ESKOM HOLDINGS LIMITED

PANEL B CONSULTANTS JOINT VENTURE

KUSILE POWER STATION

ASH DUMP TERRACE LAYER WORKS DESIGN

DETAIL DESIGN REPORT 5452-90-011 REV 7

Task Order Number: PBC JV TO#31

OCTOBER 2013

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1 INTRODUCTION

The Panel B Consultants Joint Venture (PBCJV) has been appointed by ESKOM Enterprises under PO 4500 243 653 (TO # 31) to carry out civil design for the water licensing aspects of the Kusile coal-fired power station located near Witbank in the Mpumalanga province. PBCJV is working in close liaison with ESKOM and their appointed design partners, Black and Veatch (B&V)

The concept design for the No.1 Ash Dump underwent a series of studies, reviews and reports before finalisation, per references 7,8, and 9.

Since finalisation of design report 5452-90-011 Rev5 in December 2010, the ash dump has undergone fairly extensive change in respect of its footprint and liner system. This 2013 revision 6 brings the report up to date in respect of the ash dump final design and as it has been constructed.

This updated report sets out the final detail design of the No.1 Ash Dump terrace layer works and associated facilities (final footprint, foundation drainage, lining system, clean and dirty stormwater facilities, dirty water storage dams, access roads, and general terraces). It is currently decided that ash will be disposed for 5 years in dry form in co-disposal with gypsum from the station process (80:20 ash gypsum at approximately 15% moisture content). Thereafter the No.1 Ash Dump will receive gypsum only for the balance of power station design life, to 60 years (i.e. for a further 55 years). A second ash dump, to receive ash only for 55 years, will be developed on another site at a later stage.

The ash/gypsum in the first five years will be placed onto the dump using load and haul equipment. The ash/gypsum will be placed in low height paddocks, until full design height is achieved. A similar load/haul operation will apply for the gypsum only disposal over the remaining 55 years.

The construction of the ash dump facilities will be undertaken in phases. Phase 1 will include the footprint development for the first four and a quarter years of co-disposal deposition, together with all clean and dirty water management facilities designed to accommodate the ultimate development of the overall dump.

1.1 Background

Eskom is the principal supplier of electricity in South Africa. In order to meet the growing need for electricity, and in support of the growth and development strategy of national government, Eskom has embarked on an expansion programme to develop new power stations. Part of this expansion program includes the building of a number of coal-fired power stations. A proposed new 4,800 MW coal-fired power station (Kusile Power Station) near Kendal Power Station is one of the coal-fired power stations to be built. An extremely tight design and construction program is in place to achieve a first fire on coal date for the first boiler unit of July 2013. The project has been given National priority status. A preliminary version of this report (report 5492-90-011 Rev 1) was submitted in January 2009 with the Integrated Water Licence Application (IWULA) to the Department of Water Affairs (DWA). Revision 5 of this report recorded the accepted design as at December 2010.

The accepted ash dump design took into account the associated wetland delineations as defined by Golder associates in 2008, which identified the small pan on the crest of the ash dump site, the treatment of which was incorporated into the original ash dump design. During the licencing process a revised wetland assessment was undertaken in 2011 by Wetland Consulting Services. After subsequent review of this report and intervention by DWA and DEAT (Department of Environmental Affairs and Tourism) in 2012 in respect of the small pan wetland on the crest of the ash dump site (which was to be covered by the ash dump after provision of under-drainage), it became necessary to amend the ash dump footprint so as to avoid the pan wetland (including provision for a buffer zone).

Conceptual design notes for the 2012 amended footprint, setting out the finally agreed design parameters for Phases 1 and 2 of the ash dump development are presented in Report 30300098/16/01 Rev 2 of 03 December 2012 (ref 12).

The amended footprint is shown in the Appendix drawings and the Phase design parameters in the Tables of section 4 of this report..

Again after intervention from DWA early in 2013 in respect of the previously accepted liner design, it became necessary to upgrade the ash dump liner system. The proposed amended details were submitted to DWA I in May 2013 under design note " Amended Ash Dump, Settling Tank and Ash Dump Dirty Water Dam Liner Systems, R4, May 2013(Ref 14). Details of the final liner system are shown in the drawings included in the Appendices.

This updated detail design report provides full detail of the ash dump final design as accepted for construction, but has not deviated from the original basic concept designs presented in the preliminary design report (Rev 1) except in respect of the final footprint shape and size and the liner system detail.

1.2 General

The No.1 Ash Dump is located to the West of the main Kusile Power Station complex, as shown on the B&V Block Plan in **Appendix 1.**

As at October 2013, the power station commissioning is currently scheduled as follows:

Date of first fire on coal: Unit 1: 1 December 2014
Date of first fire on coal: Unit 6: 1 November 2016

The ash dump will be constructed and commissioned in time to receive ash on 1 December 2014. Construction of the ash dump complex commenced in August 2011.

1.3 Scope

The station ash dump, approximately 2500 m by 1000 m in plan extent (211.9 ha), is formed on sloping hill-top ground to the West of the station coal stockpile and its associated natural stream and stream diversion. The general location is shown on the Kusile site layout drawing in 1.2 above.

The following general drawings are presented in **Appendix 1**:

- Block Plans
- Ash Dump General Arrangement drawing K30300098/06-201 R3
- Typical Ash Dump Cross-section drawing K30300098/06-207 Rev 0

A list of all other drawings included in Appendix 1 is also presented, covering:

- General Arrangement Drawings
- Earthworks and Ancillary Structures
- HDPE liner
- Dirty Water Drains

- Ash Dump Dirty Dam
- Clean Water Drains
- Clean Water Sediment Control Dams
- Access roads

together with a full schedule of all drawings associated with the Ash Dump, are included at the front of **Appendix 1.**

The general arrangement drawings presented show the ultimate overall development of the dump. Accompanying detail drawings are for Phase 1 of the development only.

Clean and dirty water run-off from the ash dump terrace will be managed separately according to the DWA "Best Practice" series of publications.

The ash dump terrace layer works design is to address all relevant South African regulatory requirements, in particular:

- The National Water Act, No 36 of 1998
- Government Notice No.704, Regulations on use of water for mining and related activities aimed at the protection of water resources, in terms of the National Water Act (Act 36 of 1998)
- SANS 1200: Standardised Specifications for Civil Engineering Construction
- DWAF Minimum Requirements for Waste Disposal by Landfill (Second edition, 1998)

2 DESIGN PARAMETERS

2.1 General

The following basic parameters apply to the detail design of the amended footprint for no.1 Ash Dump:

- Ash and gypsum tonnages for disposal are as scheduled in **Appendix 2**
- Assumed boiler commissioning intervals = 12 months
- Co-disposal Ash/gypsum for the 1st 4.25 yrs: Storage Volume = 18.161 x 10^6 m^3 (to the full capacity of 18 161 339m^3 of Phase 1)
- Gypsum disposal for the next 50.25 yrs: Storage Volume = 45.3 x 10^6 m^3
- (Note: the total life of the dump is limited by the footprint area and the maximum achievable height of the dump)

- (Note: the Phase1 volume/life is derived by adopting a footprint of 106ha, which was the original Phase 1 footprint area applying to the Phase 1 construction contract before the ash dump overall footprint was amended)
- Total disposal for 54.5 yrs: Storage Volume = 63.653 x 10^6 m^3
- Top elevation of dump: Varies 1510.00 to 1580 mamsl
- Dump height: Varies 27 to 102 m
- The dump will be developed to full height at elevation 1540m starting at the North end of the site, during the first 4.25 years of operation, and will progressively move forward at full height at elevation 1510m to 1550m towards the south.
- All dump side slopes are at 1V to 5H. The advancing front face will also be benched to have an effective slope of 1V to 5H.
- Ash/gypsum co-disposal and gypsum disposal will be disposed by a load/haul operation in successive paddocks of suggested size 200m by 200m, developed in 2m lifts, built to full height of the dump as quickly as possible. In this way dust suppression and irrigation water would be minimized, haul-truck distances reduced and early rehabilitation by top-soiling and grassing can commence.
- Dust suppression and rehabilitation of the top and side slope dump areas will be achieved by placement of a 100 mm permeable blanket layer of gravel, followed by top soiling and grassing.
- The storage volume/dump size derived for the first 4.25 years assumes that five boiler units are commissioned during this period, one every 12 months.
- The active area of the dump will be equivalent to the advancing face plus a 50 m section extending behind the advancing face of the dump.
- Rehabilitation establishment will take 3 years, developed progressively as each section of the dump is finalised. Irrigation will be provided for 1 year behind the active dump site. Thereafter no irrigation will be applied.
- All stormwater runoff collected from the active face, the active deposition zone and the active rehabilitation zone will be discharged to the dirty water system.
- Assumed tonnages per boiler unit for the ash dump volume calculations are:
  - Ash: 150 t/hr *0.9 load factor , 0.9 availability factor and 1.1 factor of safety = 133.7 t/hr (@o.8 t/m3 = 167.1. m3/hr, 121.956 m3/month)
  - FGD: 19.33 t/hr* 0.9 load factor, 0.9 availability factor and 1.1 factor of safety = 17.22 t/hr (@ 1.0 t/m3 density = 17.22 m3/hr, 12 753 m3/month)
- The top dump surface at nominal elevations 1540.00, 1510 and 1550 mamsl will be graded to the short sides from the dump centreline at 1V to 200H to facilitate stormwater runoff.
- The dump footprint will be provided with a double composite HDPE liner system with leakage detection in accordance with DWA "Minimum Standards" document for a class Hh disposal site.

- The liner system will have a drainage layer above it to intercept any seepage through the dumped materials. Seepage will be discharged to the dirty water system.
- A groundwater drainage system will be provided under the liner system in areas where the natural water table is shallow. Collected groundwater will be discharged to the clean water system.
- A system of concrete dirty water culverts and pipes will channel the dirty stormwater runoff from the active part of the dump and from the area in the process of rehabilitation to the Ash Dump Dirty Water Dam (ADDD).
- External Clean Water Diversion Drains
  - The 1:100 yr / 24 hr clean stormwater runoff will be kept separate from the dirty water runoff from the dump site.
  - Runoff from fully rehabilitated areas will be managed as clean water and discharged to the streams on either side of dump after passing through a series of silt retention/settling dams located around the ash dump perimeter.
  - The runoff from the incremental cleanwater catchments outside of the active footprint, flowing towards the active dump will be intercepted with temporary cut-off drains. These drains will divert the flow around the ash dump footprint, into the clean water system after passing through retention/settling dams.
  - Run-off from the ash dump footprint during the construction period will be intercepted by temporary construction phase stormwater drains discharging into the clean water system after passing through retention/settling dams.

- Ash Dump Dirty Water Dam (ADDD)
  - *Government Notice Regulation 704* specifies that a dirty water system may not spill into a clean water system more than once in 50 years, and that 800 mm freeboard be provided.
  - The ADDD will be designed to ultimately store the 1:50 yr / 8 day storm runoff from the active dump surface area and the 3 year rehabilitation zone at any time. To allow emptying and cleaning access one at a time
  - The ADDD storage is accommodated in two equal size compartments
  - A silt settling sub-compartment is provided at the dirty water inlet zone of each main compartment
  - Dust control and irrigation water will also be stored in the ADDD. The operating storage volume will be equivalent to 72 hours of dust control and irrigation water flow. The volume is based on the maximum pumping rate of 25 l/s for a period of 72 hours.

- The ADDD will be operated at or below the irrigation water storage level, at the start of each wet season, thereby providing the capacity above this to store the 1:50 yr / 8 day storm runoff.
- Dust control and irrigation water will be sourced primarily from accumulated stormwater in the ADDD, supplemented as necessary from the Station Holding / Recycle Dam.
- Excess stormwater accumulated in the ADDD will be transferred by gravity to the Station Dirty Dams for re-use in the station system.

2.2 Ash and Gypsum Production

Based on the design parameters in 2.1 above, a detailed Ash and Gypsum production schedule is presented in **Appendix 2**.
As at October 2013, the production of first ash from boiler unit 1 is schedule for 1 December 2014.

3 ASH/GYPSUM CLASSIFICATION

3.1 Classification of Ash and Gypsum

The specialist report "Classification and Environmental Evaluation of Kusile Power Station Ash and Gypsum in Terms of the Minimum Requirements: November 2008" (ref 1) is presented in **Appendix 5.**

The report concludes and classifies the ash and gypsum products as follows:

3.1.1 Ash

Using ARLP test (which is the appropriate, acceptable test for ash disposal), no element is leached above its acceptable risk limit and, therefore, the ash formally classifies as **non-hazardous**. As the ash is produced in large amounts ie 16700 t/day at full production, it can however still have a significant impact on the environment as it can increase salinity of water resources (specifically because the water table on the ash dump site is high). A dirty water and seepage management system is therefore required for disposal.
A GLB^+ site will be required.

3.1.2 Gypsum

The Gypsum is predominantly calcium sulphate dehydrate but it contains a number of minor elements, i.e. A1, 0,254%; Mg, 0.22%, P, 0.428%; plus of a number of trace elements (<0.10%), i.e. Fe, F, K, etc. The FGD Gypsum sample leached only fluoride at a concentration above it acceptable risk limit using both the TCLP and the ARLP tests. Fluoride is a moderate hazard according to the Minimum Requirements and, therefore, the gypsum formally classifies as a **moderate hazard waste**. A class Hh landfill will be required.

3.1.3 Ash/FGD Gypsum (6:1) Mixture

The Ash/ Gypsum (6:1) mixture leaches Mn, Pb and P concentrations above their acceptable risk limits using TCLP solution number 1. Because Mn and Pb are classified as high hazard species, the mixture classifies as high hazard waste. However, the mixture leaches only F at a concentration above its acceptable risk limit using the ARLP. As F classifies as a **moderate hazard** species, the **mixture classifies as moderate hazard waste**. The origin of the fluoride is mainly the gypsum and, therefore, the hazard rating of the ash is increased by mixing with gypsum. Co-disposal of the ash and gypsum will require a class $HhLB^+$ site.

3.1.4 Ash Heat of Hydration

Kendal Power Station ash (flue and bottom ash) was sampled directly off the ash conveyor and from the ash dump and was submitted for testing. (Kendal coal has the same source as for Kusile)

The following tests and repeat tests on fresh samples were undertaken:

- Free lime determination
- Heat rise from hydration
-

A specialist report on the test results is included in **Appendix 5**.

The measured free lime in the Kendal ash was found to be very low (0.4 to 0.6%) and the heat of hydration test after mixing the ash with distilled water only showed a very small increase in temperature of between 0.4 and 0.6 ^{0}C, which is consistent with the low free lime content.

It is suspected that any heat of hydration temperature rise may have occurred in the period when the quenched ash was still in the power station before reaching the ash dump.

Further in-situ tests on the Kendal ash dump are still scheduled to be undertaken in 2014 to confirm the expected low temperatures at the base of the dump.

3.2 DWAF Minimum Requirements for Waste Disposal by Landfill

The DWAF classification system (Ref1) is summarised as follows:

3.2.1 Classification System

G = General Waste
H = Hazardous Waste
H:h = Hazard Rating 3 + 4
H:H = Hazard Rating 1 – 4 all waste types
L = Large Landfill
M = Medium Landfill
S = Small Landfill

B^- = No significant leachate produced
B^+ = Significant leachate produced

Typical classifications may thus be:

GLB^+	or	$HhLB^+$	or	$HHLB^+$
GLB^-		$HhLB^-$		$HHLB^-$

3.2.2 Climatic Water Balance (CWB)

CWB is defined as B = R – E
B = Climatic water balance in mm of water
R = Rainfall in mm of water
E = Evaporation from soil surface in mm of water

If B is positive for more than one year in five for the years for which data is available,

- The site is classified B+
- There should be significant leachate generation

In the case of the Kusile ash disposal site, this is classified as B^- (water negative).

3.2.3 Hazard Ratings

Hazard Rating 1: Extremely hazardous
Hazard Rating 2: High hazard
Hazard Rating 3: Moderate hazard
Hazard Rating 4: Low hazard

3.2.4 Kusile Classification

a) **Kusile Climatic Water Balance (CWB).** The CWB assessment and rainfall data for Kusile is presented in **Appendix 6** hereto.

b) **Overall Classification**. The Kusile Ash Dump classifies as follows, according to the DWAF Minimum Requirements document:

Ash only disposed	:	GLB^-
Gypsum only	:	$H{:}hLB^-$
Ash/Gypsum co-disposal	:	$H{:}hLB^-$

4 ASH DUMP NO.1 DESIGN

4.1 Design Parameters

Design assumptions and parameters are set out in Section 2 hereto.

4.2 Ash Dump Deposition Modelling

Three dimensional volumetric models have been developed for the storage of ash/gypsum in the first 4.25 years of co-disposal, and for gypsum only for the remaining 50.25 years of the power station life. (note: the total life of the dump is limited by the footprint area and the maximum achievable height of the dump)

The modelling incorporates the build-up of ash/gypsum production tonnages as the boiler units are brought on line at twelve month intervals, per the schedule in **Appendix 2.**

The Phase 1 and Phase 2 dump volumetric modelling schematic is presented in the sketches in **Appendix 3**

The volumetric modelling output is summarised as follows:

- Co-disposal Ash/gypsum for the 1st 4.25yrs: Storage Volume = 18.161x 10^6 m^3
- Note: the Phase1 volume/life is derived by adopting a footprint of 106ha, which was the original Phase 1 footprint area applying to the Phase 1 construction contract before the ash dump overall footprint was amended)

- Gypsum disposal for the next 50.25 yrs: Storage Volume = 50.354×10^6 m^3
- Total disposal for 54.5 yrs: Storage Volume = 68.515×10^6 m^3
- Top elevation of dump: 1580.00 m
- Dump height: Varies 27 to 102 m (see dwg -207)

4.3 Ash Dump Terrace Layer Works Description

4.3.1 Topography

The Ash Dump is located to the West of the main power station terrace, on sloping ground on a spur/hill crest between two stream courses. The dump will have a footprint size of approximately 2500 m by 1000 m (211.8 ha). The maximum ground slope of ash dump footprint on the hill side has been limited to 1v to 15 h to ensure overall stability. The topography is more fully described in reference1, presented in Section 7 hereto.

4.3.2 Basic Terrace Layer Works

In accordance with the ash/gypsum $HhLB^-$ classification (see 3.2.4), the site layer works will be as follows:

The grass land site will be prepared as follows:

- Basic stripping and removal of vegetation.
- Topsoil will be removed and stockpiled for rehabilitation use. Topsoil depth is expected to be approximately 200 mm.
- The surface will be harrowed, raked to remove excess size stones, moisture conditioned and stabilised with a binding polymer application and compacted to 96% Standard Proctor density to receive the liner.
- Minor cut and fill adjustments to the terrace are required along the perimeter to ensure that clean stormwater runoff from the dump can pass over the concrete dirty water channel after rehabilitation has taken place.
- The pan area located on high ground on the ash dump footprint, has been left intact with a suitable buffer zone. This has resulted in the footprint of the ash dump having to deviate from its original design which covered the pan.
- A herringbone drainage system will be provided under the liner system in areas of the main dump footprint where the groundwater table is within 2 m of the natural ground level. (see dwg K30300098/06-211 in **Appendix 1** and the sub-surface water depth profile drawing in **Appendix 1a**. These drains will be

treated as clean drains and will discharge to the ash dump perimeter clean drain system.

- A double composite liner system with leak detection facilities to satisfy the requirements of the DWAF Minimum Requirements (see Section 4.4 below) will be placed over the entire Phase 1, 4.25 year dump footprint, (and later over the entire footprint). The liner system will include provision for accommodation of tensile stresses on the liner caused during ash/gypsum placement operations. The groundwater under drain system and the liner system will be installed in stages as the footprint extends over time.
- Details of the liner system are presented on drawings K30300098/06-220, -221 and -224 in **Appendix 1.**

4.4. Ash Dump Liner Details

To prevent contamination to the underlying soil, the Ash Dump is required to be fully lined (see Section 3 above). The Ash Dump will be provided with a double composite liner, incorporating a leakage detection system, in accordance with the DWA document "Minimum Requirements for Waste Disposal by Landfill (1998)", as modified by agreement with DWA in 2013.

The sub-grade earthworks will entail removal of vegetation and topsoil to an approximate depth of 200 mm and preparation of a smooth surface, free from large or loose angular particles and vegetative matter, treated with a polymer binder and compacted to 96% Standard Proctor density. The liner layer system will then be as follows, as depicted on drawings K30300098/06-220, 221 and -224 in **Appendix 1**:

- The foundation treatment will include the addition of a polymer binder to the water used for moisture conditioning of the ripped foundation soils before compaction, to bind loose stones and produce a surface the is acceptable for receiving the lower HDPE liner.
- A continuous 2.0 mm double-textured HDPE geo-membrane liner will be placed as the secondary (lower) liner.
- A grade A8 geofabric will be placed over the lower HDPE sheet to provide protection from the drainage layer sand.
- A leakage detection layer comprising 100 mm clean river sand, screened to minus 3 mm, will be laid onto the geofabric, to facilitate leakage drainage to the leakage detection pipes reporting to the perimeter dirty water drain, should the primary liner have minor deficiencies.
- In area around the ash dump perimeter, where the ground slope steepens, a 50mm high perforated, textured geocell retaining web (Neoweb or equal approved) will be imbedded in the sand layer to prevent migration of the sand down the slope.

- A geosynthetic clay liner (GCL) will be placed over the sand leakage detection layer to provide the required composite property of the upper (second) liner system
- A 2.0 mm double textured HDPE geomembrane liner will be installed over the sand drainage layer as the composite primary (top) liner.
- Finally, an A8 grade geofabric will be laid over the top HDPE sheet to provide protection from the overlying gravel drainage layer.
- The liner system will then be covered with a 300 mm later of selected G5 gravel, to provide drainage for the stacked ash and gypsum. This layer will be provided with a herring-bone drainage collection system of agricultural drains, reporting to the dirty water drain.
- Drawing K30300098/06-221 in **Appendix 1** provides a schematic illustration of the liner system.

4.5 Dirty Water Drainage System: General

Dirty water run-off from the ash dump has been calculated using the 1:50 year / 24 hour storm hydrology applied to the calculated maximum exposed dirty areas as the dump develops over time. Details of typical calculations are presented in Section 4.7.3 and in **Appendix 4**.

A dirty stormwater collection drain comprising rectangular concrete canal with removable precast concrete lids will be provided around the perimeter of the ash dam footprint as this is extended across the site during the various stages of development. The first phase of construction will provide for the first 4.25 years of ash/gypsum deposition. The concrete dirty stormwater channels, which also receive drainage from the leakage detection drains in 4.2 above will report to the dedicated ash dump dirty water storage dam (ADDD) via a system of dirty water drain pipes. Details of the dirty drains and pipes are provided on drawings K303000098/06-231 and -232 in **Appendix 1.**

The ADDD is separated into two operating compartments to allow cleaning. The dam will be fully lined with a double composite HDPE/GCL liner incorporating a leakage detection system. Access is provided to the concrete lined depressed operating storage compartment for silt removal. Stored dirty water will primarily be used for dust control and irrigation on the ash dump. Excess stored dirty water will be transferred to the Station Dirty Dams for re-use in the process.

The perimeter dirty water drainage canal comprises a rectangular concrete channel with pre-cast concrete lids. During the ash deposition stage when the ash is exposed, stormwater run-off will be collected into the open drain. Once rehabilitation of the exposed ash surfaces has been achieved by topsoiling and grassing, the dirty drain will be covered using the precast concrete lids, thereby allowing clean stormwater from the ash dump to flow over the covered drain, into the clean water drainage system.

The double HDPE liner on the ash dump footprint will be anchored to the upstream side of the dirty drain, with leakage outlet pipes from the leakage detection system discharging into the concrete dirty water drain at intervals.
Details of the concrete drain and the HDPE connection system are shown on the drawing K30300098/06-221 in **Appendix 1.**

The stormwater hydrology applying to the dirty water drains is presented in Section 4.7.3 hereto.

4.6 Clean Water Drainage System: General

Cleanwater run-off from the ash dump has been calculated using the 1:100 yr / 24 hour storm hydrology applied to the calculated maximum exposed clean areas as the dump develops over time. Details of typical calculations are presented in Section 4.7.3 and in **Appendix 4**.

A system of temporary clean water drains will be developed outside the 5 year footprint to intercept and lead clean stormwater from undeveloped zones of the site, away from the ash dump footprint as the footprint extends with time over the site. The drains will discharge to silt retention dams before outlet to stream. Drawings K30300098/06-320 to -327 in **Appendix 1** show details

A series of clean water channels will also be provided around the perimeter of the ash dump, outside the concrete dirty water channel, to receive clean stormwater run-off from rehabilitated surfaces of the ash dump. These drains discharge through culverts under the perimeter access road, into a collector drain and then to a series of silt retention dams, before final discharge to stream. Drawings of the clean water channels are presented in **Appendix 1.**
All clean stormwater will be discharged after silt settlement to the existing streams to the East (stream diversion canal) and West of the ash dump.

The trapezoidal clean water drains are developed in short sections of variable depth, to maintain a 1:200 gradient on the steep perimeter slopes of the ash dump footprint thereby controlling the flow regime. The drains discharge through culverts under the perimeter access road, to a further trapezoidal collector drain outside the perimeter access road and then to a series of stormwater retention/silt dams located at intervals around the ash dump perimeter. These dams have perforated outlets which will allow discharge of intercepted stormwater to stream after primary silt settling has taken place.

The collector drain outside the perimeter access road together with the silt retention dams will be constructed as a first priority, to serve as construction phase stormwater and erosion control facilities.

Drawings K30300098/06-300 and -301 in **Appendix 1** show details of the ash dump clean water system.

The stormwater hydrology applying to the clean water drains is presented in Section 4.7.3 hereto.

4.7 Ash Dump Dirty Water Dam (ADDD)

4.7.1 General

General Arrangement drawings for the ADDD are presented in **Appendix 1** (drawings K30300098/06-280 to -287 refer).

The derivation of storage capacity of the Ash Dump Dirty Water Dam (ADDD) is dependent on the maximum exposed area of un-rehabilitated ash that will apply during the deposition process, for derivation of dirty water run-off volumes.

Exposed areas have been calculated for Phase 1 of ash/gypsum deposition in the first 5 years of operation, which will involve progressive covering of the 5-year lined footprint.

The maximum exposed area for dirty water runoff derivation, occurs in the 4th year of deposition. Thereafter the dirty water catchment area decrease to a fairly constant area, during the gypsum deposition phase. During Phase 2, an additional 150 m of liner will be placed beyond the toe of the active face, every 5 years. This 150 m of liner corresponds with approximately 5 years of gypsum deposition. A cut-off berm will be developed in front of the extended liner to divert any upstream clean water run-off from entering the ash dump. This diverted water will be returned to the streams on the East and West sides of the ash dump.

The ADDD will be inter-connected to the Station Dirty Dam (SDD) by a supply line, allowing excess accumulated stormwater to be transferred from the ADDD to the SDD. The SDD is in turn connected by a pumping main to the station Holding and Recycle Dam (HRD) which in turn supplies water to the power station process. The HRD is also connected to ADDD by a gravity supply line. During drier periods of the year, irrigation and dust suppression water can be transferred to the ADDD from the HRD to supplement the operation

4.7.2 Ash Dump Dirty Dam (ADDD) Philosophy

The ADDD storage capacity derivation is set out in Section 4.7.3c following.

An 800 mm of dry freeboard has been provided above the full supply capacity/spillway level.

It is expected that during a severe storm event such as the 1:50 yr / 24 hr storm, all the station holding dams on site will be at capacity. During this event, raw water make-up supply to the Raw Water Reservoir (RWR) will be shutdown. Water from the HRD will supplement the plant. The transfer pipeline, linking the SDD and HRD, has a capacity to empty the SDD in 7 days. During the 7 days, water can be transferred by gravity from the ADDD to the SDD. This indicates that the station has the capacity to draw down all the reservoirs during and after a major storm event. The seven day buffer storage capacity at the ADDD is derived from this rationale.

At times when there is insufficient stored stormwater in the ADDD, the storage can be supplemented by a pipeline from the station Holding/Recycle Dam (in turn supplied from the SDD).

4.7.3 Ash Dump Flood Hydrology

a) Hydrology and Assumptions

- Rainfall data from station 0514618W at Wilge River
- Station Mean Annual Precipitation (MAP) = 655 mm
- Rainfall generally occurs between October and March. The 98 yrs of recorded data was analysed to determine the average weekly rainfall for these months.
- Maximum dust suppression and irrigation surface area = 854 191 m^2 (5-year co-disposal case).

- Calculated dust/irrigation water volume pumped per day = 854.19 m^3/day. This is based on 1 mm of water per day over the derived dust suppression and irrigation areas.
- Minimum storage required at the start of each month = 2 562.57 m^3 equivalent to 72 hrs of dust suppression and irrigation water.
- Maximum Installed Pump Capacity at ADDD = 25l/s. This equates to a 72 hr capacity of 6480 m^3. The operational demand storage for the ADDD will be set at 6480 m^3. Based on the actually maximum 72 hr demand, there is therefore a Factor of Safety of 2.52 on the operational storage.
- Maximum Dirty Catchment Area (5-year co-disposal case) = 1 100 000 m^2 (a catchment area of 1 603 743 m^2.is encountered during year 6. Area only occurs for a short period during year 6, therefore not considered in design).
- Coefficient of Discharge = 0.504 assumed for exposed Ash Dump. The runoff coefficient is based on surface slopes, permeability and vegetation.

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	*0*	*Very permeable*	*0*	*Thick bush & forests*	*0*
Flat area	*15*	*Permeable*	*55*	*Light bush & cultivated land*	*0*
Hilly	*80*	*Semi-permeable*	*45*	*Grasslands*	*10*
Steep areas	*5*	*Impermeable*	*0*	*Bare*	*90*

- Stormwater runoff calculated using Rational Method (suitable for small catchment areas).
- Time of Concentration assumes overland flow down the active face and then defined channel flow along the edge of ash dump.
- Design Storm for the ADDD is the 1:50 yr / 24hr storm event. Design rainfall is 122 mm.
- Longest flowpath is the longest distance that water would follow from the furthest point in the catchment to the ADDD. This was divided into the three sections; down the active face, along the front edge of the active face and then along the canal.

The flowrate (m^3/s) is calculated according to the following equation:

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

Where C =Runoff Coefficient (-)
I = Rainfall Intensity (mm/hr)
A = Catchment Area (km^2)

b) Stormwater Run-off

Clean Water Perimeter Drains

- The ash dump has been divided into a series of individual catchments, each contributing to an individual clean water canal, as defined by the topography along the canal routes.
- In order to maintain sub-critical flow conditions on the canals and to avoid large concrete drop structures, the catchment was divided into smaller sub-catchments, each served by an individual length of trapezoidal drain. This reduced the canal sizes. Each individual length of canal has its gradient restricted to a 1:200 maximum slope.
- The run-off generated from the sub-catchments will flow into separate lengths of canal, running along the perimeter of the ash dump.
- The run-off is based on a rehabilitated run-off co-efficient of 0.436.
- The total 1:100 yr / 24hr clean water run-off from the fully rehabilitated zone of the dump, will increase with time.
- The clean water drains running around the ash dump will be unlined trapezoidal canals with a 1.00 m base width, 1V: 3H side slopes.
- The clean water drain system is shown on drawings K30300098/06-300 and -301 in **Appendix 1**.
- Each section of drain will pass through a series of 900 by 900 or 1200 by 1200 concrete box culverts, running under the perimeter access road, flowing into retention / settling dams. Each retention dam will store the volume of the 1:100/24hr Storm arising from the part catchment delivering to that dam. The dams will be provided with a perforated outlet tower so that the dams will drain by gravity over a short period of time and will thus generally be empty. Each retention dam is also provided with emergency spillways designed to carry the 1:100/24hr Peak flow. The stilled clean run-off will then flow back into the natural streams surrounding the ash dump.
- Details of the silt retention dams are presented in drawings K30300098/06-320 to -327 in **Appendix 1.**

Dirty Water Perimeter Drains

- The dirty water catchment of the ash dump comprises the active dumping face, a 50 m section behind the active face, the 1-year irrigation zone and a further 2 year rehabilitation zone (based on co-disposal tonnages and rate of ash dump development).
- The run-off is based on a rehabilitated run-off co-efficient of 0.436.
- The phased development of the Ash dump is illustrated on drawing K30300098/06 -206 in **Appendix 1**
- The 4.25 year Phase 1 ash dump footprint catchment areas are shown on drawing K30300098/06-540 included in **Appendix 1**

- The establishing surface area is still considered dirty water catchment, if it encloses both irrigation and dust suppression areas. The runoff from the irrigation and dust suppressions areas will flow over the establishing area into the dirty water perimeter drains
- Phase 2 comprises the remaining 55 years of deposition. This catchment area will be divided into east and west sections, each with separate clean and dirty water drainage facilities, as shown on drawing K30300098/06-540 in Appendix 1
- The calculated dirty runoff flow rates are summarised in
- Table 4.1 below.

Table 4.1: 1:50 yr Dirty Water Runoff Flowrates

Catchment Area		Flowpath	Time of Concentration	Intensity*	Runoff C	Flowrate
	km^2	km	hrs	mm/hr	-	m^3/s
E1	0.215	0.878	0.704	119.472	0.436	3.107
E2	0.102	0.378	0.461	182.254	0.436	2.253
E3	0.219	1.765	1.044	80.438	0.436	2.135
W1	0.105	0.771	0.623	134.911	0.436	1.717
W2	0.064	1.780	1.069	78.594	0.436	0.613
W2a	0.092	0.735	0.572	146.749	0.436	1.633
W2c	0.136	0.706	0.575	146.043	0.436	2.409
W5/6	0.295	1.851	1.125	74.676	0.436	2.670
E4	0.266	1.423	0.889	94.440	0.436	3.041
W7	0.065	0.475	0.312	268.871	0.436	2.118
W8	0.376	0.922	0.616	136.438	0.436	6.218
W9	0.221	1.532	0.933	90.080	0.436	2.413
Radial Stacker	0.049	0.549	0.607	200.732	0.700	1.904

- The dirty water drains will ultimately flow into the ADDD via a series of dirty water pipes.
- The rectangular concrete canals collecting runoff from Phases 1 and 2 will have a controlled gradient of 1:200 to maintain tranquil flow and will be 2.5 m wide with a flow depth of 2.0 m. The canal depths will vary from 2.2 to 2.7 m deep. Details of the dirty water drainage system are shown on drawings K30300098/06-231 and -232 in **Appendix 1.**

c) Ash Dump Stormwater Storage Volume in the ADDD

- A graph has been produced to illustrate the ash disposal volume at the ash dump after specific disposal times. The graph is presented in **Appendix 4**.
- The stormwater storage capacity for the ADDD is 204 000 m^3, and corresponds with the 1:50 yr / 8 day storm event falling on the maximum dirty catchment area.

d) Dust Control & Irrigation Storage (Operating Storage)

- Additional storage in the ADDD is provided for 72 hours of water for dust control and irrigation over the active disposal area and the rehabilitation establishment zone.
- During the Ash - Gypsum co-disposal phase, the dust control area comprises the advancing face and a 50 m section behind the face. The irrigation zone is located behind the dust control area and extends for a length equivalent to 1 year of disposal.
- During the Gypsum disposal phase, the dust control area comprises the advancing face and a 25 m section behind the face. The irrigation zone is located behind the dust control area and extends for 50 m.
- The dust control and irrigation storage volumes are based on 1 mm/day of equivalent rainfall. (1 mm/day is equivalent to 0.5*the average annual daily rainfall at Kusile Site).
- The dust control and irrigation volumes during disposal are shown in Table 4.2 below.

Table 4.2: Dust Control and Irrigation Volumes

Years	Dust Suppression Area	Irrigation Area	Daily Volume	72 hr Volume
-	km^2	km^2	m^3/day	m^3
1	0.500	0.028	527.865	1583.595
2	0.464	0.098	562.196	1686.589

3	0.294	0.102	395.403	1186.210
4	0.680	0.175	854.191	2562.573
5	0.504	0.116	620.522	1861.565
6	0.131	0.190	320.956	962.867
7	0.098	0.114	212.206	636.619
8	0.127	0.115	241.379	724.138

- The maximum 72 hr dust suppression and irrigation volume is approximately 2562 m^3. The maximum pumping capacity from the ADDD is 25l/s.
- Based on the maximum pumping capacity, the operating storage was set at 6480 m^3, which is equivalent to 72 hrs of pumping at 25l/s.
- **Appendix 4** includes system descriptions for the Dust Suppression and Irrigation Water, and Make-up Water.

e) ADDD Storage Volume

- The ADDD storage volume is sufficient to store the dirty water run-off for 1:50 yr / 8 day storm event, and for 72 hours of dust control and irrigation.
- The required ADDD storage capacity is 210480 m^3 as shown in Table 4.3 below.

