where the relevant dam wall levels can be surveyed. An accuracy of approximately 200mm will be quite adequate for the six monthly surveys.

7.5.7 Coordination meetings

Coordination meetings are to be held at monthly intervals between the Project Manager and the Contractor. It is advisable to conduct a site inspection prior to each meeting. The Contractor provides the Project Manager and the responsible professional engineer with a copy of the results from the various monitoring activities at least one week before the next monthly coordination meeting.

7.5.8 Maintenance

Regular maintenance must be carried out throughout the life of the ADF in order to provide full and cost effective use of the facility. All maintenance actions that are identified at the coordination meetings shall be implemented before the next coordination meeting, unless otherwise agreed with the Project Manager. All maintenance work is to be done to a standard acceptable to the Project Manager.

7.5.9 Legal and safety requirements

Ash disposal facilities are hazardous areas, in terms of safety and the classification of the material, and unauthorized people shall not be allowed on to them for the following reasons:

1. The area around the pool of the ash facility is expected to behave like quicksand under certain conditions. "Sinkholes" may also occur in older facilities.

2. The ash will cause blistering of the skin after prolonged contact.

3. Ash water is poisonous. It is therefore essential to erect clearly visible warning signs and to keep the gates to the ash facility locked when there are no authorised ADF personnel on site.

Preventing public access to the facility is the legal responsibility of the Asset Owner. The minimum standards to which an ash facility is to be fenced in is set out in Regulation 26 of the Water Act (Act 54 of 1956) Section 26. The Contractor is responsible in terms of the ash facility construction and maintenance contract to prevent unauthorized access to the site. Safety on the facility shall be constantly reviewed and upgraded where necessary. Where work is being carried out on the surface of the facility, or off the beaten track, personnel shall work in pairs. Established routes across the ash paddocks shall be used wherever possible, even if this means having to walk further. Personnel shall be informed of the dangers of working on an ADF. If the above measures are adhered to a good safety record at the ash disposal site should be maintained.

The Occupational Health and Safety (OHS) Act must also be adhered to.

Stipulations and regulations of the Construction Regulations will be implemented as required.

7.5.10 Monitoring requirements during high rainfall periods

The Contractor increases the monitoring frequency for the piezometers, the filter drain outlets and the freeboard on the ADF to a weekly interval whenever the rainfall exceeds 100 mm per week. The Project Manager and the responsible professional engineer are to be notified immediately of every high rainfall incident.

The responsible professional engineer will visit the facility within three days from the date of notification and will advise the Project Manager of any additional actions that may be required.

7.6 Rehabilitation and environmental considerations

7.6.1 Environmental responsibilities

7.6.1.1 General

The Contractor shall be required to adhere to any applicable South African Environmental legislation during the construction, operation and management of the ash disposal facility/ies. The responsibility shall remain with the Contractor to keep up to date with any applicable revisions or new environmental legislation that comes into effect during the contract period. In addition the Contractor shall also comply with Eskom specific Policies, Procedures and Guidelines. Copies of the relevant Eskom documents can be obtained from the Project Manager.

The following is a list of some of the relevant legislation and other environmental documents at the time of the compilation of this document:

South African Acts:

- The Environment Conservation Act (Act 73 of 1989)
- The Water Act (Act 54 of 1956)
- The Minerals Act (Act 50 of 1991)
- The Atmospheric Pollution Prevention Act (Act 45 of 1965)
- The Occupational Health and Safety Act (Act 85 of 1993)
- The Health Act (Act 63 of 1977)
- The Road Traffic Act (Act 29 of 1989)
- The Hazardous Substances Act (Act 15 of 1973)
- The new Construction Act
- The National Environmental Management Act, Act 107 of 1998
- The National Environmental Management Waste Act, Act 59 of 2008.

Subsequent amendments to any of the above Acts are also implied.

Eskom Policies and procedures

- ESKPBAAD6 Environmental Management Policy
- ESKPBAAA9 Environmental Impact Assessment
- ESKPVAAL7 Environmental Impact Assessment
- ESKPBAAA3 Air Quality Management Policy
- ESKPBAAD4 Herbicide Management
- ESKASAAL0 The Safe Use of Pesticides and Herbicides
- ESKPBAAA8 Energy and Environmental Policy and Strategy
- ESKPBAAAC4 Waste Management Policy and Strategy

- ESKPBAAA6 Coal Utilization
- GEM6 An Eskom Purchasing Policy for Buying Environmentally Friendly Products
- ESKADAAJ4 Water Management Policy
- ESKADAAJ5 Waste Management Policy
- ESKADAAP7 Investigation of Major Incidents
- GGS0350 Generation Fire Risk Management
- GEM BULLETIN 5 Problem Plant Species on Generation Sites

7.6.1.2 Water quality

Eskom will monitor water quality of surrounding streams and groundwater.

