Eskom	Report	Group Technology

Title:	**Medupi FGD Retrofit Basic Design Report**	Unique Identifier:	**200-122784**
		Alternative Reference Number:	**178771.40.1000**
		Area of Applicability:	**Engineering**
		Documentation Type:	**Report**
		Revision:	**0**
		Total Pages:	**105**
		Next Review Date:	**Not Applicable**
		Disclosure Classification:	**CONTROLLED DISCLOSURE**

Compiled by	Functional Responsibility	Authorised by
…………………………………..	…………………………………..	…………………………………..
David Harris	**Carel van Heerden**	**Danie Odendaal**
Project Manager	**EDWL**	**General Manager**
Black & Veatch	**GT – Boiler Auxiliary**	**GT – Plant Engineering**
Date: …30 September 2014………	Date: ……………………………	Date: ……………………………

CONTENTS (VOLUME I)

Page

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

TABLES

FIGURES

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

LIST OF ATTACHMENTS (VOLUME II)

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

LIST OF ATTACHMENTS (VOLUME II)

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

LIST OF ATTACHMENTS (VOLUME II)

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

LIST OF ATTACHMENTS (VOLUME II)

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

LIST OF ATTACHMENTS (VOLUME II)

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

LIST OF ATTACHMENTS (VOLUME II)

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

LIST OF ATTACHMENTS (VOLUME II)

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

OTHER BASIC DESIGN DOCUMENTS (NOT ATTACHED)

Document	SPF File Number	Document / File Number
Medupi FGD ERA Schedule (All Activities)	200-117150	178771.24.2010.26
Estimate Plan	200-93608	178771.25.2001
Medupi FGD Retrofit FGD Technology Selection Study	200-55815	178771.41.0050
Medupi FGD Retrofit FGD Technology Selection Study Design Basis	200-93484	178771.41.0051
Navisworks 3D Model	--	--
Absorber Steel Structure 1/3 & 4/6 Structural Analysis	200-109547	006265-S4010-100
Absorber Steel Structure 2 & 5 Structural Analysis	200-109557	006265-S4010-200
Structural Analysis Raw Gas Duct w/Air Cooler 1/4	200-113436	006265-S4250-110
Structural Analysis Raw Gas Duct w/Air Cooler 1/4	200-113121	006265-S4250-111
Structural Analysis Emergency Drain Tank 1	200-110260	006265-S4381-001
Structural Analysis Reclaim Tank 1 and 2	200-110449	006265-S4381-010
Structural Analysis Limestone Slurry Feed Tank	200-110749	006265-S4381-021
Gypsum Bleed Tank 1 Structural Analysis	200-110237	006265-S4381-040
Foundation Load of Raw Gas Duct Work Units 1, 3, 4, and 6	200-109111	006265-T-BER-101
CFD Flow Simulation Study	200-110113	006265-T-STD-450
Basic Data of Elevator	200-115199	006265-T-STD-460
Layout Pumphouse Unit 1	0.84/38207	006265-Z4010-211
Layout Pumphouse Unit 2	0.84/38208	006265-Z4010-212
Layout Pumphouse Unit 3	0.84/38209	006265-Z4010-213
Layout Pumphouse Unit 4	0.84/38210	006265-Z4010-214
Layout Pumphouse Unit 5	0.84/38211	006265-Z4010-215
Layout Pumphouse Unit 6	0.84/38212	006265-Z4010-216
Placement Pump Control Station Pumphouse Unit 1	0.84/38275	006265-Z4010-511
Placement Pump Control Station Pumphouse Unit 2	0.84/38276	006265-Z4010-512
Placement Pump Control Station Pumphouse Unit 3	0.84/38277	006265-Z4010-513
Placement Pump Control Station Pumphouse Unit 4	0.84/38278	006265-Z4010-514
Placement Pump Control Station Pumphouse Unit 5	0.84/38279	006265-Z4010-515
Placement Pump Control Station Pumphouse Unit 6	0.84/38280	006265-Z4010-516
Piping System Absorber Pumphouse Unit 1	0.84/38396	006265-Z4010-711
Piping System Absorber Pumphouse Unit 2	0.84/38397	006265-Z4010-712
Piping System Absorber Pumphouse Unit 3	0.84/38398	006265-Z4010-713
Piping System Absorber Pumphouse Unit 4	0.84/38399	006265-Z4010-714
Piping System Absorber Pumphouse Unit 5	0.84/38400	006265-Z4010-715
Piping System Absorber Pumphouse Unit 6	0.84/38401	006265-Z4010-716
Dewatering Steel Structure 3.Etage Belt Filter	0.84/38935	006265-Z4020-100
Gypsum Dewatering Building Layout Platform 0.000M	0.84/38057	006265-Z4020-201
Gypsum Dewatering Building Layout Platform 6.000M	0.84/38058	006265-Z4020-202
Gypsum Dewatering Building Layout Platform 16.000M	0.84/38059	006265-Z4020-203
Placement Pump Control Station Gypsum Dewatering Building +0.000M	0.84/38351	006265-Z4020-501
Placement Pump Control Station Gypsum Dewatering Building +9.000M	0.84/38352	006265-Z4020-502
Placement Pump Control Station Gypsum Dewatering Building +16.000M	0.84/38353	006265-Z4020-503
Piping System Dewatering Building 0.000M	0.84/38435	006265-Z4020-701
Piping System Dewatering Building +9.000M	0.84/38436	006265-Z4020-702
Piping System Dewatering Building +16.000M/+21.000M	0.84/38437	006265-Z4020-703
Piping System Dewatering Building Sections	0.84/38438	006265-Z4020-704
Process Area Arrangement Cluster 1	0.84/37949	006265-Z4050-100
Process Area Arrangement Cluster 2	0.84/37950	006265-Z4050-200
Limestone Steel Structure Ball Mill	0.84/38936	006265-Z4320-100

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

OTHER BASIC DESIGN DOCUMENTS (NOT ATTACHED)

Document	SPF File Number	Document / File Number
Limestone Preparation Building Layout 0.00	0.84/38193	006265-Z4320-201
Limestone Preparation Building Layout 20.00	0.84/38194	006265-Z4320-202
Layout; limestone building, control and placement 0.00 m	0.84/38053	006265-Z4320-501
Layout; limestone building, control and placement 20.00 m	0.84/38054	006265-Z4320-502
Piping System Limestone Building 0.00M	0.84/38402	006265-Z4320-701
Piping System Limestone Building+20.0M	0.84/38403	006265-Z4320-702
Piping System Limestone Building Sections	0.84/38404	006265-Z4320-703
Layout Gypsum Bleed Tank Area Placement Pump Control	0.84/38055	006265-Z4330-501
Steelplatform Rezi Pump Pumphouse Unit 1	0.84/38933	006265-Z4380-100
Steelplatform Rezi Pump Pumphouse Unit 2/5	0.84/38952	006265-Z4380-110
Steelplatform Rezi Pump Pumphouse Unit 3/6	0.84/38953	006265-Z4380-120
Process Area Arrangement Drain Tank 1	0.84/38940	006265-Z4381-001
Process Area Arrangement Reclaim Water Tank 1	0.84/38354	006265-Z4381-010
Process Area Arrangement Reclaim Water Tank 2	0.84/38375	006265-Z4381-011
Limestone Feed Tank 1 Arrangement	0.84/38228	006265-Z4381-020
Limestone Feed Tank 2 Arrangement	0.84/38229	006265-Z4381-021
Process Area Arrangement Process Water Tank 1	0.84/38943	006265-Z4381-030
Process Area Arrangement Process Water Tank 2	0.84/38944	006265-Z4381-031
Process Area Arrangement Process Water Tank 3	0.84/38941	006265-Z4381-032
Process Area Arrangement Gypsum Bleed Tank 1	0.84/28879	006265-Z4381-040
Process Area Arrangement Waste Water Hydrocyclone Feed Tank 1&2	0.84/38222	006265-Z4381-050
Process Area Arrangement Filtrate Rcv Tank and Pump	0.84/38223	006265-Z4381-060
Process Area Arrangement Filtrate Rcv Tank 1&2	0.84/38224	006265-Z4381-065
Process Area Arrangement Cloth Wash Tank	0.84/38225	006265-Z4381-070
Process Area Arrangement Cake Wash Tank and Pump Skid	0.84/38226	006265-Z4381-075
Limestone Ball Mill Circulation Tank Arrangement	0.84/38227	006265-Z4381-120
Platform Oxi-Blower Pumphouse Unit 1	0.84/38934	006265-Z4385-100
Platform Oxi-Blower Pumphouse Unit 2/5	0.84/38954	006265-Z4385-110
Platform Oxi-Blower Pumphouse Unit 3/6	0.84/38955	006265-Z4385-120
Gypsum & Emergency Drain Tanks Foundation Plan	0.84/32840 sht. 1	
Gypsum Bleed Tank Plan, Section And Elevations	0.84/32841 sht. 1	
Emergency Drain Tank Plan, Section &Elevation	0.84/32842 sht. 1	
Gypsum & Emergency Drain Tanks Foundation, Reinforcement Layout And Details	0.84/35855 sht. 1	
Basic Design Calculation File, Emergency Drain Tank and Gypsum Bleed Tank Foundation Design	200-92903	
Makeup Water Pre-Treatment Area, Sodium Hypochlorite Tank Foundation and Bund Area, Concrete and Reinforcement Details	0.84/36625 sht. 1	
Make Up Water Pre-Treatment Area Sump Concrete and Reinforcement Details	0.84/36625 sht. 2	
Gypsum Dewatering Plant, Ground Floor at 902. 400 Level, Concrete Layout	0.84/36806 sht. 1	
Gypsum Dewatering Plant, Floor at 911. 400 Level T.O.C, General Arrangement	0.84/36806 sht. 2	
Gypsum Dewatering Plant, Floor at 918. 400 Level T.O.C, General Arrangement	0.84/36806 sht. 3	
Gypsum Dewatering Plant, Platform at 920. 800 Level T.O.C, General Arrangement	0.84/36806 sht. 4	

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

OTHER BASIC DESIGN DOCUMENTS (NOT ATTACHED)