Table 4.3: ADDD Storage Volumes

Stormwater Volume	Dust and Irrigation Volume	**Total Required Volume**
m^3	m^3	**m^3**
204 000	6480	**210480**

- The ADDD has a design total storage capacity of 227410 m^3, made up as follows:
  - Operating storage in depressed sumps in each compartment of the dam, for the irrigation and dust control operations of 11,560m^3 total. This includes an allowance for silt accumulation
  - Stormwater storage of 215850 m^3, split between the two compartments.
  - The two stormwater storage compartments are each provided with a silt trap sub-compartment at the dirty water inlet zone of each main compartment. This sub-compartment has the same depressed floor level as the operating storage zone, to allow accumulation of settled silt. The sub-compartments are separated from the operating storage zone and the stormwater storage zone by low height perforated walls.

- The ADDD will be a double compartment storage structure located to the north of the ash dump.
- The ADDD will be approximately 600 m long and 90 m wide with a maximum depth of 4.8 m.
- Ash Dump Dirty Dam drawings are presented on drawings K30300098/06-280 to 287 in **Appendix 1**.

4.7.4 Water Mass Balance

Water Mass Balance diagrams for Kusile Power Station, including the Ash Dump and Ash Dump Dirty Dam, are presented in **Appendix 7** for the following cases:

- No rainfall case
- Annual average rainfall case
- 1-day, 50 year event

4.8 Site Geotechnical Investigation

4.8.1 Introduction

The geotechnical information supplied by Partridge Maud and Associates, report reference number 1-6/07 entitled *Project Bravo - Report on Geotechnical Investigations Undertaken for the Ash Dump by Partridge Maud and Associates (PMA), June 2008 (Ref.1)* has relevance and gives the overall geotechnical conditions of the plant site.
Local geology interpretation from the Golder Associates Hydrogeological report is presented in **Appendix 1a,** together with an interpretation of the ground water depth profile, extracted from the test pit logs.

The following text is extracted from the PMA report conclusion:

i) *We do not envisage any major soil problems in the areas of the site underlain by the Dwyka tillite and Rayton shale. Shale bedrock occurs at shallow depth (less than three metres) in the latter area, while the residual tillite under the Ash Dump is characterized by relatively high consistency and shear strength at an average depth of about two metres, and perhaps double that locally. The mechanical properties of the tillite are, in addition, well known on the basis of a large number of tests carried out on both the Power Station and Ash Dump sites. This will facilitate design of the relevant parts of the dump.*

ii) *The problematical material from a founding point of view is the clayey residual diabase. This is a material of low strength, low density and high void ratio, which is susceptible to the occurrence of shear failures and significant settlements at relatively low imposed pressures. These problems should be carefully considered by the designers of the Ash Dump. Once again, a significant body of test data, from various parts of the total site, is available to underpin design decisions.*

iii) *A major concern, at least during the wet 2007/2008 summer season, was the extent to which shallow and rapid water seepage was encountered in the test pits. In many cases it proved too dangerous to descend the pits to their full depth because of the collapse of their sides under the high prevailing hydrostatic pressures. This problem was not confined to low-lying areas: some of the most rapid seepage occurred near the crest of the ridge on which the Ash Dump will be sited. It is clear, therefore, that comprehensive underdrainage will have to be provided to ensure that pore water pressures dissipate sufficiently rapidly not to prejudice the stability of the dump as it is raised. The combined flow from the drains will be substantial, and this needs to be taken into account when planning both the treatment (where this is needed) and the disposal of this water*.

Drawings K 30300098/06-202 to -205 attached in **Appendix 1** show the location and logs of the test pits excavated on the ash dump.

Soil types vary across the site, but the area has shallow topsoils with quartzitic stones and weathered shales or organic clay/silts. The topsoils are predominantly underlain by tillite and diabase, with shallow bedrock within the tillite to about 3 to 4 m depth and the deeper weathering in the diabase to depths to bedrock of about 5 m, with occasional areas in excess of 5 m.

4.8.2 Groundwater Conditions

Strong groundwater seepage was noted at relatively shallow depth in some of the test holes excavated by Partridge Maud and Associates(1) and by Knight Piésold. Hydro-geological studies undertaken by Knight Piésold indicate the presence of both a deep and a shallow water table in the area of the Ash Dump. The ground water contour drawing in **Appendix 1a** shows the interpreted zones of the ash dump site that have shallow ground water table depths.

4.9 Ash Dump Stability

A detail Stability analysis report has been prepared for the ash dump. (reference 10 and Section 7).

After feasibility appraisal of alternative ash stacking or placement methods for the 5-year duration when ash and gypsum will be placed at high rates onto the no.1 ash dump footprint (ie before the no.2 final ash dump is developed), it was concluded that the ash/gypsum co-disposal in the first 4.25 years on Ash Dump No.1 would be undertaken using conventional load and haul operations. The ash/gypsum will be placed into successive paddocks of suggested size 200m by 200m,placed in 2 m lifts. This enables good management and control over the side and front faces of the dump, which will all be maintained at a 1v to 5h slope.

The paddock method will also avoid the development of excess pore pressures in the foundation materials as the ash is stacked, which would apply in conventional stacking processes where the ash front face is advanced from the full final height of the dump onto the underlying foundation.

The ash/gypsum stacking operations will ultimately result in high stacked fills over the underlying liner system. The friction interfaces between the ash/gypsum and the liner system and between the liner and the natural foundation are thus critical to the dump stability.

The ash dump footprint is located on high ground between two stream courses (convex surface as shown on the typical cross-sections on K30300098/06-207 in **Appendix 1**). The perimeter of the ash dump footprint has been defined by restricting it to ground slopes that are not in excess of 1v to 15h, in order to ensure acceptable stability factors of safety for the dump.

In-situ samples have been taken from the in-situ foundation materials (November 2008) for laboratory tri-axial testing to supplement the sampling and testing undertaken and presented in ref [(1)].

Ash/gypsum and soil friction interface properties with HDPE and the HDPE/sand/HDPE leakage detection sandwich layer have also been investigated by laboratory shear box testing.

The testing was followed by rigorous slope stability assessments to determine the maximum allowable ash stacking height and dump bench heights/ overall effective dump slopes for maintenance of a safe stability regime during operation.

As a GCL layer was introduced into the liner sandwich late in the design (2013),
As GCL had initially proved in testing to have very low residual shear strength after wetting of the bentonite in the GCL sandwich, its was originally disallowed. However after the upgrading of the ash dump liner system as required by DWA in 2013, it was necessary to include a GCL as a component of the composite liner system. This required additional extensive numerical modelling of the ash dump stability with the low strength GCL included in the liner sandwich. KP internal report ref PE 3-00361 of 14 May 2013 (ref 13) sets out the results of the modelling and concludes that the factors of safety of the dump with GCL are acceptable, assuming that the lateral displacement of the ash stockpile base is within calculated limits.

The 2009 detail stability analysis for the ash dump and the liner system is presented in a separate report (ref 10 and Section 7 hereto).

4.10 Seepage Analysis

The ash/gypsum will be dry–disposed at approximately 15% moisture content. However, the climatic water balance is assessed to be positive and irrigation for dust control also adds water to the ash dump system. The entire footprint is provided with a double HDPE liner system as defined in Section 3.6 hereto. A preliminary seepage assessment has been undertaken, using early and incomplete hydrological data (Ref 7). The preliminary seepage analysis for the ash/gypsum dump, with an HDPE liner, shows a potential total footprint seepage varying from 69,6 to 72,9m^3/d in the period 5 to 60 years of operation.

5 CONSTRUCTION

5.1 Method

The construction of the Ash Dump layer works is presented in the following separate work method statement reports:

- WMS 5452-90-011.1: Ash Dump Layer Works, Work Method Statement
- WMS 5452-90-011.2: Ash Dump Wetland Pan Area
- WMS 5452-90-011.3: Ash Dump Dirty Dam

In order to comply with Environmental and Water Licence requirements for protection of the water in the adjacent stream beds, silt and erosion control facilities in the form of interception trenches and silt retention dams will be constructed as a first priority before the main works are commenced.

Details of the construction phase works are presented on drawings K30300098/06-215 and -216 in **Appendix 1**.

5.2 Specifications

All work will be undertaken in accordance with the drawings and the provisions of the SANS 1200 series of documents and Eskom Technical Specification P23A – Combustion Waste Terrace.

6 OPERATION

After study of alternative deposition systems and life cycle cost comparisons, it was decided to place the ash/gypsum onto the ash dump for the first 5 years of power station operation by a load and haul operation. Ash and gypsum will be delivered by conveyor to a radial stacker near the ash dump, for subsequent loading, hauling and placement into paddocks of suggested size 200m by 200m, developed in 2m lifts, spread initially over the ash dump 5-year half-footprint, to full design height on the ash dump, and then similarly over the second half of the footprint.

The power station comprises six boiler units and these will be commissioned one every twelve months, commencing 1 December 2014 (as at October 2013). The full power station ash/gypsum output will thus only be effective in the 4th year of operation.

In years 5 to 55 of operation, gypsum only will be placed at significantly reduced tonnages onto the ash dump by the same, but much smaller, load and haul operation. A second ash dump, to receive ash only after year 5 is planned to be developed later on another site, still to be selected.

The ash/gypsum load and haul deposition system will enable the ash dump operators to place the ash/gypsum in such a manner as to be free draining in shape, with minimisation of any depression that will collect and retain stormwater run-off.

Temporary artificial channels will be deployed on the exposed ash surfaces to lead stormwater down the faces to the dirty water collection dams in a controlled manner thereby preventing erosion.

Irrigation of the exposed ash surfaces will take place to achieve dust control. Irrigation water volumes will be restricted as far as possible to limit any seepage potential arising from the irrigation waters.

Exposed ash surfaces will be finally shaped at 1:5 on the side slopes and at 1:200 on the top surfaces and rehabilitated as soon as practically possible by placement of selected topsoil and vegetation cover. These areas will be irrigated to promote and sustain the vegetation.

Spillages at ash transfer houses will be contained and removed in an effective manner.

Dirty stormwater run-off from the radial stacker terrace adjacent to the ash dump will be contained by perimeter ditches, and transferred to the ADDD.

7 REFERENCES

1. Project Bravo – Report on Geotechnical Investigations undertaken at the Ash Dump, No. 1-6/07, Partridge Maude and Associates, June 2008
2. En Chem – DR. David Baldwin: Kusile Power Station project: Classification and Environmental Evaluation of Ash and FGD Gypsum in Terms of the Minimum Requirements, November 2008
3. Government Notice No.704, Regulations on use of water for mining and related activities aimed at the protection of water resources, in terms of the National Water Act (Act 36 of 1998)
4. Minimum Requirements for Waste Disposal by Landfill, DWAF, 1998
5. The National Water Act, No 36 of 1998
6. SANS 1200: Standardised Specifications for Civil Engineering Construction
7. Panel B Consultants JV, March 2010: Ash Dump No.1: Preliminary Concept Design Notes
8. Panel B Consultants JV, March 2009: Report 5452/90/017 R1: 10 Year Ash Dump-Options Study March 2009
9. Panel B Consultants JV, March 2009: Addendum to Report 5452-90-017R1: Final, May 2009
10. Panel B Consultants JV, August 2010: Report 5452/10/019 Rev3: Ash Dump Stability Analysis
11. Wetland Consulting Services report ref 689/2011: Wetland Verification, Delineation and Impact assessment for Kusile Ash Dump
12. Panel B Consultants JV, December 2012: Amended 2012 Footprint: Conceptual Design Notes
13. Knight Piesold internal report ref PE13-00361: May 2013: Numerical Modelling of Ash Dump Stability at Kusile Power Station
14. Knight Piesold Design Note: May 2013: Amended Ash Dump, Settling Tank and Ash Dump Dirty Dam Liner Systems, R4.(Included in Appendix 3)
15. Eskom Technical Specification 100820-P23A –Combustion Waste Terrace.

16. DOCUMENT CONTROL SHEET

CLIENT : ESKOM HOLDINGS LIMITED

PROJECT : KUSILE POWER STATION **PROJECT No : 30300098/22**

TITLE : ASH DUMP TERRACE LAYER WORKS DESIGN

DETAIL DESIGN REPORT 5452-90-011 REV 6

	Prepared by	Reviewed by	Approved by
ORIGINAL	NAME **J R WILLIAMSON**	NAME **A J STRAUSS**	NAME **D GRANT-STUART**
DATE	SIGNATURE	SIGNATURE	SIGNATURE
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DATE 12/01/09	SIGNATURE	SIGNATURE	SIGNATURE
REVISION 3	NAME **J R WILLIAMSON**	NAME **A J STRAUSS**	NAME **D GRANT-STUART**
DATE 31/08/10	SIGNATURE	SIGNATURE	SIGNATURE
REVISION 5	NAME **J R WILLIAMSON**	NAME **A J STRAUSS**	NAME **D GRANT-STUART**
DATE 03/12/10	SIGNATURE	SIGNATURE	SIGNATURE
REVISION 6&7	NAME **J R WILLIAMSON**	NAME **A J STRAUSS**	NAME **D GRANT-STUART**
20/10/2013			

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(a) PANEL B CJV written agreement is obtained prior to such release, and

(b) By release of the report to the Third Party, that Third Party does not acquire any rights, contractual or otherwise, whatsoever against PANEL B CJV and PANEL B CJV, accordingly, assume no duties, liabilities or obligations to that Third Party, and

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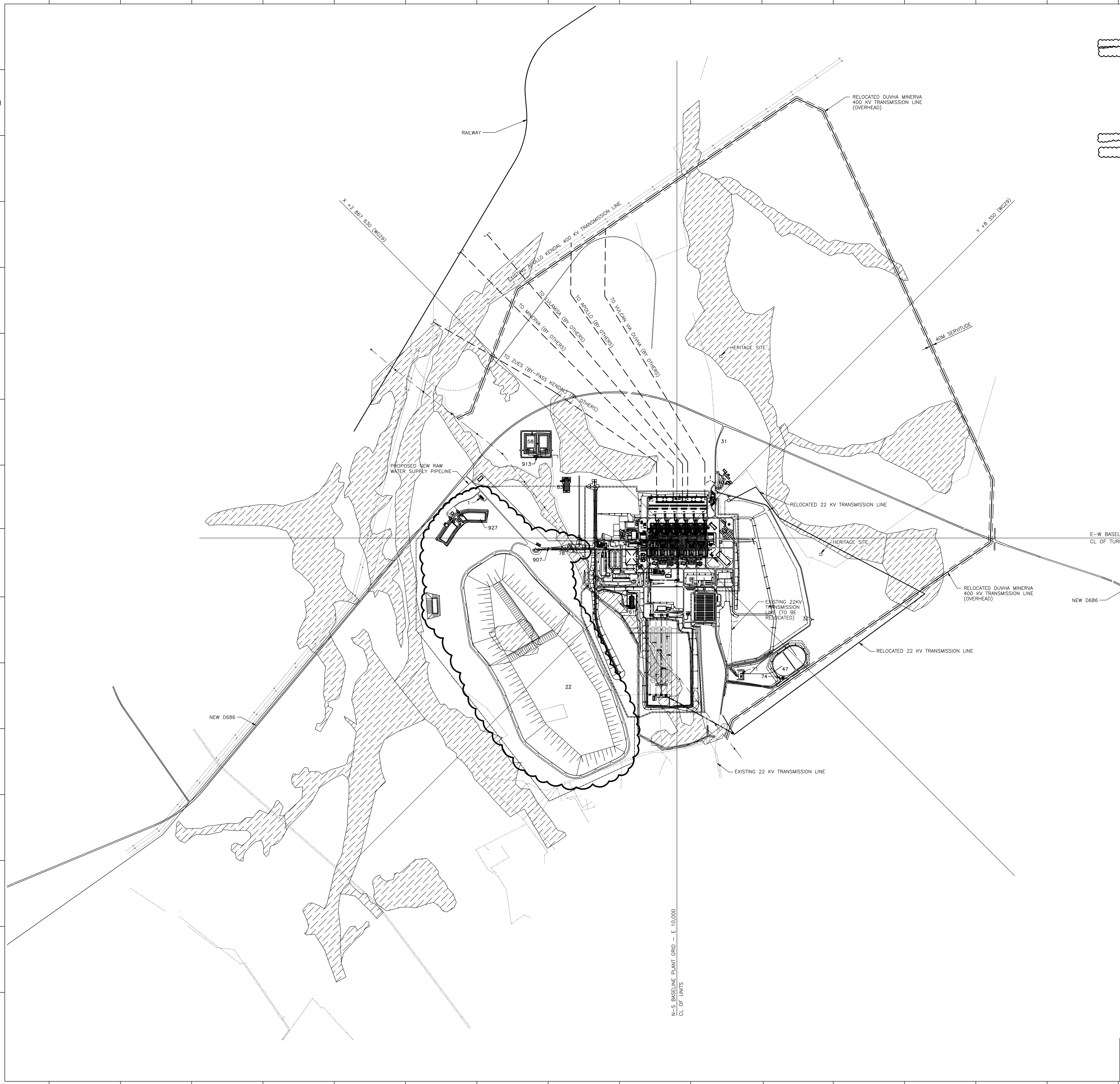
APPENDIX 1

DRAWING SCHEDULES

DRAWINGS



FACILITY LEGEND

ID	FACILITY	FOUNDATION	TIEDOWN LOCATION NORTH	TIEDOWN LOCATION EAST	REMARKS
1	ASH DUMP WORKSHOP	0.90/2200	10500.361	7702.665	COL ROW ADA/AD01
22	ASH DUMP	0.90/23271			
31	MAIN STATION ACCESS ROAD				
32	STATION ROAD				
47	RAW WATER RESERVOIR	0.90/5708			
58	STATION DIRTY DAM	0.90/3820			
61	COAL STOCK YARD/LIMESTONE BUILDING SETTLING BASIN	0.90/2411			
71	RAW WATER RESERVOIR VALVE STATION	0UXC-S5401			
74	POTABLE WATER HEAD TANK	A2-J-1237-GF-PI-01	8364.000	11254.700	
78	OVERLAND LINK CONVEYOR	0.90/521			
83	STATION DIRTY DAM SETTLING BASIN	0.90/2392			
907	ASH DUMP SUBSTATION	0.90/3518	9926.410	8356.140	COL ROW HA/H9
913	DIRTY DAM PUMP BUILDING	0.90/3820	10952.900	8377.300	COL ROW DDD/DD9
927	ASH DUMP DIRTY DAM	0.90/23302			

STATION CENTERLINE COORDINATES

(WGS/Lo29)

X = +2 867 630.000
Y = + 8 350.000
STATION ZERO DATUM LEVEL (0.000) = 1503.250 masl
(BOTTOM OF BASEPLATE – MAIN BOILER COLUMNS)

LEGEND APPLICABLE TO ALL S1000 SERIES DWGS

- WETLANDS
- GRAVE SITES
- PROPERTY BOUNDARY

GENERAL NOTES APPLICABLE TO ALL S1000 SERIES DWGS

1. WETLANDS BOUNDARIES SHOWN ARE APPROXIMATE ONLY.
2. REFER TO ESKOM DRAWING 0.90/692 SHT 0, FOR DEFINITION OF ZERO DATUM LEVEL.
3. REFER TO DRAWINGS S1003–S1013 FOR DETAILED SITE ARRANGEMENT INFORMATION.

BACKCIRCLES PER ECN-N-S-0143

APPROVED FOR CONSTRUCTION

THE DISTRIBUTION AND USE OF THE NATIVE FILE FORMAT OF THIS DRAWING OUTSIDE OF BLACK & VEATCH IS UNCONTROLLED AND SHALL BE USED FOR REFERENCE PURPOSES ONLY.

D.O.	REV	DATE	** REVISION ** INDEX REFERENCE : S2.1	REV BY	CHKD BY	AUTH BY	KKS APP	0.90 REFERENCE DRAWINGS
	10	25/AUG/10	ECN N–S–0143	MSW	MJW	GLG	MDC	
	9	12/MAY/10	ECN N–S–0106	MSW	MJW	GLG	MDC	
	8	11/FEB/10	ECN N–S–0096	MSW	MJW	GLG	MDC	
	7	21/AUG/09	ECN N–S–0067	MSW	MJW	GLG	MDC	
	6	01/JUL/09	ECN N–S–0051	MJW	GLG	MDC		
	5	16/JAN/09	ECN N–S–0036	MJW	JWF	MDC		
	4	17/OCT/08	ISSUE FOR DESIGN FREEZE	DNS	MJS	DLS		
	3	19/SEP/08	ECN–N–S–0019	JSH		DLS		
	2	18/JULY/08	ECN–N–S–0012	DNS		DLS		
	1	09/MAY/08	ECN–N–S–0005	JSH		DLS		
	0	14/MAR/08	ISSUED FOR BASIS OF CONTRACT	JSH				

AUTHORISED FOR ESKOM BY: JVT DATE: 25/AUG/10

DRAWN BY: MSW
SCALE: 1:15000

BLACK & VEATCH
Eskom

KUSILE POWER STATION
SITE LAYOUT

146838–0UXB–S1000 REV 10

0.90/136

SIZE GROOTTE A0L

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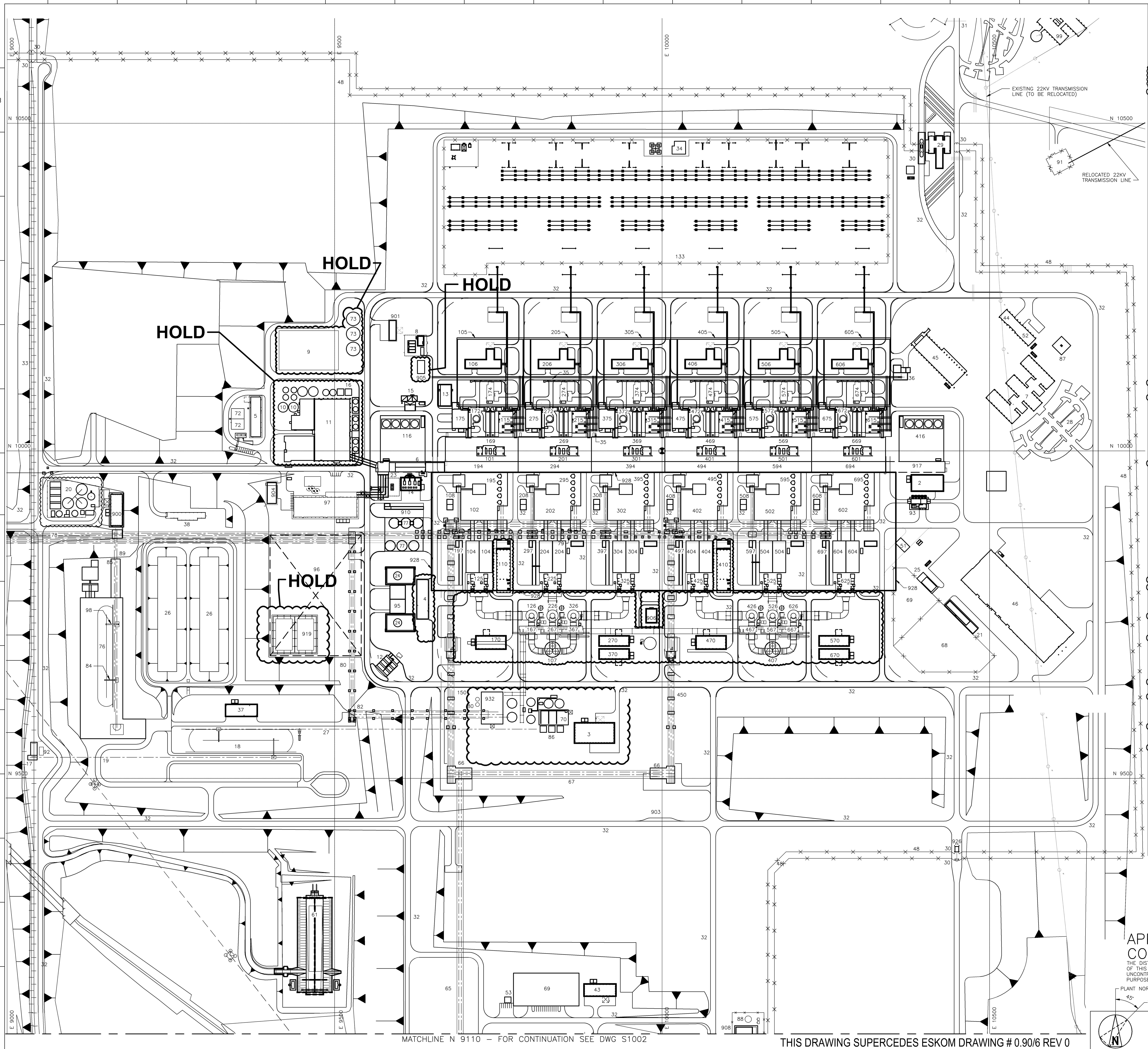


FACILITIES LEGEND

2	SUBSTATION EAST	170	FGD SUBSTATION
3	SUBSTATION SOUTH	172	CONDENSATE RESERVE TANK
4	AUX SUBSTATION A	174	AIR COOLED CONDENSER AUXILIARY BUILDING
5	FIRE WATER PUMP BUILDING	175	CONDENSATE POLISHER PLANT
6	AUX BAY EXTENSION WEST	194	AUXILIARY BAY
7	ADMINISTRATION BUILDING	195	COAL MILLS
8	HYDROGEN PLANT	197	GRIT SUMP
9	WASTEWATER TREATMENT AREA HOLD	201	TURBINE GENERATOR BUILDING
10	NEUTRALIZATION BASIN HOLD	202	STEAM GENERATOR (BOILER) BUILDING
11	WATER TREATMENT BUILDING HOLD	204	FABRIC FILTER
12	FUEL OIL UNLOADING STATION	205	AIR COOLED CONDENSER
13	DAILY ISSUE OIL STORES BUILDING	206	ACC SUBSTATION
14	AUXILIARY BOILER	208	COARSE ASH CONVEYOR
15	DIRTY OIL, TURBINE LUBE OIL, DIESEL STORAGE TANK AREA	215	GENERATOR STEP UP TRANSFORMER
16	CHEMICAL RECEIVING AND STORAGE HOLD	225	INDUCED DRAFT FANS
17	LIMESTONE RAIL / TRUCK UNLOADING HOPPER	226	WET FGD ABSORBER
18	LIMESTONE STORAGE PILE	267	FGD PUMP BUILDING
19	LIMESTONE STACKING CONVEYOR	269	STEAM EXHAUST DUCTS
20	SEWAGE TREATMENT PLANT	270	FGD SUBSTATION
21	GARAGES	272	CONDENSATE RESERVE TANK
23	PROPANE TANK	274	AIR COOLED CONDENSER AUXILIARY BUILDING
24	FUEL OIL STORAGE TANK	275	CONDENSATE POLISHER PLANT
25	STEAM CLEAN	294	AUXILIARY BAY
26	HOLDING/RECYCLING DAM	295	COAL MILLS
27	LIMESTONE RECLAIM CONVEYOR	297	GRIT SUMP
28	ADMINISTRATION BUILDING PARKING	301	TURBINE GENERATOR BUILDING
29	ACCESS CONTROL	302	STEAM GENERATOR (BOILER) BUILDING
30	SECURITY GATE	304	FABRIC FILTER
31	MAIN STATION ACCESS ROAD	305	AIR COOLED CONDENSER
32	STATION ROAD	306	ACC SUBSTATION
33	RAILROAD	308	COARSE ASH CONVEYOR
34	SUBSTATION CONTROL HOUSE	315	GENERATOR STEP UP TRANSFORMER
35	TRANSFORMER TRANSPORT RAIL SYSTEM	325	INDUCED DRAFT FANS
36	SPARE TRANSFORMER STORAGE AREA	326	WET FGD ABSORBER
37	LIMESTONE HANDLING SUBSTATION	367	FGD PUMP BUILDING
38	HOLDING/RECYCLING DAM PUMP STRUCTURE	369	STEAM EXHAUST DUCTS
43	NORTH COAL YARD SUBSTATION	370	FGD SUBSTATION
44	FIRE STATION	372	CONDENSATE RESERVE TANK
45	CANTEEN	374	AIR COOLED CONDENSER AUXILIARY BUILDING
46	WORKSHOP AND STORES BUILDING	375	CONDENSATE POLISHER PLANT
48	STATION SECURITY FENCE	394	AUXILIARY BAY
51	FILLING STATION	395	COAL MILLS
52	MEDICAL FACILITY	397	GRIT SUMP
53	COAL STOCK YARD OFFICES	401	TURBINE GENERATOR BUILDING
61	COAL STOCK YARD/LIMESTONE BUILDING SETTLING BASIN	402	STEAM GENERATOR (BOILER) BUILDING
65	TERRACE LINK CONVEYOR SY3A & SY3B	404	FABRIC FILTER
66	TERRACE COAL SILO	405	AIR COOLED CONDENSER
67	OVERSILO CONVEYOR	406	ACC SUBSTATION
68	STORAGE YARD	407	CHIMNEY (UNITS 4, 5 & 6)
69	HEAVY EQUIPMENT STORAGE AREA	408	COARSE ASH CONVEYOR
70	REAGENT PREPARATION	410	COMPRESSOR BUILDING (UNITS 4, 5, 6)
72	SERVICE/FIRE WATER TANK	415	GENERATOR STEP UP TRANSFORMER
73	DEMINERALIZED WATER STORAGE TANK HOLD	416	AUXILIARY COOLING TOWER AREA (UNITS 4, 5 & 6)
76	EMERGENCY ASH DUMP	425	INDUCED DRAFT FANS
77	FLY ASH SILOS	426	WET FGD ABSORBER
78	OVERLAND LINK CONVEYOR	450	INCLINE COAL CONVEYORS (UNITS 4, 5 & 6)
79	TRANSVERSE ASH CONVEYORS	467	FGD PUMP BUILDING
80	FGD BYPRODUCT CONVEYOR	469	STEAM EXHAUST DUCTS
82	FGD BYPRODUCT TRANSFER TOWER	470	FGD SUBSTATION
84	ASH RECLAIMER	472	CONDENSATE RESERVE TANK
85	ASH RECLAIM CONVEYOR	474	AIR COOLED CONDENSER AUXILIARY BUILDING
86	LIMESTONE SILOS (3)	475	CONDENSATE POLISHER PLANT
87	HELIPAD	494	AUXILIARY BAY
88	RADIO TOWER	495	COAL MILLS
89	ASH STACKER CONVEYOR	497	GRIT SUMP
91	22 KV SUBSTATION (BY OTHERS)	501	TURBINE GENERATOR BUILDING
92	LIMESTONE RAIL UNLOADING CONTROL BUILDING (FUTURE)	502	STEAM GENERATOR (BOILER) BUILDING
93	SANDBLAST BUILDING	504	FABRIC FILTER
95	FUEL OIL PUMP BUILDING	505	AIR COOLED CONDENSER
96	AREA FOR TEMPORARY ADMIN OFFICES AND PARKING	506	ACC SUBSTATION
97	STATION SERVICES BUILDING	508	COARSE ASH CONVEYOR
98	ASH STACKER	515	GENERATOR STEP UP TRANSFORMER
99	VISITORS CENTER	525	INDUCED DRAFT FANS
900	AUX SUBSTATION B	526	WET FGD ABSORBER
901	HYDROGEN PLANT SUBSTATION	567	FGD PUMP BUILDING
903	WEIGH BRIDGE	569	STEAM EXHAUST DUCTS
904	DIESEL GENERATOR BUILDING	570	FGD SUBSTATION
905	NITROGEN STORAGE & SUPPLY HOLD	572	CONDENSATE RESERVE TANK
906	MILL MAINTENANCE WORKSHOP	574	AIR COOLED CONDENSER AUXILIARY BUILDING
908	RADIO TOWER OFFICE	575	CONDENSATE POLISHER PLANT
910	FLY ASH SUMP	594	AUXILIARY BAY
917	AUX BAY EXTENSION EAST	595	COAL MILLS
919	CHEMICAL CLEANING POND HOLD	597	GRIT SUMP
926	GATE HOUSE	601	TURBINE GENERATOR BUILDING
928	HITACHI APRON SLAB	602	STEAM GENERATOR (BOILER) BUILDING
932	BYPRODUCT DEWATERING BUILDING	604	FABRIC FILTER
101	TURBINE GENERATOR BUILDING	605	AIR COOLED CONDENSER
102	STEAM GENERATOR (BOILER) BUILDING	606	ACC SUBSTATION
104	FABRIC FILTER	608	COARSE ASH CONVEYOR
105	AIR COOLED CONDENSER	615	GENERATOR STEP UP TRANSFORMER
106	ACC SUBSTATION	625	INDUCED DRAFT FANS
107	CHIMNEY (UNITS 1, 2 & 3)	626	WET FGD ABSORBER
108	COARSE ASH CONVEYOR	667	FGD PUMP BUILDING
110	COMPRESSOR BUILDING (UNIT 1, 2, 3)	669	STEAM EXHAUST DUCTS
115	GENERATOR STEP UP TRANSFORMER	670	FGD SUBSTATION
116	AUXILIARY COOLING TOWER AREA (UNITS 1, 2 & 3)	672	CONDENSATE RESERVE TANK
125	INDUCED DRAFT FANS	674	AIR COOLED CONDENSER AUXILIARY BUILDING
126	WET FGD ABSORBER	675	CONDENSATE POLISHER PLANT
133	HV SUBSTATION	694	AUXILIARY BAY
150	INCLINE COAL CONVEYORS (UNITS 1, 2 & 3)	695	COAL MILLS
167	FGD PUMP BUILDING	697	GRIT SUMP
169	STEAM EXHAUST DUCTS		

STATION CENTERLINE COORDINATES

(WGS/Lo29)

X = +2 867 630.000
Y = + 8 350.000
STATION ZERO DATUM LEVEL (0.000) = 1503.250 masl
(BOTTOM OF BASEPLATE – MAIN BOILER COLUMNS)

NOTES

1. SEE DWG S1000 FOR GENERAL NOTES AND LEGEND.
2. REFER TO ESKOM DRAWING 0.90/692 SHT 0, FOR DEFINITION OF ZERO DATUM LEVEL.
3. REFER TO DRAWINGS S1003–S1013 FOR DETAILED SITE ARRANGEMENT INFORMATION.

BACKCIRCLES PER ECN-N-S-0106

APPROVED FOR CONSTRUCTION

THE DISTRIBUTION AND USE OF THE NATIVE FILE FORMAT OF THIS DRAWING OUTSIDE OF BLACK & VEATCH IS UNCONTROLLED AND SHALL BE USED FOR REFERENCE PURPOSES ONLY.