The Contractor shall be responsible for upkeep of solution trenches, stormwater channels, AWRDs and other such structures to ensure that they remain effective in maintaining a zero effluent discharge system.

The Contractor shall keep in mind that the ash system forms a part of the entire Power Station water balance. All failures on the ADF with regard to dams, drains etc. must be reported to the Project Manager and the Camden environmental department. An assessment of the effect of the failure in terms of water quality and water balance must be determined between the Project Manager and the Contractor.

7.6.1.3 Air quality

Wind pollution (due to ash blow off)

During the building of the ash facility the Contractor is to ensure that ash dust pollution is kept to a standard which is in accordance with the current South African legislation, as well as any Eskom policies that may be applicable. In general, windblown-dust shall be continuously controlled by the Contractor by regular moisture conditioning of the ash or by rehabilitating the exposed ash surfaces. The exposed section of the side slope of the ADF is normally only rehabilitated after the next step-in and vehicle access above the slope has been constructed. This delay in rehabilitation will result in an exposed slope of up to 25 m wide along the perimeter of the facility. The Contractor is also responsible for dust control on this surface and may use any effective method, which is acceptable to the Project Manager, to control dust blow-off from this area. Acceptable methods are surface wetting, chemical stabilization or protection with shade cloth.

Wind pollution (construction works)

The construction plant access routes, haul, roads etc. are to be watered sufficiently to prevent any dust blow off during the entire contract period. Other dust suppression methods, deemed adequate, may also be used.

Should there be a suspicion that the air quality is in excess of the standard, then the Project Manager may arrange for the installation of dust monitors to verify the situation.

7.6.1.4 Waste management

No building rubble or other scrap is to be dumped on the ADF. Office waste shall be removed from site. The Contractor may contract with the current waste disposal contractor for Camden power station for a similar service. Cut vegetation may be used as compost for rehabilitation of the side slopes. The ADF shall at all times be completely fenced off and have the appropriate warning signs displayed. The Contractor shall be responsible for the maintenance of the fence.

Discard coal disposal

Small quantities of discard coal, not exceeding a total of 64 tonnes per month, can be dumped inside the ADF. Coal transported by truck, is to be dumped at least 400m inside the crest perimeter of the ADF. The date and weight of every disposal event are to be recorded. Dumping should preferably occur in one location and should only change when access to an area becomes difficult. The trucking of discard coal will result in a well-controlled dumping operation. Limited quantities of coal discards, not exceeding 20 tons per month, may also be pumped together with the coarse ash to the ash facility. Coal has no cohesion and will reduce the strength of the outer wall of the dam if mixed with the fine ash from the precipitator fields. Mixing of coal discards with fine ash is therefore not permitted.

7.6.1.5 Land management

Veld fires

Any veld fires during the first two growing seasons after rehabilitation can be disastrous. The Contractor shall take all the steps necessary to control fires and a veld fire management plan shall be submitted timeously to the Project Manager for approval. The existing fire breaks are to be maintained to prevent any spread of veld fires from the ADF area.

Erosion control

The Contractor shall be responsible for the protection of all areas subject to erosion by providing any necessary drainage works, temporary or permanent and by taking all other reasonable precautions as may be necessary to prevent scouring of banks, ash slopes and other areas.

Any erosion damage occurring during the operation of the facility shall be thoroughly repaired and the areas restored to their original condition. Such repair work shall be carried out as soon as possible after damage was caused with all eroded topsoil reclaimed from drains and other areas where possible.

7.6.2 Rehabilitation requirements

7.6.2.1 General

Generally the New ADF will be rehabilitated by the placing of a 300mm thick layer of topsoil on top of the facility and the planting of indigenous grass.

The Contractor shall, in accordance with the requirements of this document, be responsible for the:

- gradual stripping and stockpiling of topsoil
- gradual shaping of side slopes and top of the facility
- gradual spreading of topsoil to cover shaped the facility side slopes and top surface
- planting of grass for erosion control on prepared slopes
- establishment of veld grass on the prepared areas
- establishment of indigenous trees and shrubs
- aftercare of rehabilitated areas to ensure continued stability and eventual self-sustainability
- the upkeep of a complete rehabilitation progress manual

Pollution control

The Contractor shall take all reasonable measures to minimize dust, mud on nearby roads and walkways and inconvenience to the public or others because of the construction of the works.