Document	SPF File Number	Document / File Number
Gypsum Dewatering Plant, Floor at 924. 400 Level T.O.C, General Arrangement	0.84/36806 sht. 5	
Gypsum Dewatering Plant, Plan On Roof, General Arrangement	0.84/36806 sht. 6	
Gypsum Dewatering Plant, East Elevation	0.84/36806 sht. 7	
Gypsum Dewatering Plant, West Elevation	0.84/36806 sht. 8	
Gypsum Dewatering Plant, North And South Elevations	0.84/36806 sht. 9	
Gypsum Dewatering Plant, Section A-A	0.84/36806 sht. 10	
Gypsum Dewatering Plant, Section B-B	0.84/36806 sht. 11	
Gypsum Dewatering Plant, Crawl Beams Below Trusses, General Arrangement	0.84/36806 sht. 12	
Gypsum Dewatering Building, Foundation Concrete Layout and Details	0.84/36806 sht. 13	
Gypsum Dewatering Building, Foundation Reinforcement Layout and Details	0.84/36806 sht. 14	
Limestone Preparation Building, Steelwork, General Arrangement Plans	0.84/36914 sht. 1	
Limestone Preparation Building, Steelwork, General Arrangement, Elevations And Section	0.84/36914 sht. 2	
Limestone Preparation Building, Ball Mill Hall Foundations	0.84/36914 sht. 3	
FGD Common Substation, Slab at +2. 720m Level Concrete Layout and Details	0.84/36915 sht. 1	
FGD Common Substation, Slab at +7. 530m Level Concrete Layout and Details	0.84/36915 sht. 2	
FGD Common Substation, General Arrangement, Roof Layout	0.84/36915 sht. 3	
FGD Common Substation, General Arrangement Elevations	0.84/36915 sht. 4	
FGD Common Substation, General Arrangement Sections	0.84/36915 sht. 5	
FGD Common Substation, Beams For Slab at +2.720m Level, Reinforcement Details	0.84/36915 sht. 6	
FGD Common Substation, Beams For Slab at +2.720m Level, Reinforcement Details	0.84/36915 sht. 7	
FGD Common Substation, Ribs For Slab at +2.720m Level, Reinforcement Details	0.84/36915 sht. 8	
FGD Common Substation, Beams For Slab at +7.530m Level, Reinforcement Details	0.84/36915 sht. 9	
FGD Common Substation, Beams For Slab at +7.530m Level, Reinforcement Details	0.84/36915 sht. 10	
FGD Common Substation, Ribs For Slab at +7.530m Level, Reinforcement Details	0.84/36915 sht. 11	
FGD Common Substation, Typical Foundation Details For Corner Column Foundations	0.84/36915 sht. 12	
FGD Common Substation, Typical Foundation Details For Edge Column Foundations	0.84/36915 sht. 13	
FGD Common Substation, Typical Foundation Details For Interior Column Foundations	0.84/36915 sht. 14	
FGD Common Substation, Typical Foundation Details Starter Bars For All Foundations	0.84/36915 sht. 15	
FGD Make Up Water Pre Treatment Building, Steel General Arrangement	0.84/37850 sht. 1	
FGD Makeup Water Pre Treatment Building, Foundation Layout	0.84/37850 sht. 2	

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

OTHER BASIC DESIGN DOCUMENTS (NOT ATTACHED)

Document	SPF File Number	Document / File Number
FGD Makeup Water Pre Treatment Building, Foundation Reinforcement	0.84/37850 sht. 3	
Absorber Pump House Unit 6, Plan Level 902. 400, Steel Col. Layout	0.84/37852 sht. 1	
Absorber Pump House Unit 6, General Arrangement, Roof Layout	0.84/37852 sht. 2	
Absorber Pump House Unit 6, Sections, Column Lines 1F and 2F	0.84/37852 sht. 3	
Absorber Pump House Unit 6, Sections, Column Lines 3F and F-F	0.84/37852 sht. 4	
Absorber Pump House Unit 6, Sections, Column Lines 1AB; 5F; 7F and 8F	0.84/37852 sht. 5	
Absorber Pump House Unit 6, Load Bearing Truss Col.Line GF and HF	0.84/37852 sht. 6	
Absorber Pump House Unit 6, Load Bearing Truss Col.Line EF and FF	0.84/37852 sht. 7	
Absorber Pump House Unit 6, Load Bearing Truss Col.Line CF and DF	0.84/37852 sht. 8	
Absorber Pump House Unit 6, Load Bearing Truss Col.Line AF and BF	0.84/37852 sht. 9	
Absorber Pump House Unit 6, Column Footing Layout	0.84/37852 sht. 10	
Absorber Pump House Unit 6, Column Footing Details	0.84/37852 sht. 11	
Absorber Pump House Unit 6, Floor Plan Level 902,400	0.84/37935 sht. 1	
Absorber Pump House Unit 6 Floor Plan Level 905,800	0.84/37935 sht. 2	
Absorber Pump House & Substation Unit 6, Roof Plan	0.84/37935 sht. 3	
Absorber Pump House & Substation Unit 6, Section A-A & C-C	0.84/37935 sht. 4	
Absorber Pump House & Substation Unit 6, Section B-B & D-D	0.84/37935 sht. 5	
Absorber Pump House & Substation Unit 6 Section E-E & F-F	0.84/37935 sht. 6	
Absorber Pump House & Substation Unit 6 Elevations - North & East	0.84/37935 sht. 7	
Absorber Pump House & Substation Unit 6 Elevations - South & West	0.84/37935 sht. 8	
FGD Common Substation, Floor Plan at Level 902.400	0.84/37936 sht. 1	
FGD Common Substation, Floor Plan at Level 905.120	0.84/37936 sht. 2	
FGD Common Substation, Floor Plan At Level 909.625	0.84/37936 sht. 3	
FGD Common Substation, Sections A-A and B-B	0.84/37936 sht. 4	
FGD Common Substation, Elevations North and South	0.84/37936 sht. 5	
Gypsum Dewatering Plant, Plan Level 902.400	0.84/37937 sht. 1	
Gypsum Dewatering Plant, Plan Level 911.400	0.84/37937 sht. 2	
Gypsum Dewatering Plant, Plan Level 918.400	0.84/37937 sht. 3	
Gypsum Dewatering Plant, Plan Level 924.400	0.84/37937 sht. 4	
Gypsum Dewatering Plant, Plan Roof Level	0.84/37937 sht. 5	
Gypsum Dewatering Plant, Section A-A	0.84/37937 sht. 6	
Gypsum Dewatering Plant, Section B-B	0.84/37937 sht. 7	
Gypsum Dewatering Plant, Elevations	0.84/37937 sht. 8	
Limestone Preparation Building, Floor Plan Level 902.400	0.84/37938 sht 1	
Limestone Preparation Building, Floor Plan Level 902.400	0.84/37938 sht 2	
Limestone Preparation Building, Elevations North & South	0.84/37938 sht 3	
Limestone Preparation Building, Elevations West & East	0.84/37938 sht 4	

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

OTHER BASIC DESIGN DOCUMENTS (NOT ATTACHED)

Document	SPF File Number	Document / File Number
Limestone Preparation Building, Limestone Silo Gallery P/S/E	0.84/37939 sht. 1	
Makeup Water Pretreatment Building, Floor Plans	0.84/37940 sht. 1	
Makeup Water Pretreatment Building, Sections	0.84/37940 sht. 2	
Makeup Water Pretreatment Building, Elevations	0.84/37940 sht. 3	
Limestone Offloading Building, Floor Plan Level 895.800	0.84/37941 sht. 1	
Limestone Offloading Building, Floor Plan Level 902.400	0.84/37941 sht. 2	
Limestone Offloading Building, Section A-A	0.84/37941 sht. 3	
Limestone Offloading Building, Section B-B	0.84/37941 sht. 4	
Limestone Offloading Building, Elevations North and West	0.84/37941 sht. 5	
Limestone Offloading Building, Elevations South and East	0.84/37941 sht. 6	
Common Pump Building, Floor Plan Level 902.400	0.84/37942 sht. 1	
Common Pump Building, Sections A-A and B-B	0.84/37942 sht. 2	
Common Pump Building, Elevations	0.84/37942 sht. 3	
Gypsum Storage Building, Floor Plan Level 902.400	0.84/37943 sht. 1	
Gypsum Storage Building, Section A-A	0.84/37943 sht. 2	
Gypsum Storage Building, Elevations South and West	0.84/37943 sht. 3	
Gypsum Storage Building, Elevations North And East	0.84/37943 sht. 4	
Limestone and Gypsum Handling Substation, Ground Floor Plan Level 902,400	0.84/37944 sht. 1	
Limestone and Gypsum Handling Substation, Ground Floor Plan Level 905,100	0.84/37944 sht. 2	
Limestone and Gypsum Handling Substation, Sections A-A & B-B	0.84/37944 sht. 3	
Limestone and Gypsum Handling Substation, Elevations North & East	0.84/37944 sht. 4	
Limestone and Gypsum Handling Substation, Elevations South & West	0.84/37944 sht. 5	
Diesel Generator Building, Ground Floor Plan	0.84/37945 sht. 1	
Diesel Generator Building, Sections A-A & B-B	0.84/37945 sht. 2	
Diesel Generator Building, Elevations	0.84/37945 sht. 3	
ZLD Treatment Building, Floor Plan Level 902.400	0.84/37946 sht. 1	
ZLD Treatment Building, Floor Plan Level 905.600	0.84/37946 sht. 2	
ZLD Treatment Building, Floor Plan Level 911.600	0.84/37946 sht. 3	
ZLD Treatment Building, Section A-A	0.84/37946 sht. 4	
ZLD Treatment Building, Section B-B	0.84/37946 sht. 5	
ZLD Treatment Building, Elevations East and South	0.84/37946 sht. 6	
ZLD Treatment Building, Elevations West and North	0.84/37946 sht. 7	
Absorber Substation Unit 6, Cable Room Plan Level 902,400	0.84/37947 sht. 1	
Absorber Substation Unit 6, Switchgear Room Plan Level 905,800	0.84/37947 sht. 2	
Absorber Substation Unit 6, HVAC Room Plan Level 911,800	0.84/37947 sht. 3	
Emergency Generator Substation, Ground Floor Plan Level 902,400	0.84/37948 sht. 1	
Emergency Generator Substation, First Floor Plan Level 905,800	0.84/37948 sht. 2	
Emergency Generator Substation, Section A-A & B-B	0.84/37948 sht. 3	
Emergency Generator Substation, Elevations North & East	0.84/37948 sht. 4	
Emergency Generator Substation, Elevations South & West	0.84/37948 sht. 5	
Diesel Generator Building, Roof Plan and Sections	0.84/38294 sht. 1	