PLANT NORTH
45°
TRUE NORTH

0 50 100 150
SCALE IN METERS

D.O.	REV	DATE	** REVISION **	REV BY	CHKD BY	AUTH BY	KKS APP
	9	12/MAY/10	ECN N–S–0106	MSW	MJW	GLG	MDC
	8	11/FEB/10	ECN N–S–0096	MSW	MJW	GLG	MDC
	7	21/AUG/09	ECN N–S–0067	MSW	MJW	GLG	MDC
	6	01/JUL/09	ECN N–S–0051	MJW	GLG	MDC	
	5	16/JAN/09	ECN N–S–0036	MJW	JWF	MDC	
	4	17/OCT/08	ISSUE FOR DESIGN FREEZE	DNS	MJS	DLS	
	3	19/SEP/08	ECN–N–S–0019	JSH		DLS	
	2	18/JULY/08	ECN–N–S–0012	DNS		DLS	
	1	09/MAY/08	ECN–N–S–0005	JSH		DLS	
	0	14/MAR/08	ISSUED FOR BASIS OF CONTRACT	JSH			

INDEX REFERENCE : S 2.1

0.90 REFERENCE DRAWINGS

DRG REGISTR	
DESIGN APPROVED	
KKS APP	
DO AUTH	
CHKD BY	
DRAWN BY	MSW
SCALE	1:2000

AUTHORISED FOR ESKOM BY: JVT
DATE: 12/MAY/10

BLACK & VEATCH

Eskom

KUSILE POWER STATION

STATION LAYOUT

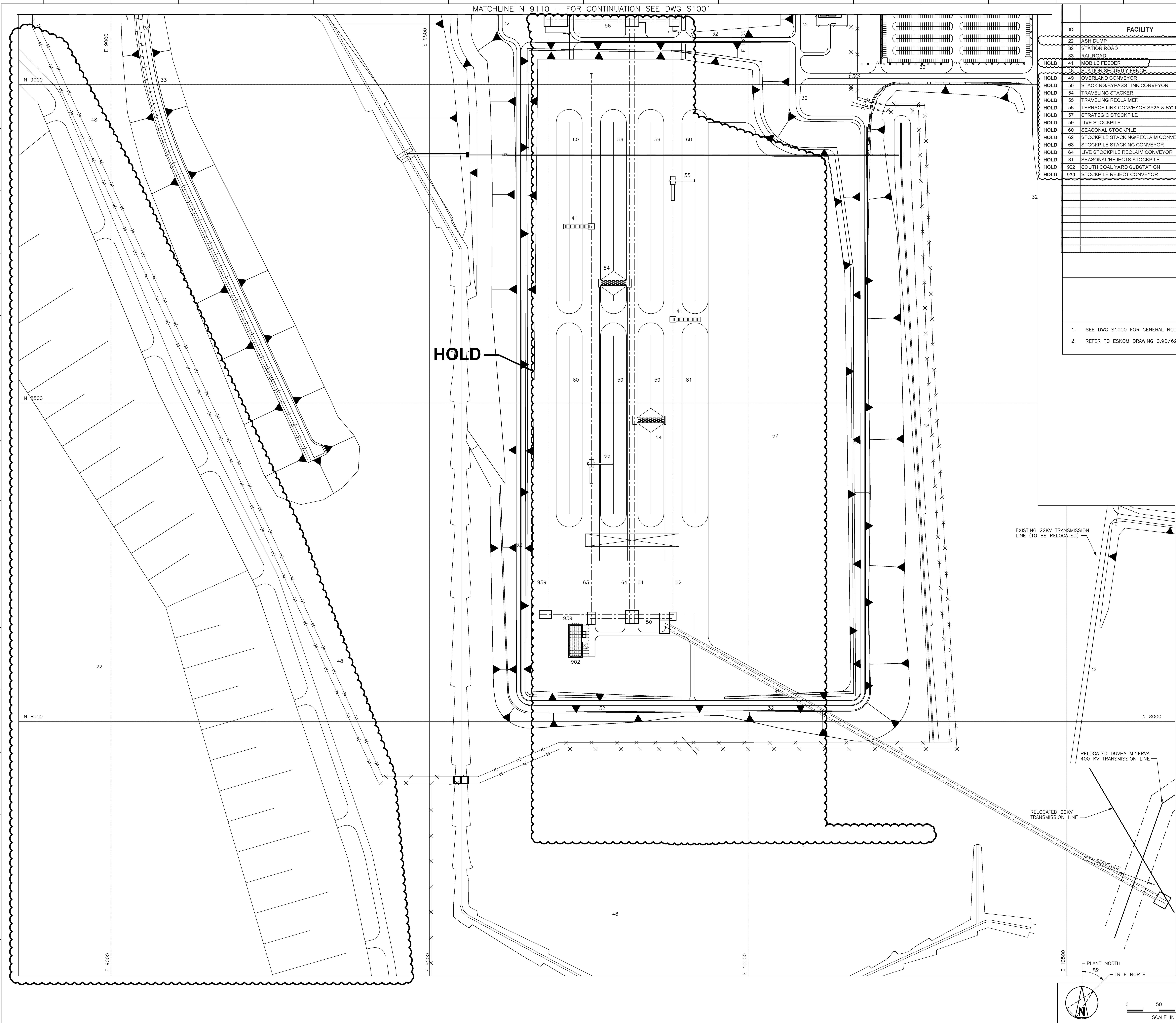
146838–0UXB–S1001

REV 9

0.90/137

SHEET | REV

SIZE GROOTTE A0L



FACILITY LEGEND

	ID	FACILITY	FOUNDATION	TIEDOWN LOCATION NORTH	TIEDOWN LOCATION EAST	REMARKS
	22	ASH DUMP	0.90/23271			
	32	STATION ROAD				
	33	RAILROAD				
HOLD	41	MOBILE FEEDER				
	48	STATION SECURITY FENCE				
HOLD	49	OVERLAND CONVEYOR				
HOLD	50	STACKING/BYPASS LINK CONVEYOR				
HOLD	54	TRAVELING STACKER				
HOLD	55	TRAVELING RECLAIMER				
HOLD	56	TERRACE LINK CONVEYOR SY2A & SY2B				
HOLD	57	STRATEGIC STOCKPILE				
HOLD	59	LIVE STOCKPILE				
HOLD	60	SEASONAL STOCKPILE				
HOLD	62	STOCKPILE STACKING/RECLAIM CONVEYOR				
HOLD	63	STOCKPILE STACKING CONVEYOR				
HOLD	64	LIVE STOCKPILE RECLAIM CONVEYOR				
HOLD	81	SEASONAL/REJECTS STOCKPILE				
HOLD	902	SOUTH COAL YARD SUBSTATION	0.90/3529	8102.850	9720.350	COL ROW ES1/ESL
HOLD	939	STOCKPILE REJECT CONVEYOR				

STATION CENTERLINE COORDINATES

(WGS/Lo29)

X = +2 867 630.000
Y = + 8 350.000
STATION ZERO DATUM LEVEL (0.000) = 1503.250 masl
(BOTTOM OF BASEPLATE – MAIN BOILER COLUMNS)

NOTES

1. SEE DWG S1000 FOR GENERAL NOTES AND LEGEND.
2. REFER TO ESKOM DRAWING 0.90/692 SHT 0, FOR DEFINITION OF ZERO DATUM LEVEL.

APPROVED FOR CONSTRUCTION

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D.O.	REV	DATE	** REVISION **	REV BY	CHKD BY	AUTH BY	KKS APP
	10	25/AUG/10	ECN N-S-0143	MSW	MJW	GLG	MDC
	9	12/MAY/10	ECN N-S-0106	MSW	MJW	GLG	MDC
	8	11/FEB/10	ECN N-S-0096	MSW	MJW	GLG	MDC
	7	21/AUG/09	ECN-N-S-0067	MSW	MJW	GLG	MDC
	6	01/JUL/09	ECN-N-S-0051	MJW	GLG	MDC	
	5	16/JAN/09	ECN-N-S-0036	MJW	JWF	MDC	
	4	17/OCT/08	ISSUE FOR DESIGN FREEZE	DNS	MJS	DLS	
	3	19/SEP/08	ECN-N-S-0012	JSH		DLS	
	2	18/JULY/08	ECN-N-S-0012	DNS		DLS	
	1	09/MAY/08	ECN-N-S-0005	JSH		DLS	
	0	14/MAR/08	ISSUED FOR BASIS OF CONTRACT	JSH			

INDEX REFERENCE : S 2.1 C 8.2

0.90 REFERENCE DRAWINGS

AUTHORISED FOR ESKOM BY: JVT DATE: 25/AUG/10

DRAWN BY: MSW
SCALE: 1:2000

BLACK & VEATCH
Eskom

KUSILE POWER STATION
COAL STOCK YARD LAYOUT

146838-0UEB-S1002 REV 10

0.90/135

SIZE GROOTTE A0L

REE26856 A1APN017 08/25/10 14:54:03
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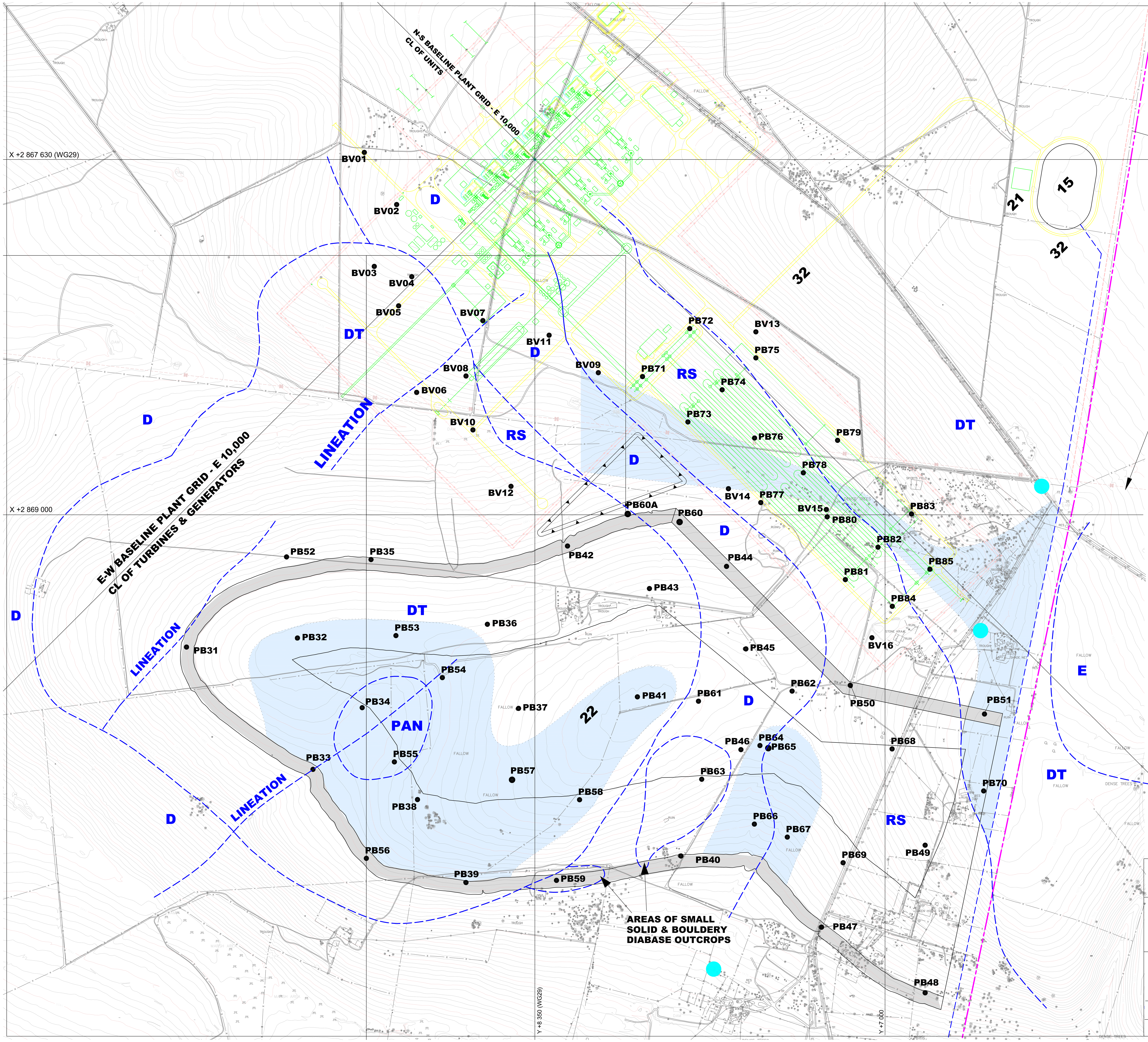
APPENDIX 1A

ASH DUMP GEOLOGY AND SUB-SURFACE WATER DEPTH PROFILE



GEOLOGICAL CONTACT

PB70 TEST PITS

AREAS WITH RAPID SEEPAGE IN THE SUBSOIL (SUMMER 2007/8)

(NOTE: SLOW SEEPAGE WAS NOTED IN MOST OTHER PITS)

GEOLOGICAL EXPLANATION

E	ECCA GROUP
DT	DWYKA TILLITE
D	DIABASE
RS	RAYTON SHALE

Interpretation by:
PARTRIDGE, MAUD & ASSOCIATES
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PRELIMINARY

Eskom

PROJECT BRAVO ASH DUMP AND COAL STOCKYARD

PLAN SHOWING SURFACE GEOLOGY AND TEST PITS

SCALE 1:5000 | PLAN 0.90/36

MAY., 2008

APPENDIX 2

ASH PRODUCTION SCHEDULES

Kusile Power Station: Waste Production
ASH/FGD PRODUCTION SCHEDULE

Unit Input Parameters

Ash Output (t/hr)	150.00	Ash S.G.	0.80	Ash Volume (m^3/hr)	187.50
Gypsum Output (t/hr)	19.33	Gypsum S.G.	1.00	Gypsum Volume (m^3/hr)	19.33
Ash Load Factor	0.90	Ash Availability Factor	0.90	Ash Factor of Safety	1.10
Gypsum Load Factor	0.90	Gypsum Availability Factor	0.90	Gypsum Factor of Safety	1.10

Adjusted Unit Output

Ash Output (t/hr)	133.65	Ash Volume (m^3/hr)	167.06	Monthly Ash Volume (m^3)	121956
Gypsum Output (t/hr)	17.22	Gypsum Volume (m^3/hr)	17.22	Monthly Gypsum Volume (m^3)	12573

Commissioning Schedule (relative to project time zero)

Co-Disposal Duration (months): 60

Feb 17 2017 (assume 2 week delay to March 1 2017)

Unit 1 (months):	0	July 1, 2013
Unit 2 (months):	8	March 1, 2014
Unit 3 (months):	16	November 1, 2014
Unit 4 (months):	24	July 1, 2015
Unit 5 (months):	32	March 1, 2016
Unit 6 (months):	40	November 1, 2016

Ash Dump No. 1 Production Schedule

Period (months) Start	End	Units Online	Inc. Ash (m^3)	Inc. FGD (m^3)	Total Ash (m^3)	Total FGD (m^3)	Total (m^3)
0	4	1	487823	50291	487823	50291	538114
4	8	1	487823	50291	975645	100582	1076227
8	12	2	975645	100582	1951290	201165	2152455
12	16	2	975645	100582	2926935	301747	3228682
16	20	3	1463468	150874	4390403	452621	4843024
20	24	3	1463468	150874	5853870	603495	6457365
24	28	4	1951290	201165	7805160	804660	8609820
28	32	4	1951290	201165	9756450	1005825	10762275
32	36	5	2439113	251456	12195563	1257281	13452844
36	40	5	2439113	251456	14634675	1508737	16143412
40	44	6	2926935	301747	17561610	1810485	19372095
44	48	6	2926935	301747	20488545	2112232	22600777
48	52	6	2926935	301747	23415480	2413980	25829460
52	56	6	2926935	301747	26342415	2715727	29058142
56	60	6	2926935	301747	29269350	3017475	32286825
60	64	6	0	301747	29269350	3319222	32588572
64	68	6	0	301747	29269350	3620970	32890320
68	72	6	0	301747	29269350	3922717	33192067
72	76	6	0	301747	29269350	4224465	33493815
76	80	6	0	301747	29269350	4526212	33795562
80	84	6	0	301747	29269350	4827960	34097310
84	88	6	0	301747	29269350	5129707	34399057
88	92	6	0	301747	29269350	5431455	34700805
92	96	6	0	301747	29269350	5733202	35002552
96	100	6	0	301747	29269350	6034950	35304300
100	104	6	0	301747	29269350	6336697	35606047
104	108	6	0	301747	29269350	6638445	35907795
108	112	6	0	301747	29269350	6940192	36209542
112	116	6	0	301747	29269350	7241940	36511290
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124	128	6	0	301747	29269350	8147182	37416532
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204	208	6	0	301747	29269350	14182132	43451482
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256	260	6	0	301747	29269350	18104849	47374199
260	264	6	0	301747	29269350	18406597	47675947
264	268	6	0	301747	29269350	18708344	47977694
268	272	6	0	301747	29269350	19010092	48279442
272	276	6	0	301747	29269350	19311839	48581189
276	280	6	0	301747	29269350	19613587	48882937
280	284	6	0	301747	29269350	19915334	49184684
284	288	6	0	301747	29269350	20217082	49486432
288	292	6	0	301747	29269350	20518829	49788179
292	296	6	0	301747	29269350	20820577	50089927
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308	312	6	0	301747	29269350	22027566	51296916
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460	464	6	0	301747	29269350	33493971	62763321
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472	476	6	0	301747	29269350	34399213	63668563
476	480	6	0	301747	29269350	34700961	63970311
480	484	6	0	301747	29269350	35002708	64272058
484	488	6	0	301747	29269350	35304456	64573806
488	492	6	0	301747	29269350	35606203	64875553
492	496	6	0	301747	29269350	35907951	65177301
496	500	6	0	301747	29269350	36209698	65479048
500	504	6	0	301747	29269350	36511446	65780796
504	508	6	0	301747	29269350	36813193	66082543
508	512	6	0	301747	29269350	37114941	66384291
512	516	6	0	301747	29269350	37416688	66686038
516	520	6	0	301747	29269350	37718436	66987786
520	524	6	0	301747	29269350	38020183	67289533
524	528	6	0	301747	29269350	38321931	67591281
528	532	6	0	301747	29269350	38623678	67893028
532	536	6	0	301747	29269350	38925426	68194776
536	540	6	0	301747	29269350	39227173	68496523
540	544	6	0	301747	29269350	39528921	68798271
544	548	6	0	301747	29269350	39830668	69100018
548	552	6	0	301747	29269350	40132416	69401766
552	556	6	0	301747	29269350	40434163	69703513
556	560	6	0	301747	29269350	40735911	70005261
560	564	6	0	301747	29269350	41037658	70307008
564	568	6	0	301747	29269350	41339406	70608756
568	572	6	0	301747	29269350	41641153	70910503
572	576	6	0	301747	29269350	41942900	71212250
576	580	6	0	301747	29269350	42244648	71513998
580	584	6	0	301747	29269350	42546395	71815745
584	588	6	0	301747	29269350	42848143	72117493
588	592	6	0	301747	29269350	43149890	72419240
592	596	6	0	301747	29269350	43451638	72720988
596	600	6	0	301747	29269350	43753385	73022735
600	604	6	0	301747	29269350	44055133	73324483
604	608	6	0	301747	29269350	44356880	73626230
608	612	6	0	301747	29269350	44658628	73927978
612	616	6	0	301747	29269350	44960375	74229725
616	620	6	0	301747	29269350	45262123	74531473
620	624	6	0	301747	29269350	45563870	74833220
624	628	6	0	301747	29269350	45865618	75134968
628	632	6	0	301747	29269350	46167365	75436715
632	636	6	0	301747	29269350	46469113	75738463
636	640	6	0	301747	29269350	46770860	76040210
640	644	6	0	301747	29269350	47072608	76341958
644	648	6	0	301747	29269350	47374355	76643705
648	652	6	0	301747	29269350	47676103	76945453
652	656	6	0	301747	29269350	47977850	77247200
656	660	6	0	301747	29269350	48279598	77548948
660	664	6	0	301747	29269350	48581345	77850695
664	668	6	0	301747	29269350	48883093	78152443
668	672	6	0	301747	29269350	49184840	78454190
672	676	6	0	301747	29269350	49486588	78755938
676	680	6	0	301747	29269350	49788335	79057685
680	684	6	0	301747	29269350	50090083	79359433
684	688	6	0	301747	29269350	50391830	79661180
688	692	6	0	301747	29269350	50693578	79962928
692	696	6	0	301747	29269350	50995325	80264675
696	700	6	0	301747	29269350	51297073	80566423
700	704	6	0	301747	29269350	51598820	80868170
704	708	6	0	301747	29269350	51900568	81169918
708	712	6	0	301747	29269350	52202315	81471665
712	716	6	0	301747	29269350	52504062	81773412
716	720	6	0	301747	29269350	52805810	82075160

Ash Dump No. 1 Production Schedule **co-disposal 4.25 years** **boiler commiss every 12 months**

	Period (months)		Units Onli	Inc. Ash (m3)	Inc. FGD (m3)	Total Ash (m3)	Total FGD (m3)	Total (m3)	
Years	Start	End							
	0	3	1	365,866.88	37,718.44	365,866.88	37,718.44	403,585.31	
	3	6	1	365,866.88	37,718.44	731,733.75	75,436.87	807,170.62	
	6	9	1	365,866.88	37,718.44	1,097,600.63	113,155.31	1,210,755.93	
1	9	12	1	365,866.88	37,718.44	1,463,467.50	150,873.74	1,614,341.24	
	12	15	2	731,733.75	75,436.87	2,195,201.25	226,310.61	2,421,511.86	
	15	18	2	731,733.75	75,436.87	2,926,935.00	301,747.49	3,228,682.49	
	18	21	2	731,733.75	75,436.87	3,658,668.75	377,184.36	4,035,853.11	
2	21	24	2	731,733.75	75,436.87	4,390,402.50	452,621.23	4,843,023.73	
	24	27	3	1,097,600.63	113,155.31	5,488,003.13	565,776.54	6,053,779.66	
	27	30	3	1,097,600.63	113,155.31	6,585,603.75	678,931.84	7,264,535.59	
	30	33	3	1,097,600.63	113,155.31	7,683,204.38	792,087.15	8,475,291.52	
3	33	36	3	1,097,600.63	113,155.31	8,780,805.00	905,242.46	9,686,047.46	
	36	39	4	1,463,467.50	150,873.74	10,244,272.50	1,056,116.20	11,300,388.70	
	39	42	4	1,463,467.50	150,873.74	11,707,740.00	1,206,989.94	12,914,729.94	
	42	45	4	1,463,467.50	150,873.74	13,171,207.50	1,357,863.69	14,529,071.19	
4	45	48	4	1,463,467.50	150,873.74	14,634,675.00	1,508,737.43	16,143,412.43	
	48	51	5	1,829,334.38	188,592.18	16,464,009.38	1,697,329.61	18,161,338.98	Phase 1
	51	54	5	0	188,592.18	16,464,009.38	1,885,921.79	18,349,931.16	
	54	57	5	0	188,592.18	16,464,009.38	2,074,513.96	18,538,523.34	
5	57	60	5	0	188,592.18	16,464,009.38	2,263,106.14	18,727,115.52	
	60	63	6	0	226,310.61	16,464,009.38	2,489,416.76	18,953,426.13	
	63	66	6	0	226,310.61	16,464,009.38	2,715,727.37	19,179,736.75	
	66	69	6	0	226,310.61	16,464,009.38	2,942,037.98	19,406,047.36	
6	69	72	6	0	226,310.61	16,464,009.38	3,168,348.60	19,632,357.97	
	72	75	6	0	226,310.61	16,464,009.38	3,394,659.21	19,858,668.59	
	75	78	6	0	226,310.61	16,464,009.38	3,620,969.83	20,084,979.20	
	78	81	6	0	226,310.61	16,464,009.38	3,847,280.44	20,311,289.82	
7	81	84	6	0	226,310.61	16,464,009.38	4,073,591.06	20,537,600.43	
	84	87	6	0	226,310.61	16,464,009.38	4,299,901.67	20,763,911.04	
	87	90	6	0	226,310.61	16,464,009.38	4,526,212.28	20,990,221.66	
	90	93	6	0	226,310.61	16,464,009.38	4,752,522.90	21,216,532.27	
8	93	96	6	0	226,310.61	16,464,009.38	4,978,833.51	21,442,842.89	
	96	99	6	0	226,310.61	16,464,009.38	5,205,144.13	21,669,153.50	
	99	102	6	0	226,310.61	16,464,009.38	5,431,454.74	21,895,464.12	
	102	105	6	0	226,310.61	16,464,009.38	5,657,765.36	22,121,774.73	
9	105	108	6	0	226,310.61	16,464,009.38	5,884,075.97	22,348,085.34	
	108	111	6	0	226,310.61	16,464,009.38	6,110,386.58	22,574,395.96	
	111	114	6	0	226,310.61	16,464,009.38	6,336,697.20	22,800,706.57	
	114	117	6	0	226,310.61	16,464,009.38	6,563,007.81	23,027,017.19	
10	117	120	6	0	226,310.61	16,464,009.38	6,789,318.43	23,253,327.80	
	120	123	6	0	226,310.61	16,464,009.38	7,015,629.04	23,479,638.42	
	123	126	6	0	226,310.61	16,464,009.38	7,241,939.65	23,705,949.03	
	126	129	6	0	226,310.61	16,464,009.38	7,468,250.27	23,932,259.64	
11	129	132	6	0	226,310.61	16,464,009.38	7,694,560.88	24,158,570.26	
	132	135	6	0	226,310.61	16,464,009.38	7,920,871.50	24,384,880.87	
	135	138	6	0	226,310.61	16,464,009.38	8,147,182.11	24,611,191.49	
	138	141	6	0	226,310.61	16,464,009.38	8,373,492.73	24,837,502.10	
12	141	144	6	0	226,310.61	16,464,009.38	8,599,803.34	25,063,812.71	
	144	147	6	0	226,310.61	16,464,009.38	8,826,113.95	25,290,123.33	
	147	150	6	0	226,310.61	16,464,009.38	9,052,424.57	25,516,433.94	
	150	153	6	0	226,310.61	16,464,009.38	9,278,735.18	25,742,744.56	
13	153	156	6	0	226,310.61	16,464,009.38	9,505,045.80	25,969,055.17	
	156	159	6	0	226,310.61	16,464,009.38	9,731,356.41	26,195,365.79	
	159	162	6	0	226,310.61	16,464,009.38	9,957,667.02	26,421,676.40	
	162	165	6	0	226,310.61	16,464,009.38	10,183,977.64	26,647,987.01	
14	165	168	6	0	226,310.61	16,464,009.38	10,410,288.25	26,874,297.63	
	168	171	6	0	226,310.61	16,464,009.38	10,636,598.87	27,100,608.24	
	171	174	6	0	226,310.61	16,464,009.38	10,862,909.48	27,326,918.86	
	174	177	6	0	226,310.61	16,464,009.38	11,089,220.10	27,553,229.47	
15	177	180	6	0	226,310.61	16,464,009.38	11,315,530.71	27,779,540.09	
	180	183	6	0	226,310.61	16,464,009.38	11,541,841.32	28,005,850.70	
	183	186	6	0	226,310.61	16,464,009.38	11,768,151.94	28,232,161.31	
	186	189	6	0	226,310.61	16,464,009.38	11,994,462.55	28,458,471.93	
16	189	192	6	0	226,310.61	16,464,009.38	12,220,773.17	28,684,782.54	

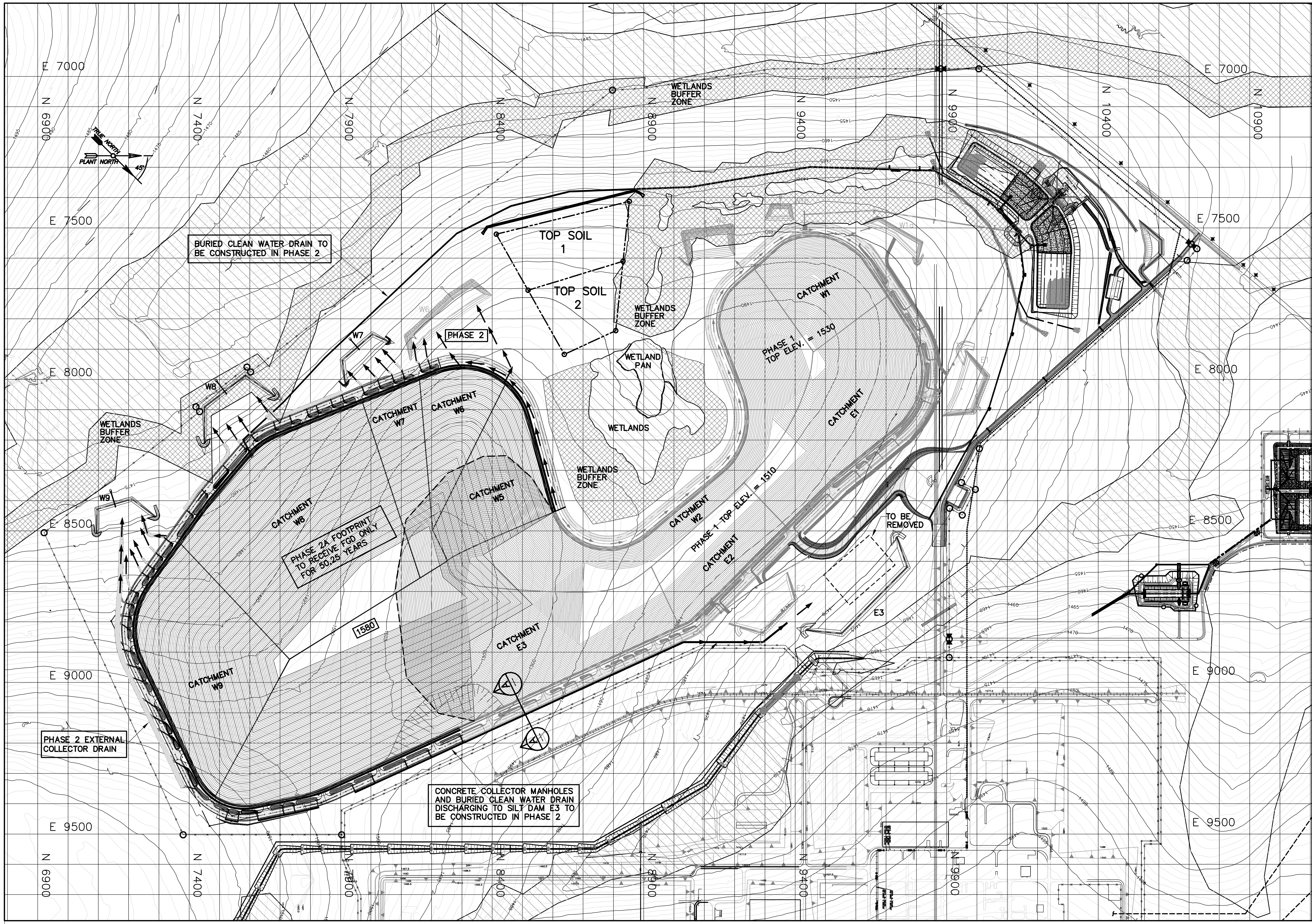
	192	195	6	0	226,310.61	16,464,009.38	12,447,083.78	28,911,093.16
	195	198	6	0	226,310.61	16,464,009.38	12,673,394.40	29,137,403.77
	198	201	6	0	226,310.61	16,464,009.38	12,899,705.01	29,363,714.38
17	201	204	6	0	226,310.61	16,464,009.38	13,126,015.62	29,590,025.00
	204	207	6	0	226,310.61	16,464,009.38	13,352,326.24	29,816,335.61
	207	210	6	0	226,310.61	16,464,009.38	13,578,636.85	30,042,646.23
	210	213	6	0	226,310.61	16,464,009.38	13,804,947.47	30,268,956.84
18	213	216	6	0	226,310.61	16,464,009.38	14,031,258.08	30,495,267.46
	216	219	6	0	226,310.61	16,464,009.38	14,257,568.69	30,721,578.07
	219	222	6	0	226,310.61	16,464,009.38	14,483,879.31	30,947,888.68
	222	225	6	0	226,310.61	16,464,009.38	14,710,189.92	31,174,199.30
19	225	228	6	0	226,310.61	16,464,009.38	14,936,500.54	31,400,509.91
	228	231	6	0	226,310.61	16,464,009.38	15,162,811.15	31,626,820.53
	231	234	6	0	226,310.61	16,464,009.38	15,389,121.77	31,853,131.14
	234	237	6	0	226,310.61	16,464,009.38	15,615,432.38	32,079,441.75
20	237	240	6	0	226,310.61	16,464,009.38	15,841,742.99	32,305,752.37
	240	243	6	0	226,310.61	16,464,009.38	16,068,053.61	32,532,062.98
	243	246	6	0	226,310.61	16,464,009.38	16,294,364.22	32,758,373.60
	246	249	6	0	226,310.61	16,464,009.38	16,520,674.84	32,984,684.21
21	249	252	6	0	226,310.61	16,464,009.38	16,746,985.45	33,210,994.83
	252	255	6	0	226,310.61	16,464,009.38	16,973,296.07	33,437,305.44
	255	258	6	0	226,310.61	16,464,009.38	17,199,606.68	33,663,616.05
	258	261	6	0	226,310.61	16,464,009.38	17,425,917.29	33,889,926.67
22	261	264	6	0	226,310.61	16,464,009.38	17,652,227.91	34,116,237.28
	264	267	6	0	226,310.61	16,464,009.38	17,878,538.52	34,342,547.90
	267	270	6	0	226,310.61	16,464,009.38	18,104,849.14	34,568,858.51
	270	273	6	0	226,310.61	16,464,009.38	18,331,159.75	34,795,169.13
23	273	276	6	0	226,310.61	16,464,009.38	18,557,470.36	35,021,479.74
	276	279	6	0	226,310.61	16,464,009.38	18,783,780.98	35,247,790.35
	279	282	6	0	226,310.61	16,464,009.38	19,010,091.59	35,474,100.97
	282	285	6	0	226,310.61	16,464,009.38	19,236,402.21	35,700,411.58
24	285	288	6	0	226,310.61	16,464,009.38	19,462,712.82	35,926,722.20
	288	291	6	0	226,310.61	16,464,009.38	19,689,023.44	36,153,032.81
	291	294	6	0	226,310.61	16,464,009.38	19,915,334.05	36,379,343.42
	294	297	6	0	226,310.61	16,464,009.38	20,141,644.66	36,605,654.04
25	297	300	6	0	226,310.61	16,464,009.38	20,367,955.28	36,831,964.65
	300	303	6	0	226,310.61	16,464,009.38	20,594,265.89	37,058,275.27
	303	306	6	0	226,310.61	16,464,009.38	20,820,576.51	37,284,585.88
	306	309	6	0	226,310.61	16,464,009.38	21,046,887.12	37,510,896.50
26	309	312	6	0	226,310.61	16,464,009.38	21,273,197.73	37,737,207.11
	312	315	6	0	226,310.61	16,464,009.38	21,499,508.35	37,963,517.72
	315	318	6	0	226,310.61	16,464,009.38	21,725,818.96	38,189,828.34
	318	321	6	0	226,310.61	16,464,009.38	21,952,129.58	38,416,138.95
27	321	324	6	0	226,310.61	16,464,009.38	22,178,440.19	38,642,449.57
	324	327	6	0	226,310.61	16,464,009.38	22,404,750.81	38,868,760.18
	327	330	6	0	226,310.61	16,464,009.38	22,631,061.42	39,095,070.80
	330	333	6	0	226,310.61	16,464,009.38	22,857,372.03	39,321,381.41
28	333	336	6	0	226,310.61	16,464,009.38	23,083,682.65	39,547,692.02
	336	339	6	0	226,310.61	16,464,009.38	23,309,993.26	39,774,002.64
	339	342	6	0	226,310.61	16,464,009.38	23,536,303.88	40,000,313.25
	342	345	6	0	226,310.61	16,464,009.38	23,762,614.49	40,226,623.87
29	345	348	6	0	226,310.61	16,464,009.38	23,988,925.11	40,452,934.48
	348	351	6	0	226,310.61	16,464,009.38	24,215,235.72	40,679,245.09
	351	354	6	0	226,310.61	16,464,009.38	24,441,546.33	40,905,555.71
	354	357	6	0	226,310.61	16,464,009.38	24,667,856.95	41,131,866.32
30	357	360	6	0	226,310.61	16,464,009.38	24,894,167.56	41,358,176.94
	360	363	6	0	226,310.61	16,464,009.38	25,120,478.18	41,584,487.55
	363	366	6	0	226,310.61	16,464,009.38	25,346,788.79	41,810,798.17
	366	369	6	0	226,310.61	16,464,009.38	25,573,099.40	42,037,108.78
31	369	372	6	0	226,310.61	16,464,009.38	25,799,410.02	42,263,419.39
	372	375	6	0	226,310.61	16,464,009.38	26,025,720.63	42,489,730.01
	375	378	6	0	226,310.61	16,464,009.38	26,252,031.25	42,716,040.62
	378	381	6	0	226,310.61	16,464,009.38	26,478,341.86	42,942,351.24
32	381	384	6	0	226,310.61	16,464,009.38	26,704,652.48	43,168,661.85
	384	387	6	0	226,310.61	16,464,009.38	26,930,963.09	43,394,972.46
	387	390	6	0	226,310.61	16,464,009.38	27,157,273.70	43,621,283.08
	390	393	6	0	226,310.61	16,464,009.38	27,383,584.32	43,847,593.69
33	393	396	6	0	226,310.61	16,464,009.38	27,609,894.93	44,073,904.31