Progress manual

The Contractor shall start and keep progress manuals fully documenting the progress made and significant factors influencing the rehabilitation process. The manual must be made available upon the Project Manager's request.

7.6.2.2 Materials

Whether the quality of material is specified or not, the Contractor shall at all times use material of the best possible quality and shall price his tender accordingly.

Plants

Plants shall be true to name, healthy and well rooted. Plants shall have a good form typical of their type unless specifically specified otherwise. Containerized plants shall not be root bound. Plants shall grow well and be free from scars or damage, insect pests, diseases or parasites.

Each plant shall be handled, packed and transported in the accepted industry manner for that species or variety and all the necessary precautions shall be taken to ensure that the plants will arrive at the site in a condition for successful growth.

During delivery to the site, plants shall be adequately protected from damage by sun, wind or other causes.

Containers shall be in good condition and the soil shall be free from weeds.

Containerized plants not planted out immediately shall be stored and maintained in nursery like conditions i.e. including storage under shade cloth, well watered and inspected for routine maintenance until they are planted out.

The Contractor shall be prepared to find plants anywhere in the country. Only if the Project Manager is convinced beyond doubt that the plants specified cannot be obtained, will substitutes be considered. Substitutes will be decided on by the Project Manager. The Contractor will be informed in writing.

The Contractor shall assure himself of the availability of specified plants before tendering.

Tree stakes

Tree stakes shall, unless otherwise specified, be treated poles (round droppers) complying with SABS 457, 35 mm minimum diameter and 2 400 mm long. These shall be used of both single and multiple staking. Creosoted timber will not be accepted.

Tree ties

Tree ties for fixing trees to stakes shall be of plastic, rubber or other similar material which supports the tree in a substantial manner, and shall be approved by the Project Manager. Ties shall be such to minimize abrasion and to allow for sufficient space around the tree trunk to permit growth.

7.6.2.3 Equipment

The Contractor shall provide sufficient plant and equipment of adequate capacity, suitable for the work and site conditions, to fulfil his obligations in terms of the Contract. In all cases the most suitable equipment for the particular application shall be used in the interests of time saving and efficiency. In each case the Project Manager shall be approached to authorize the proposed equipment.

7.6.2.4 Preliminary works

The rehabilitation of the ADF and other ashed areas to be rehabilitated shall take place in phases. Work shall commence as soon as an area becomes available for rehabilitation. The Contractor is to programme accordingly.

Stripping of topsoil

Topsoil shall be stripped and stockpiled for future use from those areas to be ashed on. The process shall be gradual and in accordance with the ash disposal programme.

The depth of stripping is to vary according to the soil formation. The Contractor shall in general strip soils down to the hydromorphic horizon. Soil from the hydromorphic horizons (such as soil with a high clay percentage and/or wet soils) shall not be acceptable for use as topsoil. Only topsoil with up to, but not exceeding, 30% of coarse particles and stone shall be acceptable. The stone or coarse particles shall also not exceed 250 mm in diameter. Where stripping takes place from areas which will not be ashed upon in the future the areas shall be contoured after stripping as to blend in smoothly with the existing levels. The areas shall be left without any slacks or hollows where water and contours can accumulate. Unless it is used immediately, the topsoil shall be stored in positions as indicated or approved by the Project Manager, in the following manner:

- establish veld grass, or other vegetation as instructed, on heaps to be left for periods in excess of three months
- Take any further preventative steps necessary to protect the heaps from erosion.

The Contractor shall manage his rehabilitation programme in such a manner that stripped topsoil is re-used as soon as possible for rehabilitation purposes.

Preparation for planting

1) Slopes not exceeding 1:10

This includes the top of the ADF.

   a) Topsoil Spreading.

      i) Spread topsoil evenly to a minimum thickness of 300 mm over the total graded area.

   b) Shaping

      i) Work the topsoil in to a minimum depth of 300 mm ensuring a smooth final surface without any slacks and hollows where ponding can take place.

   c) Fertilizers

      i) Apply fertilizers evenly at the following rates:

         (1) 250 kg/ha 4:3:4 (30) + Zn

         (2) 300 kg/ha Superphosphate (10,5% P)

      ii) Application shall be carried out not more than 1 week prior to planting. The mixing of inorganic fertilizers and seed shall not be acceptable.