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

OTHER BASIC DESIGN DOCUMENTS (NOT ATTACHED)

Document	SPF File Number	Document / File Number
Diesel Generator Building, Elevations	0.84/38294 sht. 2	
Diesel Generator Building, Foundations and Wall Footings Concrete Layout and Details	0.84/38294 sht. 3	
Diesel Generator Building, Foundations and Wall Footings Reinforcement Layout and Details	0.84/38294 sht. 4	
Diesel Generator Building, FGD, Floor Slab Concrete Layout and Details	0.84/38294 sht. 5	
Common Pump Building, General Arrangement of Steelwork, Roof Plan and Sections	0.84/38434 sht. 1	
Common Pump Building, General Arrangement of Steelwork, Elevations	0.84/38434 sht. 2	
Common Pump Building, Foundations	0.84/38434 sht. 3	
Limestone and Gypsum Handling Substation, Slab at 905.100 Level Concrete Layout and Details	0.84/38510 sht. 1	
Limestone and Gypsum Handling Substation, General Arrangement of Steelwork, Roof Plan and Section	0.84/38510 sht. 2	
Limestone and Gypsum Handling Substation, General Arrangement of Steelwork, Elevations	0.84/38510 sht. 3	
Limestone and Gypsum Handling Substation, Beams B1 to B6 at 905. 100 Level Reinforcement Details	0.84/38510 sht. 4	
Limestone and Gypsum Handling Substation, Beams B7 to B12 at 905. 100 Level Reinforcement Details	0.84/38510 sht. 5	
Limestone and Gypsum Handling Substation, Slab at 905.100 Level Reinforcement Layout and Details	0.84/38510 sht. 6	
Limestone and Gypsum Handling Substation, Foundations	0.84/38510 sht. 7	
Limestone and Gypsum Handling Substation, Foundations	0.84/38510 sht. 8	
Silos at Limestone Preparation, Steelwork General Arrangement Plans	0.84/38932 sht. 1	
Silos at Limestone Preparation, Steelwork General Arrangement North And East Elevations	0.84/38932 sht. 2	
Limestone Silo Support Structure, Foundations	0.84/38932 sht. 3	
Gypsum Storage Building, Foundations Concrete Layout and Details	0.84/38947 sht 1	
Gypsum Storage Building, General Arrangement of Steelwork Ground Floor Plan	0.84/38947 sht 2	
Gypsum Storage Building, General Arrangement of Steelwork Roof Plan	0.84/38947 sht 3	
Gypsum Storage Building, General Arrangement of Steelwork North And South Elevations	0.84/38947 sht 4	
Gypsum Storage Building, General Arrangement of Steelwork North And South Elevations	0.84/38947 sht 5	
Gypsum Storage Building, General Arrangement of Steelwork Section A-A	0.84/38947 sht 6	
Gypsum Storage Building, Conveyor Gallery General Arrangement of Steelwork	0.84/38947 sht 7	
ZLD Treatment Building, Foundation Concrete Layout and Details	0.84/38948 sht 1	
ZLD Treatment Building, Ground Floor at 902.400 Level Concrete Layout and Details	0.84/38948 sht 3	
ZLD Treatment Building, Ground Floor at 905.600 and 909. 900 Level Concrete Layout and Details	0.84/38948 sht 4	
ZLD Treatment Building, Ground Floor at 911.600 Level Concrete Layout and Details	0.84/38948 sht 5	

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

OTHER BASIC DESIGN DOCUMENTS (NOT ATTACHED)

Document	SPF File Number	Document / File Number
ZLD Treatment Building, General Arrangement of Steelwork Roof Plan	0.84/38948 sht 6	
ZLD Treatment Building, General Arrangement of Steelwork North And South Elevations	0.84/38948 sht 7	
ZLD Treatment Building, General Arrangement of Steelwork East And West Elevations	0.84/38948 sht 8	
ZLD Treatment Building, General Arrangement of Steelwork Sections	0.84/38948 sht 9	
Absorber Substation Unit 6, Floor at 902.400 Level Concrete Layout and Details	0.84/38949 sht. 1	
Absorber Substation Unit 6, Floor at 905.800 Level Concrete Layout and Details	0.84/38949 sht. 2	
Absorber Substation Unit 6, Floor at 911.800 Level Concrete Layout and Details	0.84/38949 sht. 3	
Absorber Substation Unit 6, General Arrangement, West Elevation	0.84/38949 sht. 4	
Absorber Substation Unit 6, General Arrangement, Sections	0.84/38949 sht. 5	
Absorber Substation Unit 6, General Arrangement of Roof	0.84/38949 sht. 6	
Absorber Substation Unit 6, Beams at 905.800 Level Reinforcement Details	0.84/38949 sht. 7	
Absorber Substation Unit 6, Beams at 911.800 Level Reinforcement Details	0.84/38949 sht. 8	
Absorber Substation Unit 6, Slab at 905.800 Level Reinforcement Details	0.84/38949 sht. 9	
Absorber Substation Unit 6, Slab at 905.800 Level Reinforcement Details	0.84/38949 sht. 10	
Absorber Substation Unit 6, Column Foundations and Wall Footings, Concrete Layout	0.84/38949 sht. 11	
Absorber Substation Unit 6, Column at Grid Line CE, DE X 2E, 3E Reinforcement Details	0.84/38949 sht. 12	
Essential Services Substation, Foundation Layout	0.84/38950 sht 1	
Essential Services Substation, Foundations	0.84/38950 sht 2	
Emergency Generator Substation, Floor at 902.400 Level Concrete Layout and Details	0.84/38950 sht 3	
Emergency Generator Substation, Floor at 905.800 Level Concrete Layout and Details	0.84/38950 sht 4	
Emergency Generator Substation, Floor at 911.300 Level Concrete Layout and Details	0.84/38950 sht 5	
Emergency Generator Substation, General Arrangement of Steelwork Layout of Roof	0.84/38950 sht 6	
Emergency Generator Substation, General Arrangement of Steelwork North And East Elevations	0.84/38950 sht 7	
Emergency Generator Substation, General Arrangement of Steelwork South And West Elevations	0.84/38950 sht 8	
Emergency Generator Substation General Arrangement of Steelwork Sections	0.84/38950 sht 9	
Emergency Generator Substation, Column and Ring Beam Reinforcement Details	0.84/38950 sht 10	
Emergency Generator Substation, Beams at 905.800 Level Reinforcement Details	0.84/38950 sht 11	
Emergency Generator Substation, Floor at 905.800 Level Reinforcement Layout and Details	0.84/38950 sht 12	

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

OTHER BASIC DESIGN DOCUMENTS (NOT ATTACHED)

Document	SPF File Number	Document / File Number
Limestone Offloading Building, Ground Floor at 902.400 Level Layout	0.84/38964 sht 1	
Limestone Offloading Building, General Arrangement of Steelwork, Roof Plan and Sections	0.84/38964 sht 2	
Limestone Offloading Building, General Arrangement of Steelwork North Elevation	0.84/38964 sht 3	
Limestone Offloading Building, General Arrangement of Steelwork South Elevation	0.84/38964 sht 4	
Limestone Offloading Building, General Arrangement of Steelwork East Elevation	0.84/38964 sht 5	
Limestone Offloading Building, General Arrangement of Steelwork West Elevation	0.84/38964 sht 6	
Limestone Offloading Building, General Arrangement of Steelwork Sections	0.84/38964 sht 7	
Limestone Unloading and Receiving Building, Foundations	0.84/38964 sht 8	
Limestone Unloading and Receiving Building, Foundations	0.84/38964 sht 9	
Limestone Unloading and Receiving Building, Foundations	0.84/38964 sht 10	
Limestone Unloading and Receiving Building, Foundations	0.84/38964 sht 11	
Limestone Unloading and Receiving Building, Foundations	0.84/38964 sht 12	
Limestone Unloading and Receiving Building, Foundations	0.84/38964 sht 13	
Limestone Unloading and Receiving Building, Foundations	0.84/38964 sht 14	
Limestone Unloading and Receiving Building, Foundations	0.84/38964 sht 15	
Limestone Unloading and Receiving Building, Foundations	0.84/38964 sht 16	
Limestone Unloading and Receiving Building, Foundations	0.84/38964 sht 17	
Soil Borings Location Coordinates, sheet 1 of 2	0.84/39029 sht 1	178771-DS-00001
Soil Borings Location Coordinates, sheet 2 of 2	0.84/39029 sht 2	178771-DS-00002
Basic Design Calculation File, FGD Makeup Water Pre-Treatment Area: Sodium Hypochlorite Foundation and Sump Pit Design	200-98541	
Basic Design Calculation File, Limestone Preparation Building, Ball Mill Hall	200-99433	
Basic Design Calculation File, FGD Common Substation	200-99435	
Medupi FGD Design Calculation File, Stormwater Drainage For Area West of Boiler to Road 09	200-99437	
Basic Design Calculation File, Gypsum Dewatering Building	200-99730	
Basic Design Calculation File, Limestone Preparation Building, Day Silo Bay Support Structure	200-102307	
Basic Design Calculation File, FGD Makeup Water Pre-Treatment Building	200-102512	
Basic Design Calculation File, Absorber Pump House Steel Structure and Foundation Design	200-102526	
Basic Design Calculation File, Raw Water Pump Station, Plinth Design	200-103034	
Basic Design Calculation File, Emergency Generation Building	200-108081	
Basic Design Calculation File, ZLD Building	200-109051	
Basic Design Calculation File, Common Pump Building	200-109052	
Basic Design Calculation File, Limestone and Gypsum Handling Substation	200-109266	
Basic Design Calculation File, Limestone Receiving Building	200-110226	
Basic Design Calculation File, Gypsum Storage Building	200-110444	

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

OTHER BASIC DESIGN DOCUMENTS (NOT ATTACHED)

Document	SPF File Number	Document / File Number
Basic Design Calculation File, Absorber Pump House Substation Concrete and Foundation Design.........................	200-110445	
Basic Design Calculation File, Essential Service Substation...	200-110446	
Medupi FGD: Geotechnical Investigation Scope of Works	200-115317	

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

1. INTRODUCTION

The Medupi Power Station Flue Gas Desulfurization (FGD) Retrofit Project consists of the addition of FGD systems to six 800 megawatt (MW) coal fired steam electric generating units being constructed in Limpopo Province, approximately 15 kilometres (km) west of the town of Lephalale, South Africa. The units are planned to enter commercial operation sequentially beginning at the end of 2014. The FGD Project will result in the addition of wet limestone open spray tower FGD systems to each of the operating units and will be operational within six years following commercial operation of the respective generating units.