	396	399	6	0	226,310.61	16,464,009.38	27,836,205.55	44,300,214.92
	399	402	6	0	226,310.61	16,464,009.38	28,062,516.16	44,526,525.54
	402	405	6	0	226,310.61	16,464,009.38	28,288,826.78	44,752,836.15
34	405	408	6	0	226,310.61	16,464,009.38	28,515,137.39	44,979,146.76
	408	411	6	0	226,310.61	16,464,009.38	28,741,448.00	45,205,457.38
	411	414	6	0	226,310.61	16,464,009.38	28,967,758.62	45,431,767.99
	414	417	6	0	226,310.61	16,464,009.38	29,194,069.23	45,658,078.61
35	417	420	6	0	226,310.61	16,464,009.38	29,420,379.85	45,884,389.22
	420	423	6	0	226,310.61	16,464,009.38	29,646,690.46	46,110,699.84
	423	426	6	0	226,310.61	16,464,009.38	29,873,001.07	46,337,010.45
	426	429	6	0	226,310.61	16,464,009.38	30,099,311.69	46,563,321.06
36	429	432	6	0	226,310.61	16,464,009.38	30,325,622.30	46,789,631.68
	432	435	6	0	226,310.61	16,464,009.38	30,551,932.92	47,015,942.29
	435	438	6	0	226,310.61	16,464,009.38	30,778,243.53	47,242,252.91
	438	441	6	0	226,310.61	16,464,009.38	31,004,554.15	47,468,563.52
37	441	444	6	0	226,310.61	16,464,009.38	31,230,864.76	47,694,874.13
	444	447	6	0	226,310.61	16,464,009.38	31,457,175.37	47,921,184.75
	447	450	6	0	226,310.61	16,464,009.38	31,683,485.99	48,147,495.36
	450	453	6	0	226,310.61	16,464,009.38	31,909,796.60	48,373,805.98
38	453	456	6	0	226,310.61	16,464,009.38	32,136,107.22	48,600,116.59
	456	459	6	0	226,310.61	16,464,009.38	32,362,417.83	48,826,427.21
	459	462	6	0	226,310.61	16,464,009.38	32,588,728.44	49,052,737.82
	462	465	6	0	226,310.61	16,464,009.38	32,815,039.06	49,279,048.43
39	465	468	6	0	226,310.61	16,464,009.38	33,041,349.67	49,505,359.05
	468	471	6	0	226,310.61	16,464,009.38	33,267,660.29	49,731,669.66
	471	474	6	0	226,310.61	16,464,009.38	33,493,970.90	49,957,980.28
	474	477	6	0	226,310.61	16,464,009.38	33,720,281.52	50,184,290.89
40	477	480	6	0	226,310.61	16,464,009.38	33,946,592.13	50,410,601.51
	480	483	6	0	226,310.61	16,464,009.38	34,172,902.74	50,636,912.12
	483	486	6	0	226,310.61	16,464,009.38	34,399,213.36	50,863,222.73
	486	489	6	0	226,310.61	16,464,009.38	34,625,523.97	51,089,533.35
41	489	492	6	0	226,310.61	16,464,009.38	34,851,834.59	51,315,843.96
	492	495	6	0	226,310.61	16,464,009.38	35,078,145.20	51,542,154.58
	495	498	6	0	226,310.61	16,464,009.38	35,304,455.82	51,768,465.19
	498	501	6	0	226,310.61	16,464,009.38	35,530,766.43	51,994,775.80
42	501	504	6	0	226,310.61	16,464,009.38	35,757,077.04	52,221,086.42
	504	507	6	0	226,310.61	16,464,009.38	35,983,387.66	52,447,397.03
	507	510	6	0	226,310.61	16,464,009.38	36,209,698.27	52,673,707.65
	510	513	6	0	226,310.61	16,464,009.38	36,436,008.89	52,900,018.26
43	513	516	6	0	226,310.61	16,464,009.38	36,662,319.50	53,126,328.88
	516	519	6	0	226,310.61	16,464,009.38	36,888,630.11	53,352,639.49
	519	522	6	0	226,310.61	16,464,009.38	37,114,940.73	53,578,950.10
	522	525	6	0	226,310.61	16,464,009.38	37,341,251.34	53,805,260.72
44	525	528	6	0	226,310.61	16,464,009.38	37,567,561.96	54,031,571.33
	528	531	6	0	226,310.61	16,464,009.38	37,793,872.57	54,257,881.95
	531	534	6	0	226,310.61	16,464,009.38	38,020,183.19	54,484,192.56
	534	537	6	0	226,310.61	16,464,009.38	38,246,493.80	54,710,503.17
45	537	540	6	0	226,310.61	16,464,009.38	38,472,804.41	54,936,813.79
	540	543	6	0	226,310.61	16,464,009.38	38,699,115.03	55,163,124.40
	543	546	6	0	226,310.61	16,464,009.38	38,925,425.64	55,389,435.02
	546	549	6	0	226,310.61	16,464,009.38	39,151,736.26	55,615,745.63
46	549	552	6	0	226,310.61	16,464,009.38	39,378,046.87	55,842,056.25
	552	555	6	0	226,310.61	16,464,009.38	39,604,357.49	56,068,366.86
	555	558	6	0	226,310.61	16,464,009.38	39,830,668.10	56,294,677.47
	558	561	6	0	226,310.61	16,464,009.38	40,056,978.71	56,520,988.09
47	561	564	6	0	226,310.61	16,464,009.38	40,283,289.33	56,747,298.70
	564	567	6	0	226,310.61	16,464,009.38	40,509,599.94	56,973,609.32
	567	570	6	0	226,310.61	16,464,009.38	40,735,910.56	57,199,919.93
	570	573	6	0	226,310.61	16,464,009.38	40,962,221.17	57,426,230.55
48	573	576	6	0	226,310.61	16,464,009.38	41,188,531.78	57,652,541.16
	576	579	6	0	226,310.61	16,464,009.38	41,414,842.40	57,878,851.77
	579	582	6	0	226,310.61	16,464,009.38	41,641,153.01	58,105,162.39
	582	585	6	0	226,310.61	16,464,009.38	41,867,463.63	58,331,473.00
49	585	588	6	0	226,310.61	16,464,009.38	42,093,774.24	58,557,783.62
	588	591	6	0	226,310.61	16,464,009.38	42,320,084.86	58,784,094.23
	591	594	6	0	226,310.61	16,464,009.38	42,546,395.47	59,010,404.84
	594	597	6	0	226,310.61	16,464,009.38	42,772,706.08	59,236,715.46
50	597	600	6	0	226,310.61	16,464,009.38	42,999,016.70	59,463,026.07

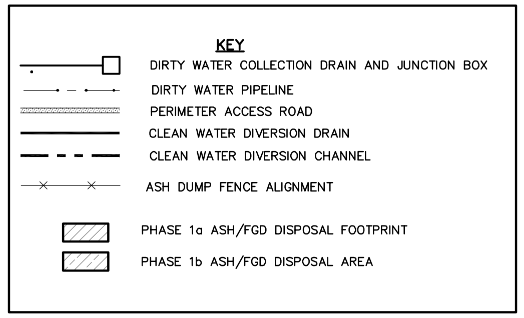
	600	603	6	0	226,310.61	16,464,009.38	43,225,327.31	59,689,336.69	
	603	606	6	0	226,310.61	16,464,009.38	43,451,637.93	59,915,647.30	
	606	609	6	0	226,310.61	16,464,009.38	43,677,948.54	60,141,957.92	
51	609	612	6	0	226,310.61	16,464,009.38	43,904,259.15	60,368,268.53	
	612	615	6	0	226,310.61	16,464,009.38	44,130,569.77	60,594,579.14	
	615	618	6	0	226,310.61	16,464,009.38	44,356,880.38	60,820,889.76	
	618	621	6	0	226,310.61	16,464,009.38	44,583,191.00	61,047,200.37	
52	621	624	6	0	226,310.61	16,464,009.38	44,809,501.61	61,273,510.99	
	624	627	6	0	226,310.61	16,464,009.38	45,035,812.23	61,499,821.60	
	627	630	6	0	226,310.61	16,464,009.38	45,262,122.84	61,726,132.22	
	630	633	6	0	226,310.61	16,464,009.38	45,488,433.45	61,952,442.83	
53	633	636	6	0	226,310.61	16,464,009.38	45,714,744.07	62,178,753.44	
	636	639	6	0	226,310.61	16,464,009.38	45,941,054.68	62,405,064.06	
	639	642	6	0	226,310.61	16,464,009.38	46,167,365.30	62,631,374.67	
	642	645	6	0	226,310.61	16,464,009.38	46,393,675.91	62,857,685.29	
54	645	648	6	0	226,310.61	16,464,009.38	46,619,986.53	63,083,995.90	
	648	651	6	0	226,310.61	16,464,009.38	46,846,297.14	63,310,306.51	
	651	654	6	0	226,310.61	16,464,009.38	47,072,607.75	63,536,617.13	Phase 1+2
	654	657	6	0	226,310.61	16,464,009.38	47,298,918.37	63,762,927.74	(orig foot)
55	657	660	6	0	226,310.61	16,464,009.38	47,525,228.98	63,989,238.36	
	660	663	6	0	226,310.61	16,464,009.38	47,751,539.60	64,215,548.97	
	663	666	6	0	226,310.61	16,464,009.38	47,977,850.21	64,441,859.59	
	666	669	6	0	226,310.61	16,464,009.38	48,204,160.82	64,668,170.20	
56	669	672	6	0	226,310.61	16,464,009.38	48,430,471.44	64,894,480.81	
	672	675	6	0	226,310.61	16,464,009.38	48,656,782.05	65,120,791.43	
	675	678	6	0	226,310.61	16,464,009.38	48,883,092.67	65,347,102.04	
	678	681	6	0	226,310.61	16,464,009.38	49,109,403.28	65,573,412.66	
57	681	684	6	0	226,310.61	16,464,009.38	49,335,713.90	65,799,723.27	
	684	687	6	0	226,310.61	16,464,009.38	49,562,024.51	66,026,033.88	
	687	690	6	0	226,310.61	16,464,009.38	49,788,335.12	66,252,344.50	
	690	693	6	0	226,310.61	16,464,009.38	50,014,645.74	66,478,655.11	
58	693	696	6	0	226,310.61	16,464,009.38	50,240,956.35	66,704,965.73	
	696	699	6	0	226,310.61	16,464,009.38	50,467,266.97	66,931,276.34	
	699	702	6	0	226,310.61	16,464,009.38	50,693,577.58	67,157,586.96	
	702	705	6	0	226,310.61	16,464,009.38	50,919,888.20	67,383,897.57	
59	705	708	6	0	226,310.61	16,464,009.38	51,146,198.81	67,610,208.18	
	708	711	6	0	226,310.61	16,464,009.38	51,372,509.42	67,836,518.80	
	711	714	6	0	226,310.61	16,464,009.38	51,598,820.04	68,062,829.41	
	714	717	6	0	226,310.61	16,464,009.38	51,825,130.65	68,289,140.03	
60	717	720	6	0	226,310.61	16,464,009.38	52,051,441.27	68,515,450.64	

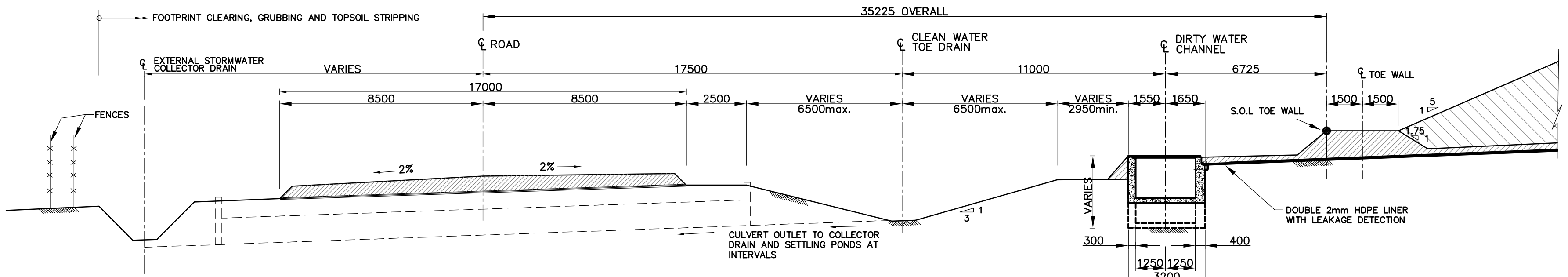
APPENDIX 3

ASH DUMP VOLUMETRIC MODELLING SKETCHES



PLAN
SCALE 1:5000





TYPICAL CROSS SECTION (A)
SCALE 1:100

D.O.	REV	DATE	** REVISION **	REV BY	CHKD BY	AUTH BY	KKS APP	REFERENCE DRAWINGS
	P1	15/11/12	ISSUDE FOR APPROVAL	JMcK	JRW	JRW		
	P	8/11/12	ISSUED FOR APPROVAL	JMcK	JRW	JRW		

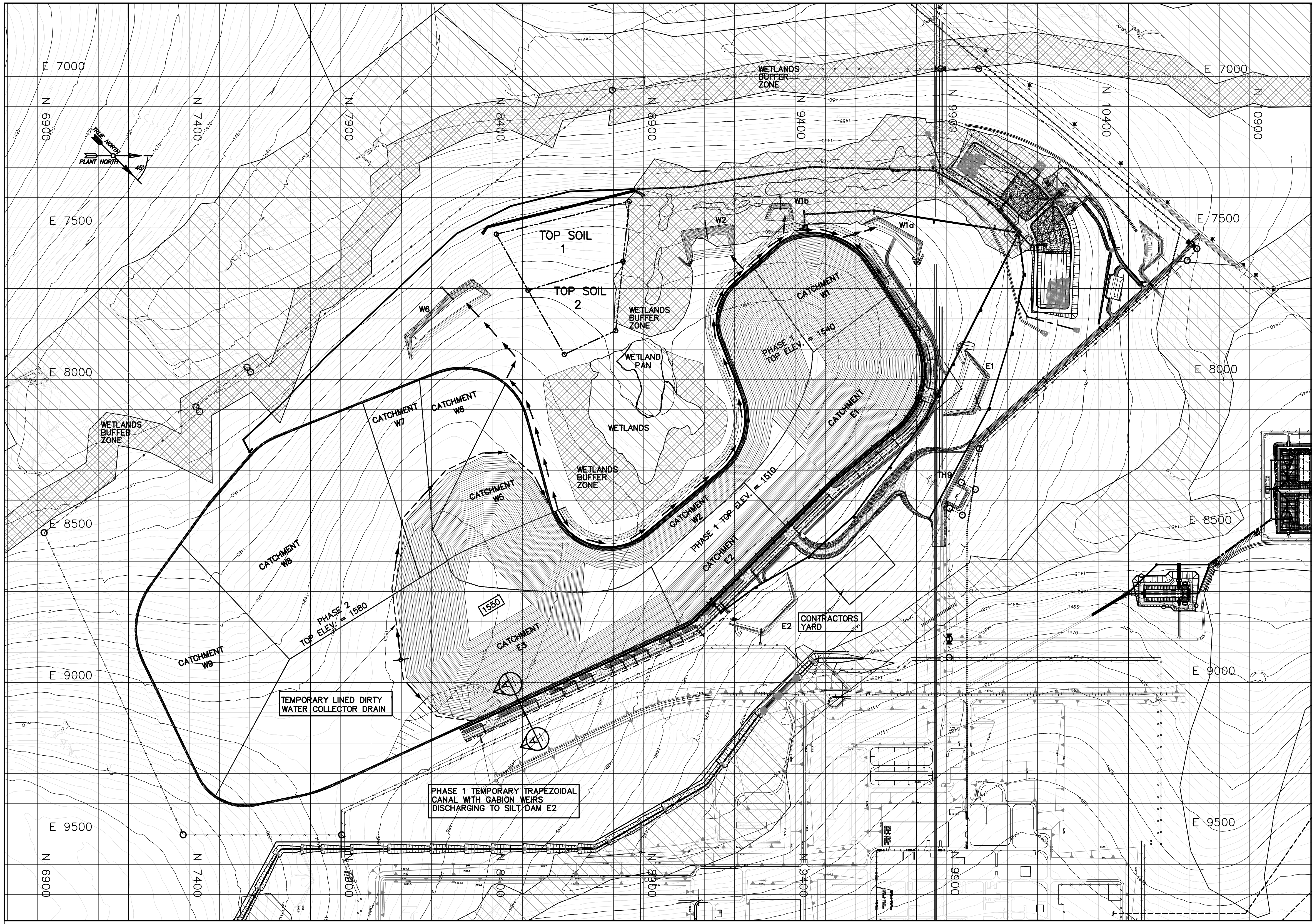
INDEX REFERENCE :

DRG REGISTR			AUTHORISED FOR ESKOM BY: MOW	DATE
DESIGN APPROVED		JRW		
KKS APP				
DO AUTH			PANEL B CONSULTANTS JOINT VENTURE	
CHKD BY		JRW	Knight Piésold CONSULTING	
DRAWN BY	26/3/10	JMcK		
SCALE			Eskom	

KUSILE POWER STATION
ASH DUMP No 1
AMENDED FOOTPRINT
CONCEPT PLAN PHASE 2

DRG. No. K30300098/06-SK101 — REV P1

0.90/ — SHEET A0 — REV P1

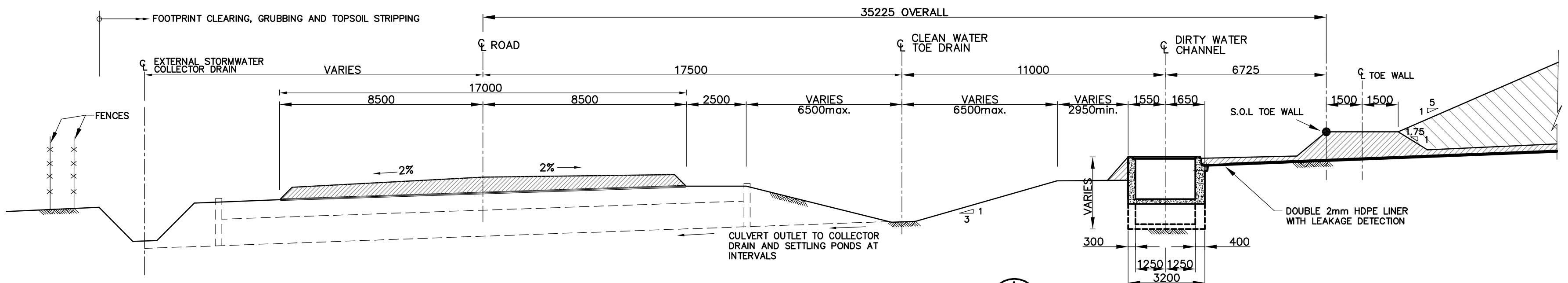


KEY

- DIRTY WATER COLLECTION DRAIN AND JUNCTION BOX
- DIRTY WATER PIPELINE
- PERIMETER ACCESS ROAD
- CLEAN WATER DIVERSION DRAIN
- CLEAN WATER DIVERSION CHANNEL
- ASH DUMP FENCE ALIGNMENT
- PHASE 1a ASH/FGD DISPOSAL FOOTPRINT
- PHASE 1b ASH/FGD DISPOSAL AREA

PLAN

SCALE 1:5000



TYPICAL CROSS SECTION (A)

SCALE 1:100

P 8/11/10 ISSUED FOR APPROVAL

REFERENCE DRAWINGS

PANEL B CONSULTANTS JOINT VENTURE

Knight Piésold CONSULTING

Eskom

KUSILE POWER STATION

ASH DUMP No 1
AMENDED FOOTPRINT
CONCEPT PLAN PHASE 1

DRG. No. K30300098/06-SK100 REV P

0.90/

SHEET A0 REV P

APPENDIX 4

STORMWATER HYDROLOGY AND HYDRAULIC CALCULATION RECORD

ARCUS GIBB CONSULTING • DESIGN • MANAGEMENT | SSI A DHV COMPANY | Knight Piésold CONSULTING

PANEL B CONSULTANTS JOINT VENTURE
Calculation Record

Client Name: ESKOM **Page:** 1 **of** 36

Project Name: Kusile Power Station **Job No:** 303-00098/06

Calculation Title: 10 yr Ash Dump Stormwater – Dirty and Clean Systems Hydrology and Hydraulic Calculations Amended Footprint, Rev 01 (October 2013)

Calculation No./File No.: Z:\303-00098\04\A\CALCULATIONS\ASH DUMP - 10 YR\Hydraulic Design\Ash Dump Calculation Record 201310 Rev 01.doc

Calculation is: ☐ Preliminary ☒ Final

Objective: Detailed hydraulic design of the clean and dirty stormwater systems and the ash dump dirty dam including the energy dissipation structures.

Unverified assumptions requiring subsequent verification			
No.	**Assumption**	**Verified by**	**Date**
	None		

This section applies to computer generated calculations

Program Name/Number: ______ **Version:** ______

Program Name/Number: ______ **Version:** ______

Evidence of or reference to computer program verification, if applicable:

Bases or reference thereto supporting application of the computer program to the physical problem:

Review and approval						
Rev	Prepared by	Date	Verified by	Date	Approved by	Date
00	Nicholas Pilz	February 2011				
01	Nicholas Pilz	October 2013				

1. PURPOSE:

To calculate the size of various unlined diversion canals conveying stormwater runoff around the Coal Stock Yard as well as the associated hydraulic structures such as the concrete drop structures.

2. REFERENCES:

1	Ash Dump No.1 – General Arrangement Plan	30300098/06-201	Rev	1
2	Ash Dump No.1 – Geotechnical Plan	30300098/06-202	Rev	1
3	Ash Dump No.1 – Phase 1 GA & Setting Out Co-ordinates	30300098/06-206	Rev	2
4	Ash Dump No.1 – Typical Overall Sections	30300098/06-207	Rev	0
5	Wetland / Pan Drainage Plan and Details	30300098/06-208	Rev	2
6	Wetland / Pan Drainage – DN100 Kabelflex Longitudinal Section	30300098/06-209	Rev	2
7	Footprint Site Preparation – Phase 1	30300098/06-210	Rev	2
8	Footprint Site Preparation – Phase 1 Details	30300098/06-211	Rev	2
9	Ash Dump No.1 - Footprint Site Preparation Phase 2 - General Arrangement	30300098/06-212	Rev	2
10	Terracing of Radial Stacker – General Arrangement Plan	30300098/06-213	Rev	2
11	Ash Dump No.1 - Construction Phase 2 Storm Water Management GA and Details	30300098/06-214	Rev	2
12	Ash Dump Dirty Dam – Construction Phase Storm Water Management GA	30300098/06-215	Rev	1
13	Ash Dump No.1 – Construction Phase Storm Water Management GA	30300098/06-216	Rev	1
14	Workshop Terrace – General Arrangement & Typical Sections	30300098/06-217	Rev	2
15	Pump Station Terrace – General Arrangement & Typical Sections	30300098/06-218	Rev	2
16	Ash Dump No. 1 – Storm Water Diversion/Collection Channels – Typical Sections & Details	30300098/06-219	Rev	1
17	HDPE Liner General Arrangement, Phase 1	30300098/06-220	Rev	2
18	Sections And Details, Phase 1	30300098/06-221	Rev	2
19	Drainage above HDPE Liner – General Arrangement & Details, Phase 1	30300098/06-224	Rev	2
20	Ash Dump No.1 - Phase 2 General Arrangement And Setting Out Co-ordinates	30300098/06-225	Rev	2
21	Ash Dump No.1 - Footprint Site Preparation Phase 2 - Details and Sections	30300098/06-226	Rev	2
22	Dirty Water Management – General Arrangement & Details, Phase 1	30300098/06-231	Rev	1
23	Dirty Water Drains – Concrete Details	30300098/06-232	Rev	2
24	ADDD – General Arrangement and Setting Out Co-ordinates	30300098/06-280	Rev	2
25	ADDD – Sections And Details – Sheet 1 of 2	30300098/06-281	Rev	2
26	ADDD – Sections And Details – Sheet 2 of 2	30300098/06-282	Rev	2
27	ADDD – Compartment No. 1 Inlet – General Arrangement & Details	30300098/06-283	Rev	2
28	ADDD – Compartment No. 1 Outlet – General Arrangement & Details	30300098/06-284	Rev	2
29	ADDD – Spillway No.1 – General Arrangement & Details	30300098/06-285	Rev	2
30	ADDD – Spillway No.2 – General Arrangement & Details	30300098/06-286	Rev	2
31	ADDD – Energy Dissipator No. 1 – General Arrangement & Details	30300098/06-287	Rev	2
32	ADDD – Leakage Detection Sump – General Arrangement & Details	30300098/06-288	Rev	1
33	ADDD – Compartment No. 2 Inlet – General Arrangement & Details	30300098/06-289	Rev	1
34	ADDD – Compartment No. 2 Outlet – General Arrangement & Details	30300098/06-290	Rev	1

35	ADDD – Compartment No. 1 Basin Division Walls & Details	30300098/06-295	Rev	1
36	ADDD – Compartment No. 2 Basin Division Walls & Details	30300098/06-296	Rev	1
37	Clean Water Management – Phase 1 General Arrangement	30300098/06-301	Rev	1
38	Clean Water Management Phase 2 - General Arrangement	30300098/06-302	Rev	2
39	Clean Water Drains, Sheet 1 of 6	30300098/06-303	Rev	2
40	Clean Water Drains, Sheet 2 of 6	30300098/06-304	Rev	2
41	Ash Dump No.1 - Phase 2 Clean Water Drains, Sheet 3 of 6	30300098/06-305	Rev	2
42	Ash Dump No.1 - Phase 2 Clean Water Drains, Sheet 4 of 6	30300098/06-306	Rev	2
43	Ash Dump No.1 -Phase 2 Clean Water Drains, Sheet 5 of 6	30300098/06-307	Rev	2
44	Ash Dump No. 1 – Bulk Material Storage Stockpile Diversion Channels	30300098/06-320	Rev	1
45	Ash Dump No. 1 – Silt Retention Dam (E1) – Plan and Details	30300098/06-321	Rev	1
46	Ash Dump No. 1 – Silt Retention Dam (E2) – Plan and Details	30300098/06-322	Rev	1
47	Ash Dump No. 1 – Silt Retention Dam (W1) – Plan and Details	30300098/06-323	Rev	1
48	Ash Dump No. 1 – Silt Retention Dam (W2) – Plan and Details	30300098/06-324	Rev	1
49	Ash Dump No. 1 – Silt Retention Dam (W3) – Plan and Details	30300098/06-325	Rev	1
50	Ash Dump No. 1 – Silt Retention Dam (W4) – Plan and Details	30300098/06-326	Rev	1
51	Ash Dump No. 1 – Silt Retention Dam (W5) – Plan and Details	30300098/06-327	Rev	1
52	Ash Dump No.1 - Phase 2 Silt Retention Dam (W7) Plan And Details	30300098/06-331	Rev	2
53	Ash Dump No.1 - Phase 2 Silt Retention Dam (W8) Plan And Details	30300098/06-332	Rev	2
54	Ash Dump No.1 - Phase 2 Silt Retention Dam (W9) Plan And Details	30300098/06-333	Rev	2
55	Ash Dump No.1 - Phase 2 Silt Retention Dam (E3) Plan And Details	30300098/06-334	Rev	2
56	Ash Dump No.1 - Phase 2 Water Collection Outfall Pipe - Plan And Details	30300098/06-335	Rev	2
57	Perimeter Access Road – General Arrangement	30300098/06-340	Rev	2
58	Access Road No. 3 – General Arrangement and Setting Out Co-ordinates	30300098/06-370	Rev	2
59	Ash Dump Phase 2 - Clean Water Drains - Culvert Cross-Sections sht 1	30300098/06-536	Rev	1
60	Ash Dump Phase 2 - Clean Water Drains - Culvert Cross-Sections sht 2	30300098/06-537	Rev	1
61	Ash Dump Phase 1 - Clean Water Culvert Cross-Sections for Temp. Drain	30300098/06-538	Rev	1
62	Ash Dump Phase 2 - Clean Water Culvert Cross-Sections for Drop Boxes	30300098/06-539	Rev	1

3. ASSUMPTIONS

Clean Water Canals sized for the 1 : 100 year flood event
Dirty Water Canals sized for the 1 : 50 year flood event

Density of water =	1000 kg/m^3
Acceleration due to gravity =	9.81m/s^2
Sub-critical flow conditions require Froude Number	> 0.70
Allowance for groundwater seepage =	10%
Additional freeboard =	300 mm
Mannings' n-value for unlined canals =	0.023
Mannings' n-value for lined canals =	0.018
Mannings' n-value for concrete culverts =	0.012

Additional assumptions are listed in the detailed hydrology and hydraulic calculations, where applicable.

4. PROCEDURE/METHODOLOGY OF DESIGN:

4.1 Determine Catchment Areas
4.2 Calculate the 1 : 50 and 1 : 100 year flood peaks
4.3 Determine the location of the proposed surface canals
4.4 Calculate canal sizes for the given flowrates
4.5 Design associated structures such as energy dissipators and culverts
4.6 Calculate run-off volumes and determine the required ADDD and the various clean water retention pond storage capacities.

5. FLOOD HYDROLOGY CALCULATIONS

5.1 Catchment Characteristics

5.1.1 Dirty Catchment Area

Dirty water catchment area comprises:

- Active dumping face,
- a 50 m section behind the active face
- 1-year irrigation zone
- Further 2 years of rehabilitation zone

The Phase 1 footprint of 106.7ha will accommodate ash/F6D disposal for 25 years.

Phase 2 comprises the remaining 55 years of deposition.

The run-off from the catchment area surrounding the radial stacker is also considered dirty. This catchment area will remain dirty for the 55yr disposal period.

The catchment areas during dirty disposal are shown in Table 1 below.

Table 1: Dirty Water Catchment Areas

Phase	Deposition Period	Total Area
-	Years	km^2
1	1 – 4.25	1.195
2	4.25 – 55*	0.928
Radial Stacker	1 – 55	0.049

* The catchment areas in phase two will remain essentially constant for the remaining years of deposition i.e. to year 55.

5.1.2 Clean Catchment Area

The ash dump has been divided into a series of individual catchments, each contributing to an individual clean water canal, as defined by the topography along the canal routes.

Figure 1: Ashdump Catchment Areas

5.1.3 Catchment Run-off Coefficients

The runoff coefficient is based on surface slopes, permeability and vegetation.

- Run-off co-efficient of 0.504 is based on a rehabilitated dirty catchment areas;
- Run-off co-efficient of 0.436 is based on a rehabilitated clean catchment areas;
- Run-off co-efficient of 0.700 is based on a rehabilitated dirty catchment area and concrete surface for the radial stacker platform.

5.1.4 Time of Concentration

The Time of Concentration for overland flow conditions uses the equation shown below:

$$T_c = 0.604 \left(\frac{rL}{S^{0.5}} \right)^{0.467} \qquad \text{Equation 1}$$

Where T_c = Time of Concentration (hrs)
r = Roughness coefficient
L = Longest Flowpath (m)
S = Catchment Slope (m/m)

The Time of Concentration for defined watercourses uses the equation shown below:

$$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385} \qquad \text{Equation 2}$$

Where T_c = Time of Concentration (hrs)
L = Longest Flowpath (m)
S_{av} = Average Catchment Slope (m/m)

Time of Concentration assumes overland flow down the active face and defined channel flow along the edge of ash dump.

Longest flowpath is the longest distance that water would follow from the furthest point in the catchment to the end of the flowpath.

5.1.5 Rainfall

Mean Annual Precipitation (MAP) = 655mm

The rainfall station 0514618W at Wilge Rivier was chosen as the most reliable due to the length of its record (98 years) as well as the fact that the station is still in operation.

Table 2 : Characteristics of Rainfall Station – 0514618W

Rainfall Station	Mean Annual Precipitation (mm)	Record (years)
0514618W	701	98

Table 3 : Design Rainfall for Station 0514618W

Duration (Days)	Return Period (years)						
	2	5	10	20	50	100	200
1 day	50	70	84	100	122	141	162
2 days	64	89	109	129	160	187	217
3 days	74	102	123	147	181	210	243
7 days	100	135	161	188	226	258	292

Recommended return period point precipitation:

- 122 mm is used to determine the 50 year flood event (dirty water system);
- 141 mm is used to determine the 100 year flood event (clean water system).

5.2 Flood Peak Determination

Small catchment areas therefore deterministic approach was adopted. Rational Method was used to determine flood peaks. Flood peaks calculated using following equation:

$$Q = \frac{C.I.A}{3.6}$$ Equation 3

Where Q = Peak Flow (m^3/s)
C = runoff coefficient
I = Rainfall Intensity (mm/hr)
A = Catchment Area (km^2)

Intensity is the Point Precipitation divided by the Time of Concentration.

5.3 Stormwater Runoff

5.3.1 Dirty Water Runoff

The calculated dirty water runoff flowrates are summarised in Table 4 below.

Table 4 : 1:50 yr Dirty Water Runoff Flowrates

Catchment Area		Flowpath	Time of Concentration	Intensity*	Runoff C	Flowrate
	km^2	km	hrs	mm/hr	-	m^3/s
E1	0.215	0.878	0.704	119.472	0.436	3.107
E2	0.102	0.378	0.461	182.254	0.436	2.253
E3	0.219	1.765	1.044	80.438	0.436	2.135
W1	0.105	0.771	0.623	134.911	0.436	1.717
W2	0.064	1.780	1.069	78.594	0.436	0.613
W2a	0.092	0.735	0.572	146.749	0.436	1.633
W2c	0.136	0.706	0.575	146.043	0.436	2.409
W5/6	0.295	1.851	1.125	74.676	0.436	2.670
E4	0.266	1.423	0.889	94.440	0.436	3.041
W7	0.065	0.475	0.312	268.871	0.436	2.118
W8	0.376	0.922	0.616	136.438	0.436	6.218
W9	0.221	1.532	0.933	90.080	0.436	2.413
Radial Stacker	0.049	0.549	0.607	200.732	0.700	1.904

* Intensity based on 1:50 yr 24 hr Point Precipitation of 122 mm

5.3.2 Clean Water Runoff

The calculated clean water runoff flowrates for Phase 1 and 2 are summarised in Table 5 and 6 respectively below.

Table 5: 1:100yr Clean Water Runoff Flowrates (Phase 1)

Catchment Area		Flowpath	Time of Concentration	Intensity*	Runoff C	Flowrate
Clean Catchment	km^2	Km	hrs	mm/hr	-	m^3/s
CWT1	0.034	0.674	0.645	218.463	0.436	0.890
CWT2	0.094	0.697	0.662	212.988	0.436	2.424
CWT3	0.124	0.688	0.659	214.091	0.436	3.215
CWT4	0.042	0.551	0.570	247.365	0.436	1.254
CWT5	0.030	0.531	0.556	253.617	0.436	0.922
CWT6	0.048	0.556	0.570	247.192	0.436	1.440
CWT7	0.019	0.458	0.493	285.844	0.436	0.675
CWT8	0.019	0.452	0.484	291.415	0.436	0.683
CWT9	0.028	0.466	0.486	289.970	0.436	0.975
CWT10	0.040	0.593	0.554	254.672	0.436	1.222
CWT11	0.015	0.386	0.251	560.908	0.436	1.001
CWT12	0.021	0.387	0.257	549.491	0.436	1.381
CWT13	0.024	0.355	0.237	594.294	0.436	1.725
CWT14	0.021	0.365	0.243	579.345	0.436	1.494
CWT15	0.017	0.455	0.300	470.140	0.436	0.956
CWT16	0.016	0.417	0.274	515.042	0.436	0.977
CWT17	0.045	0.565	0.345	408.991	0.436	2.241
CWT18	0.086	0.654	0.421	334.892	0.436	3.502
CWT19	0.065	0.540	0.373	377.696	0.436	2.959
CWT20	0.104	0.710	0.408	345.374	0.436	4.343
CWT21	0.125	0.836	0.470	300.250	0.436	4.547
CWT22	0.050	0.672	0.404	348.675	0.436	2.103
CWT77	0.047	0.628	0.802	175.898	0.436	0.995
CWT78	0.034	0.592	0.775	181.918	0.436	0.743
CWT79	0.031	0.604	0.784	179.873	0.436	0.675
CWT80	0.031	0.592	0.775	182.025	0.436	0.690
CWT81	0.028	0.580	0.762	185.112	0.436	0.635
CWT82	0.030	0.594	0.769	183.380	0.436	0.669
CWT83	0.027	0.594	0.764	184.590	0.436	0.596
CWT84	0.038	0.624	0.783	179.994	0.436	0.827
CWT85	0.032	0.630	0.781	180.425	0.436	0.698
CWT86	0.031	0.642	0.786	179.392	0.436	0.666
CWT87	0.024	0.636	0.776	181.744	0.436	0.525
CWT88	0.030	0.656	0.789	178.756	0.436	0.658
CWT89	0.029	0.656	0.783	179.979	0.436	0.628

* Intensity based on 1:100 yr 24 hr Point Precipitation of 141 mm

Table 6 : 1:100yr Clean Water Runoff Flowrates (Phase 2)

Catchment Area		Flowpath	Time of Concentration	Intensity*	Runoff C	Flowrate
Clean Catchment	km^2	km	hrs	mm/hr	-	m^3/s
CWT35	0.0201	0.6162	0.7834	179.9901	0.4360	0.4377
CWT36	0.0320	0.6408	0.7996	176.3303	0.4360	0.6849
CWT37	0.0258	0.6374	0.7934	177.7219	0.4360	0.5550
CWT38	0.0334	0.6514	0.8027	175.6596	0.4360	0.7107
CWT39	0.0343	0.6619	0.8056	175.0140	0.4360	0.7281
CWT40	0.0421	0.6866	0.8208	171.7935	0.4360	0.8757
CWT41	0.0278	0.6690	0.8022	175.7739	0.4360	0.5932
CWT42	0.0321	0.6796	0.8069	174.7449	0.4360	0.6789
CWT43	0.0317	0.6760	0.8020	175.8005	0.4360	0.6751
CWT44	0.0306	0.7042	0.8188	172.2072	0.4360	0.6381
CWT45	0.0363	0.7077	0.8197	172.0165	0.4360	0.7563
CWT46	0.0294	0.7499	0.8447	166.9279	0.4360	0.5955
CWT47	0.0443	0.7500	0.8424	167.3769	0.4360	0.8990
CWT48	0.0506	0.7147	0.8169	172.5946	0.4360	1.0589
CWT49	0.0533	0.6937	0.8020	175.8126	0.4360	1.1359
CWT50	0.0542	0.6725	0.7878	178.9824	0.4360	1.1751
CWT51	0.0413	0.6161	0.7463	188.9220	0.4360	0.9465
CWT52	0.0275	0.5739	0.7138	197.5275	0.4360	0.6580
CWT53	0.0162	0.5457	0.6899	204.3709	0.4360	0.4023
CWT54	0.0171	0.5598	0.7084	199.0330	0.4360	0.4121
CWT55	0.0066	0.3204	0.2134	660.8231	0.4360	0.5273
CWT56	0.0053	0.2867	0.2009	701.6851	0.4360	0.4531
CWT57	0.0061	0.2846	0.2033	693.7182	0.4360	0.5171
CWT58	0.0095	0.2751	0.3491	403.8841	0.4360	0.4628
CWT59	0.0139	0.3099	0.4383	321.6850	0.4360	0.5428
CWT60	0.0152	0.3227	0.4863	289.9323	0.4360	0.5346
CWT61	0.0154	0.3296	0.5011	281.3959	0.4360	0.5260
CWT62	0.0107	0.2965	0.4615	305.5087	0.4360	0.3967
CWT63	0.0117	0.2763	0.4271	330.1387	0.4360	0.4670
CWT64	0.0102	0.2501	0.3716	379.4634	0.4360	0.4695
CWT65	0.0072	0.2329	0.2957	476.7707	0.4360	0.4146
CWT66	0.0028	0.2068	0.1823	773.2840	0.4360	0.2592
CWT67	0.006	0.210	0.1829	770.8981	0.436	0.5337
CWT68	0.003	0.186	0.1622	869.0634	0.436	0.3532
CWT69	0.017	0.534	0.7555	186.6250	0.436	0.3908

Catchment Area		Flowpath	Time of Concentration	Intensity*	Runoff C	Flowrate
Clean Catchment	km^2	km	hrs	mm/hr	-	m^3/s
CWT70	0.031	0.552	0.7634	184.6918	0.436	0.6987
CWT71	0.039	0.576	0.7746	182.0222	0.436	0.8593
CWT72	0.041	0.578	0.7732	182.3574	0.436	0.9157
CWT73	0.048	0.616	0.7968	176.9674	0.436	1.0336
CWT74	0.050	0.610	0.7927	177.8758	0.436	1.0781
CWT75	0.045	0.628	0.8020	175.8132	0.436	0.9501
CWT76	0.050	0.622	0.7965	177.0258	0.436	1.0644
CWT77	0.047	0.628	0.8016	175.8977	0.436	0.9954

* Intensity based on 1:100 yr 24 hr Point Precipitation of 141 mm

6. HYDRAULIC CALCULATIONS

6.1 Dirty Water Canals and Pipeline

Dirty canals designed to carry dirty water stormwater runoff plus leakage.