2) Slopes in excess of 1:10 (10 %)

   a) Grading of Side Wall Steps

      i) Edge of side slope steps to be graded to create an even slope with a rough surface. Ash clods shall not exceed 350 mm in diameter.

   b) Sodding

      i) For erosion control purposes slopes exceeding 5 metres in length shall be stabilized by planting 450 mm wide sod strips. The strips shall be spaced 5 m apart measuring from the toe of the slope in each case. Sods shall be secured in place using pegs or any other approved method.

c) Topsoil Spreading

i) Topsoil shall be spread evenly to a minimum thickness of 300 mm over the total graded area.

d) Veld grass

i) Rough veld grass stalks shall be spread over topsoil to a depth of 40-60 mm.

e) Shaping

i) The slope shall be evenly smoothed ensuring that all signs of terracing are removed and that the ash, topsoil and veld grass are thoroughly mixed. Ash clods exceeding 100 mm in diameter may protrude through the topsoil layer.

f) Fertilizers

i) Apply fertilizers evenly at the following rates:

(1) 250 kg/ha 4:3:4 (30) + Zn

(2) 300 kg/ha Superphosphate (10,5% P)

ii) Application shall be carried out not more than 1 week prior to planting. The mixing of inorganic fertilizers and seed shall not be acceptable.

7.6.2.5 Planting procedure

Tree planting

To avoid erosion problems, trees shall not be planted on slopes in excess of 1:3. The trees shall be planted in groups of 3-5 plants ensuring a minimum coverage 50 plants/ha. Certain trees are sensitive to the direction of a slope and the planting plan shall take this into account.

The following plant species may be used:

- Acacia karroo (Sweet Thorn) – Plant on east and west slopes
- Diospyros (Blue Bush) – Plant on north lycoides slope
- Rhus pyroides (Common Wild Currant) – Plant on any slope
- Ziziphus (Buffalo Thorn) – Plant on north mucronata slope

- Rhus lancea (Karree) – Plant on east and west slopes

Scarifying

The total area to be seeded or planted shall be scarified to a minimum depth of 20 mm. Scarification shall be done horizontally across slopes. Seeding shall take place directly following scarifying. In the event of the scarified surface becoming smooth again before seeding, the Contractor shall re-scarify to ensure a suitable seed bed.

Seeding

Seeding shall take place as early as possible during the growing season. The Contractor is expected to programme accordingly. The seed mixture to be used shall be made up as follows unless agreed differently with the Project Manager:

Grass species	*kg/ha*
Chloris gayana	2
Eragrostis tef	3
Eragrostis curvula	3
Aragrostis chloromelas	1
Aragrostis lehmanniana	1
Enneapogon cenchroides	2
Aragrostis echonochloidea	1
Themeda triandra	1
Digitaria eriantha	2
Cynodon dactylon	2
Hypperrhenia hirta	1
Panicum maximum	1

Where specific grass seed cannot be obtained by the Contractor, he may replace it with another species in consultation and agreement with the Project Manager. The change will be of the same monetary value.

No seeded sections shall be taken over prior to a successful germination rate of at least 70% (measured as 70% of the total area and/or 70% of any particular seeded area of at least 2 500 m^2) can be proven by the Contractor. In addition, there shall be no bare patches in excess of 500 mm in diameter or half a meter squared in area. Germination shall be regarded as successful when the grass sward is 5 mm above ground level and identifiable as of the types sown.

7.6.2.6 Care after planting

The Contractor shall protect newly seeded/planted areas against undue traffic and/or other disturbances throughout the contract and maintenance periods.

7.6.2.7 Maintenance

The Contractor shall adequately maintain construction areas for a period of 6 months. Maintenance shall include:

- Continuous repair of damage caused by erosion or any other cause. Erosion gullies exceeding 100 mm in width may be repaired by placing Cynodon spp sods or clumps in the gullies that have begun to form so as to effectively stop them from developing.

- Maintenance of acceptable grass cover with reseeding/sodding as necessary.

The Contractor shall be required to apply a top dressing of 150 kg/ha ammonium sulphate to seeded areas 4 to 6 weeks after germination under favourable growing conditions. (If in doubt the Contractor should discuss this aspect with the Project Manager).