The Medupi plant is currently under construction. Each of these units has been designed and is being constructed with provisions incorporated into the space and equipment design to accommodate the installation of wet limestone FGD systems. Each of the six FGD absorbers will treat the flue gas from one boiler; commercial-grade saleable gypsum will be produced as a byproduct. A cluster of three absorbers will be located near each of the plant's two chimneys. Systems for makeup water, limestone preparation, FGD byproduct (gypsum) dewatering and storage/disposal, and treatment of the wastewater stream will be common to all FGD absorbers in the plant.

The basic design presented herein was developed by a collaborative team blend of Eskom, Steinmüller Engineering, and Black & Veatch with an integrated division of responsibility. Basic design for the FGD Process and associated facilities was performed by the team for the complete scope of work necessary to fully integrate the FGD into the operating plant.

The content of this document is based upon a multi-contract engineering, procurement, and construction management (EpCM) approach in line with the Project Definition planning. This approach is under review and may be revised to a multi-package engineering, procurement, and construction (EPC) (or hybrid) approach at a later stage. Changes to the contracting approach will affect the results presented herein.

2. SUPPORTING CLAUSES

2.1 SCOPE

This report presents the results of the Basic Design Phase, including project scope definition, execution planning, and estimated capital and operations and maintenance costs.

2.1.1 Purpose

This document summarises the status and outcome of the Medupi FGD Retrofit Basic Design phase results and activities and describes the achievement of the design goals in terms of meeting the stakeholder requirements. This document, together with the design output documentation of the Basic Design Phase, will be submitted to a project design review board for technical assessment.

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions with specific reference to Medupi Power Station.

2.2 NORMATIVE / INFORMATIVE REFERENCES

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

2.2.1 Normative

[1] Design Base Standard – Doc no: 474-190

[2] Design Review Procedure – Doc no: 240-5311 3685

[3] Engineering Drawing Office and Engineering Documentation Standard – N.PSZ 45-698

2.2.2 Informative

[4] Medupi User Requirements (URS) Rev. 4 – Doc no: NC/001

[5] Medupi Project Design Manual (PDM) – Doc no: 200-32065

[6] Eskom Air Quality Strategy – Doc no: 32-1143

[7] National Environmental Management Act 2004 (Act 39 2004)

[8] Medupi FGD Retrofit Conceptual Design Report Rev. 2 - Doc no: 200-61771

[9] Modification of Chimney Compensator and Nozzles, and Addition of Coating to the 316L Stainless Flue Liners, Rev. 1 – Doc no. 203-44134

[10] For Information Only: Medupi Power Station, FGD, Jones and Wagener Letters for Co-Disposal of Ash and Gypsum – Doc no: 257-185172

[11] Guideline: Possible alternatives for the disposal of chemical wastes produced by the Flue Gas Desulphurisation process – Doc no: 200-128401

[12] Scope of Works, Concept Design for disposal of waste produced by the Medupi Flue Gas Desulphurisation Retrofit Project – Doc no: 200-137848

2.3 DEFINITIONS

None.

2.3.1 Classifications

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 ABBREVIATIONS

Abbreviation	Description
AC	Alternating Current
BOP	Balance of Plant
CaF_2	Calcium Fluoride
$CaCl_2$	Calcium Chloride
$CaCO_3$	Calcium Carbonate
$CaSO_3$	Calcium Sulphite
$CaSO_4$	Calcium Sulphate
$CaSO_4 \cdot 2H_2O$	Calcium Sulphate Dihydrate
CCCW	Closed Cycle Cooling Water
CDR	Concept Design Report (SPF file 200-61771)
CPP	Condensate Polisher Plant

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Abbreviation	Description
DC	Direct Current
DCS	Distributed Control System
ECP	Engineering Change Proposal
EDG	Emergency Diesel Generator
EIA	Environmental Impact Assessment
ENS	Effluent Neutralisation Sump
EPC	Engineering, Procurement, and Construction (Contract)
EpCM	Engineering, Procurement, and Construction Management (project approach)
FGD	Flue Gas Desulfurization
FMECA	Failure Modes, Effects, and Criticality Analysis
HAZOP	Hazard and Operability (Analysis)
HCl	Hydrogen Chloride
HF	Hydrogen Fluoride
I/O	Input and Output
ID	Induced Draft
IT	Information Technology
km	Kilometre
kV	Kilovolt
LFCR	Levelized Fixed Charge Rate
LV	Low Voltage
m	Metre
$MgSO_4$	Magnesium Sulphate
MPa	Mega Pascal
MV	Medium Voltage
MW	Megawatt
MWh	Megawatt-hour
O_2	Oxygen
O&M	Operations and Maintenance
ppm	Parts per Million
P&ID	Piping and Instrument Diagram
PDRA	Project Definition Readiness Assessment
PDM	Project Design Manual
PWDR	Present Worth Discount Rate
RAM	Reliability, Availability, and Maintainability (Analysis)
SO_2	Sulphur Dioxide
SO_3	Sulphur Trioxide
TOC	Total Organic Compounds
UPS	Uninterruptible Power Supply
V	Volt

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Abbreviation	Description
ZAR	South African Rand
ZLD	Zero Liquid Discharge

3. BASIC DESIGN INFORMATION

3.1 KEY DESIGN ASSUMPTIONS

A project design basis was established at the outset of the project to define the technical and functional requirements to which the Medupi FGD Retrofit Project is to be designed.

The Project Design Manual (PDM) (178771.22.0000, SPF file 200–61989), attached, was prepared specifically for the Medupi FGD Retrofit Project consistent with the Medupi Power Station User Requirements Specification Revision 4 [4]. A Project Design Manual [5] was previously prepared for the Medupi Power Station Project which served as the model for this document.

A conceptual design for the Medupi FGD Retrofit was concluded in May 2012. The Medupi FGD Retrofit Conceptual Design Report [8] documents the results of the Concept Design phase and serves as the baseline from which the Basic Design was performed.

3.2 DESIGN APPROACH

The content of this document is based upon a multi-contract EpCM approach in line with the Project Definition planning. This approach is under review and may be revised to a multi-package EPC (or hybrid) approach at a later stage. Changes to the contracting approach will affect the results presented herein.

3.2.1 Design Inputs

In support of the National Environmental Management: Air Quality Act (Act No. 39 of 2004) [7], Eskom's Air Quality Strategy [6] established a sulphur dioxide emissions target of less than 400 mg/Nm^3 at 6 percent O_2 for power stations commissioned between 2002 and 2017 and recommended that flue gas desulphurization be retrofit to the Medupi Power Station.

As described further in Section 3.3.1, the Medupi FGD Retrofit is designed to accommodate differentiation in coal quality (design coal and "worst" coal), limestone quality (85 percent purity and 96 percent purity), and operation with and without attemperation air (the attemperation air must be added to the flue gas at the inlet of the fabric filter in order to protect the fabric filter, if the temperature of the flue gas is too high). The "worst" coal has higher sulphur content in comparison to the design coal.

As described further in Section 3.3.2, a significant change in the design basis compared to the Concept Design phase is the limestone qualities. In order to be able to use also limestone with lower quality, two different limestone qualities (one with 96 wt. percent calcium carbonate ($CaCO_3$) and one with 85 wt. percent $CaCO_3$) were chosen for the design of the plant and all subsystems. Assumed limestone analyses were developed and used for the Basic Design; however the actual limestone composition is not yet defined.

3.2.1.1 Open Issues from the Concept Phase

The following issues were identified in the Conceptual Design Report [8] and end-of-phase reviews for resolution or completion during the Basic Design phase of the project.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Table 1: Open Issues from Concept Phase

Item No.	Origin	Action	Comments or Resolution	Closed Date
1		Ensure all interfacing packages are informed accordingly	Eskom comments on the Interface List received 6-Feb-14	6-Feb-14
3		Evaluation of existing Unit/BOP network to accommodate the additional controllers	Duplicate item; refer to item R25	15-Apr-13
4		Evaluation of the HVAC/space/flooring in existing rooms for additional equipment	Duplicate item; refer to item R26	15-Apr-13
5		Advise client and confirm client requirements for a dedicated ZLD control room	Will be dedicated control room. Added to Record of Decision Table item 6 (see Section 3.2.1.2)	03-Jun-13
6		Evaluate the option of issuing a variation to the existing Medupi Alstom C&I contract	Duplicate item; refer to item R35	15-Apr-13
7		Evaluation of existing Unit/BOP electrical system to accommodate the additional Unit/BOP loads	Duplicate item; refer to item R15	15-Apr-13
8		Identification of requirement as well as interface/tie-in points for FGD auxiliary transformers	Refer to Section 3.5.3.15.1 herein. Indicative quotation received from Grid Planning on 25-Mar-14	25-Mar-14
9		Investigate requirement as well as location of FGD diesel generator	Refer to Section 3.5.3.15.4 herein	16-Jan-14
10		Update the PDM to reflect the correct civil codes and standards	Duplicate item; refer to item R37	15-Apr-13
11		Geotechnical Study must be done to determine the soil conditions for areas of FGD and ZLD	Duplicate item; refer to item R38	15-Apr-13
12		Evaluate the need for potable and fire water booster pumps	Duplicate item; refer to items R8 and R9	31-Oct-13
13		Limestone and Gypsum railing, delivery and off take specification/clarification	Refer to Sections 3.5.3.6 and 3.5.3.7 herein	5-Dec-13
14		Integrate the required materials handling facilities for loading and unloading limestone, bulk fuel oil, gypsum and general cargo with the rail yard	Limestone Receiving drawing revised to add grade elevation. This is the starting point for the rail design to be developed	14-Apr-14