Canals sized for Phase 1A, Phase 1B and Phase 2 (East and West)

Dirty water design parameters:

- Concrete lined rectangular canals with a 2.50 m base width and vertical side slopes;
- Lined Canal Mannings' n = 0.018;
- Canal slopes = 1 : 250;
- Canal depth = flow depth + 10% allowance for groundwater + 300mm freeboard (Sub-critical flow conditions);
- Canal depth = flow depth + 2 * Energy Head (Super-critical flow conditions).

Flow depth was calculated using the Mannings' equation:

$$Q = \frac{AR^{2/3}S^{1/2}}{n} \qquad \text{Equation 4}$$

Where Q = Peak Flow (m^3/s)
A = Cross Section Flow Area (m^2)
R = Hydraulic Radius (m)
S = Canal Slope (m/m)
n = Mannings' n value (0.023)

Table 7 : Concrete Lined Rectangular Dirty Water Canal Sizes

Drain	Flow Rate	Flow Depth	Velocity	Energy Head	Froude No.	Total Depth
-	m^3/s	m	m/s	m	-	m
Canal 1	8.545	1.310	2.609	0.347	0.728	2.004
Canal 2	11.797	1.678	2.813	0.403	0.693	1.978
Canal 3	5.687	0.969	2.347	0.281	0.761	1.531
Canal 4	7.562	1.196	2.530	0.326	0.739	1.848

Rectangular concrete canals discharge into concrete pipes leading to the ADDD.

Pipe 1 –to JB5 (Blue Line)
Pipe 2 –to JB5 (Red Line)
Pipe 3 – JB5 to ADDD Compartment 2 (Yellow Line)
Pipe 4 – JB5 to ADDD Compartment 1 (Green Line)
Pipe 5 – Phase 2 (west) to JB5 (Purple Line)
Pipe 6 – Radial Stacker platform to JB5 (Orange Line)

The pipeline layout is shown in Figure 2.

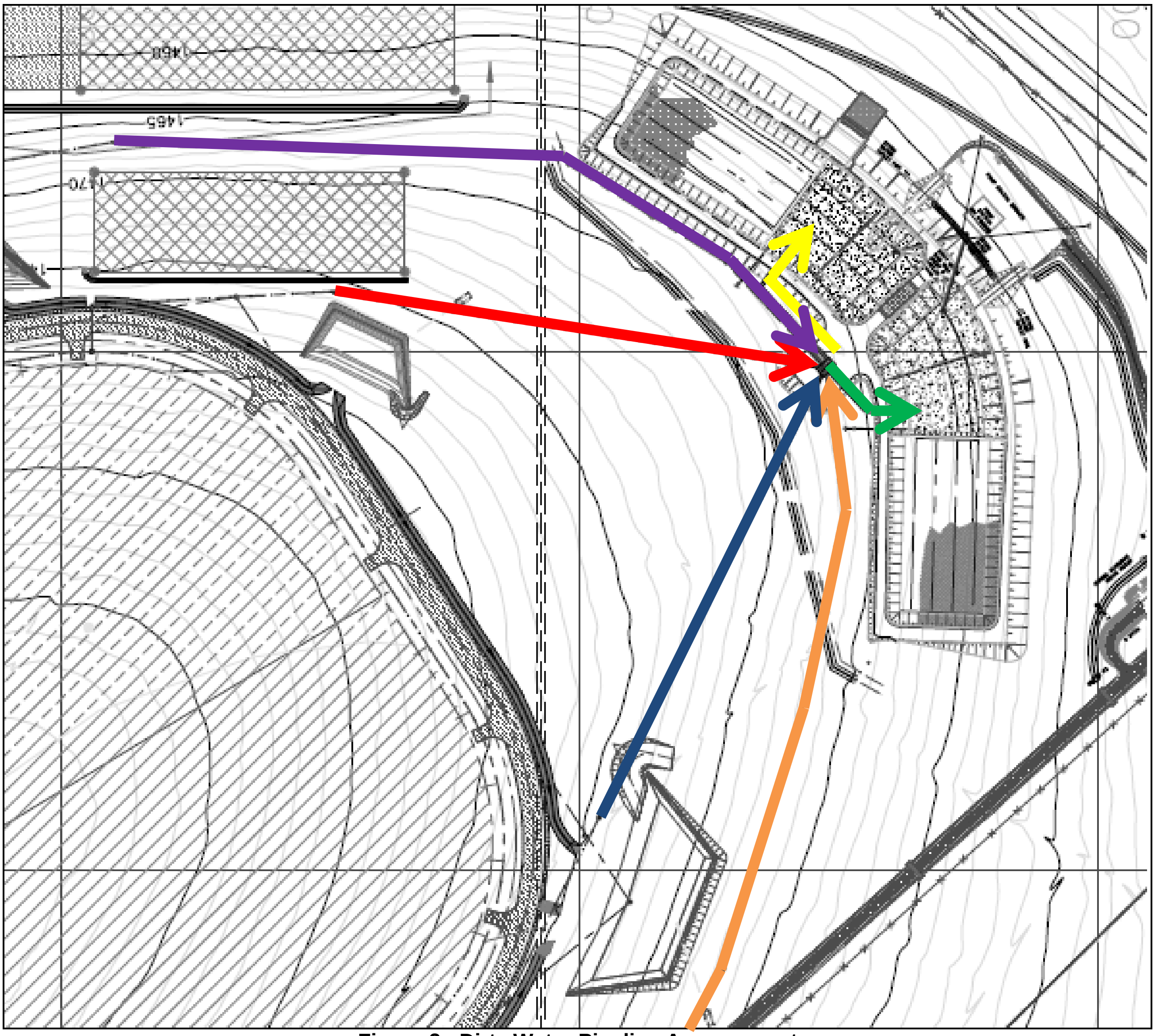


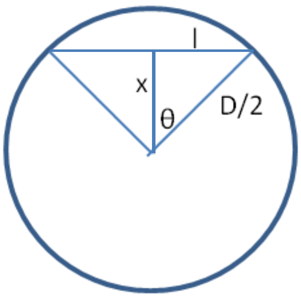
Figure 2 : Dirty Water Pipeline Arrangement

The following approach was taking in sizing the pipelines leading from the dirty water canals to the ADDD. A typical pipe sizing calculation is shown below.

<u>Pipe flowing partially full</u>:

Pipe 1 required capacity = 8.54 m^3/s
Assume optimal pipe efficiency at 75% full

Diameter	2.000	m
Pipe Gradient	0.005	m/m
Mannings' n	0.012	
x	0.500	m
l	0.866	m
2l	1.732	m
cos θ	0.5	
θ	60	degrees
2θ	120	degrees
Wetted Area	2.527	m^2



Wetted Perimeter	4.189	m
Hydraulic Radius	0.603	m
Velocity	4.208	m/s (based on Mannings' Formula)
Flowrate	10.634	m^3/s

The proposed 2.000 m diameter pipeline is sufficient to pass the design flow of 8.54 m^3/s under open channel flow conditions.

Pipe flowing full:

Design Flow	8.540	m^3/s
Headwater Level	1479.640	m
Tailwater Level	1470.500	m
Height Loss	9.140	m
Pipeline Length	1528.470	m
Minor Losses *	13.500	
Pipe Roughness:	3.00E-04	m
K. Viscosity	1.14E-06	m^2/s

* Minor losses assumes and entrance loss coefficient of 0.5 and an exit loss coefficient of 1.0. Assuming inspection manholes at every 200m, Pipe 1 has 9 manholes.

The pipe diameter required to pass the design flow was calculated according to the Swamee – Jain equation:

$$f = \frac{0.25}{\left[\log_{10}\left(\frac{\varepsilon}{3.7D} + \frac{5.74}{Re^{0.9}}\right)\right]^2}$$

Equation 5

Where f = Friction Factor
ε = Pipe roughness (m)
D = Pipe diameter (m)
Re = Reynolds Number

The Swamee – Jain equation was re-arranged to solve for the required pipe diameter, and through an iterative process, the 2.000 m diameter pipe has sufficient capacity to pass the design flow of 8.54 m^3/s under full flow conditions.

The required dirty water pipe diameters are summarised in Table 8.

Table 8 : Required Dirty Water Pipe Diameters

Pipeline	Required Flow Capacity	Required Pipe Diameter
-	m^3/s	mm
Pipe 1	8.54	2000
Pipe 2	11.79	2250
Pipe 3	22.23	2250
Pipe 4	22.23	2250
Pipe 5	7.56	2000
Pipe 6	1.904	1200

Pipes 3 and 4 will terminate at with an impact type energy dissipator. Sizing calculations for the energy dissipators are presented in **Appendix 4.**

Ash dump site requires pipes with the following internal pipe diameters:

- 1200
- 2000
- 2250

Check was carried out to determine the flow velocities in the pipe sections for a range of flowrates. This was carried out to determine whether self-scouring velocities are achieved.

The flow velocities and the flowrates in each of the pipe sections is summarised in Table 9.

Table 9 : Flow Velocities at varying Flowrates

Flowrate	Flow Velocity in Pipeline (m/s)		
m^3/s	1200 Ø	2000 Ø	2250 Ø
0.10	1.22	1.14	1.12
0.25	1.60	1.50	1.48
0.50	1.96	1.85	1.82
1.00	2.38	2.27	2.24
1.50	2.64	2.55	2.52

Flow velocity in the pipes is greater than 1 m/s for all flows greater than 100 l/s. This can be assumed to be self scouring under the majority of flow conditions.

6.2 Clean Water Perimeter Drains

Design to maintain sub-critical flow conditions in the canals to avoid large concrete drop structures.

Each sub-catchments served by an individual length of trapezoidal drain terminating in a culvert running under Ash Dump perimeter road.

Clean water design parameters:

- Unlined trapezoidal drains with a 1.00 m base width, 1V: 3H side slopes;
- Unlined drain Mannings' n = 0.023;
- Drain slopes = 1 : 200;
- Drain depth = flow depth + 10% allowance for groundwater + 300mm freeboard (Sub-critical flow conditions).

Flow depth was calculated using the Mannings' equation:

$$Q = \frac{AR^{2/3}S^{1/2}}{n}$$ Equation 6

Where Q = Peak Flow (m^3/s)
A = Cross Section Flow Area (m^2)
R = Hydraulic Radius (m)
S = Canal Slope (m/m)
n = Mannings' n value (0.023)

Table 10 : Unlined Trapezoidal Clean Water Drain Sizes (Phase 1)

Drain	Flow Rate	Flow Depth	Velocity	Energy Head	Froude No.	Total Depth
-	m^3/s	M	m/s	m	-	M
CWT1	0.716	0.546	1.378	0.097	0.640	0.900
CWT2	1.999	1.025	1.763	0.159	0.623	1.427
CWT3	2.676	0.354	0.893	0.041	0.580	0.690
CWT4	1.029	0.580	1.171	0.070	0.619	0.938
CWT5	0.753	0.664	1.263	0.081	0.631	1.030
CWT6	1.192	0.423	0.983	0.049	0.594	0.766
CWT7	0.554	0.363	0.905	0.042	0.582	0.700
CWT8	0.564	0.455	1.023	0.053	0.600	0.800
CWT9	0.813	0.312	0.832	0.035	0.571	0.643
CWT10	1.054	0.315	0.836	0.036	0.571	0.646
CWT11	1.001	0.377	0.924	0.043	0.585	0.715
CWT12	1.381	0.428	0.990	0.050	0.595	0.771
CWT13	1.725	0.418	0.976	0.049	0.593	0.760
CWT14	1.494	0.488	1.063	0.058	0.605	0.836
CWT15	0.956	0.408	0.965	0.047	0.591	0.749
CWT16	0.977	0.413	0.970	0.048	0.592	0.754
CWT17	2.241	0.612	1.207	0.074	0.624	0.973
CWT18	3.502	0.750	1.354	0.093	0.641	1.125
CWT19	2.959	0.695	1.296	0.086	0.635	1.064
CWT20	4.343	0.826	1.430	0.104	0.650	1.208
CWT21	4.547	0.843	1.447	0.107	0.652	1.227
CWT22	2.103	0.594	1.187	0.072	0.621	0.954

Table 11 : Unlined Trapezoidal Clean Water Drain Sizes (Phase 2)

Drain	Flow Rate	Flow Depth	Velocity	Energy Head	Froude No.	Total Depth
-	m^3/s	M	m/s	m	-	m
CWT35	0.438	0.295	0.789	0.032	1.924	0.696
CWT36	0.685	0.367	0.889	0.040	2.166	0.919
CWT37	0.555	0.331	0.841	0.036	2.052	0.807
CWT38	0.711	0.373	0.898	0.041	2.185	0.940
CWT39	0.728	0.378	0.904	0.042	2.159	0.827
CWT40	0.876	0.412	0.949	0.046	2.276	0.928
CWT41	0.593	0.342	0.856	0.037	0.562	0.624
CWT42	0.679	0.365	0.887	0.040	0.579	0.703
CWT43	0.675	0.364	0.886	0.040	0.571	0.664
CWT44	0.638	0.354	0.873	0.039	0.580	0.711
CWT45	0.756	0.385	0.913	0.042	0.581	0.715
CWT46	0.596	0.343	0.857	0.037	0.588	0.754

Drain	Flow Rate	Flow Depth	Velocity	Energy Head	Froude No.	Total Depth
-	m^3/s	M	m/s	m	-	m
CWT47	0.899	0.418	0.956	0.047	0.573	0.676
CWT48	1.059	0.451	0.997	0.051	0.578	0.702
CWT49	1.136	0.466	1.016	0.053	0.578	0.701
CWT50	1.175	0.474	1.025	0.054	0.576	0.690
CWT51	0.947	0.428	0.969	0.048	0.582	0.723
CWT52	0.658	0.360	0.880	0.039	0.574	0.677
CWT53	0.402	0.282	0.771	0.030	0.589	0.759
CWT54	0.412	0.286	0.776	0.031	0.595	0.796
CWT55	0.527	0.323	0.830	0.035	0.598	0.813
CWT56	0.453	0.300	0.797	0.032	0.599	0.821
CWT57	0.517	0.320	0.825	0.035	0.591	0.771
CWT58	0.463	0.303	0.801	0.033	0.577	0.696
CWT59	0.543	0.327	0.836	0.036	0.559	0.611
CWT60	0.535	0.325	0.833	0.035	0.560	0.614
CWT61	0.526	0.322	0.829	0.035	0.569	0.655
CWT62	0.397	0.280	0.768	0.030	0.564	0.630
CWT63	0.467	0.304	0.803	0.033	0.569	0.652
CWT64	0.470	0.305	0.804	0.033	0.565	0.633
CWT65	0.415	0.287	0.778	0.031	0.571	0.660
CWT66	0.259	0.226	0.683	0.024	0.570	0.658
CWT91	0.534	0.325	0.833	0.035	0.569	0.655
CWT67	0.353	0.264	0.745	0.028	0.559	0.608
CWT68	0.391	0.278	0.765	0.030	0.565	0.635
CWT69	0.699	0.370	0.895	0.041	0.565	0.635
CWT70	0.859	0.409	0.945	0.046	0.561	0.615
CWT71	0.916	0.421	0.961	0.047	0.544	0.549
CWT72	1.034	0.446	0.992	0.050	0.570	0.657
CWT73	1.078	0.455	1.003	0.051	0.555	0.591
CWT74	0.950	0.429	0.970	0.048	0.559	0.606
CWT75	1.064	0.452	0.999	0.051	0.580	0.707
CWT76	0.995	0.438	0.982	0.049	0.588	0.749
CWT77	0.438	0.295	0.789	0.032	0.590	0.763

Clean water drains terminate at concrete culverts, running under the perimeter access road

Culverts sized to maintain flowrate without causing backwater in canal.

Culvert capacity calculated using Mannings' equation:

$$Q = \frac{AR^{2/3}S^{1/2}}{n}$$ Equation 7

Where Q = Peak Flow (m^3/s)
A = Cross Section Flow Area (m^2)
R = Hydraulic Radius (m)
S = Canal Slope (m/m)
n = Mannings' n value (0.023)

Initially select a culvert size
→ calculate flow depth in culvert
→ calculate velocity and energy head
→ check flow depth + energy head < height of culvert
→ check flow area in clean water drain ≤ culvert area

If not, add additional culvert (750 x 750 culvert only) or increase culvert size and repeat process.

Table 12 : Clean Water Drain Culvert Sizing (Phase 1)

Drain	Arrangement	Flow Rate	Flow Depth	Velocity	Energy Head	Total Depth
-	-	m^3/s	m	m/s	m	M
CWT1	2No 750 x 750	0.890	0.248	1.923	0.188	0.625
CWT2	4No 750 x 750	2.424	0.290	2.296	0.269	0.828
CWT3	2No 750 x 750	3.215	0.622	2.869	0.420	1.461
CWT4	2No 750 x 750	1.254	0.317	2.165	0.239	0.794
CWT5	2No 750 x 750	0.922	0.257	1.955	0.195	0.646
CWT6	2No 750 x 750	1.440	0.350	2.268	0.262	0.875
CWT7	1No 750 x 750	0.675	0.381	1.940	0.192	0.764
CWT8	1No 750 x 750	0.683	0.386	1.949	0.194	0.773
CWT9	2No 750 x 750	0.975	0.270	2.006	0.205	0.680
CWT10	2No 750 x 750	1.222	0.322	2.181	0.243	0.807
CWT11	2No 750 x 750	1.001	0.311	2.146	0.235	0.780
CWT12	2No 750 x 750	1.381	0.388	2.373	0.287	0.962
CWT13	2No 750 x 750	1.725	0.326	2.354	0.282	1.109
CWT14	2No 750 x 750	1.494	0.410	2.431	0.301	1.012
CWT15	2No 900 x 900	0.956	0.261	2.032	0.210	0.682
CWT16	2No 900 x 900	0.977	0.265	2.047	0.214	0.692
CWT17	2No 900 x 900	2.241	0.465	2.678	0.365	1.196
CWT18	2No 1200 x 1200	3.502	0.497	2.934	0.439	1.375
CWT19	2No 1200 x 1200	2.959	0.444	2.779	0.393	1.231
CWT20	2No 1200 x 1200	4.343	0.576	3.141	0.503	1.582
CWT21	3No 750 x 750	4.547	0.433	2.919	0.434	1.301
CWT22	2No 1200 x 1200	2.103	0.354	2.479	0.313	0.980
CWT78	1No 900 x 900	0.743	0.396	2.086	0.222	0.840

Drain	Arrangement	Flow Rate	Flow Depth	Velocity	Energy Head	Total Depth
-	-	m^3/s	m	m/s	m	M
CWT79	1No 900 x 900	0.675	0.369	2.033	0.211	0.790
CWT80	1No 900 x 900	0.690	0.375	2.045	0.213	0.801
CWT81	1No 900 x 900	0.635	0.353	2.000	0.204	0.760
CWT82	1No 900 x 900	0.669	0.367	2.029	0.210	0.786
CWT83	1No 900 x 900	0.596	0.337	1.966	0.197	0.731
CWT84	1No 900 x 900	0.827	0.428	2.144	0.234	0.897
CWT85	1No 900 x 900	0.698	0.378	2.051	0.214	0.807
CWT86	1No 900 x 900	0.666	0.365	2.026	0.209	0.784
CWT87	1No 900 x 900	0.525	0.307	1.897	0.183	0.674
CWT88	1No 900 x 900	0.658	0.362	2.019	0.208	0.778
CWT89	1No 900 x 900	0.628	0.350	1.995	0.203	0.756

Table 13 : Clean Water Drain Culvert Sizing (Phase 2)

Drain	Arrangement	Flow Rate	Flow Depth	Velocity	Energy Head	Total Depth
-	-	m^3/s	m	m/s	m	M
CWT35	1No 900 x 900	0.438	0.270	1.800	0.165	0.600
CWT36	1No 900 x 900	0.685	0.373	2.041	0.212	0.798
CWT37	1No 900 x 900	0.555	0.320	1.927	0.189	0.699
CWT38	1No 900 x 900	0.711	0.383	2.061	0.217	0.816
CWT39	1No 1200 x 1200	0.728	0.301	2.017	0.207	0.716
CWT40	1No 1200 x 1200	0.876	0.342	2.133	0.232	0.806
CWT41	1No 900 x 900	0.593	0.336	1.963	0.196	0.729
CWT42	1No 900 x 900	0.679	0.370	2.036	0.211	0.793
CWT43	1No 900 x 900	0.675	0.369	2.033	0.211	0.790
CWT44	1No 900 x 900	0.638	0.354	2.003	0.204	0.763
CWT45	1No 1200 x 1200	0.756	0.309	2.041	0.212	0.733
CWT46	1No 900 x 900	0.596	0.337	1.965	0.197	0.730
CWT47	1No 1200 x 1200	0.899	0.349	2.149	0.235	0.819
CWT48	1No 1200 x 1200	1.059	0.391	2.254	0.259	0.909
CWT49	1No 1200 x 1200	1.136	0.412	2.300	0.270	0.951
CWT50	1No 1200 x 1200	1.175	0.422	2.322	0.275	0.971
CWT51	1No 1200 x 1200	0.947	0.362	2.182	0.243	0.847
CWT52	1No 900 x 900	0.658	0.362	2.019	0.208	0.778
CWT53	1No 900 x 900	0.402	0.255	1.756	0.157	0.569
CWT54	1No 900 x 900	0.412	0.259	1.768	0.159	0.578

Drain	Arrangement	Flow Rate	Flow Depth	Velocity	Energy Head	Total Depth
-	-	m^3/s	m	m/s	m	M
CWT55	1No 900 x 900	0.527	0.308	1.899	0.184	0.676
CWT56	1No 900 x 900	0.453	0.277	1.818	0.169	0.614
CWT57	1No 900 x 900	0.517	0.304	1.889	0.182	0.668
CWT58	1No 900 x 900	0.463	0.281	1.830	0.171	0.622
CWT59	1No 900 x 900	0.543	0.315	1.915	0.187	0.689
CWT60	1No 900 x 900	0.535	0.312	1.906	0.185	0.682
CWT61	1No 900 x 900	0.526	0.308	1.898	0.184	0.675
CWT62	1No 900 x 900	0.397	0.252	1.748	0.156	0.564
CWT63	1No 900 x 900	0.467	0.283	1.834	0.171	0.626
CWT64	1No 900 x 900	0.470	0.284	1.837	0.172	0.628
CWT65	1No 900 x 900	0.415	0.260	1.770	0.160	0.580
CWT66	1No 900 x 900	0.259	0.188	1.532	0.120	0.427
CWT67	1No 900 x 900	0.534	0.311	1.906	0.185	0.681
CWT68	1No 900 x 900	0.353	0.233	1.688	0.145	0.523
CWT69	1No 900 x 900	0.391	0.250	1.740	0.154	0.558
CWT70	1No 900 x 900	0.699	0.378	2.052	0.215	0.807
CWT71	1No 900 x 900	0.859	0.441	2.165	0.239	0.919
CWT72	1No 1200 x 1200	0.916	0.353	2.162	0.238	0.829
CWT73	1No 1200 x 1200	1.034	0.385	2.240	0.256	0.896
CWT74	1No 1200 x 1200	1.078	0.396	2.267	0.262	0.920
CWT75	1No 1200 x 1200	0.950	0.362	2.185	0.243	0.849
CWT76	1No 1200 x 1200	1.064	0.393	2.259	0.260	0.913
CWT77	1No 1200 x 1200	0.995	0.375	2.215	0.250	0.875

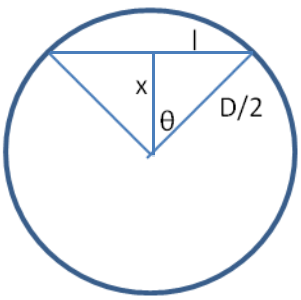
CWT67 to CWT89 all report to a collection pipeline running down the east side of the Ash Dump.

The following approach was taking in sizing the collection pipeline. The pipeline was divided into four sections and sized for each section. A typical pipe sizing calculation is shown below.

<u>Pipe flowing partially full</u>:

Pipe 3 required capacity = 10.981 m^3/s
Assume optimal pipe efficiency at 75% full

Diameter	2.000	m
Pipe Gradient	0.005	m/m
Mannings' n	0.012	
x	0.500	m
l	0.866	m
2l	1.732	m
cos θ	0.5	
θ	60	degrees
2θ	120	degrees



Wetted Area 2.527 m^2
Wetted Perimeter 4.189 m
Hydraulic Radius 0.603 m

Velocity 4.208 m/s (based on Mannings' Formula)
Flow rate 10.981 m^3/s

The proposed 2.000 m diameter pipeline is sufficient to pass the required flow of 10.981 m^3/s under open channel flow conditions.

The required collection pipeline diameters and reporting catchments are summarised in Table 14.

Table 14 : Required Collection Pipeline Diameters

Pipeline	Contributing Catchments	Flow Rate	Required Pipe Diameter	Pipe Length
-	-	m^3/s	mm	m
Pipe 1	CWT67 to CWT71	2.836	1350	400
Pipe 2	CWT72 to CWT75	6.813	1800	392
Pipe 3	CWT76 to CWT80	10.981	2000	328
Pipe 4	CWT81 to CWT89	16.882	2500	522

The collection pipeline will terminate with an impact type energy dissipator. Sizing calculations for the energy dissipator is presented in **<u>Appendix 4</u>.**

7. ASH DUMP DIRTY DAM STORAGE CAPACITY

7.1 Ash Dump Stormwater Storage Volume

The required stormwater storage capacity for the Ash Dump Dirty Dam (ADDD) is 204 000 m^3, and corresponds with the 1:50 yr / 24 hr storm event falling on the maximum dirty catchment area of 1 553 596 m^2. This volume was provided by Black & Veatch.

7.2 Dust Suppression & Irrigation Storage (Operational Storage)

ADDD is provided for 72 hours of operational storage for dust suppression and irrigation (see Appendix B).

During Ash - FGD Co-disposal phase:

- Dust Suppression Area : Advancing face and a 50 m section behind the face
- Irrigation Area : Equivalent to 1 year of disposal behind Dust Suppression Area

During FGD disposal phase :

- Dust Suppression Area : Advancing face and a 25 m section behind the face
- Irrigation Area : Extends for 50 m behind the Dust Suppression Area

Dust control and irrigation storage volumes are based on 1 mm/day of equivalent rainfall.
1 mm/day is equivalent to 0.5*the average annual daily rainfall at Kusile Site.

The dust control and irrigation volumes during disposal are shown in Table 15 below.

Table 15 : Dust Control and Irrigation Volumes

Years	Dust Suppression Area	Irrigation Area	Daily Volume	72 hr Volume
-	km^2	km^2	m^3/day	m^3
1	0.500	0.028	527.865	1583.595
2	0.464	0.098	562.196	1686.589
3	0.294	0.102	395.403	1186.210
4	0.680	0.175	854.191	2562.573
5	0.504	0.116	620.522	1861.565
6	0.131	0.190	320.956	962.867
7	0.098	0.114	212.206	636.619
8	0.127	0.115	241.379	724.138

The maximum pumping capacity from the ADDD is 25l/s.

Based on the maximum pumping capacity, the Operational storage was set at 6480 m^3, which is equivalent to 72 hrs of pumping at 25l/s.

7.3 ADDD Storage Volume

ADDD storage volume is sufficient to store the maximum dirty water run-off for 1:50 yr / 24hr storm event, and for 72 hours of dust control and irrigation.

Table 16 : Required ADDD Storage Volume

Stormwater Volume	Dust and Irrigation Volume	Total Required Volume
m^3	m^3	m^3
204 000	6480	210480

ADDD has a design total storage capacity of 227410 m^3, which includes an allowance for silt accumulation in the sump.

8. CLEAN WATER RETENTION PONDS

Clean stormwater runoff flows into retention / settling dams.

Stilled clean run-off will then flow back into the natural streams surrounding the ash dump.

Catchment areas are small (<10km^2) therefore a triangular hydrograph can be used to determine the stormwater volume.

The shaded area under the graph represents the storm volume.

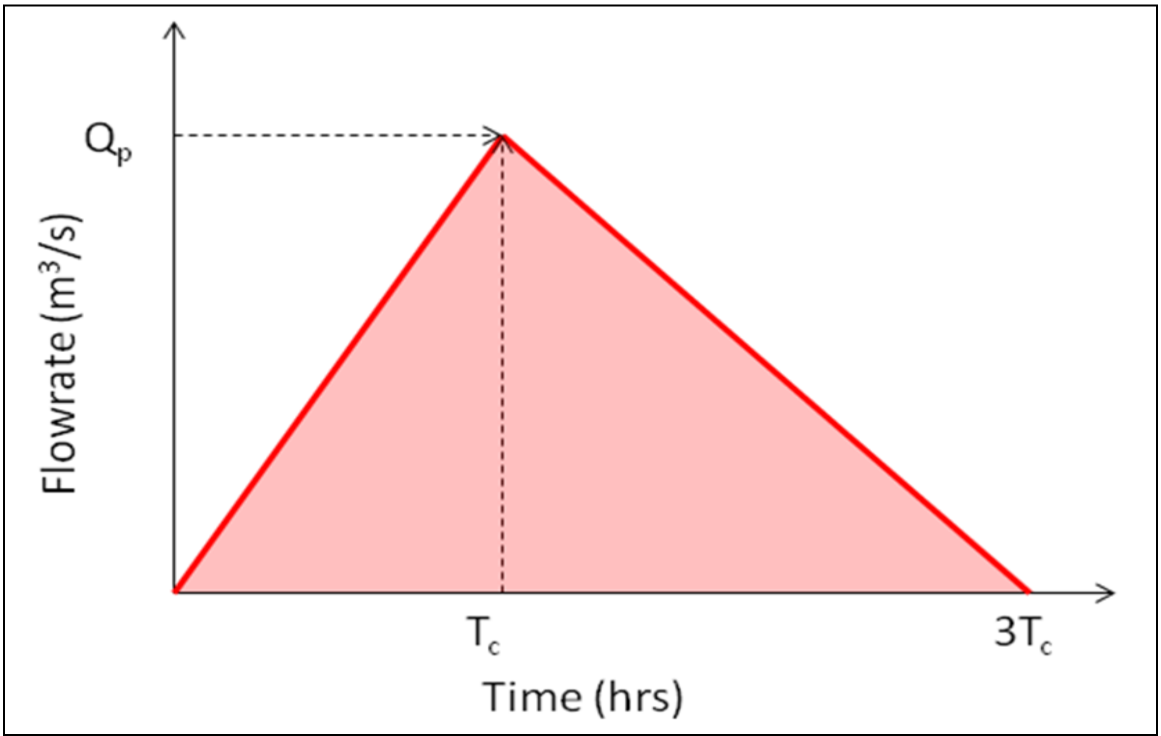


Figure 3: Triangular Hydrograph used to calculate the storm volume

Table 17 : Clean Stormwater Volumes (Phase 1)

Drain	Flow Rate	Time of Concentration	Flood Volume
-	m^3/s	Hrs	m^3
CWT1	0.716	0.802	3100
CWT2	1.999	0.803	8665
CWT3	2.676	0.791	11435
CWT4	1.029	0.695	3860
CWT5	0.753	0.681	2767
CWT6	1.192	0.689	4437
CWT7	0.554	0.601	1797
CWT8	0.564	0.586	1785
CWT9	0.813	0.583	2560
CWT10	1.054	0.642	3652
CWT11	1.001	0.251	1358
CWT12	1.381	0.257	1914
CWT13	1.725	0.237	2210

Drain	Flow Rate	Time of Concentration	Flood Volume
-	m^3/s	Hrs	m^3
CWT14	1.494	0.243	1964
CWT15	0.956	0.300	1548
CWT16	0.977	0.274	1445
CWT17	2.241	0.345	4172
CWT18	3.502	0.421	7962
CWT19	2.959	0.373	5964
CWT20	4.343	0.408	9573
CWT21	4.547	0.470	11531
CWT22	2.103	0.404	4593
CWT78	0.743	0.775	3111
CWT79	0.675	0.784	2857
CWT80	0.690	0.775	2885
CWT81	0.635	0.762	2610
CWT82	0.669	0.769	2779
CWT83	0.596	0.764	2457
CWT84	0.827	0.783	3497
CWT85	0.698	0.781	2944
CWT86	0.666	0.786	2827
CWT87	0.525	0.776	2200
CWT88	0.658	0.789	2801
CWT89	0.628	0.783	2659

Table 18 : Clean Stormwater Volumes (Phase 2)

Drain	Flow Rate	Time of Concentration	Flow Volume
-	m^3/s	Hrs	m^3
CWT35	0.4377	0.6206	1851
CWT36	0.6849	0.6369	2957
CWT37	0.5550	0.6306	2378
CWT38	0.7107	0.6399	3081
CWT39	0.7281	0.6429	3167
CWT40	0.8757	0.6580	3881
CWT41	0.5932	0.6394	2569
CWT42	0.6789	0.6441	2958
CWT43	0.6751	0.6393	2924
CWT44	0.6381	0.6560	2821
CWT45	0.7563	0.6569	3348
CWT46	0.5955	0.6827	2716
CWT47	0.8990	0.6837	4090
CWT48	1.0589	0.6624	4671

Drain	Flow Rate	Time of Concentration	Flow Volume
-	m^3/s	Hrs	m^3
CWT49	1.1359	0.7834	1851.4919
CWT50	1.1751	0.7996	2957.4087
CWT51	0.9465	0.7934	2377.8681
CWT52	0.6580	0.8027	3080.7354
CWT53	0.4023	0.8056	3167.4346
CWT54	0.4121	0.8208	3881.1349
CWT55	0.5273	0.8022	2569.3513
CWT56	0.4531	0.8069	2958.2788
CWT57	0.5171	0.8020	2924.0883
CWT58	0.4628	0.8188	2821.2684
CWT59	0.5428	0.8197	3347.5938
CWT60	0.5346	0.8447	2716.2366
CWT61	0.5260	0.8424	4089.5707
CWT62	0.3967	0.8169	4671.2025
CWT63	0.4670	0.8020	4919.2955
CWT64	0.4695	0.7878	4998.8973
CWT65	0.4146	0.7463	3814.7698
CWT66	0.2592	0.7138	2536.3324
CWT67	0.5337	0.6899	1498.9679
CWT68	0.3532	0.7084	1576.5551
CWT69	0.3908	0.2134	607.5338
CWT70	0.6987	0.2009	491.6291
CWT71	0.8593	0.2033	567.5378
CWT72	0.9157	0.3491	872.5473
CWT73	1.0336	0.4383	1284.6436
CWT74	1.0781	0.4863	1403.8319
CWT75	0.9501	0.5011	1423.3569
CWT76	1.0644	0.4615	988.7395
CWT77	0.995	0.802	4309

CWT4 to CWT14	East 1 retention pond (Required Volume = 19842 m^3)
CWT15	West 1a retention pond (Required Volume = 1548 m^3)
CWT1 to CWT3	East 2 retention pond (Required Volume = 29624 m^3)
CWT67 to CWT89	East 3 retention pond (Required Volume = 44732 m^3)
CWT16 to CWT17	West 1b retention pond (Required Volume = 2993 m^3)
CWT18 to CWT20	West 2 retention pond (Required Volume = 23910 m^3)
CWT21 to CWT22	West 5/6 retention pond (Required Volume = 27225 m^3)

CWT36 to CWT39 West 7 retention pond (Required Volume = 6000 m^3)

CWT40 to CWT50 West 8 retention pond (Required Volume = 34700 m^3)

CWT51 to CWT66 West 9 retention pond (Required Volume = 20395 m^3)

Some of the clean water catchments do not flow directly into the retention ponds. In these cases, a collector drain has been constructed to divert the runoff into the retention pond.