8 COST ESTIMATE / TRADE OFF STUDY

A high level life cycle costing study of the EIA conceptual design report was conducted by Eskom and is presented in Appendix F. Cost estimates were undertaken for the capital works as well as the operation and maintenance costs based on the conceptual designs. The detailed breakdown of the costs is given in the appendices and the summary of the cost comparison for Site 1 and Site 3 is presented in the table below.

Table 20: Cost Comparison for Site 1 and Site 3:

Criteria	Site 1	Site 3 (3A & 3B)
Total CAPEX	R 1.35 billion	R 2.67 billion
Total Lifecycle Cost Net Present Value (including CAPEX and OPEX for operation from 2017 to 2033)	R 1.972 billion	R 2.409
Footprint capacity to 2033	Yes	Yes, but 2 sites required (3A and 3B)

The following is excluded from the cost estimate:

- Design fees
- Specialist study fees
- Escalation

The major cost is the lining system as it is designed in accordance with the Department of Water Affairs Minimum requirements. In order to create flexibility in terms of capital expenditure the installation of the liner may be phased over a maximum of 4 to 5 years.

As indicated previously in the report, a Class C barrier is required in terms of the Waste Classification report. The liner system calls for a 300mm clay layer, as well as other layers (discussed in the relevant section of the report). Testing will be conducted in August 2014 on the ADF footprint on Site 1 to determine the permeability of the in situ soils. If the permeability is less than 10^{-5}cm per second then the in situ soils may be used instead of the clay layer. Importation of clay is possible however may not be economically viable. The rate for clay used in the liner assumes that the clay is imported from one commercial source located in close proximity to the site.

The average annual operation and maintenance costs of the proposed ADF on Site 1 and all the associated infrastructure is estimated to be approximately R36.5 million per year, based on the NPV (net present value) of future disbursements as per the *High Level Life Cycle Costing Study of the EIA Conceptual Design Report* by Eskom, presented in Appendix F.

9 RECOMMENDATION

Site 1 is the only site that can accommodate the ash within a single footprint and achieve the total production over the design period. The rate of rise is within the allowable maximum per year whereas Sites 3A and 3B exceed this due to their smaller footprints.

Sites 3A and B do not individually accommodate the ash production over the 19 years operation period and therefore cannot be compared directly to the cost of Site 1. However Sites 3A and 3B combined (NPV Cost of R2.409 billion) can be compared directly with Site 1 (NPV Cost of R1.972 billion) with regards to total lifecycle cost.

Site 1 is both technically and economically feasible over the other two sites and should be taken into the next phase, detail design. Site 1 is the preferred site as it can accommodate the full ash production for the 17 years while keeping within the 40 metres allowable height. The shape of the ADF will also facilitate the ease of operations. The combination of Sites 3A and 3B may be looked at only as a back-up to Site 1.

The liner system (as per DEA Requirements) comes at a high cost and should be interrogated in order to motivate for a relaxation. The design should be within an Acceptable Risk Level (ARL) and this should be taken into account when the liner system is revisited. It is recommended that the Source Path Receptor (SPR) approach be adopted as a tool in the next phase to motivate for the relaxation of the liner requirements.

Testing will be conducted in August 2014 on the ADF footprint on Site 1 to determine the permeability of the in situ soils. If the permeability is less than 10^{-5}cm per second then the in situ soils may be used instead of the clay layer, however the 1.5mm thick HDPE liner must be increased to 2mm thick. Importation of clay is possible however may not be economically viable.

10 CONCLUDING REMARKS

Conceptual Engineering design was undertaken for the three sites considered at this stage of the project. The technologies did not differ for any of the sites. Only Site 1 alone accommodates all the ash generated over the 17 years remaining life of the power station. It also poses a lesser hazard in the event of failure than the other two sites.

Site 1 is the preferred site and should be taken to the next phase.

ZITHOLELE CONSULTING (PTY) LTD

D Jansen Van Rensburg Pr.Eng N Rajasakran Pr.Eng

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APPENDIX A

WASTE CLASSIFICATION REPORT

APPENDIX B

GEOTECHNICAL INVESTIGATION REPORT

APPENDIX C

CONCEPTUAL ENGINEERING DRAWINGS

APPENDIX D

DESIGN CALCULATIONS FOR STORMWATER MANAGEMENT

APPENDIX E

STAGE CURVES FOR ADF OPTIONS

APPENDIX F

HIGH LEVEL LIFE CYCLE COSTING STUDY OF THE EIA CONCEPTUAL DESIGN REPORT

APPENDIX G

WATER BALANCE DIAGRAMS