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Item No.	Origin	Action	Comments or Resolution	Closed Date
R1	CDR page 284/966	Flow Modelling to ensure that duct-stack system is favourable for wet operation	Neither the Steinmüller nor Black & Veatch scope for the Basic Design included condensation and wet flow modelling to identify whether the existing wet stack liquid collection provisions will perform adequately under the updated FGD Design Basis or if they require modifications that should be accounted for in the basic design execution (see Section 3.24.1 item 1)	Open
R2	CDR page 284/966	Third party condensation calculations	Duplicate item; refer to item R1	31-Oct-13
R3	CDR page 284/966	Third party review for the need of additional liquid collection facilities in the breeching and flue	Refer to Section 3.5.3.4 herein	4-Feb-14
R4	CDR page 284/966	Third party review of flue discharge velocities and buoyancy to determine if exit modifications are necessary for adequate dispersion and elimination of possible plume downwash which may be caused by the wake formed on the downwind side of the flue and stack shell (such as a choke; reduction in diameter at flue exit)	Eskom is reviewing dispersion capability at stack exit Updated stack exit conditions were developed during Basic Design execution (see Section 3.24.1 item 2)	Open
R5	CDR page 284/966	Review and validate the “No Reheat Dispersion Modelling Study” document to determine the accuracy of: a) existing criteria, b) meteorological data, c) dispersion type and modelling domain, and the current Steinmüller parameter flow data	Duplicate item; refer to item R4	11-Dec-13
R6	CDR page 284/966	Review adequacy of existing chimney drain piping and chimney drain system termination points for the case of additional liquid collection	Duplicate item; refer to item R3	31-Oct-13
R7	CDR page 284/966	Review continuous emissions monitoring system to determine if any modifications may be required due to the FGD retrofit project	No modifications are required	13-Jun-13
R8	CDR page 296/966	Evaluate the fire protection system to evaluate the need for a booster pump	Fire water booster pump is required	16-Jan-14
R9	CDR page 296/966	Evaluate the potable water system to evaluate the need for a booster pump	Potable water booster pump is required	31-Oct-13

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Item No.	Origin	Action	Comments or Resolution	Closed Date
R10	CDR page 296/966	Determine where service connections are required for plant maintenance	Captured on the P&IDs	5-Dec-13
R11	CDR page 296/966	Confirm the design inlet temperature for equipment cooling	Cooling water temperature is 34 °C	16-Jan-14
R12	CDR page 296/966	Evaluate the cooling tower location	Cooling tower location near FGD ZLD Treatment System confirmed during Basic Design	23-Jan-14
R13	CDR page 304/966	Develop the expected system draft losses for the design and expected cases including duct and FGD pressure drop following layout of the FGD inlet and outlet ductwork	Expected system draft losses developed and reviewed by the project team during Basic Design	23-Jan-14
R14	CDR page 304/966	Evaluate the system impacts of the addition of a gas-to-gas heater on ID fan operations	Fan capacity was reviewed during Basic Design and is adequate for anticipated gas cooling heat exchanger pressure loss	31-Oct-13
R15	CDR page 331/966	Evaluate if the existing electrical system will be able to support the addition of FGD unit and BOP loads. The cost for the supply and installation of the station service transformers was not included in the FGD retrofit project cost in the conceptual design report	Refer to Section 3.11 herein	27-Mar-14
R16	CDR page 345/966	Arrangement and configuration of the gypsum material handling facilities	Refer to Section 3.5.3.7 herein and Record of Decision Table items 2, 3, 4, and 5 (see Section 3.2.1.2)	1-Aug-13
R17	CDR page 345/966	Arrangement and configuration of the commercial-grade gypsum temporary storage facilities	Not needed; refer to Record of Decision Table item 3 (see Section 3.2.1.2)	1-Aug-13
R18	CDR page 363/966	Update the Medupi Water Balance with the FGD system design	Water balance was updated following Concept Design on 27-Mar-12. FGD water balance is complete; Medupi overall water balance is under revision	Open
R19	CDR page 363/966	Verify the FGD wastewater chemistry and quantity	Wastewater chemistry can not be definitively established until the final limestone analysis is established at procurement. Assumptions are documented in the wastewater treatment mass balance. Issue identified for resolution during execution (see Section 3.24.1 item 19)	12-Sep-13
R20	CDR page 363/966	Evaluate wastewater treatment systems to determine the best option for treating the FGD wastewater. The evaluation should include other treatment options such as eutectic freeze desalination	Reviewed during Basic Design; basis for the Basic design is brine concentrator/crystallizer technology as described in Section 3.5.3.8 herein	17-Oct-13

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Item No.	Origin	Action	Comments or Resolution	Closed Date
R21	CDR page 363/966	Determine the dilution ratio to re-use the effluent from the condensate polisher regeneration	Condensate polisher regeneration effluent will not be used in FGD; refer to Section 3.5.3.5 herein	24-Oct-13
R22	CDR page 363/966	Evaluate whether the backwash flow from the sand filter can be directed to the Reclaim Water Tanks	FGD Makeup Water pretreatment backwash will be directed to the dirty water drains system; refer to Section 3.5.3.5 herein	11-Jul-13
R23	CDR page 363/966	Evaluate whether the ZLD distillate can be directed to the Reclaim Water Tanks	ZLD distillate may be returned to FGD Reclaim Water Tanks; refer to Section 3.5.3.8 herein	18-Feb-14
R24	CDR page 379/966	Addition of a dedicated control room for the ZLD equipment	Will be dedicated control room. Added to Record of Decision Table item 6 (see Section 3.2.1.2)	03-Jun-13
R25	CDR page 379/966	Capability of the existing BOP network to accommodate additional FGD controllers	The FGD DCS system is on its own network and will have a dedicated loop with dedicated controllers and network equipment. Therefore there should be little to no effect to the on the overall plant network traffic. A bi-directional loop is provided for reliability so that a break in the fibre will not affect the network	7-Aug-14
R26	CDR page 379/966	Evaluate HVAC/ space/floor loading capacity in existing rooms for the additional supply	Additional space is not available in the existing unit C&I equipment rooms; refer to Record of Decision Table item 24 (see Section 3.2.1.2)	22-Apr-13
R27	CDR page 33/966	Evaluate the addition of flue gas reheat to reduce the FGD water consumption	Refer to Section 3.5.3.2 herein and Record of Decision Table item 12 (see Section 3.2.1.2)	8-Aug-13
R28	CDR page 33/966	Confirm the commercial operation date for the first Medupi generating unit. Update FGD project schedules accordingly	The basis for the Basic Design is commercial operation of Unit 6 in December 2014	14-Apr-13
R29	CDR page 33/966	Evaluate if the existing tunnels will be able to support the addition of the new power cables. CDR assumed that adequate space was available. No additional tunnels are considered due to congestion in main plant areas	Rack space is existing and is allocated for the FGD cables	24-Jan-14
R30	CDR page 33/966	Confirm quantity of FGD make-up water pre-treatment backwash as there is a limitation on the allowable flow to the dirty water drains system	Backwash quantity is within allocation	12-Sep-13
R31	CDR page 33/966	Confirm the supply, quality and chemical reactivity of limestone	Limestone Quality Range Study was performed during Basic Design; refer to Section 3.3 herein	11-Jul-13

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Item No.	Origin	Action	Comments or Resolution	Closed Date
R32	CDR page 33/966	Determine the configuration and means of support for isolation of the bypass duct (the current exhaust duct to the chimney)	Refer to Section 3.5.3.2 herein	20-Aug-14
R33	CDR page 33/966	Interface details need to be developed for all interfacing systems	Eskom comments on the Interface List received 6-Feb-14	6-Feb-14
R34	CDR page 33/966	RAM study	Refer to Section 3.16.3 herein	6-Jun-14
R35	Medupi Design Review Meeting 24/05/2012	Evaluate the option of issuing a variation to the existing Medupi Alstom C&I contract	Cost estimate basis is a stand-alone DCS; refer to Section 3.5.3.16 herein	Open
R37	Medupi Design Review Meeting 24/05/2012	Update the PDM to reflect the correct civil codes and standards	Review and revisions completed during Basic Design	25-Feb-14
R38	Medupi Design Review Meeting 24/05/2012	Conduct a geotechnical study to determine the soil conditions for areas of FGD and ZLD	Eskom to complete prior to start of detailed design. Issue identified for resolution during execution (see Section 3.24.1 item 3)	Open
R39	Email: Additional Action	Limestone and Gypsum railing, delivery and offtake	Duplicate item; refer to 13	14-Apr-13

3.2.1.2 Record of Decision Log

Changes in FGD and balance of plant designs compared to the previous conceptual design were tracked and evaluated by the team for approval. A record of these changes and approvals was maintained in the Record of Decision Log (178771.40.2000, SPF file 200-137693), attached.

3.2.2 Design Process

Black & Veatch was responsible for the overall project execution coordination and technical coordination and among the project parties (Eskom, Steinmüller, and Black & Veatch). This includes documenting the design basis and applying the change management process. Technical coordination was facilitated through the use of the design toolset to avoid physical interferences and coordinate design conditions at terminal and interface points.

3.2.3 Design Verification

Each of the project parties reviewed the work done by others during the execution of the Basic Design. Important aspects of this review include quality, accuracy, completeness, and conformance to project requirements; however this review does not relieve the originator of accountability for that work.

A log of the unverified assumptions made during Basic Design (attached) was developed to track those assumptions which were relied upon to develop the design. These unverified assumptions will need to

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

be reviewed and resolved during the execution phase through the use of vendor submittals, additional studies/investigations, coordination with the existing plant, etc. It is assumed that the flue gas ductwork design will include both the positive and negative pressure design cases (a value of +/-40 mbar, at the design temperature of 200° C.