These collection drains are initially used in the stormwater management system during the construction phase of the ash dump. (*See ADDD Phase 1 Construction Stormwater Management Calculation Record and ADDD Phase 1 Construction Stormwater Management Calculation Record*)

9.1 TEMPORARY CLEAN WATER INTERCEPTION DRAINS

During construction of Phases 1 and 2, clean water interception drains will be constructed along the 4.25 yr footprint to prevent cleanwater from entering the open footprint, as shown on drawings K303 00098/06/216 and K303 00098/06/214.

Table 19 : 1:10yr Temporary Clean Water Runoff Flowrates

Catchment Area		Flowpath	Time of Concentration	Intensity*	Runoff C	Flowrate
Clean Catchment	km^2	Km	hrs	mm/hr	-	m^3/s
West	0.145	1.073	0.812	103.509	0.436	1.819
East	0.172	1.052	0.711	118.123	0.436	2.463

* Intensity based on 1:10 yr 24 hr Point Precipitation of 84 mm

9.2 TEMPORARY CLEAN WATER INCEPTION DRAIN SIZING

The temporary clean water drains were designed to maintain sub-critical flow conditions in the canals to avoid large concrete drop structures.

Each sub-catchments served by an individual length of trapezoidal drain terminating in a culvert running under Ash Dump perimeter road.

Clean water design parameters:

- Unlined trapezoidal drains with a 1.00 m base width, 1V: 3H side slopes;
- Unlined drain Mannings' n = 0.023;
- Drain slopes = 1 : 200;
- Drain depth = flow depth + 10% allowance for groundwater + 300mm freeboard (Sub-critical flow conditions).

Flow depth was calculated using the Mannings' equation:

$$Q = \frac{AR^{2/3} S^{1/2}}{n} \qquad \text{Equation 6}$$

Where Q = Peak Flow (m^3/s)
A = Cross Section Flow Area (m^2)
R = Hydraulic Radius (m)
S = Canal Slope (m/m)
n = Mannings' n value (0.023)

Table 20 : Temporary Unlined Trapezoidal Clean Water Drain Sizes

Drain	Flow Rate	Flow Depth	Velocity	Energy Head	Froude No.	Total Depth
-	m^3/s	M	m/s	m	-	m
West Drain	1.819	0.389	1.133	0.065	0.589	1.3
East Drain	2.463	0.470	1.261	0.081	0.598	1.4

9.3 TEMPORARY CLEAN WATER RETENTION PONDS

Table 21 : Temporary Clean Stormwater Volumes

Drain	Flow Rate	Time of Concentration	Flood Volume
-	m^3/s	Hrs	m^3
West Drain	1.819	1.073	7972
East Drain	2.463	1.052	9456

The flood volumes from West and East drain catchments are diverted into West 5 and East 2 retention ponds respectively.

APPENDIX 1

Dirty Water Catchment Areas

APPENDIX 2

Clean Water Catchment Areas

APPENDIX 3

Dirty Water Catchment Area Graph

APPENDIX 4

Energy Dissipator Design Calculations

Pipe 3 and Pipe 4 Energy Dissipators

Inlet flow from Plant Terrace

Q =	22.23m^3/s
Pipe Wetted Area 2250 Ø =	3.976 m^2
Velocity =	5.591 m/s
$y_e = (A/2)^{1/2}$ =	1.672 m
$Fr = u / \sqrt{gy_e}$ =	1.186
$H_0 = y_e + v^2/2g$ =	2.455 m

From Figure 8-C-2,

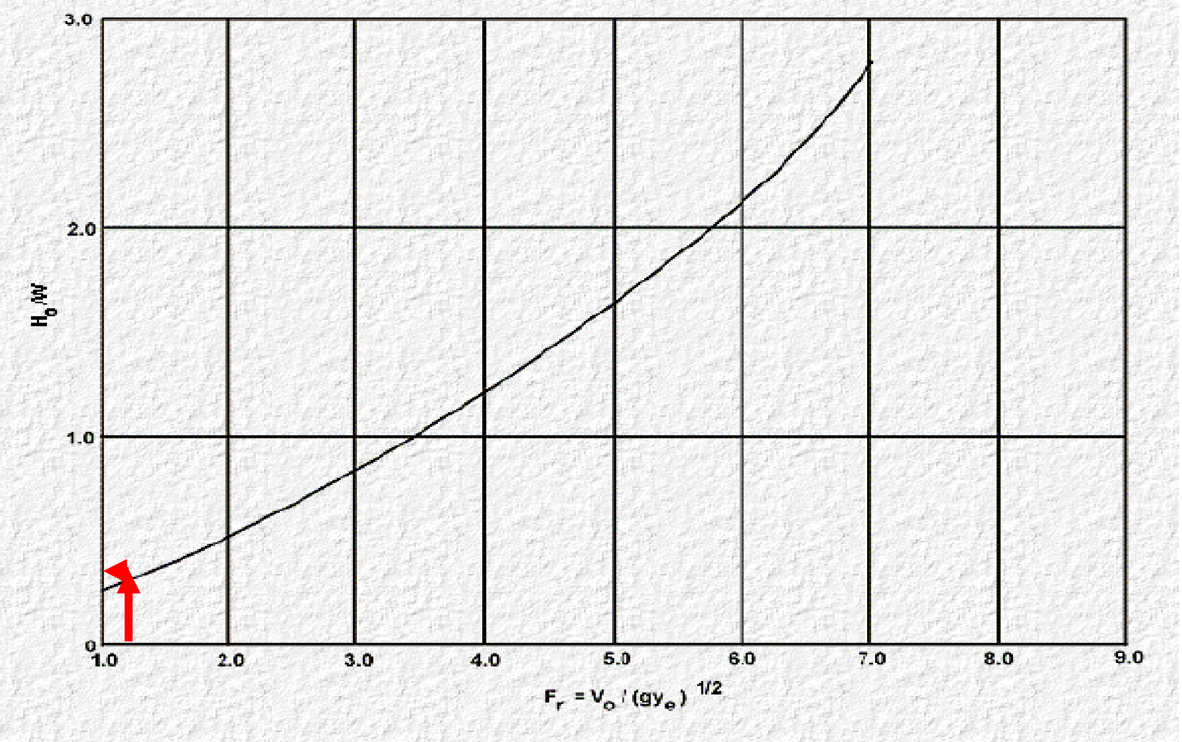


Figure 8-C-2. Design Curve - Baffle Wall Dissipator

H_0/W =	0.371
W =	6.800 m

The energy dissipator has the following dimensions based on Figure 8-C-1 :

h_1 =	5.04 m	w_2 =	2.27 m
L =	8.85 m	t_3 =	0.60 m
h_2 =	4.27 m	t_2 =	0.30 m
h_3 =	1.13 m	t_1 =	0.60 m
L_1 =	4.00 m	t_4 =	0.40 m
L_2 =	4.85 m	t_5 =	0.15 m
h_4 =	3.33 m	w_1 =	0.58 m

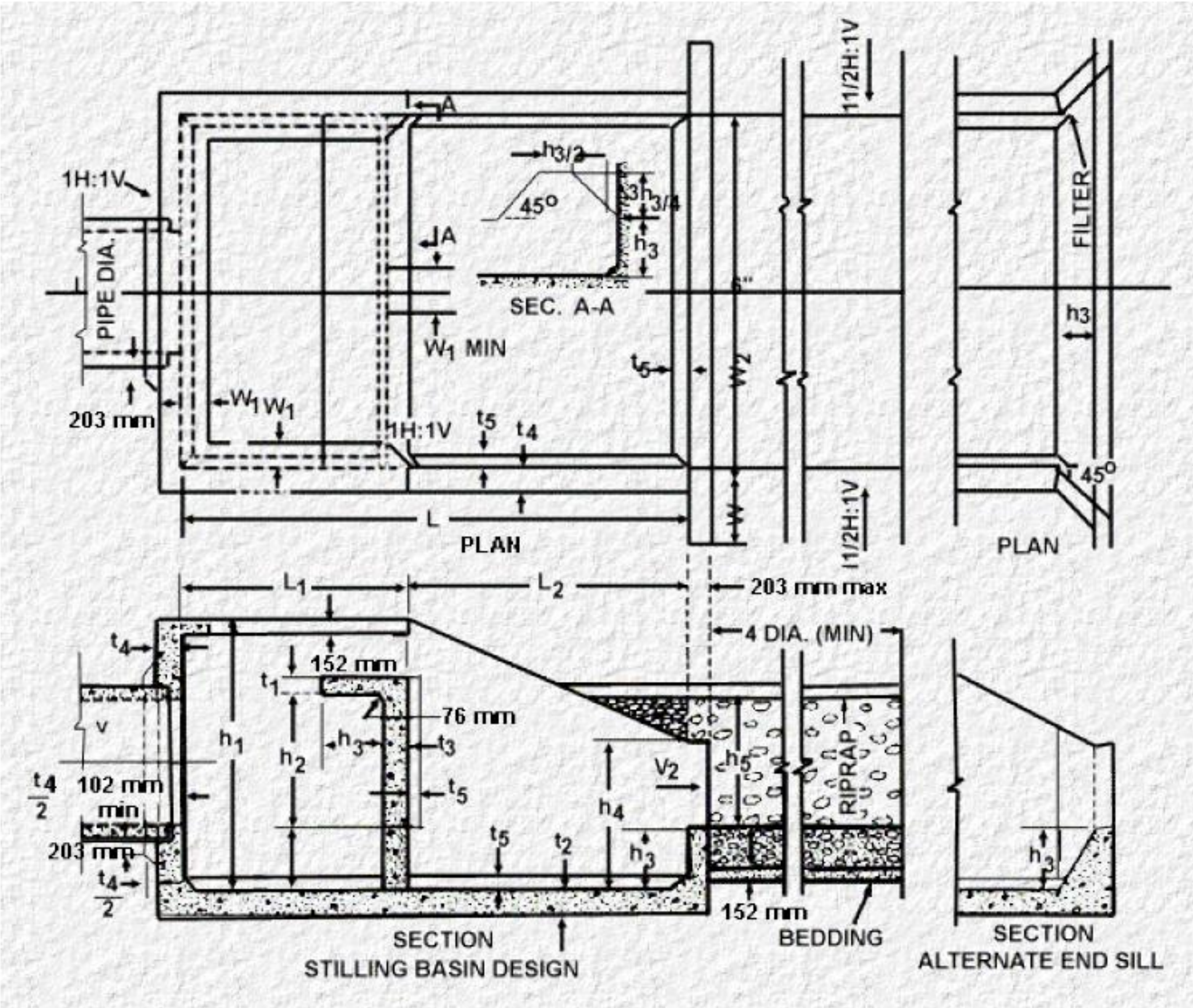


Figure 8-C-1. Baffle - Wall Energy Dissipator - USBR Type VI

Collection Pipeline (Phase 2 East side) Energy Dissipator

Clean runoff from east side of Ash Dump (CWT67 to CWT91)

Q =	$18.857 m^3/s$
Pipe Wetted Area 2500 Ø =	$3.884\ m^2$
Velocity =	4.885 m/s
$y_e = (A/2)^{1/2}$ =	1.393 m
$Fr = u / \sqrt{g y_e}$ =	1.321
$H_0 = y_e + v^2/2g$ =	2.609 m

From Figure 8-C-2,

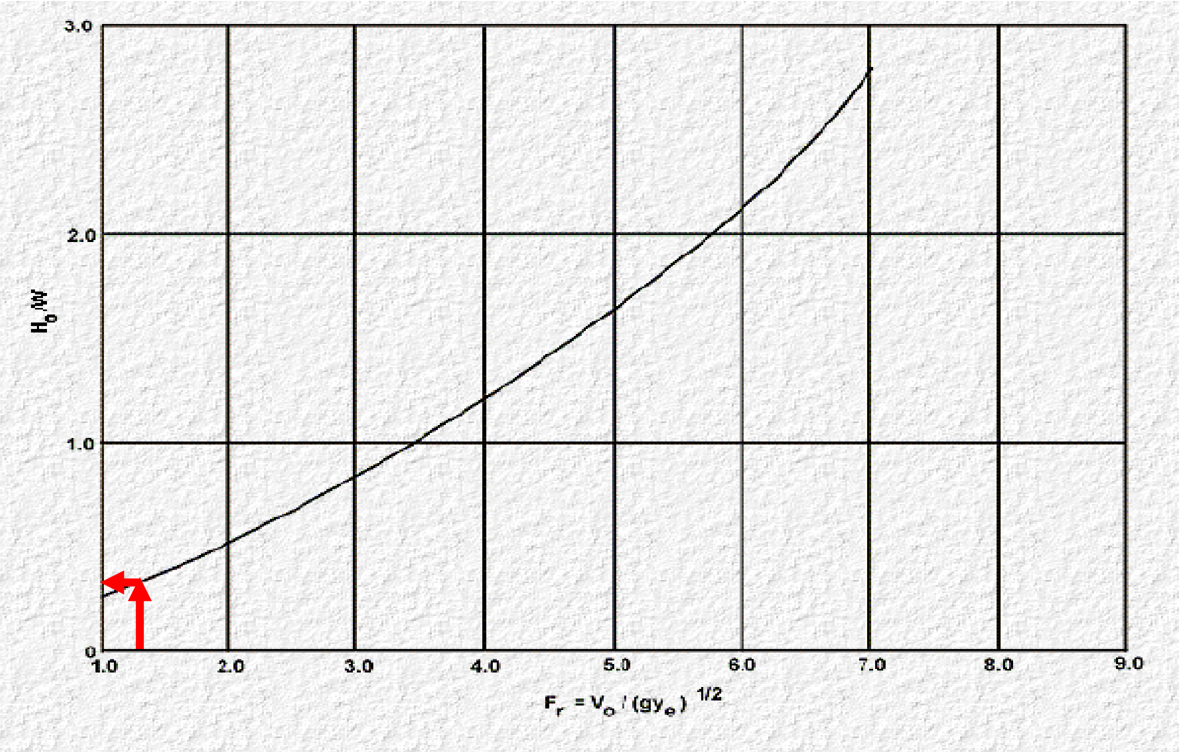


Figure 8-C-2. Design Curve - Baffle Wall Dissipator

H_0/W =	0.400
W =	6.52 m

The energy dissipator has the following dimensions based on Figure 8-C-1 :

h_1 =	4.67 m	w_2 =	0.91 m
L =	8.10 m	t_3 =	0.36 m
h_2 =	2.29 m	t_2 =	0.36 m
h_3 =	1.02 m	t_1 =	0.25 m
L_1 =	3.48 m	t_4 =	0.36 m
L_2 =	4.67 m	t_5 =	0.20 m
h_4 =	2.57 m	w_1 =	0.46 m

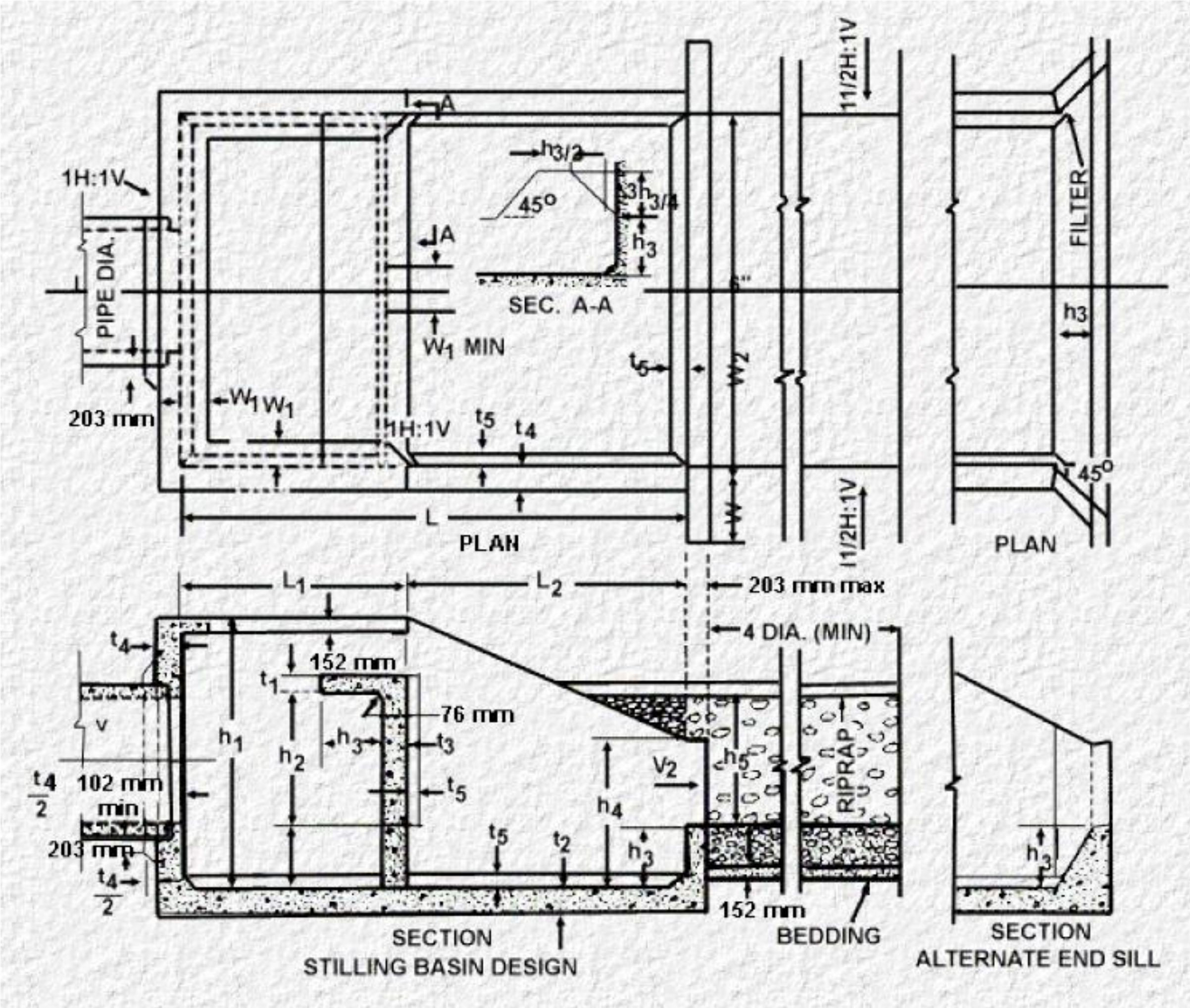


Figure 8-C-1. Baffle - Wall Energy Dissipator - USBR Type VI

APPENDIX 5

System Descriptions

PLAN

SCALE 1:5000

D.O.	REV	DATE	** REVISION ** / INDEX REFERENCE :	REV BY	CHKD BY	AUTH BY	KKS APP	REFERENCE DRAWINGS
	P	03/10/13	REPORT DRAWING	JMcK	JRW	JRW		

DRG REGISTR		
DESIGN APPROVED		JRW
KKS APP		
DO AUTH		DO
CHKD BY		RDD
DRAWN BY	21/07/10	JMcK
SCALE		

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JOINT VENTURE
Knight Piésold CONSULTING

Eskom

KUSILE POWER STATION

ASH DUMP No 1
CATCHMENT AREAS

DRG. No. K30300098/06-540 | REV P

0.90/23320 | SHEET A0 | REV P

APPENDIX 5

SPECIALIST REPORTS

Report: P962: *Classification and Environmental Evaluation of Kusile Power Station Ash and FGD Gypsum in Terms of the Minimum Requirements: November 2008"*

Letter: Enchem P1232: Available Lime Content of an Eskom Power Station Ash

En-Chem Consultants cc (1990/019297/23)
4 Seminole Close, Montagu Park
George, South Africa
P O Box 10324,
George, 6530, South Africa
Tel: 044 874 3638 Fax: 27 86 689 7896
Cell: 082 820 1691 e-mail: ecconsultants@mweb.co.za

TO: Rob Williamson
COMPANY: Knight Piesold
FAX/e-mail: jwilliamson@knightpiesold.com
FROM: David A Baldwin **DATE:** 13 March 2013
PAGES: 8 (including this one) **REFERENCE:** P1232

Re: Available Lime Content of an Eskom Power Station Ash

En-Chem Consultants was requested by Knight Piesold to evaluate the quantity of free lime available in samples of ash. The certificates of analysis for various samples of ash were provided by Waterlab (Pty) Ltd., a company accredited in terms of the SA National Accreditation System (certificate number:T0391). Copies of the certificates of analysis are attached to this letter.

The composition of a power station ash can quite variable and depends on the source of the coal and the temperature of combustion (usually ~1200^{o}C). The actual composition of the coal from the same mine also varies as different areas of a seam are recovered. Lime as calcium oxide, CaO, in the samples of ash were found to range from 5.64% to 6.59% using XRF, but most of this is bound up due to the very high temperatures used which produce various minerals including glassy materials up in various minerals. The presence of free lime in a power station ash does occur but usually the quantities are usually low. The typical composition of the ash from the XRD results is given in the table below and includes ash that is newly generated, ash that has weathered and ash that is 10 years old. Note that the free lime measured by titration is low, i.e. 0.4% to 0.6%. A slag and ash produced in the steel industry on the other hand can have free lime contents up to 11%.

Mineral	**Range, %**
Amorphous	52.48 to 62.58
Calcite, $CaCO_3$	0.17 top 4.1
Hematite, Fe_2O_3	0.76 to 1.11
Mullite, $3Al_2O_32SiO_2$ or $2Al_2O_3$ SiO_2	26.57 to 31.49
Quartz, SiO_2	8.59to 12.32
Free Lime	0.4 to 0.6

Another measure of the free lime content is the increase in temperature due to the heat of hydration produced when free lime reacts with water. Results reported by Waterlab on the temperature rise over a period of 10 minutes after mixing 20g of ash with 40mls of distilled water showed a very small increase of between 0.4 ^{o}C and 0.6 ^{o}C. These results confirm the results of the free lime determination, i.e. the amount of free lime in the ash samples is very small.

Yours Sincerely

D A Baldwin, PhD, Pr.Sci.Nat, MIWM, MSACI

WATERLAB (PTY) LTD

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CERTIFICATE OF ANALYSES
AVAILABLE LIME DETERMINATION

Date received: 2013-02-26
Project number: 177
Report number: 38767
Date completed: 2013-03-08
Order number:

Client name: Knight Piesold
Address: PO Box 221, Rivonia, 2120
Telephone: 011 806 7045
Facsimile: 011 806 7100
Contact person: Rob Williamson
Email: jwilliamson@knightpiesold.com
Email: joubertjg@eskom.co.za

	Available Lime Determination			
	Fresh Ash from Power Station	Fresh Ash form Dump	1 Year Ash on Slide Slope	10 Year Old Ash
	23254	23255	23256	23257
Available Lime (CaO) %	0.60	0.40	0.05	0.05

[s] =Results obtained from sub-contracted laboratory

E. Botha
Geochemistry Project Manager

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CERTIFICATE OF ANALYSES
X-RAY DIFFRACTION

Date received: 2013-02-26
Project number: 177
Report number: 38767
Date completed:
Order number:

Client name: Knight Piesold
Address: PO Box 221, Rivonia, 2120
Telephone: 011 806 7045
Facsimile: 011 806 7100
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Email: joubertjg@eskom.co.za

Composition (%) [s]					
Fresh Ash from Power Station			**Fresh Ash form Dump**		
23254			**23255**		
Mineral	Amount (weight %)	Error	**Mineral**	Amount (weight %)	Error
Amorphous	58.56	1.11	Amorphous	62.58	1.11
Calcite	0.25	0.21	Calcite	0.17	0.1
Hematite	1.11	0.2	Hematite	0.99	0.21
Mullite	31.49	0.96	Mullite	26.57	0.93
Quartz	8.59	0.54	Quartz	9.68	0.57

Composition (%) [s]					
1 Year Ash on Slide Slope			**10 Year Old Ash**		
23256			**23257**		
Mineral	Amount (weight %)	Error	**Mineral**	Amount (weight %)	Error
Amorphous	52.48	1.2	Amorphous	54.59	1.2
Calcite	3.48	0.36	Calcite	4.1	0.36
Hematite	1.04	0.29	Hematite	0.76	0.3
Mullite	30.68	0.99	Mullite	29.41	0.99
Quartz	12.32	0.54	Quartz	11.14	0.54

[s] Results obtained from sub-contracted laboratory

Note:

After milling, the material was prepared for XRD analysis using a backloading preparation method. It was analysed with a PANalytical Empyrean diffractometer with PIXcel detector and fixed slits with Fe filtered Co-K_ radiation. The phases were identified using X'Pert Highscore plus software. The relative phase amounts (weight %) were estimated using the Rietveld method. Errors are on the 3 sigma level in the column to the right of the amount (in weight per cent).

Comment:

- In case the results do not correspond to results of other analytical techniques, please let me know for further fine tuning of XRD results.
- Mineral names may not reflect the actual compositions of minerals identified, but rather the mineral group
- Errors reported for phases occurring in minor amounts are sometimes larger than that of the quantity reported, indicating the possible absence of those phases.
- Due to preferred orientation and crystallite size effects results may not be as accurate as shown in the table.
- Talc in sample 22704 may be overestimated

Amorphous phases, if present, were not taken into account in the quantification.

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Ideal Mineral compositions:
Chlorite (Mg,Fe)5Al(AlSi3O10)(OH)8
Hornblende Ca2[Mg4(Al,Fe)]Si7AlO22(OH)2
Lizardite Mg3Si2O5(OH)4
Muscovite K Al2 ((OH)2 Al Si3 O10)
Pyrite FeS2
Quartz SiO2
Talc Mg3Si4O10(OH)2
Pyrrhotite Fe1-xS

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CERTIFICATE OF ANALYSES
X-RAY FLUORESENCE

Date received: 2013-02-26
Project number: 177
Report number: 38767
Date completed: 2013-03-04
Order number:

Client name: Knight Piesold
Address: PO Box 221, Rivonia, 2120
Telephone: 011 806 7045
Facsimile: 011 806 7100
Contact person: Rob Williamson
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Email: joubertjg@eskom.co.za

Major Elements	Major Element Concentration (wt %)[s]			
	Fresh Ash from Power Station	Fresh Ash form Dump	1 Year Ash on Slide Slope	10 Year Old Ash
	23254	23255	23256	23257
SiO_2	51.47	51.88	53.13	52.34
TiO_2	2.46	2.35	2.22	2.35
Al_2O_3	28.31	26.78	26.23	26.27
Fe_2O_3	3.88	4.54	3.96	4.16
MnO	0.04	0.06	0.04	0.04
MgO	0.96	0.84	0.86	1.07
CaO	6.27	6.73	5.64	6.59
Na_2O	0.55	0.42	0.75	0.63
K_2O	1.1	1.1	0.97	0.86
P_2O_5	1.88	2.08	1.66	1.59
Cr_2O_3	0.04	0.04	0.04	0.04
SO_3	0.27	0.14	<0.01	0.24
LOI	2.23	2.5	4	3.31
Total	99.46	99.46	99.5	99.49
H_2O-	<0.01	0.2	0.29	0.23

[s] =Results obtained from sub-contracted laboratory

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Geochemistry Project Manager

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Trace Elements	Trace Element Concentration (ppm) [s]			
	Fresh Ash from Power Station	Fresh Ash form Dump	1 Year Ash on Slide Slope	10 Year Old Ash
	23254	23255	23256	23257
As	17.6	11.3	5.74	7.52
Ba	1083	1004	1003	1072
Bi	<1.00	<1.00	<5.00	<5.00
Br	1.4	1.15	1.21	1.32
Cd	<5.00	<1.00	<5.00	1.9
Ce	327	365	324	320
Cl	914	979	1223	926
Co	<5.00	<5.00	<5.00	<5.00
Cs	2.69	<5.00	1.86	1.16
Cu	65.6	61.2	51.6	51.9
Ga	62.6	52.5	53.5	50.7
Ge	<5.00	<5.00	<5.00	<5.00
Hf	9.23	9.69	10	10.8
Hg	1.26	<1.00	<1.00	<1.00
La	<5.00	<5.00	<5.00	<5.00
Lu	1.69	1.51	1.79	1.59
Mo	8.79	11	5.31	6.16
Nb	55.4	53.5	50.2	55.9
Nd	52.1	42.5	37.9	32.1
Ni	28.3	36.3	34.8	22.9
Pb	48.1	37.5	34.6	40.9
Rb	58.8	55.8	57.2	49.7
Sb	<5.00	<5.00	1.27	<5.00
Sc	23.5	21.1	27.8	20.2
Se	<1.00	<1.00	<1.00	<1.00
Sm	19.6	14.4	16.5	16
Sn	<1.00	5.91	<1.00	<5.00
Sr	2324	2398	1830	2072
Ta	4.49	3.09	5.07	4.84
Te	25.7	25.3	19.4	27.1
Th	48.5	45.4	44.6	49.2
Tl	1.93	1.37	1.26	1.54
U	17.8	18.8	14.3	16.5

Results continued on next page

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Contact person: Rob Williamson
Email: jwilliamson@knightpiesold.com
Email: joubertjg@eskom.co.za

Trace Elements	Trace Element Concentration (ppm) [s]			
	Fresh Ash from Power Station	Fresh Ash form Dump	1 Year Ash on Slide Slope	10 Year Old Ash
	23254	23255	23256	23257
V	81.9	37.4	47.1	47
W	5.92	5.13	5.64	5.32
Y	121	114	99	109
Yb	15.7	13.8	15.3	14.7
Zn	83.1	62	60.7	61.3
Zr	405	411	391	419

[s] =Results obtained from sub-contracted laboratory

E. Botha
Geochemistry Project Manager

Sample No	**23254**
Description	**Ash from Power Station**
Sample Mass (g)	**20**
Volume Dist Water (ml)	**40**

Time (min)	Temperature (°C)
0	25.4
1	25.8
2	25.8
3	26.0
4	26.0
5	26.0
6	26.0
7	26.0
8	26.0
9	26.0
10	26.0

Sample No	**23255**
Description	**Fresh Ash from Dump**
Sample Mass (g)	**20**
Volume Dist Water (ml)	**40**

Time (min)	Temperature (°C)
0	25.9
1	26.2
2	26.3
3	26.4
4	26.4
5	26.4
6	26.4
7	26.4
8	26.4
9	26.5
10	26.5

Sample No	**23256**
Description	**1-Year ash on side slope**
Sample Mass (g)	**20**
Volume Dist Water (ml)	**40**

Time (min)	Temperature (°C)
0	26.1
1	26.4
2	26.5
3	26.5
4	26.4
5	26.5
6	26.4
7	26.4
8	26.5
9	26.5
10	26.5

Sample No	**23257**
Description	**Old ash 10 Years**
Sample Mass (g)	**20**
Volume Dist Water (ml)	**40**

Time (min)	Temperature (°C)
0	26.2
1	26.5
2	26.5
3	26.5
4	26.6
5	26.6
6	26.6
7	26.5
8	26.6
9	26.6
10	26.6

Sample No	
Description	**BLANK (Distilled Water)**
Sample Mass (g)	0
Volume Dist Water (ml)	40

Time (min)	Temperature (°C)
0	26.5
1	26.4
2	26.4
3	26.4
4	26.4
5	26.4
6	26.4
7	26.4
8	26.4
9	26.4
10	26.4

Room Temperature (aircondition controlled : 25°C)

23254	23255	23256	23257	BLANK
0.6	0.6	0.4	0.4	0.1

APPENDIX 6

KUSILE CLIMATIC WATER BALANCE ASSESSMENT

14 Eglin Road
Sunninghill
P O Box 2700
Rivonia
2128

Tel: +27 11 519 4746
Fax: +27 11 807 5670

Date: 04 January 2012

Our Reference: *30300098/09*

Attention: Ms Moloto Maditsietsi (BHT)
Department of Water Affairs
Cell: 082 887 4332

Dear Madam,

CORRECTION NOTICE FOR KUSILE POWER STATION: ASH DUMP DIRTY DAMS SUBMISSION

Knight Piésold (Pty) Ltd as part of Panel B Joint Venture submitted applications for the Ash Dump Dirty Dams (ADDD) as well as the C & I licence for the Ash dump to the DWA on 13 May 2011.

On the 3rd of January 2012 a query from DWA was received regarding the climatic water balance. Upon investigation it was found that the figures in the climatic water balance (form DW905) do not correspond with the climatic water balance provided in Appendix B.6 (the Ash Dump Design report). This is due to a misinterpretation of the data obtained from the weather bureau.

This notice serves to provide corrected information for both form DW905 and Appendix B.6.

Please do not hesitate to contact us (details provided below) should you have any questions, queries or comments regarding this letter.

Yours sincerely,

TANIA OOSTHUIZEN
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Cc: Candice Beech, Environmental Advisor, Kusile Power Station Project

Kusile Climatic Water Balance Assessment (Corrected)

Kusile Project Climatic Water Balance

Annual precipitation data for the Kusile site is based on records from Station 0514618W on the Wilge River. This station has a long history of data and was decided to be the most representative of the site. The best available evaporation data is for station B2E001 (Bronkhorstspruitdam). The mean annual evaporation (MAE S-pan) is 1532 mm. When converted to MAE A-pan it is 1931 mm.

The climatic water balance is defined by:

B = R – E

where B is the water balance (indicated by B+ when rainfall exceeds evaporation and B – alternatively), R is the precipitation (in mm) and E is the evaporation (in mm). The assessment of positive and negative water balance is based on the wet season of the five years on record with the highest rainfall. If four of the worst years yield B+, a water surplus is indicated with certainty and leaching can be expected. If four of the worst years yield B-, a water deficit can be expected and leaching will only occur under extreme circumstances.

When considering the 98 years of available data (1905 – 2003), only one year (1995) yielded a positive water balance result. Therefore, a B- water balance is the case for the Kusile site.

Table 1 below presents a climatic water balance based on an assessment of the last 30 years to determine the ten wettest years.

Table 1: Climatic Water Balance Kusile

YEAR	30 YEARS WET SEASON TOTALS (NOVEMBER TO APRIL)		
	PRECIPITATION (mm)	A-Pan EVAPORATION (mm)	WATER BALANCE (mm)
1995	1378.7	1111	267.7
1989	1018.4	1111	-92.6
1999	823.8	1111	-287.2
2003	815.8	1111	-295.2
1993	654.2	1111	-456.8
1992	690.6	1111	-420.4
1990	774.4	1111	-336.6
1986	637.5	1111	-473.5
1974	808.7	1111	-302.3
1994	710.4	1111	-400.6

The results in Table 1 of the last 30 years also indicate that only one year yielded B+ water balance, which indicates an overall B- rating for Kusile site. The raw data is presented on the following page.