Eskom will follow the Design Review Procedure [2] to baseline the Basic Design.

3.2.4 Design Criteria

The PDM (178771.22.0000, SPF file 200–61989), attached, was prepared which detailed the plant design and performance criteria.

Refer to the following documents (attached) for additional information on the Design Criteria.

Document	SPF File Number	Document / File Number
FGD Redundancy and Size Evaluation	200-92612	006265-S-TAB-010
Balance of Plant Sizing Criteria	200-55814	178771.41.0103

3.2.5 Codes and Standards

The PDM (178771.22.0000, SPF file 200–61989), attached, was prepared which detailed the plant design and performance criteria. Section 2.0 of the PDM identifies the applicable South African codes, local codes and ordinances, Eskom-specific codes, or international codes, processes, and standards to be used in the design of the plant/facility/system.

3.3 KEY DESIGN DRIVERS

3.3.1 Controlling Design Cases

The Medupi FGD Retrofit will be designed to accommodate variations in coal and limestone quality. The FGD system will also be designed to cater for the operation of the attemperation air system that will be installed as part of the Medupi Power Station as a preventative measure to reduce the flue gas temperature at the inlet of the Fabric Filter Plant. The following design cases were considered in the design of the FGD:

- Design Coal, 100 percent BMCR, 85 percent $CaCO_3$ in limestone
- Worst Coal, 100 percent BMCR, 85 percent $CaCO_3$ in limestone
- Worst Coal + attemperating air, 100 percent BMCR, 85 percent $CaCO_3$ in limestone
- Design Coal, 100 percent BMCR, 96 percent $CaCO_3$ in limestone
- Worst Coal, 100 percent BMCR, 96 percent $CaCO_3$ in limestone
- Worst Coal + attemperating air, 100 percent BMCR, 96 percent $CaCO_3$ in limestone

Each of the design cases mentioned above influences FGD plant performance as well as mass and volume flow rates. The controlling design cases are different for each parameter. Respectively the highest value of the parameter was chosen for the design of the plant. An evaluation of the FGD Design Controlling Cases (P06259-S-TAB-015, SPF file 200-925446), attached, identified the design parameters which would establish the design basis for FGD and auxiliary systems design.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Table 2: Design Load Cases

Load case	Design Coal pH 5.1	Design Coal pH 5.4	Worst Coal pH 5.1	Worst Coal pH 5.4	Worst Coal + Attemp Air pH 5.1	Worst Coal + Attemp Air pH 5.4
Volume Flow [Nm³/h, dry @ 6% O_2]	2,427,381	2,427,381	2,495,388	2,495,388	2,716,068	2,716,068
Act. O_2 [%]	4.64	4.64	4.55	4.55	6.65	6.65
Inlet Temperature [°C]	137.0	137.0	137.0	137.0	137.0	137.0
Inlet Pressure [mbar]	928.7	928.7	931.2	931.2	934.3	934.3
H_2O [Vol-%]	8.33	8.33	8.84	8.84	8.02	8.02
SO_2 conc. Inlet [mg/Nm³,dry @ 6% O_2]	3.405	3.405	5.338	5.338	5.378	5.378
SO_3 Inlet conc. [mg/Nm³,dry @ 6% O_2]	34	34	53	53	53	53
HCl conc. Inlet [mg/Nm³,dry @ 6% O_2]	160	160	160	160	160	160
Limestone quality [% $CaCO_3$]	85	96	85	96	85	96

3.3.2 Limestone Quality

A decision was made to revise the design basis limestone quality so that the FGD system design could accommodate a lower quality limestone, which might be more readily available. The change in limestone quality impacted nearly all aspects of the new facilities, including sizing and layout for the limestone handling and preparation systems, the absorbers, gypsum processing and handling systems, and water treatment system.

A Limestone Quality Range Study (006265-T-STD-110, SPF file 200-113244), attached, was performed to to qualitatively evaluate the suitability and impact of different limestone qualities on sizing, process performance, operations and maintenance of FGD equipment.

3.3.3 Water Quality

The initial water supply for the project will be sourced from the Mokolo Dam. The Mokolo water supply will eventually be replaced by water from the Crocodile-West water system. The water quality and constituents for these two sources of water were included in Article 1.4.4 “Water” of the PDM (178771.22.0000, SPF file 200–61989), attached. The water quality and constituents influenced the design of the FGD Makeup Water Pretreatment and Waste Water/Zero Liquid Discharge Treatment systems.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

3.3.4 Geology and Seismology

The geology and seismology information associated with the station site was included in Article 1.6.3 “Geology and Seismology” of the PDM (178771.22.0000, SPF file 200–61989), attached. The site is underlain by sedimentary rocks of the Waterberg Group and there are several faults located in the area. This information influenced the design outcome of the civil, structural, chemical, and low pressures services sections.

3.4 PROCUREMENT STRATEGY

A Project Procurement Plan (178771.23.1110, SPF file 200-92430), attached, was developed to provide Engineering input to the Procurement Strategy to be developed by Eskom Commercial. A Project Procurement Matrix is included to define the plan for executing the purchasing, contracting, technical and procurement specifications, expediting, inspection and testing, remittance, logistics and material control for the equipment, material and services; and for each procurement package.

The Project Procurement Matrix defines the contract breakdown structure for the project execution schedule described in Section 3.20 and the project cost estimate described in Section 3.21.1.

The contents of the Project Procurement Plan are based upon a multi-contract EpCM approach in line with the Project Definition planning. This approach is under review and may be revised to a multi-package EPC (or hybrid) approach at a later stage. Changes to the contracting approach will affect the cost and schedule for the project. It is recommended that a packaging workshop be held to vet the schedule and interface coordination issues prior to finalization of the contracting and packaging strategies.

3.5 PROJECT DESCRIPTION

3.5.1 Project Breakdown Structure

The Kraftwerk Kennzeichen System (KKS) system was used as the basis for classifying and designating both plant equipment and their associated documents, including the project execution schedule described in Section 3.20 and the project cost estimate described in Section 3.21.1. The following Table contains a list of the Codes and Descriptions used to breakdown the areas, systems, sub-systems, specifications, and major components.

The project breakdown structure used herein is based upon a multi-contract EpCM approach in line with the Project Definition planning. This approach is under review and may be revised to a multi-package EPC (or hybrid) approach at a later stage. Changes to the contracting approach will affect the coding applied in the cost estimate and the schedule for the project.

Table 3: Work Breakdown Structure

Medupi ERA Area		Medupi ERA Systems / Specification	
Code Value	**Description**	**Code Value**	**Description**
ABS	3-2-1 Absorber Area	AAA	Administration & Milestones
ABA	6-5-4 Absorber Area	GRP	Grouping Plan
BMH	Bulk Material Handling Area	FWL	Firewall
CSA	FGD Common Substation Area	ANK	DC Switchgear (110 / 220V)
MWA	FGD Makeup Water Area	BCT	AC Power Supply (6600V)

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

GDA	Gypsum Dewatering Area	BCG	FGD Auxiliary Transformer
LPA	Limestone Preparation Area	BFG	AC Power Supply (400V)
RAY	Rail Yard Area	BN_	Essential Service AC
STC	Startup & Commissioning	BRV	Emergency Generation
SUB	Substation Area	BSB1	Utility Rack -EC
ZLD	ZLD Area	BSB2	Utility Rack -PDC
ALL	All Areas	BTW	24V DC Power Supply
		CFU	Construction Facilities Area
		CMA	Communications
Medupi ERA Company		CPU	Lightning Protection
Code Value	**Description**	EEB	Earthing
EC	Engineering Consultant	EEC	Raceway / Cable Tray
A	All	GAU1	Site Arrangement
V	Vendor	GAU2	Demolition Drawing
PDC	Process Design Consultant	GAU3	Plot Plan
E	Eskom	GNG	Zero Discharge Treatment
		GNG2	TOC Scavenger
		GNR	Zero Liquid Discharge (ZLD) Building
Medupi ERA Discipline		GNR1	Zero Liquid Discharge (ZLD) Area
Code Value	**Description**	GKC	FGD Potable Water
C	Civil	GKC2	FGD Sanitary
M	Mechanical	HTD1	Flue Gas Desulfurization
E	Electrical	HTD2	Absorber Pump House
A	All	HNA	Flue Gas Duct
P	Procurement	HNC	Induced Draft Fan
CN	Construction	HTG	Oxidation Air
PM	Project Management	UBD1	Limestone Off-Loading and Storage Area
CH	Chemical	HTJ	Limestone Receiving Store Reclaim Area Conveyor
L	LPS	HTJ1	Limestone Prep Area Conveyor
V	Vendor	UBD	Limestone Unloading and Receiving Building
		HTK	FGD Additive Preparation and Supply
		HTK2	FGD Additive Preparation and Supply - Silos and Slide gate
Medupi ERA Deliverable		HTL	Gypsum Bleed Tank / Absorber Drain Tank Area 4-6
Code Value	**Description**	HTL5	Gypsum Bleed Tank / Absorber Drain Tank Area 1-3
ADMIN	Administration & Milestones	HTL1	Gypsum Hydrocyclone and Belt Filter + Filtrate
AR	Architectural	HTL2	Gypsum Bleed Drain System
CA	Conveyor Arrangement	HTL3	Waste Water HC Feed Tanks
GEO	Geotechnical Design	HTL4	Waste Water Hydrocyclone 1-3

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

SPEC	Specification	HTN	FGD Solids Dewatering
D	Ductwork	HTP	FGD Solids Conveying and Storage
CNST	Construction	HTQ1	FGD Process Water Supply
F	Foundation	HTQ3	Process Water Tank 1-3
OL	PDC Rack General Arrangement	HTQ4	Waste Water Reclaim
RD	Roads & Grading Plan	HTT1	FGD Blowdown Limestone Slurry Preparation Building Sumps
SD	Site Drainage Plan	HTT2	FGD Blowdown Recycle Pump Building Sumps Units 1-3
ST	Steel/Concrete Structures	HTT3	FGD Blowdown Recycle Pump Building Sumps Units 4-6
U	Undergrounds	HTT4	FGD Blowdown ZLD Sumps
CALC	Calculations	HTT5	FGD Blowdown Gypsum Dewatering Building Sumps
FD	Functional Descriptions	HTT6	FGD Blowdown FGD Makeup Water Pretreatment Sump
GA	General Arrangements	HTT7	FGD Blowdown Process Water Tanks Sump
HVAC	HVAC	HTT8	FGD Blowdown Reclaim Water Tanks Sump
INS	Insulation	HTT9	FGD Blowdown ZLD Holding Tank Sump
ISO	Isometrics & Hangers	HTT10	FGD Blowdown Gypsum Bleed/Absorber Drain Tank Sumps
MAD	Maintenance & Access Drawings	HY_	Distributed Control System
MB	Mass Balances	LBG	FGD Auxiliary Steam
MFD	Material Handling Flow Diagrams	PGB	FGD and Wastewater Treatment Closed Cycle Cooling Water
PFD	PFD's	QFB	FGD Compressed Air
PID	Piping & Instrument Diagrams	SGA	FGD Fire Protection
SYSD	System Descriptions	STU	Electrical Tunnels / Underground Utilities
COMM	Communications	UAD	Switchyard Area
CP	Construction Power	UBE	FGD Common Substation
ERTH	Earthing	UBD4	Limestone Unloading and Gypsum Storage Area Substation
LP	Lightning Protection	UBD5	FGD Essential Services Substation
TRAY	Tray	UBD6	Absorber Pump House Substation
SCHEM	Schematic Diagrams	UBN	Emergency Generation Building
SL	Single Line Drawings	UGA1	FGD Makeup Water Pretreatment Area
CSP	Control System Philosophy	UGA	FGD Makeup Water Pretreatment Building
LIST	Lists	UGA2	Raw Water Pump Building
LOG	Logics	UGE	Gypsum Storage Building
HU	Hook-Ups	UGQ	Gypsum Dewatering Building
SA	Site Arrangement	UGQ1	Gypsum Dewatering Area
DD	Demolition Drawing	UGQ2	Gypsum Storage Area
PP	Plot Plan	UHE	Chimney Flow Model

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

CIR	Circuits	UHT1	FGD Area GA for 6, 5, 4
HAZ	HAZID	UHT2	FGD Area GA for 3, 2, 1
RAM	RAM Study	UUU	FGD Common Pump Building (Potable, CCCW, Air Compressor, Fire)
FEM	FMECA	UVE1	Limestone Preparation Area
		UVE	Limestone Preparation Building
		UZA	Roads and Grading
		UGM	Site Drainage
		GEO	Geotechnical Design
		HAZ	HAZID
		FEM	FMECA
		RAM	RAM Study
		61.3901	FRP Ductwork
		61.4000	Structural Steel and Carbon Steel Ductwork
		63.2800	DC System and UPS
		63.3601	Medium Voltage Switchgear and Bus
		63.3603	Low Voltage Switchgear and Motor Control Centres
		63.3800	FGD Station Service Transformers
		65.2300	FGD Wastewater Treatment (ZLD)
		65.3240	Gypsum Dewatering System
		67.0400	Material Handling System (Furnish & Install)
		67.9200	Pumps and Agitators
		67.9277	Absorber Spray (Recycle) Pumps
		67.9300	Compressed Air Equipment
		67.9441	Oxidation Air Blowers
		67.9732	Limestone Slurry Preparation System
		71.0204	Railroad Construction
		71.0402	Substructures Construction
		71.0403	Superstructures Construction
		73.0000	Electrical Construction
		73.0600	Substation Construction
		73.0604	Construction IT and Communication (Furnish and Install (Construction)
		73.5001	Permanent Plant IT
		74.0000	Control & Instrumentation
		65.3211	FGD Absorber (Furnish Only)
		77.0453	Material Handling System
		77.1000	Mechanical Construction
		77.5450	Field Erected Tanks
		78.0102	Geotechnical Investigation
		78.0106	Surveying

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

	78.0600	Site Services (Furnish & Install)
	78.0601	Medical Services
	78.0602	Security Services
	78.1300	Construction Canteen Operation
	STC	Startup & Commissioning

3.5.2 Existing Facilities

The Medupi plant is currently under construction. Each of these units has been designed and is being constructed with provisions incorporated into the space and equipment design to accommodate the installation of wet limestone FGD systems. Each of the FGD systems is designed to provide desulfurization for a single generating unit at the site. The Site Arrangement (178771-CGAU-G1001, SPF file 0.84/28836) and Plot Plan (178771–CGAU–G1000 SPF file 0.84/36776), attached, show the existing construction plan and the new FGD equipment. Each of the six generating units is independently operated; common facilities are provided for electrical power, water, coal supply, and coal combustion waste disposal.

Each of the units is currently equipped with fabric filters and induced draft (ID) fans. The fabric filters remove the majority of the fly ash from the coal combustion process, and the ID fans provide the necessary draft to overcome the system resistance. The ID fans were designed with additional margin to overcome the additional system resistance due to the future installation of the FGD equipment.

The ID fans currently discharge directly to the chimney flue associated with each unit. The FGD system will include additional dampers and ductwork to divert flue gas to the FGD absorbers and return it to the chimney and to provide a bypass of the FGD systems as may be required by system operation. The chimney flues are lined with corrosion-resistant liners to handle saturated flue gas resulting from future operation of an FGD plant.

Modifications required for the existing facilities are described in Section 3.5.4.

3.5.3 FGD Retrofit Project Facilities

Each FGD absorber will treat the flue gas from one of the six boilers; commercial-grade saleable gypsum will be produced as a byproduct. A cluster of three absorbers will be located near each of the plant's two chimneys. Systems for makeup water, reagent preparation, FGD byproduct (gypsum) dewatering and storage/disposal, and treatment of the wastewater stream will be common to all FGD absorbers in the plant.

The project scope includes the following:

- FGD system, including pumps, agitators, oxidation air blowers
- Flue gas ductwork and draft system modifications
- Makeup water supply and pretreatment
- Chimney modifications
- Limestone receiving, storage, and handling system
- Limestone preparation system
- Gypsum refinement and dewatering system
- Gypsum handling and storage systems and waste gypsum disposal

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

- FGD zero liquid discharge (ZLD) treatment system and waste disposal
- Auxiliary steam system
- Closed cycle cooling water system inlcuding wet cooling tower and heat exchanger
- Fire protection systems and facilities
- Compressed air supply
- Potable water supply
- Blowdown sumps
- High voltage power supply
- Medium voltage power supply
- Low voltage power supply
- Emergency electrical supply and emergency diesel generator
- Essential electrical supply
- Control equipment for equipment protection, operation, and monitoring
- Interconnecting piping systems
- Onsite fencing, roads, and railroad interfaces
- Drainage systems, including storm water, sanitary, chemical, and wastewater
- Construction facilities (associated with this project)

3.5.3.1 FGD System

The sulphur contained in the coal will form sulphur dioxide (SO_2) when combusted. Uncontrolled SO_2 emissions for the design (1.2 percent sulphur, air dried basis) coal will be approximately 3,714 mg/Nm^3 (milligram per normal cubic metre), dry, actual oxygen (O_2)[1] and approximately 5,855 mg/Nm^{3}for the worst-case (1.8 percent sulphur, air dried basis) coal, dry, actual O_2. In order to comply with the environmental protection limit of 400 mg/Nm^3 (dry) at 6 percent O_2[2], it is necessary that the Medupi plants be capable of reducing the SO_2 by 94 percent from the worst-case coal.

In the wet limestone FGD process, limestone (consisting primarily of $CaCO_3$) reacts with the gaseous SO_2 and forms nontoxic gypsum crystals ($CaSO_4 \cdot 2 H_2O$). To achieve this reaction, the limestone must be ground into fine particles to provide maximum surface area for the reaction. A mixture of limestone, reaction byproducts, and water will be recirculated from the absorber reaction tank to spray headers in the upper part of the absorber. The slurry will be atomized into fine droplets by spray nozzles and distributed throughout the flue gas entering the absorber.

The absorber will be a large cylindrical tower with several limestone slurry spraying levels, where the acidic flue gas comes into contact with the limestone slurry. A study to evaluate the whether the absorber should be insulated was performed (refer to the Rubber Lining vs Rubber Lining with Insulation Study Cost Estimation, 006265-T-STD-001, SPF file 200-92792), with a recommendation to insulate the absorber. A decision on this is pending, and will need to be resolved during the execution phase of the project, however the cost estimate presented herein includes the cost to insulate the absorbers.

---

[1] 3,405 mg/Nm³, dry at 6 percent O_2

[2] 5,338 mg/Nm³, dry at 6 percent O_2

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

During their return to the absorber reaction tank, the slurry droplets will absorb the acid components SO_2, SO_3 (sulphur trioxide), HF (hydrogen fluoride), and HCl (hydrogen chloride) from the flue gas. The water from the slurry will evaporate and saturate the flue gas, cooling it to the adiabatic saturation temperature. The water loss will be compensated for by the addition of process water.

Solids retention time in the absorber reaction tank and the addition of the oxidation air will allow the formation and growth of gypsum crystals. The oxidation air will be supplied by air compressors located near the absorbers and will be fed into the absorber sump through lances that will distribute the air in the absorber sump. The air that is blown into the reaction tank is needed to oxidize the calcium sulphite ($CaSO_3$) to calcium sulphate ($CaSO_4$). To minimize the potential for scaling at the wet/dry interface, the oxidation air will be quenched with water (refer to the Wet Oxidation Cooling Study, 006265-T-STD-004, SPF file 200-100123), although the design for this was not completed during the Basic Design, the required equipment and materials have been included in the project cost estimate.

Above the spray banks, a coarse separator (mist eliminator) will be installed for initial droplet separation from the flue gas. Downstream of this, a second mist eliminator stage will remove the majority of any liquid droplets still remaining. The runoff from the droplet separators will be returned to the absorber. The flue gas, relieved of the majority of the SO_2 and saturated with water, will leave the absorber and flow to the chimney.