Rainfall

Rainfall Station – 0514618W
Record 1905 – 2003

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Avg	30yr Rating	6month total	Water balance
1905	32.3	85	123.6	123.2	86.2	93	14	0	0	0	0	11.7	569	47.417		**525**	-586
1906	108.9	70.1	172.8	208	140	23.4	66	0	0	0	0	21	810.2	67.517		**680.3**	-430.7
1907	82.8	174.6	101.5	140.8	23.6	52	5.1	0	0	21.6	17.5	9.1	628.6	52.383		**497.6**	-613.4
1908	90.1	69.7	124.7	323.7	160.9	203.7	5	11.4	0	0	59.4	5.6	1054.2	87.850		**887.7**	-223.3
1909	27.6	112.9	201.2	126.7	60.8	59	0	0	23.1	0	0	14.2	625.5	52.125		**560.6**	-550.4
1910	104.8	61.5	115.8	146.7	48	43	80.2	65.4	0	1.3	2	0.8	669.5	55.792		**495.2**	-615.8
1911	59.1	86.3	60	96.8	116.9	64.1	91.2	2.5	0	0	0	0	576.9	48.075		**515.3**	-595.7
1912	24.7	60.2	125.5	139.8	72.6	79.1	59.2	0	0	0	23.4	0.5	585	48.750		**536.4**	-574.6
1913	88.3	47	54.3	83.8	103.9	106.2	33.2	21.1	0	0	18.5	5.8	562.1	46.842		**428.4**	-682.6
1915	61.4	102.8	78.1	35.9	18.5	70.4	18	2.6	0	0	0	0	387.7	32.308		**323.7**	-787.3
1916	35.4	63.8	111	67.7	159	37.3	35.6	37.3	24.4	0.8	50.6	18.3	641.2	53.433		**474.4**	-636.6
1917	57.5	218.6	154.6	191.7	111.8	175.8	0	0	0	7.4	92	5.1	1014.5	84.542		**852.5**	-258.5
1918	48.2	102.4	128.7	108.8	84.2	98.6	14.3	1.8	0	3	0	5.1	595.1	49.592		**537**	-574
1919	45.4	155.8	128.3	83.9	82.2	73.5	22	11.9	0	7.1	0	20.3	630.4	52.533		**545.7**	-565.3
1920	187.2	71.1	106.4	101.9	158.7	244.5	22.3	14.6	0	0	0	25.9	932.6	77.717		**704.9**	-406.1
1921	74.4	150	108.9	65.2	134.7	131.8	0	41.2	36	0	83.4	20.8	846.4	70.533		**590.6**	-520.4
1922	67.5	139.5	144.2	219	85.7	52.8	33.5	0.5	4.1	2.3	0	7.1	756.2	63.017		**674.7**	-436.3
1923	32	126.1	98.4	79.2	81.6	113.1	27.3	38.6	0	0	2.3	20.9	619.5	51.625		**525.7**	-585.3
1924	71.4	156.9	155	102.9	140.8	222.2	67.4	90.9	20.3	0.3	1	80.8	1109.9	92.492		**845.2**	-265.8
1925	31.8	120.9	85.9	61.9	66.7	57.4	22.1	47.2	2.8	25.7	0	9.6	532	44.333		**414.9**	-696.1
1926	23.1	141.6	60.4	137.8	73.8	84.4	6.5	0	0	86.1	16.8	18	648.5	54.042		**504.5**	-606.5
1927	158	46.3	68.2	142.2	76.5	38.4	15.4	1	0	0	32	9.7	587.7	48.975		**387**	-724
1928	42.3	168.6	88.5	86.9	82.6	126.8	15	17.6	11.9	0	0.5	83.2	723.9	60.325		**568.4**	-542.6

PANEL B CONSULTANTS JOINT VENTURE

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Avg	30yr Rating	6month total	Water balance
1929	206	103.9	176.3	119.2	149.2	84	28.8	5.6	0	28.7	16.5	0.8	919	76.583		**661.4**	-449.6
1930	16.1	32.8	59.7	85.8	50.7	71.4	53.8	0	1	71.7	0	0	443	36.917		**354.2**	-756.8
1931	46.3	98.8	73.9	223.6	60.8	33.3	9.4	17	0.3	0	0	38.6	602	50.167		**499.8**	-611.2
1932	45.8	134	79.5	80.3	78.7	56.9	24.2	0.5	5.3	0	0	19.8	525	43.750		**453.6**	-657.4
1933	5	235.4	165.3	217.6	233.1	75.7	70.1	27.9	6.4	37.9	15.6	81.3	1171.3	97.608		**997.2**	-113.8
1934	45.5	136.6	152.9	76.3	92.7	117.9	8.2	3.1	0	0	5.3	3.1	641.6	53.467		**584.6**	-526.4
1935	16	83.1	92.7	140.5	116.5	147.8	46	126.1	0	0.5	0	31.7	800.9	66.742		**626.6**	-484.4
1936	70.7	191.9	90.5	180.3	170	26	24.5	5.1	0	0.5	0	17.3	776.8	64.733		**683.2**	-427.8
1937	80.7	27	196.2	179.4	57.5	29.5	109.5	7.1	11.2	16.3	7.1	8.5	730	60.833		**599.1**	-511.9
1938	67.6	80.4	174.4	118.7	230	108.7	18.6	57.7	0	60.5	5	19.6	941.2	78.433		**730.8**	-380.2
1939	67.7	213	171.2	90.4	68.7	68	30.9	31.3	68.9	0	1.1	75.8	887	73.917		**642.2**	-468.8
1940	29.5	164.5	135.9	108.8	88.3	104.7	97.2	0	0	0.3	1	39.4	769.6	64.133		**699.4**	-411.6
1941	56.1	30.3	95.2	147	62.5	93.5	36.1	41.7	16.3	0	17.5	22.9	619.1	51.592		**464.6**	-646.4
1942	101	136.4	158.7	101.3	81.1	60	117.5	44.9	0	57.2	54.8	28.8	941.7	78.475		**655**	-456
1943	81.5	115.8	100.7	153.9	242.1	80.5	5.8	6.4	52.4	0	0	36.3	875.4	72.950		**698.8**	-412.2
1944	93.3	142.8	65.3	115.3	88.9	63.2	65.8	13.2	0	0	0	0	647.8	53.983		**541.3**	-569.7
1945	31.8	61.2	74.4	220.1	254.7	97.9	9.7	13.7	0	0	0	0	763.5	63.625		**718**	-393
1946	27.8	53.8	135.1	79	84.8	118.4	22.9	0.3	9.7	2.3	0	8	542.1	45.175		**494**	-617
1947	36.6	148.2	170	171.4	18.8	89.1	24.9	18	0	0	0	20.3	697.3	58.108		**622.4**	-488.6
1948	98.5	128.5	50.1	181.5	5.1	16.5	44.7	19.5	3	0	0	18.3	565.7	47.142		**426.4**	-684.6
1949	65.2	150.3	125.3	84.4	59.6	33.7	95.5	8.4	3.3	1.8	0	9	636.5	53.042		**548.8**	-562.2
1950	20	70.3	117.7	86	98.6	45.8	76.7	66.5	1.5	2	25.9	2.8	613.8	51.150		**495.1**	-615.9
1951	109.3	6.6	149.4	61.5	126.7	29	10.9	6.4	3.6	17.8	0.5	0	521.7	43.475		**384.1**	-726.9
1952	23.5	125.3	85.9	78	106.5	101	37.6	7.2	0	0	0.6	2.1	567.7	47.308		**534.3**	-576.7
1953	25.9	198.9	91.1	121.7	111.1	77.9	37.6	9	0	0	0.8	9.4	683.4	56.950		**638.3**	-472.7
1954	30.2	119.2	45.3	184.4	171	86.7	64.5	12.5	13.5	0	1	0	728.3	60.692		**671.1**	-439.9
1955	67.2	84.3	192.1	92.5	147.3	98.3	0.3	105.2	12.4	6.5	0	73.1	879.2	73.267		**614.8**	-496.2

PANEL B CONSULTANTS JOINT VENTURE

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Avg	30yr Rating	6month total	Water balance
1956	135.5	89.2	146	72.2	105.3	114.1	33	24.9	41.9	63.5	22.9	69.1	917.6	76.467		**559.8**	-551.2
1957	67.9	44	24.3	156.6	63	53.5	112.6	11.5	0	0	0	68.5	601.9	50.158		**454**	-657
1958	107.6	102.4	151	129.3	63.1	37.5	41.9	13.5	0.5	9	0	4	659.8	54.983		**525.2**	-585.8
1959	14	158.8	134.4	69	40.6	87.4	75	16.7	5.5	2.5	26	8.7	638.6	53.217		**565.2**	-545.8
1960	52.8	124.7	117.7	59.5	61.9	89.3	89	29.3	9.6	8	0	16	657.8	54.817		**542.1**	-568.9
1961	64.2	71	46.5	60	159	55.8	51.5	0	2.5	0	4.5	10	525	43.750		**443.8**	-667.2
1962	54.1	171.9	79.5	137.2	15.3	44.5	79.7	15.8	91.5	17.7	0	0	707.2	58.933		**528.1**	-582.9
1963	38	95	84	187.5	36.5	33.2	36	11	5.1	0	6	8	540.3	45.025		**472.2**	-638.8
1964	214.5	26	188	90.4	29	3.6	36.8	24	0	5	1	0	618.3	51.525		**373.8**	-737.2
1965	8	86.1	51.3	57.5	63.5	11.6	11.7	10	23	0	0.9	4	327.6	27.300		**281.7**	-829.3
1966	95	103.2	92.9	216.7	172	75.2	194.7	19.5	0	0.5	26.5	1.2	997.4	83.117		**854.7**	-256.3
1967	86.8	127.7	120.4	105.1	57.9	94.7	63.4	27.9	0.1	10	9.7	0.3	704	58.667		**569.2**	-541.8
1968	45	106.9	99.4	81.3	105.1	174.3	42.1	65	0	0.7	2.5	11.7	734	61.167		**609.1**	-501.9
1969	138.1	121	173.8	40	91.2	52.3	35	11.2	1	1	16	9.8	690.4	57.533		**513.3**	-597.7
1970	140	149.8	104.6	190	33.1	49.8	91.3	17	1.3	0	0	35.6	812.5	67.708		**618.6**	-492.4
1971	38.6	149	142.1	173.7	52.6	140.4	28	7.5	0.7	0	6.7	20.3	759.6	63.300		**685.8**	-425.2
1972	58.3	83.7	85.4	131.8	46.9	102.5	64	0	0	0	3.1	46	621.7	51.808		**514.3**	-596.7
1973	73.1	59.8	184.5	151.6	24.7	1.8	60.4	6	3.1	13.5	0.5	14	593	49.417		**482.8**	-628.2
1974	15.5	82	89.3	331.1	163	41.1	102.2	14	9.5	0.1	0	0.5	848.3	70.692	**9**	**808.7**	-302.3
1975	34.6	205.4	116.2	146.7	125.3	115.3	36.5	28	0	0	0	7.8	815.8	67.983	**13**	**745.4**	-365.6
1976	109.5	97	89.5	126.5	6	82	39.2	5.5	0	0	2.2	30.5	587.9	48.992	**22**	**440.2**	-670.8
1977	48.1	62	73.2	352.6	97.6	110.3	33.3	1.8	0	0.4	15.2	21.7	816.2	68.017	**12**	**729**	-382
1978	67.6	31	37.1	66	26.2	38	38.7	6.7	0	10.7	14.3	7.8	344.1	28.675	**30**	**237**	-874
1979	110.5	148.3	54.3	178	198.7	78.1	11.3	2	0	0	0	43	824.2	68.683	**11**	**668.7**	-442.3
1980	19.3	205.3	73.8	147.3	87.3	99.4	36.5	0	13.5	0	12.5	23	717.9	59.825	**16**	**649.6**	-461.4
1981	47.5	67.2	64.2	137.5	45.6	90	4.5	0	0.6	34.5	0	8.5	500.1	41.675	**28**	**409**	-702
1982	84.6	31.2	97.2	103.7	46.2	69.1	18.2	17	18	11.5	38	8	542.7	45.225	**25**	**365.6**	-745.4

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Avg	30yr Rating	6month total	Water balance
1983	85.2	204.6	112.5	66.5	58.5	91	6.8	0.6	19.7	15	9	0	669.4	55.783	**18**	**539.9**	-571.1
1984	107.3	72.2	69.3	88.6	137.6	103.8	0.5	16.8	0	0.5	15	35.3	646.9	53.908	**20**	**472**	-639
1985	80.5	28.6	121.3	106.8	58.1	64.4	27.5	0	11.5	0	1.5	0.5	500.7	41.725	**27**	**406.7**	-704.3
1986	92.7	104.9	160.2	97.8	16.6	250	8	0	0	0	25	99.7	854.9	71.242	**8**	**637.5**	-473.5
1987	40.6	182.6	158.7	99.5	68.3	91.4	19.5	0	14	3.4	8.8	40.1	726.9	60.575	**15**	**620**	-491
1988	108.2	40.3	124.3	59.9	200.2	58.2	54.6	1.5	80.8	0	11.9	2	741.9	61.825	**14**	**537.5**	-573.5
1989	49.5	248.7	194.4	76	177.6	152.9	168.8	10.9	0	5.5	2	9	1095.3	91.275	**2**	**1018.4**	-92.6
1990	51.1	72.8	161.2	127.3	175	234.6	3.5	9	20.9	0	0	7.3	862.7	71.892	**7**	**774.4**	-336.6
1991	68.8	47.3	171	123.2	91.1	17.2	22.6	0	2.2	0	17.5	0	560.9	46.742	**24**	**472.4**	-638.6
1992	125.7	129	161.8	75.9	164.8	126.1	33	6.6	0	0	3.1	60.1	886.1	73.842	**6**	**690.6**	-420.4
1993	222.2	135.9	136.2	127.4	184.8	60.8	9.1	0	0	0	0	24.3	900.7	75.058	**5**	**654.2**	-456.8
1994	71	150.8	133.5	104.5	14.8	211.3	95.5	19.4	0	0	9	24.5	834.3	69.525	**10**	**710.4**	-400.6
1995	92.4	203.8	257.3	315	405.8	101.7	95.1	13.2	0	1	5.5	0	1490.8	124.233	**1**	**1378.7**	267.7
1996	100.6	39.7	49.6	100.5	7.3	241.8	35.5	88.5	0	5.6	3.6	21.3	694	57.833	**17**	**474.4**	-636.6
1997	72.7	128	54.7	109.9	44.2	64	0.3	0	0	0	0	37.4	511.2	42.600	**26**	**401.1**	-709.9
1998	58.6	220	136.6	47.2	27	55.3	38.7	31.8	8.5	0	0	4.8	628.5	52.375	**21**	**524.8**	-586.2
1999	58.2	101.7	136.5	192.6	181.5	132.6	78.9	32.8	7	1.6	0	21.1	944.5	78.708	**3**	**823.8**	-287.2
2000	121.9	64.8	110.8	33.5	53.4	13.6	13.2	42.9	10.2	0	0	12.6	476.9	39.742	**29**	**289.3**	-821.7
2001	131.1	163.1	92	30.4	66.3	24	49.6	31.6	17.7	0	26.9	19.7	652.4	54.367	**19**	**425.4**	-685.6
2002	91.8	28.2	153	114.6	72.7	83.5	17.5	0	5	0	3	0	569.3	47.442	**23**	**469.5**	-641.5
2003	51.7	26.1	140.5	112.2	221.5	278	37.5	7	8.2	25.5	0	0	908.2	75.683	**4**	**815.8**	-295.2

Evaporation

B2E001 Zone4A	Mean Annual Evaporation	S Pan	1532	mm
		A pan	1931	mm

	Monthly Evaporation as a percentage of MAE for 4a Evaporation Zone (%)											
Monthly evap	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
%	10.78	10.17	11.2	11	9.17	9.05	6.96	5.86	4.76	5.21	6.9	8.94

	Monthly A-pan Evaporation for 4a Evaporation Zone (mm)												**6 months total**
A-pan	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
values	208	196	216	212	177	175	134	113	92	101	133	173	**1111**

	Monthly S-Pan Evaporation for 4a Evaporation Zone (mm)												**6 months total**
S-pan	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
values	165	156	172	169	140	139	107	90	73	80	106	137	**882**

APPENDIX 7

WATER MASS BALANCE

Appendix D

Water Mass Balance Diagrams

Appendix D
Water Mass Balance Diagrams

The following documents the assumptions and methods used to develop the water mass balance diagrams. In the following sections, the balance around each major process shown on the water mass balance diagrams is discussed.

Steam Cycle

To develop the balance around the steam cycle the steaming rate of 636.1 kg/s was assumed. This value is from the guarantee boiler maximum continuous rating (BMCR) heat balance from Hitachi. The daily makeup flow was calculated assuming 2 percent of the steaming rate is lost as non-recoverable steam losses (60 percent of the 2 percent) and various liquid losses (remaining 40 percent of the 2 percent). The 2 percent is a conservative Black & Veatch (B&V) design value which includes the water used/lost for condensate polishing, soot blowing, seal water and leaks. Eskom experience is that, at the Majuba Plant, they operate at somewhat above this value (2 percent to 3 percent) while, at the Matimba Plant, the makeup is typically less than 1 percent. At Kusile, it is expected that the modern, state-of-the-art design of the turbines, boilers, condensate polishers, and makeup water treatment equipment will allow 2 percent maximum makeup to be readily achievable. Top of furnace wall soot blowing flows were provided by Hitachi as 3.2 kg/s for a duration of 4 hours per day for each unit. Bottom of furnace wall soot blowing flows are from service water and will be discussed with the miscellaneous water uses.

Condensate Polishing

The condensate flow through the condensate polishers is calculated assuming a turbine maximum continuous rating (TMCR) equal to 97 percent of the BMCR (617.0 kg/s). Steam condensing in the air-cooled condenser only accounts for about 70 percent of the TMCR steam flow (431.9 kg/s). Thus, condensate flow to the condensate polishers for the water balance is based on the 431.9 kg/s. Regeneration/rinse flows to the Process Drains Recovery Sump and Neutralization Sump are based on the Process Flow Diagrams and Water Mass Balances supplied by PDNA.

Demineralization

The flow in and out of the demineralization plant is based on 2 percent of the BMCR, plus water used for regeneration of the demineralizers. Makeup to the demineralization plant is taken from the Filtered Water Tanks 1 and 2 (process). Regeneration water requirements for the Primary and Polishing Demineralisation Plants and wastewater flows to the Neutralisation Sump are based on values provided by the PDNA process flow diagrams and mass balances.

Auxiliary Cooling Tower

The balance of water around the auxiliary cooling towers is based on values supplied by the cooling tower system bidders. Evaporation rate is assumed to be 264.6 m^3/h and makeup rate is 354 m^3/h, assuming operation at four cycles of concentration. These values are at design heat load and atmospheric conditions and average evaporation and makeup rates should be at least 20 percent less.

Plant Potable Water Uses

Potable water consumption (permanent) is conservatively based on a maximum of 1,500 people at the site in any one day at 250 liters per day per person, including visitors and contract maintenance personnel. Normal staffing will be less. Construction water consumption is included in the water mass balance <u>for the five build-out cases.</u> *(revised 12 Jan 2012)*

Mine Potable Water Uses

The potable water requirement for the mine was set by Eskom at 25 million liters per month.

Miscellaneous Service Water Uses

Miscellaneous plant and equipment use per unit is estimated at 272 m^3/day based on Black & Veatch experience at large coal fired power plants. This value does not include the water needed for bottom of furnace wall soot blowing. The furnace soot blowing flow was obtained from Hitachi and is based on 13.9 kg/s for each of eight blowers for a duration of 45 seconds each three times per day.

Ultrafiltration Pretreatment System

The ultrafiltration pretreatment system, including backwash from the auto backwash filters, is based on a recovery of 91.62 percent (producing reject water equal to 8.38 percent of the influent flow). This recovery is based on the PDNA process flow diagrams and mass balances. Wastewater from the auto backwash filters and UF system are directed to the Dirty Drains System.

Flue Gas Desulfurization Scrubbers

The water use by the scrubbers is based on the Rev. A 100 percent maximum continuous rating (MCR) design case scrubber mass balance submitted by Alstom, Rev B, dated June 21, 2010, using ‘Limestone A’. According to the FGD mass balance, raw water is used for gypsum wash and vacuum filter vacuum pump seal water, with holding/recycle dam water supplied for other uses.

FGD Chloride Purge Flow to the ZLED Wastewater Treatment System

The FGD chloride purge stream flow is from the Rev. A 100 percent MCR design case scrubber mass balance submitted by Alstom, dated March 23, 2010, using 'Limestone A'. The zero liquid effluent discharge (ZLED) wastewater treatment system will use clarifiers, brine concentrator evaporators and crystallizers for treatment. Based on the PDNA process flow diagrams and mass balances, distillate flow will be 95.47 percent of the inlet wastewater flow. It is assumed the balance is contained within the dewatered sludges from the ZLED pretreatment and evaporative processes. Condensate is assumed to be returned to the process drains recovery tanks for reuse; although alternatively it can be directed to the Station Drains System for eventual reuse as FGD system makeup.

Bottom Ash Processing (SSCC)

For the submerged scraper chain conveyor (bottom ash processing), it is assumed that 7 m^3/hr is lost to evaporation for each unit based on Black & Veatch experience for large coal fueled power plants. Water used in washing of the coarse ash was based on the current design value of 1,920 m^3/d (refer to email from Benjamin Connell on April 26, 2010). The loss of water in each unit is made up from the holding/recycle dam.

Fly Ash Processing

For fly ash processing, the solids are assumed to be conditioned to 13 percent moisture content. Fly ash would be wetted by water from the holding/recycle dam.

Active Ash Dump

The total ash dump area is based on the Panel B Consultants' Report "Kusile Power Station Ash Dump Development Plan, Rev 3," dated 14 May, 2010. The maximum "active" area (dirty catchment area) was reported to be 1,603,743 m^3 in the report. To obtain a value for stormwater runoff for the water balance, a runoff coefficient of 0.504, the value used by the Panel B consultants, is applied to the total stormwater collected over the area. Water entrained in the ash dump is equal to the sum of moisture contained in the conditioned fly ash, bottom ash, and FGD solids. An irrigation and dust control water stream is shown with flow based on the Panel B Report as 854.19 m^3 per day maximum (Year 4). Water for irrigation/dust control will be taken from the ash dump dirty dam supplemented, if necessary, by water transferred from the holding/recycle dam.

Ash Dump Dirty Dam

Water that is collected in the Ash Dump Dirty Dam (ADDD) is used for irrigation and dust control on the active areas of the ash dump. The ADDD is being sized to contain all stormwater runoff from the ash dump during an 8 day, 50 year rainfall event, as modeled by KPC. The ADD volume will provide settlement time for the runoff prior to discharge to the SDD. The outlet of the ADDD to the SDD is elevated to avoid transport of solids to the SDD. After high rainfall events, water will be transferred from the ADDD to the Station Dirty Dam by gravity in a reasonable amount of time that will not exceed the flow being transferred from the SDD to the HRD for process use. This value is approximately16,890 m^3/day based on full load operation of six units.

Station Dirty-Dirty Areas (Boiler Block and Fabric Filter Areas). These are areas around the boiler block and fabric filters that will contribute grit-laden stormwater to the unitised Yard Grit Sumps. The areas based on the current site areas of 7,874 m^2, and 7,935 m^2 for Unit 1, and Units 2 – 6, respectively.

Unitised Yard Grit Sumps

These unitised grit sumps located near the fabric filters collect grit-laden stormwater from the dirty-dirty areas and washdown water from the boiler building(s). These sumps will be designed with an overflow weir to allow grit to settle out and the water to run over the weir into a clear well. The water will then be pumped to the CSY/LB settling facility.

Station Dirty-Dirty Areas (Limestone Building, Coal Storage Yard, Emergency Ash Dump)

The Coal Storage Yard (CSY) Settling Basin collects grit laden stormwater runoff from the coal storage yard, limestone handling areas, fly ash handling areas and flue gas desulphurization limestone preparation and byproduct dewatering areas. The CSY is based on an area of 550,034 m^2. Limestone storage and handling areas is based on 132,687 m^2. The areas around the fly ash handling areas and FGD scrubber areas were based on areas of 11,401 m^2 and 10,940 m^2, respectively. Other minor areas contributing stormwater to the CSY/LB total to 29,160 m^2. These values for estimated areas were provided by Black & Veatch Civil Engineer Stephen Reitz on April 28, 2010. These areas are combined on the water mass diagram for simplicity since they all drain to CSY settling tanks. For stormwater runoff from these areas, a runoff factor of 0.82 was applied.

CSY/LB Settling Facility

The coal storage yard settling facility includes two 20,315 m^2 compartments for collected rainfall. The stilling basin was based on an area of 5,600 m^2. The contribution from direct rainfall on the basins, however, is minute in comparison with the rainfall runoff flows, as is the case for all the drains dams. The CSY/LB settling facility will be sized to contain all stormwater runoff from the station dirty-dirty areas associated with the limestone building, coal storage yard, emergency ash dump and other areas mentioned above during a 1 day, 50 year rainfall event. The balance around the CSY settling basin is a simple in-minus-out calculation.

Station Dirty-Clean Areas

Stormwater from station dirty areas containing no grit and draining to the station dirty dam is based on 297,193 m^2 (as provided by Black & Veatch civil engineer Stephen Reitz on April 28, 2010). The runoff coefficient for these areas was assumed to be 0.82 for the purposes of the water balance.

Station Dirty Dam

The station dirty dam rainfall and evaporation flows are based on a total area of 78,300 m^2 and the associated settling facility has an area of 5,600 m^2 (as provided by Stephen Reitz on March 23, 2009) for collected rainfall. The balance around the station dirty dam is a simple in-minus-out calculation. The station dirty dam has two cells with total volume sized to contain all stormwater runoff from the station dirty-clean areas and additional process wastewater during a 1 day, 50 year rainfall event. Only enough water to balance the holding/recycle dam is pumped forward to the holding/recycle dam. During the 50 year rainfall, the water mass balance diagram indicates a surge for the station dirty dam. After high rainfall periods, water from the ADDD will only be transferred to the SDD when sufficient capacity exists to do so.

Holding/Recycle Dam

The holding/recycle dam rainfall and evaporation flows are based on a total area of 50,146 sq m (as provided by Stephen Reitz on March 23, 2009). The holding/recycle dam has two cells with total volume sufficient to supply water to the FGD scrubbers and ash systems for approximately 3 days of operation, without makeup. To maintain level, water is supplied to the holding/recycle dam from the station dirty dam and raw water. During most periods, other than periods of high rainfall, the Holding/Recycle Dam will require raw water supplied from the Kendal water pipeline. The Holding/Recycle Dam is not designed to contain any stormwater from station areas.

Raw Water Reservoir

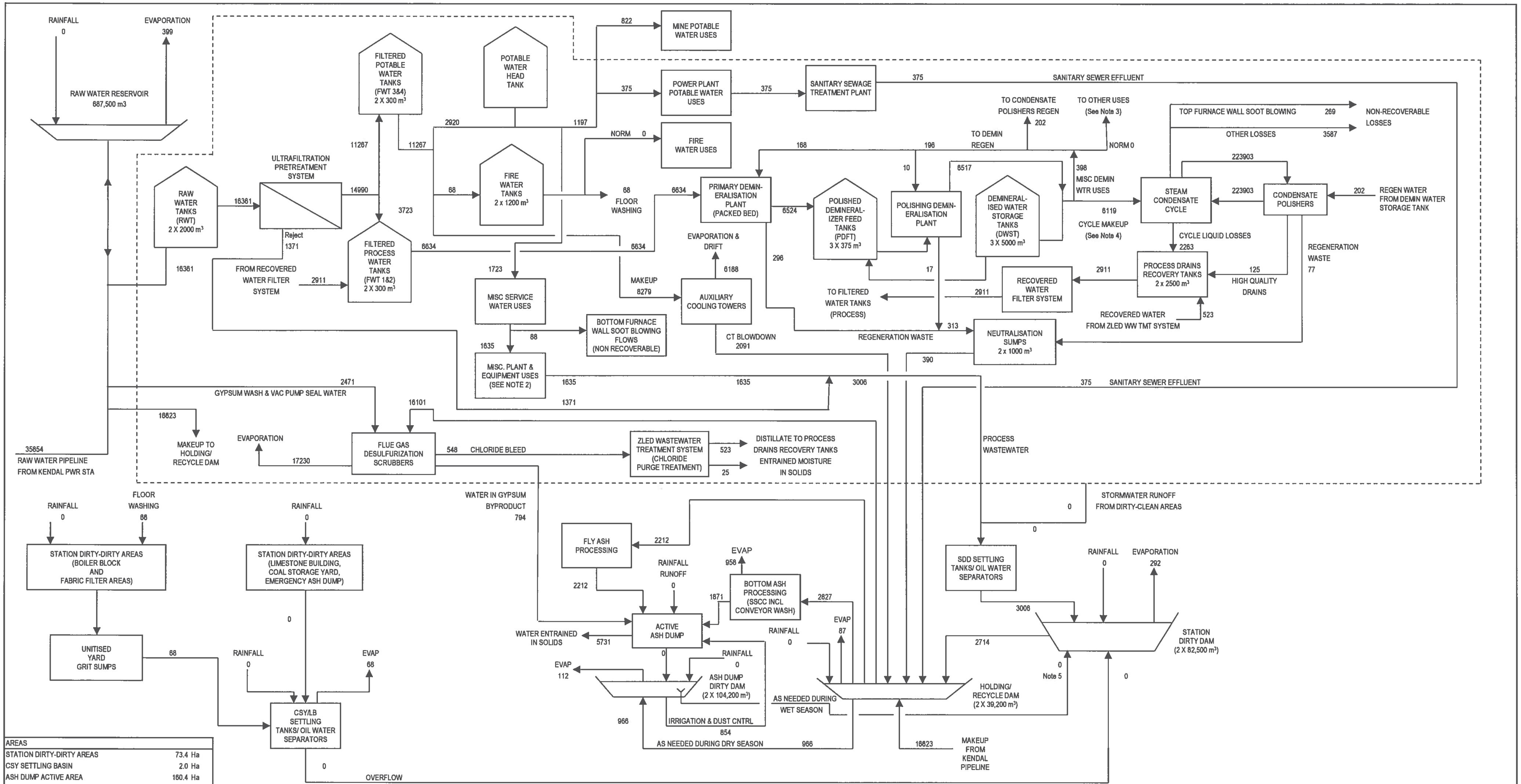
The raw water reservoir rainfall and evaporation flows are based on an area of 114,746 m^2 (as provided by Black & Veatch civil engineer Stephen Reitz on May 17, 2010).

Evaporation

Evaporation values for the various reservoirs and dams shown on the water balance are calculated by multiplying an annual lake evaporation rate of 1,270 mm/y by the surface area of the reservoir or dam. The assumed lake evaporation rate was based on information from the South Africa DEAT website.

Rainfall

Four rainfall case water balances are presented. Water Balances WMB-1B is a “No Rainfall” case. Water mass balance WMB-2B is an “Average Annual Rainfall” case and is based on a total of 683 mm of rainfall in an average year. This value is divided by 365 days to get a per day rainfall amount. Water mass balance WMB-6B is a “1 Day, 50 year Rainfall” case and is based on 126 mm of rainfall received in 1 day. A fourth “Low Rainfall” case, Water Balance WMB-12, is provided based on the average of the five lowest annual rainfall amounts from the 95 year period from 1908 through 2003 at a gauge station in Mpumalanga Province.



AREAS	
STATION DIRTY-DIRTY AREAS	73.4 Ha
CSY SETTLING BASIN	2.0 Ha
ASH DUMP ACTIVE AREA	160.4 Ha
ASH DUMP DIRTY DAM	3.2 Ha
HOLDING/RECYCLE POND	2.5 Ha
STATION DIRTY-CLEAN AREAS	29.7 Ha
STATION DIRTY DAM & STILLING BASIN	8.4 Ha
GRIT SUMPS CATCHMENT AREA	4.8 Ha

NOTES
1 Values given are in m3/day.
2 Misc. service water uses include ACC washing, hose bibs, seal water, etc.
3 Misc. demin water uses such as closed cycle system makeup (normally 0 flow).
4 Cycle makeup based on 2 percent of steaming rate.
5 Flow from the ADDD to the SDD after a large rainfall event will only occur after the SDD level is drawn down and will not exceed the transfer rate from the SDD to the HRD.
6 Values assume a 97.44 % overall capacity factor (each unit at 100% capacity except for 14 day outage every 1-1/2 years).

REV	DATE	DESCRIPTION	BY	CHK'D	APP'D
7	8-30-10	UPDATE PER CURRENT DESIGN	DRM	KRW	KRW
8	9-27-11	UPDATE PER CURRENT DESIGN	DRM	KRW	KRW

REV	DATE	DESCRIPTION	BY	CHK'D	APP'D
0	2-14-08	INITIAL ISSUE	DRM	KRW	KRW
1	5-30-08	UPDATE	DRM	KRW	KRW
2	6-24-08	UPDATE	DRM	KRW	KRW
3	8-5-08	UPDATE	DRM	KRW	KRW
4	10-21-08	UPDATE	DRM	KRW	KRW
5	11-10-08	UPDATE	DRM	KRW	KRW
6	6-26-09	UPDATE	DRM	KRW	KRW

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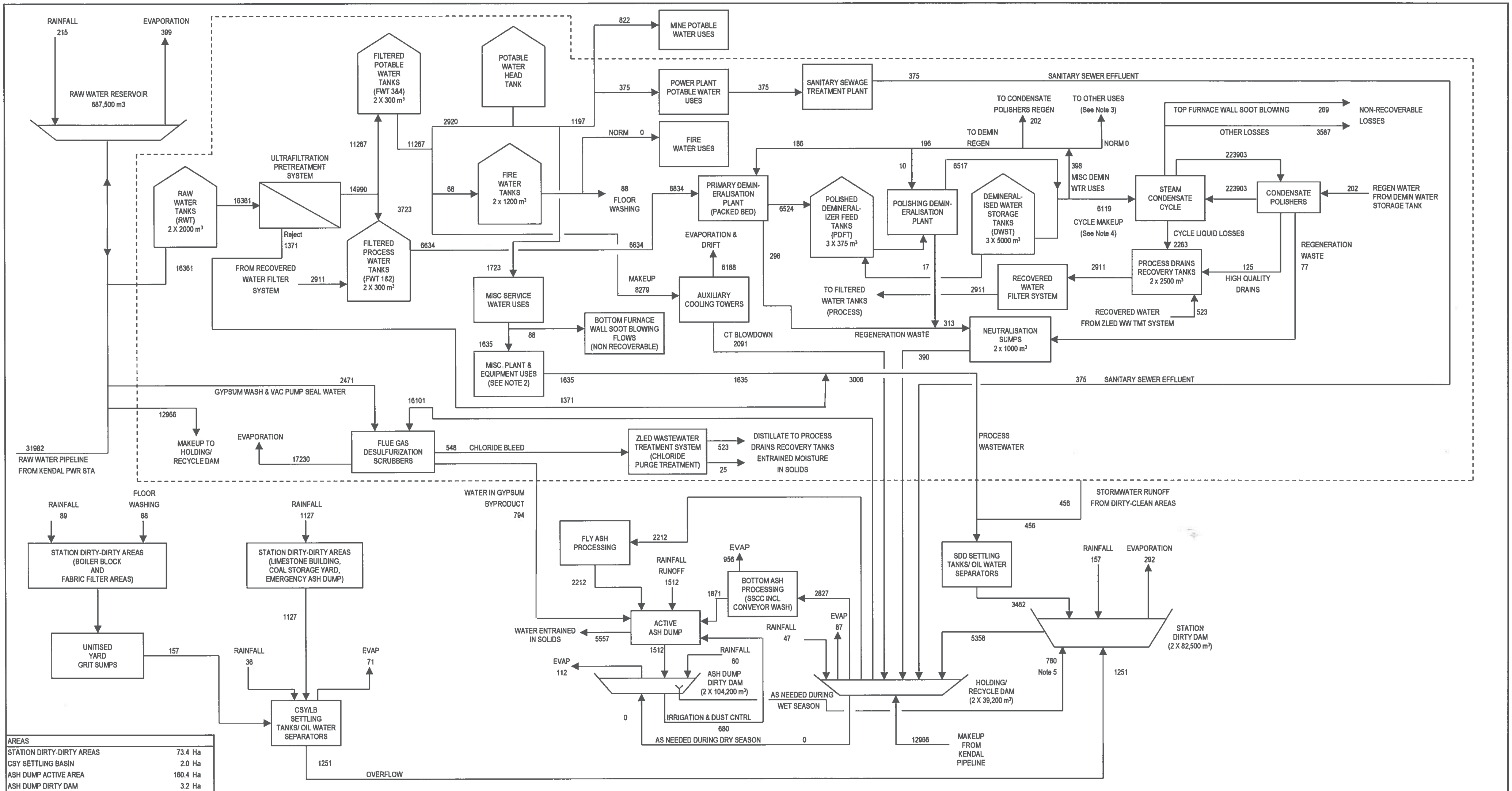
ENGINEERED BY:	DRM	DATE:	2/14/2008
DRAWN BY:	DRM	DATE:	2/14/2008
CHECKED BY:	KRW	DATE:	2/19/2008

CLIENT: ESKOM
PROJECT: KUSILE POWER STATION
PROJECT NO.: 146838
DRAWING: WMB-1B
REV: 8
TITLE: WATER MASS BALANCE NO RAINFALL CASE

USER: WEI04450
FILE: M:\Projects\146838 Project Bravo\Water Mass Balances\Water Mass Balances\BRAVO WMB 10 20 2008.xls]PFD W FGD PURGE TMT
DATE: 9/29/11 12:17:20



AREAS	
STATION DIRTY-DIRTY AREAS	73.4 Ha
CSY SETTLING BASIN	2.0 Ha
ASH DUMP ACTIVE AREA	160.4 Ha
ASH DUMP DIRTY DAM	3.2 Ha
HOLDING/RECYCLE POND	2.5 Ha
STATION DIRTY-CLEAN AREAS	29.7 Ha
STATION DIRTY DAM & STILLING BASIN	8.4 Ha
GRIT SUMPS CATCHMENT AREA	4.8 Ha

NOTES
1 Values given are in m3/day.
2 Misc. service water uses include ACC washing, hose bibs, seal water, etc.
3 Misc. demin water uses such as closed cycle system makeup (normally 0 flow).
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REV	DATE	DESCRIPTION	BY	CHK'D	APP'D
7	8-30-10	UPDATE PER CURRENT DESIGN	DRM	KRW	KRW
8	9-27-11	UPDATE PER CURRENT DESIGN	DRM	KRW	KRW

REV	DATE	DESCRIPTION	BY	CHK'D	APP'D
0	2-14-08	INITIAL ISSUE	DRM	KRW	KRW
1	5-30-08	UPDATE	DRM	KRW	KRW
2	6-24-08	UPDATE	DRM	KRW	KRW
3	8-5-08	UPDATE	DRM	KRW	KRW
4	10-21-08	UPDATE	DRM	KRW	KRW
5	11-10-08	UPDATE	DRM	KRW	KRW
6	6-26-09	UPDATE	DRM	KRW	KRW

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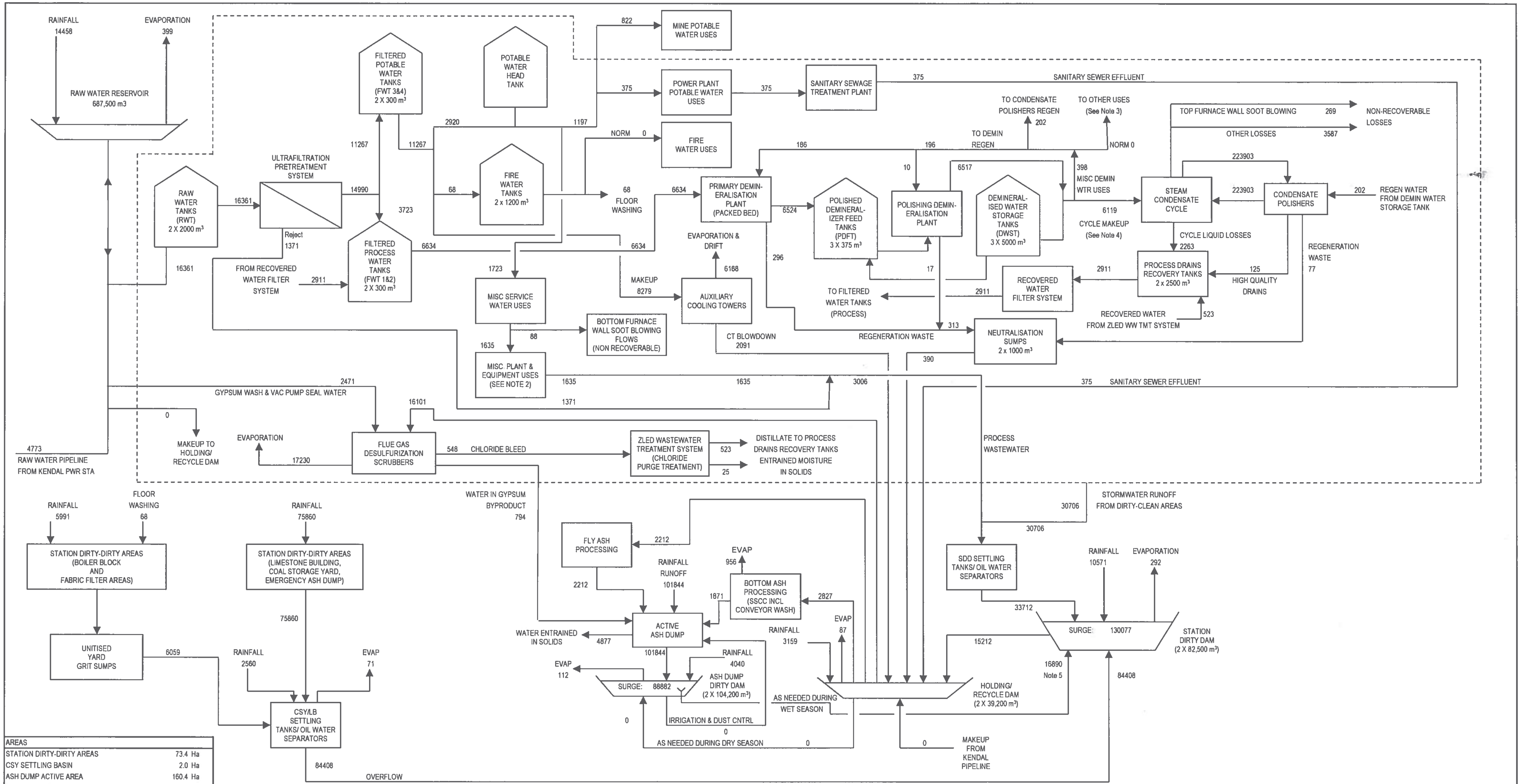
ENGINEERED BY:	DRM	DATE:	2/14/2008
DRAWN BY:	DRM	DATE:	2/14/2008
CHECKED BY:	KRW	DATE:	2/19/2008

CLIENT: ESKOM
PROJECT: KUSILE POWER STATION
PROJECT NO.: 146838
DRAWING: WMB-2B
REV: 8
TITLE: WATER MASS BALANCE ANNUAL AVG RAINFALL CASE

USER: WE04450
FILE: M:\Projects\146838 Project Bravo\Water Mass Balances\Water Mass Balances\[BRAVO WMB 10 20 2008.xls]PFD W FGD PURGE TMT
DATE: 9/29/11 12:23:06



AREAS	
STATION DIRTY-DIRTY AREAS	73.4 Ha
CSY SETTLING BASIN	2.0 Ha
ASH DUMP ACTIVE AREA	160.4 Ha
ASH DUMP DIRTY DAM	3.2 Ha
HOLDING/RECYCLE POND	2.5 Ha
STATION DIRTY-CLEAN AREAS	29.7 Ha
STATION DIRTY DAM & STILLING BASIN	8.4 Ha
GRIT SUMPS CATCHMENT AREA	4.8 Ha

NOTES
1 Values given are in m3/day.
2 Misc. service water uses include ACC washing, hose bibs, seal water, etc.
3 Misc. demin water uses such as closed cycle system makeup (normally 0 flow).
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REV	DATE	DESCRIPTION	BY	CHK'D	APP'D
7	8-30-10	UPDATE PER CURRENT DESIGN	DRM	KRW	KRW
8	9-27-11	UPDATE PER CURRENT DESIGN	DRM	KRW	KRW

REV	DATE	DESCRIPTION	BY	CHK'D	APP'D
0	2-14-08	INITIAL ISSUE	DRM	KRW	KRW
1	5-30-08	UPDATE	DRM	KRW	KRW
2	6-24-08	UPDATE	DRM	KRW	KRW
3	8-5-08	UPDATE	DRM	KRW	KRW
4	10-21-08	UPDATE	DRM	KRW	KRW
5	11-10-08	UPDATE	DRM	KRW	KRW
6	6-26-09	UPDATE	DRM	KRW	KRW

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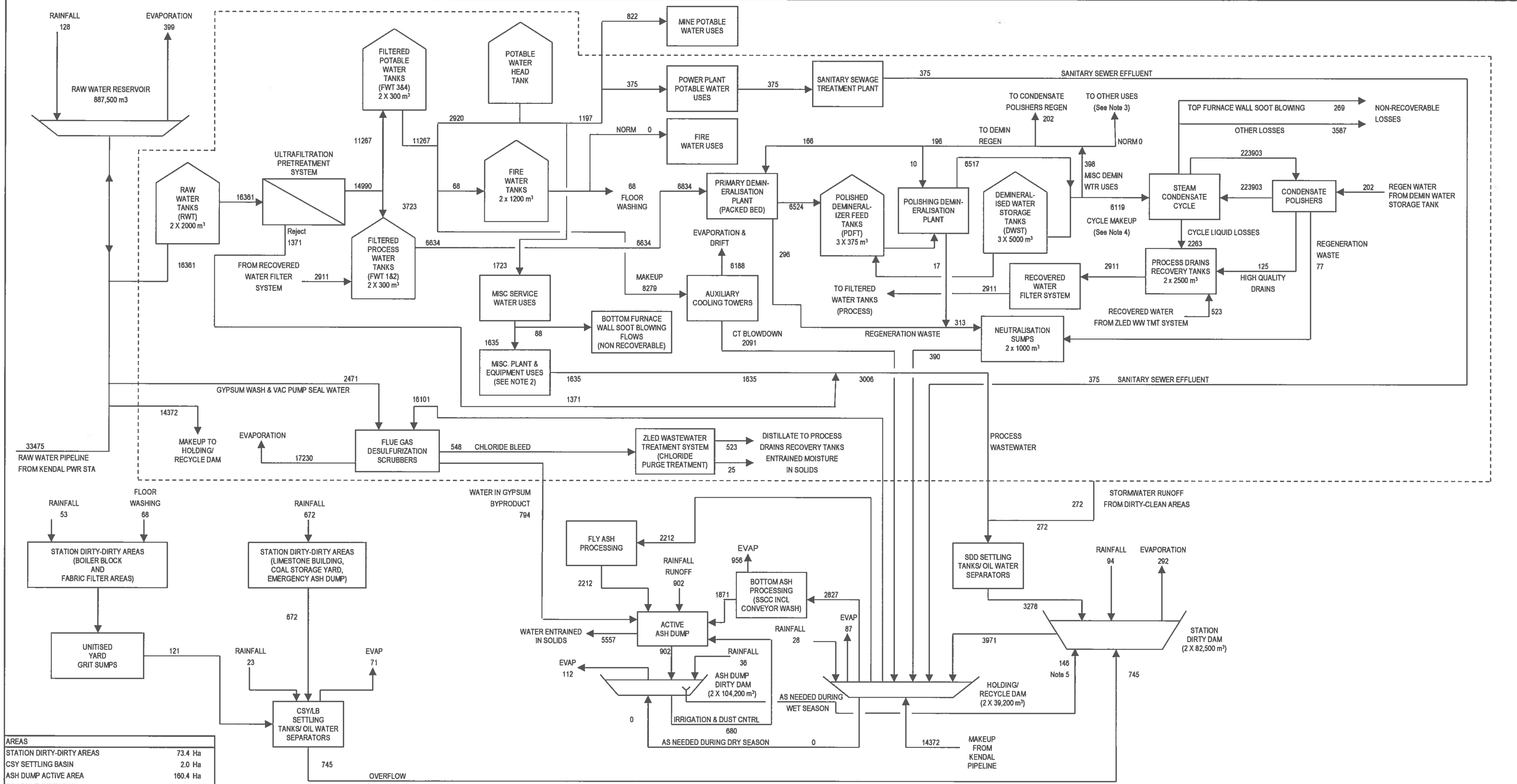
ENGINEERED BY:	DRM	DATE:	2/14/2008
DRAWN BY:	DRM	DATE:	2/14/2008
CHECKED BY:	KRW	DATE:	2/19/2008

CLIENT: ESKOM
PROJECT: KUSILE POWER STATION
PROJECT NO.: 146838
DRAWING: WMB-6B
REV: 8
TITLE: WATER MASS BALANCE 1-DAY, 50-YEAR EVENT

USER: WE04450
FILE: M:\Projects\146838 Project Bravo\Water Mass Balances\Water Mass Balances\[BRAVO WMB 10 20 2008.xls]PFD W FGD PURGE TMT
DATE: 9/29/11 12:25:40



AREAS	
STATION DIRTY-DIRTY AREAS	73.4 Ha
CSY SETTLING BASIN	2.0 Ha
ASH DUMP ACTIVE AREA	160.4 Ha
ASH DUMP DIRTY DAM	3.2 Ha
HOLDING/RECYCLE POND	2.5 Ha
STATION DIRTY-CLEAN AREAS	29.7 Ha
STATION DIRTY DAM & STILLING BASIN	8.4 Ha
GRIT SUMPS CATCHMENT AREA	4.8 Ha

NOTES
1 Values given are in m3/day.
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REV	DATE	DESCRIPTION	BY	CHK'D	APP'D	REV	DATE	DESCRIPTION	BY	CHK'D	APP'D
						0	9-27-11	INITIAL ISSUE	DRM	KRW	KRW

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ENGINEERED BY:	DRM	DATE:	2/14/2008
DRAWN BY:	DRM	DATE:	2/14/2008
CHECKED BY:	KRW	DATE:	2/19/2008

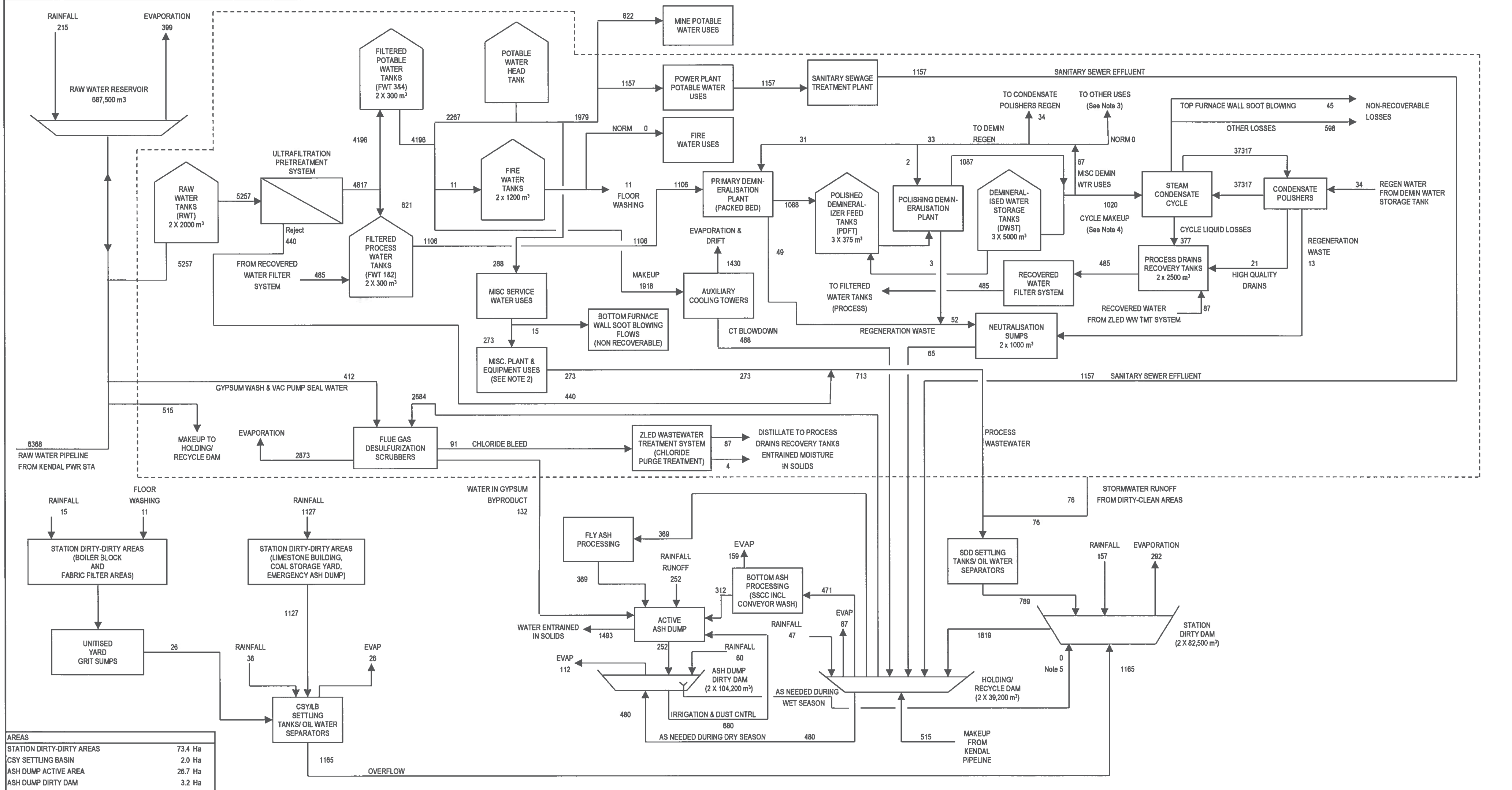
CLIENT: ESKOM

PROJECT NO.: 146838 DRAWING: WMB-12 REV: 0

PROJECT: KUSILE POWER STATION

TITLE: WATER MASS BALANCE LOW RAINFALL YEAR CASE

USER: WEI04450
FILE: M:\Projects\146838 Project Bravo\Water Mass Balances\Water Mass Balances\BRAVO WMB 10.20.2008.xls]PFD W FGD PURGE TMT
DATE: 9/29/11 12:28:20



AREAS	
STATION DIRTY-DIRTY AREAS	73.4 Ha
CSY SETTLING BASIN	2.0 Ha
ASH DUMP ACTIVE AREA	28.7 Ha
ASH DUMP DIRTY DAM	3.2 Ha
HOLDING/RECYCLE POND	2.5 Ha
STATION DIRTY-CLEAN AREAS	5.0 Ha
STATION DIRTY DAM & STILLING BASIN	8.4 Ha
GRIT SUMPS CATCHMENT AREA	0.8 Ha

NOTES
1 Values given are in m3/day.
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REV	DATE	DESCRIPTION	BY	CHK'D	APP'D	REV	DATE	DESCRIPTION	BY	CHK'D	APP'D
						0	9-27-11	INITIAL ISSUE	DRM	KRW	KRW

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ENGINEERED BY:	DRM	DATE:	2/14/2008
DRAWN BY:	DRM	DATE:	2/14/2008
CHECKED BY:	KRW	DATE:	2/19/2008

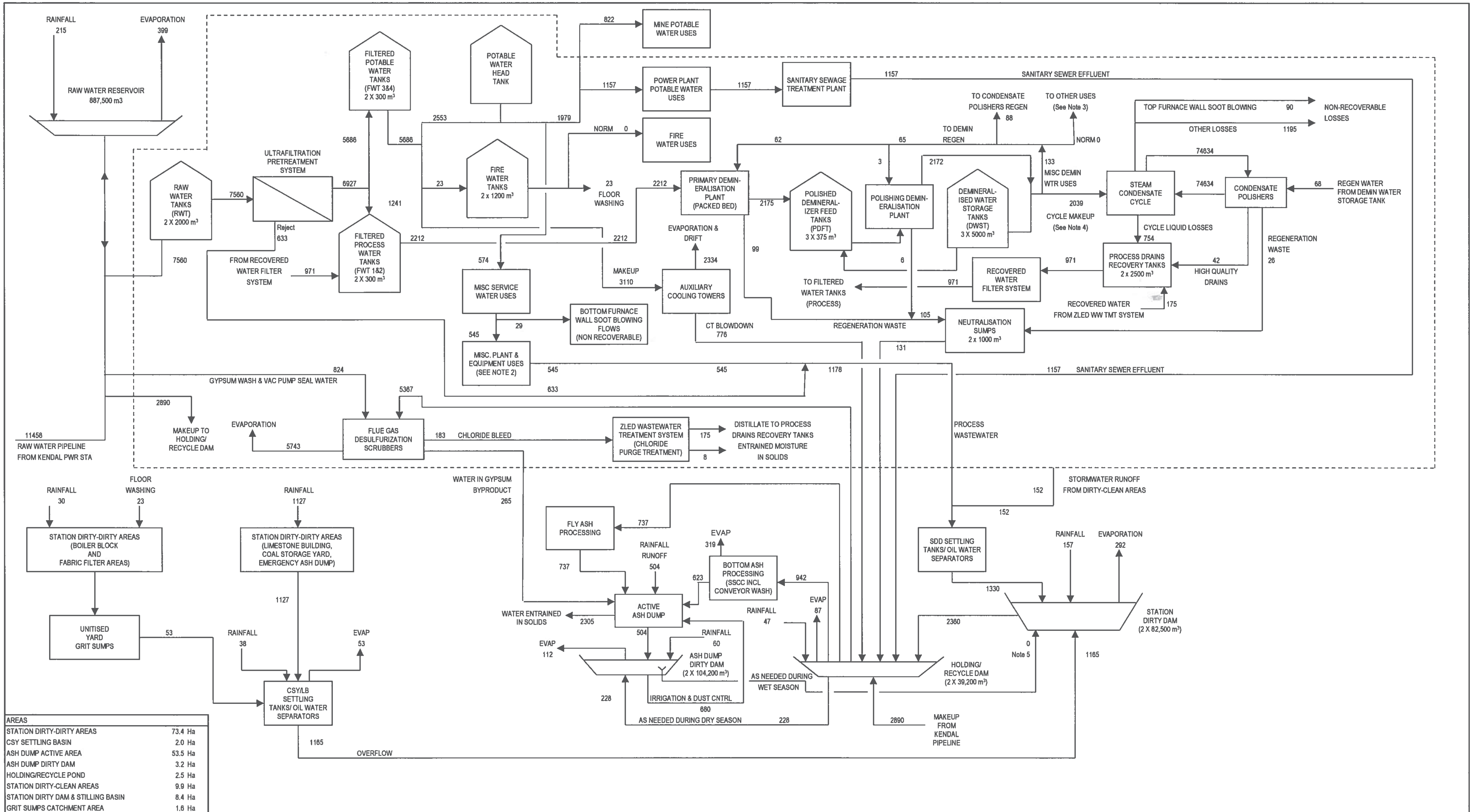
CLIENT: ESKOM

PROJECT: KUSILE POWER STATION

PROJECT NO.: 146838 DRAWING: WMB-7 REV: 0

TITLE: WATER MASS BALANCE ANNUAL AVG RAINFALL CASE CONSTRUCTION CASE - 1 UNIT OPERATIONAL

USER: WE04450
FILE: M:\Projects\146838 Project Bravo\Water Mass Balance\Water Mass Balances\[BRAVO WMB 10 20 2008.xls]PFD W FGD PURGE TMT
DATE: 9/29/11 12:36:51



AREAS	
STATION DIRTY-DIRTY AREAS	73.4 Ha
CSY SETTLING BASIN	2.0 Ha
ASH DUMP ACTIVE AREA	53.5 Ha
ASH DUMP DIRTY DAM	3.2 Ha
HOLDING/RECYCLE POND	2.5 Ha
STATION DIRTY-CLEAN AREAS	9.9 Ha
STATION DIRTY DAM & STILLING BASIN	8.4 Ha
GRIT SUMPS CATCHMENT AREA	1.6 Ha

NOTES
1 Values given are in m3/day.
2 Misc. service water uses include ACC washing, hose bibs, seal water, etc.
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REV	DATE	DESCRIPTION	BY	CHK'D	APP'D
0	9-27-11	INITIAL ISSUE	DRM	KRW	KRW

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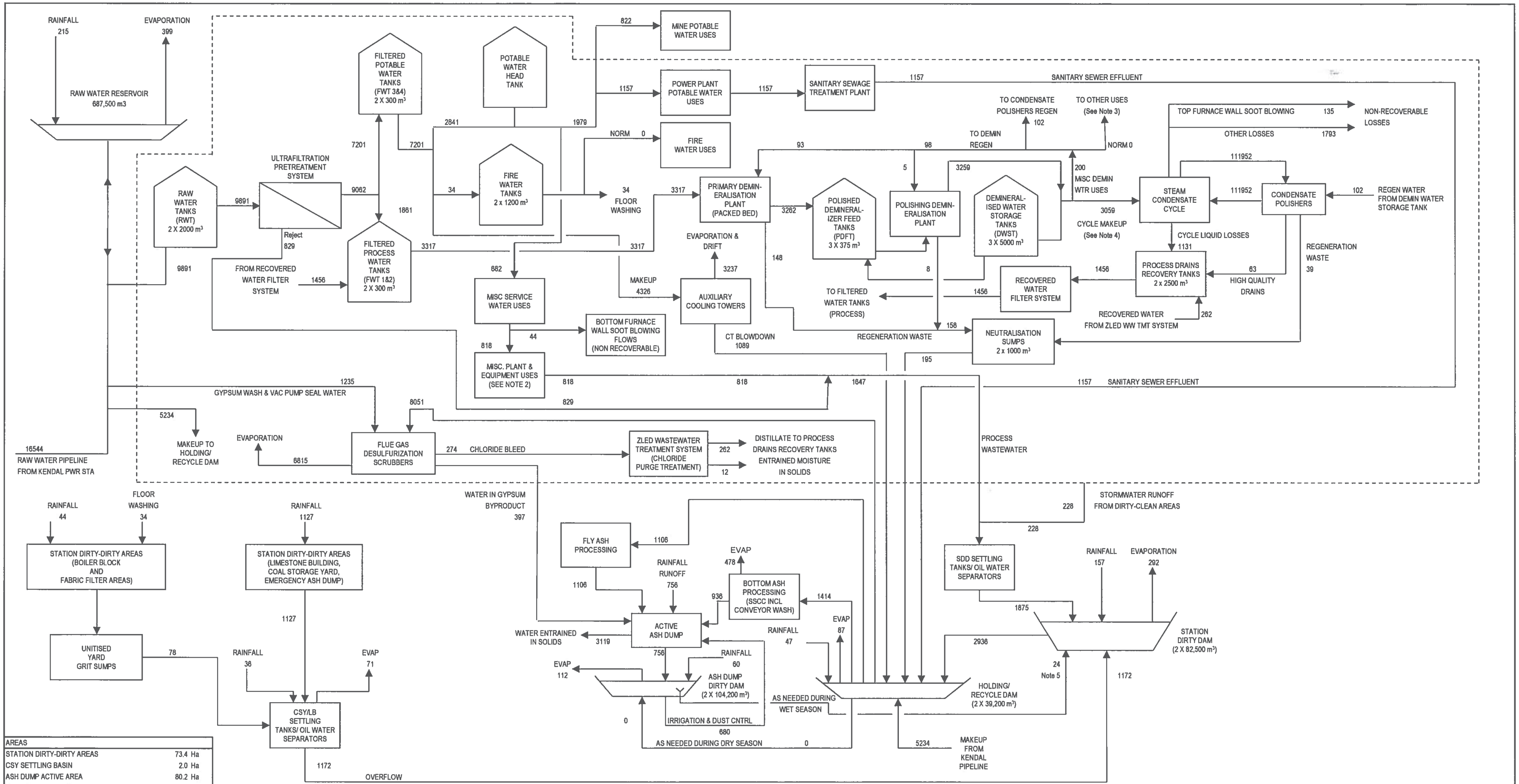
ENGINEERED BY:	DRM	DATE:	2/14/2008
DRAWN BY:	DRM	DATE:	2/14/2008
CHECKED BY:	KRW	DATE:	2/19/2008

CLIENT: ESKOM
PROJECT: KUSILE POWER STATION
PROJECT NO.: 146838
DRAWING: WMB-8
REV: 0
TITLE: WATER MASS BALANCE
ANNUAL AVG RAINFALL CASE
CONSTRUCTION CASE - 2 UNITS OPERATIONAL

USER: WEI04450
FILE: M:\Projects\146838 Project Bravo\Water Mass Balances\Water Mass Balances\BRAVO WMB 10 20 2008.xls]PFD W FGD PURGE TMT
DATE: 9/29/11 12:50:55



AREAS	
STATION DIRTY-DIRTY AREAS	73.4 Ha
CSY SETTLING BASIN	2.0 Ha
ASH DUMP ACTIVE AREA	80.2 Ha
ASH DUMP DIRTY DAM	3.2 Ha
HOLDING/RECYCLE POND	2.5 Ha
STATION DIRTY-CLEAN AREAS	14.9 Ha
STATION DIRTY DAM & STILLING BASIN	8.4 Ha
GRIT SUMPS CATCHMENT AREA	2.4 Ha

NOTES
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REV	DATE	DESCRIPTION	BY	CHK'D	APP'D	REV	DATE	DESCRIPTION	BY	CHK'D	APP'D
						0	9-27-11	INITIAL ISSUE	DRM	KRW	KRW

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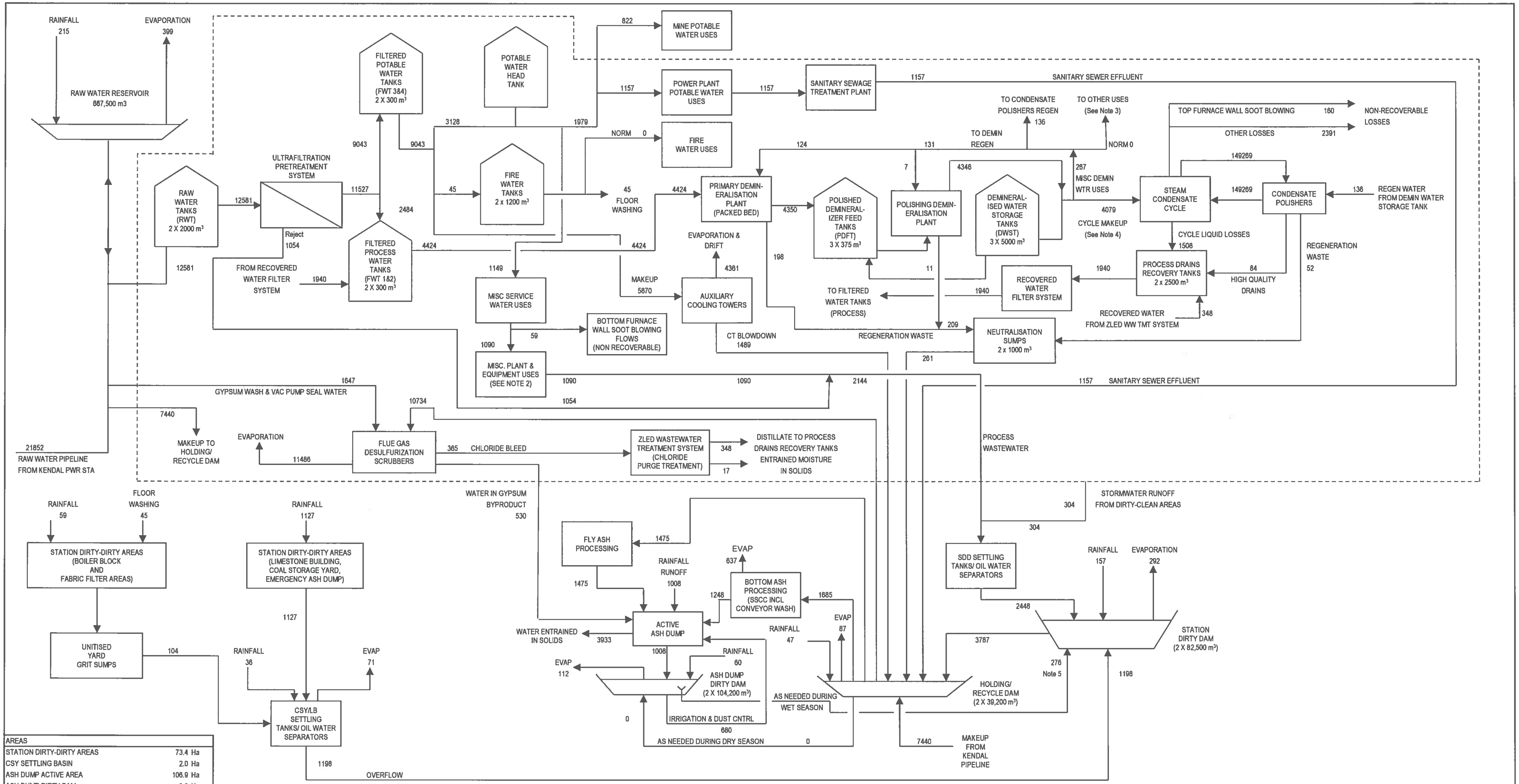
ENGINEERED BY:	DRM	DATE:	2/14/2008
DRAWN BY:	DRM	DATE:	2/14/2008
CHECKED BY:	KRW	DATE:	2/19/2008

CLIENT: ESKOM
PROJECT NO.: 146838 DRAWING: WMB-9 REV: 0
PROJECT: KUSILE POWER STATION
TITLE: WATER MASS BALANCE ANNUAL AVG RAINFALL CASE CONSTRUCTION CASE - 3 UNITS OPERATIONAL

USER: WEI04450
FILE: M:\Projects\146838 Project Bravo\Water Mass Balances\Water Mass Balances\BRAVO WMB 10 20 2008.xls]PFD W FGD PURGE TMT
DATE: 9/29/11 12:54:45



AREAS	
STATION DIRTY-DIRTY AREAS	73.4 Ha
CSY SETTLING BASIN	2.0 Ha
ASH DUMP ACTIVE AREA	106.9 Ha
ASH DUMP DIRTY DAM	3.2 Ha
HOLDING/RECYCLE POND	2.5 Ha
STATION DIRTY-CLEAN AREAS	19.8 Ha
STATION DIRTY DAM & STILLING BASIN	8.4 Ha
GRIT SUMPS CATCHMENT AREA	3.2 Ha

NOTES
1 Values given are in m3/day.
2 Misc. service water uses include ACC washing, hose bibs, seal water, etc.
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REV	DATE	DESCRIPTION	BY	CHK'D	APP'D
0	9-27-11	INITIAL ISSUE	DRM	KRW	KRW
6	6-26-09	UPDATE	DRM	KRW	KRW

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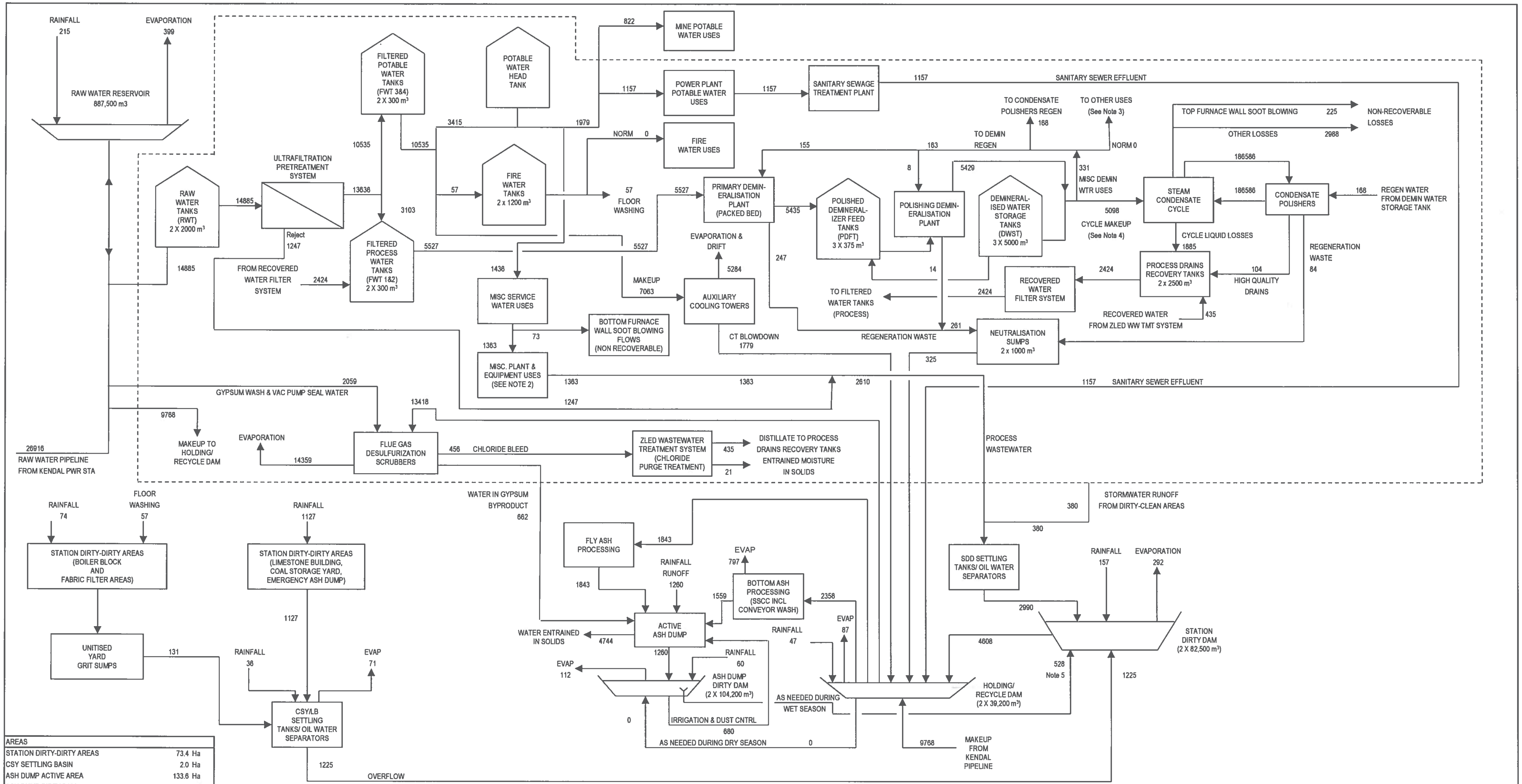
ENGINEERED BY:	DRM	DATE:	2/14/2008
DRAWN BY:	DRM	DATE:	2/14/2008
CHECKED BY:	KRW	DATE:	2/19/2008

CLIENT: ESKOM
PROJECT: KUSILE POWER STATION
PROJECT NO.: 146838 DRAWING: WMB-10 REV: 0
TITLE: WATER MASS BALANCE ANNUAL AVG RAINFALL CASE CONSTRUCTION CASE - 4 UNITS OPERATIONAL

USER: WE04450
FILE: M:\Projects\146838 Project Bravo\Water Mass Balances\[BRAVO WMB 10 20 2008.xls]PFD W FGD PURGE TMT
DATE: 9/29/11 12:58:37



AREAS	
STATION DIRTY-DIRTY AREAS	73.4 Ha
CSY SETTLING BASIN	2.0 Ha
ASH DUMP ACTIVE AREA	133.6 Ha
ASH DUMP DIRTY DAM	3.2 Ha
HOLDING/RECYCLE POND	2.5 Ha
STATION DIRTY-CLEAN AREAS	24.8 Ha
STATION DIRTY DAM & STILLING BASIN	8.4 Ha
GRIT SUMPS CATCHMENT AREA	4.0 Ha

NOTES
1 Values given are in m3/day.
2 Misc. service water uses include ACC washing, hose bibs, seal water, etc.
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REV	DATE	DESCRIPTION	BY	CHK'D	APP'D
0	9-27-11	INITIAL ISSUE	DRM	KRW	KRW

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ENGINEERED BY:	DRM	DATE:	2/14/2008
DRAWN BY:	DRM	DATE:	2/14/2008
CHECKED BY:	KRW	DATE:	2/19/2008

CLIENT: ESKOM
PROJECT: KUSILE POWER STATION
PROJECT NO.: 146838 DRAWING: WMB-11 REV: 0
TITLE: WATER MASS BALANCE ANNUAL AVG RAINFALL CASE CONSTRUCTION CASE - 5 UNITS OPERATIONAL

USER: WE00450
FILE: M:\Projects\146838 Project Bravo\Water Mass Balances\Water Mass Balances\[BRAVO WMB 10.20.2008.xls]PFD W FGD PURGE TMT
DATE: 9/29/11 13:02:36