A summary of the major absorber design parameters is provided in Table 4.

Table 4: Absorber Design Parameters

Parameter	Value
Flue Gas Volume	2,590,000,Nm³/hr, dry, 6% O_2
SO_2 Removal Efficiency (%)	up to 95
Absorber Height (m)	35.5
Absorber Diameter (m)	17.5
Reaction Tank Diameter (m)	21.5
No. of Spray Banks	4 and 1 spare
Recirculation Pumps (m³/hr)	9,600 (4 and 1 spare)
Mist Eliminator	2 Stage with Flushing System
No. of Reaction Tank Agitators	4 with Oxidation Air Lances
Absorber Gas Velocity (m/s)	4
Materials of Construction	Carbon Steel with Rubber Lining

The absorber slurry will be limited to a concentration of 30,000 parts per million (ppm) of chlorides for material considerations, and a bleed stream of liquid from the absorber reaction tank will be required to maintain the concentration below this level. This bleed stream will be treated in the FGD ZLD Treatment System so that the usable liquid can be returned for reuse by the FGD plant or existing water treatment plant, and a waste stream of salts and sludge will be produced for disposal in landfill facilities. Details regarding these landfill disposal facilities are being developed separately from this report.

A bleed stream of the absorber slurry will be pumped from the absorber reaction tank to the gypsum bleed tank for storage until it is processed in the gypsum dewatering system described below.

Refer to the following documents (attached) for additional information on the FGD System.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Document	SPF File Number	Document / File Number
PFD Design Coal, 85% $CaCO_3$	0.84/30068	006265-R-PFD-001
PFD Worst Coal, 85% $CaCO_3$	0.84/30067	006265-R-PFD-002
PFD Worst Coal, Attemperating Air, 85% $CaCO_3$	0.84/30066	006265-R-PFD-003
PFD Design Coal, 96% $CaCO_3$	0.84/30065	006265-R-PFD-004
PFD Worst Coal, 96% $CaCO_3$	0.84/30064	006265-R-PFD-005
PFD Worst Coal, Attemperating Air, 96% $CaCO_3$	0.84/30063	006265-R-PFD-006
FGD Design Controlling Cases	200-92546	P06259-S-TAB-015
Absorber Sizing Design Report	200-93401	006265-A-SKI-001
Rubber Lining vs Rubber Lining with Insulation Study Cost Estimation	200-92792	006265-T-STD-001
FGD Oxidation Air Blower Optimize Energy Consumption Study	200-99553	006265-T-STD-201
Wet Oxidation Cooling Study	200-100123	006265-T-STD-004
Operability Study	200-92095	006265-T-STD-100
FGD Startup and Shutdown Concept	200-99436	006265-T-STD-200
System Description Absorber and Oxidation Air	200-57986	006265-T-HBU-505
P&ID Absorber 1	0.84/29755	006265-R-PID-001
P&ID Absorber 2	0.84/38961	006265-R-PID-002
P&ID Absorber 3	0.84/38962	006265-R-PID-003
P&ID Absorber 4	0.84/38963	006265-R-PID-004
P&ID Absorber 5	0.84/38946	006265-R-PID-005
P&ID Absorber 6	0.84/38965	006265-R-PID-006
P&ID Oxidation Air Absorber 1	0.84/36058	006265-R-PID-091
P&ID Oxidation Air Absorber 2	0.84/38982	006265-R-PID-092
P&ID Oxidation Air Absorber 3	0.84/38983	006265-R-PID-093
P&ID Oxidation Air Absorber 4	0.84/38984	006265-R-PID-094
P&ID Oxidation Air Absorber 5	0.84/38985	006265-R-PID-095
P&ID Oxidation Air Absorber 6	0.84/38986	006265-R-PID-096
General Arrangement, Unit 1 Absorber Pump Building	(not yet assigned)	178771-1UHT-G2017
General Arrangement, Unit 2 Absorber Pump Building	(not yet assigned)	178771-2UHT-G2018
General Arrangement, Unit 3 Absorber Pump Building	(not yet assigned)	178771-3UHT-G2019
General Arrangement, Unit 4 Absorber Pump Building	(not yet assigned)	178771-4UHT-G2020
General Arrangement, Unit 5 Absorber Pump Building	(not yet assigned)	178771-5UHT-G2021
General Arrangement, Unit 6 Absorber Pump Building	0.84/36796	178771-6UHT-G2022
Absorber 1+4 Overview	0.84/38429	006265-Z4010-100
Absorber 1+4 Sections	0.84/38430	006265-Z4010-101
Absorber 2+5 Overview	0.84/38431	006265-Z4010-200
Absorber 2+5 Sections	0.84/38432	006265-Z4010-201
Absorber 3+6 Overview	0.84/38325	006265-Z4010-300
Absorber 3+6 Sections	0.84/38326	006265-Z4010-301
Spraybanks Overview	0.84/37879	006265-Z4145-001
Mist Eliminator	0.84/37878	006265-Z4146-001
FGD Absorber Erection Manual	200-108895	006265-T-STD-250

3.5.3.2 Flue Gas Duct System

The flue gas coming from the boiler will pass through the fabric filter and the ID fan upstream of the FGD plant.

It is planned that the existing ductwork from the ID fans to the chimney will be retained as bypass ductwork around the new FGD plant. The bypass will protect the absorbers in case of malfunction/emergency conditions (for example, no cooling water is available and high temperature flue gas is incoming) or curtailment of the raw water supply to the Medupi Power Station. To avoid a complete plant shutdown in case of a short-term absorber malfunction, the flue gas can be routed

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

through the bypass ductwork system until the absorber can be restarted. The bypass will also provide startup flexibility, so that the boiler and FGD can be started up independent of each other.

The path of the flue gas leaving the existing plant ID fans for the chimney will be modified to allow the addition of an absorber inlet and outlet duct and with the addition of dampers, the existing ductwork will serve as a bypass of the FGD system. The inlet, outlet, and bypass dampers will be double louver dampers. Seal air blowers will supply sealing air between the dampers to minimize any leakage of flue gas through a closed damper. A recommendation for the location and tie-in and a support concept was presented for the additional loads for the bypass damper located within the existing ductwork is presentedin the document, "Support of Bypass Tie-In with Hitachi Duct Design Study" (006265-T-STD-210, SPF file 200-108729), attached. The support of the dampers at the inlet to the bypass ducts at absorbers 1, 3, 4 and 6 is more difficult because of the load imposed upon the Hitachi duct beneath the dampers. It is believed that this part can support the additional load, but as an alternative, a solution with additional support for the damper was also presented. Eskom is investigating the support and connection provisions with Hitachi, for further resolution during the execution phase.

Flue gas will enter the absorber and flow from bottom to top.

An analysis was performed to determine the feasibility and operating characteristics of flue gas cooling options upstream of the FGD absorbers. The addition of flue gas cooling has the potential to reduce the amount of water evaporated and discharged with the clean flue gas. This would reduce the overall process water requirements for the FGD system. The layout of the ductwork and equipment supports the future addition of flue gas cooling heat exchangers, however this equipment is not included in the Basic Design or the cost estimate presented herein, however it is planned to be added to the scope in the execution phase.

Refer to the following documents (attached) for additional information on the Flue Gas Duct System.

Document	SPF File Number	Document / File Number
System Description Flue Gas Path and Bypass	200-58510	006265-T-HBU-504
P&ID Flue Gas Path Absorber 1	0.84/37976	006265-R-PID-151
P&ID Flue Gas Path Absorber 2	0.84/38973	006265-R-PID-152
P&ID Flue Gas Path Absorber 3	0.84/38976	006265-R-PID-153
P&ID Flue Gas Path Absorber 4	0.84/38987	006265-R-PID-154
P&ID Flue Gas Path Absorber 5	0.84/38993	006265-R-PID-155
P&ID Flue Gas Path Absorber 6	0.84/38994	006265-R-PID-156
Material Concept for the Inlet Duct	200-107275	006265-T-STD-240
Technical Evaluation of Flue Gas Cooling Options	200-110410	006265-T-STD-260
Support of Bypass Tie-In with Hitachi Duct Design Study	200-108729	006265-T-STD-210
General Arrangement, FGD Area Units 1-3	0.84/37963	178771-CUHT-G2015
General Arrangement, FGD Area Units 4-6	0.84/37964	178771-CUHT-G2016
Raw Gas Duct with Aircooler 1/4 Duct Overview	0.84/38345	006265-Z4250-110
Raw Gas Duct with Aircooler 2/5 Duct Overview	0.84/38346	006265-Z4250-120
Raw Gas Duct with Aircooler 3/6 Duct Overview	0.84/38347	006265-Z4250-130
Clean Gas Duct Absorber 1/4 Duct Overview	0.84/38348	006265-Z4250-210
Clean Gas Duct Absorber 2/5 Duct Overview	0.84/38349	006265-Z4250-220
Clean Gas Duct Absorber 3/6 Duct Overview	0.84/38350	006265-Z4250-230

3.5.3.3 Draft System

The existing ID fans have been provided with sufficient additional pressure capacity to provide the additional pressure increase necessary to overcome the system resistance of the FGD retrofit. As a part of the final design, the following items are recommended for further evaluation to optimize the design of the ductwork and minimize the pressure losses through the existing ductwork.

- Install turning vanes in the ID fan discharge elbow (if not already installed)

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

- Install a splitter plate and turning vanes in the "T" box that is located immediately downstream of the ID fans
- Consideration should be given to replacing the "T" box that is located downstream of the absorber to reduce pressure loss

Refer to the following documents (attached) for additional information on the Draft System.

Document	SPF File Number	Document / File Number
Induced Draft Fan Analysis Study	200-55815	178771.41.0104

3.5.3.4 Chimney

The existing chimneys will be reused with minor modifications needed. Each chimney contains the flues from three boilers. The inside diameter of the existing flues is adequate for the flue gas flow volumes, and the borosilicate block liner's transitional velocity for condensation re-entrainment is sufficiently above the calculated worst-case design so that re-entrainment of moisture droplets will not occur.

The steel flue liner material for Medupi is identical to the Kusile Power Station project, which uses 316 L stainless steel. As explained in an Engineering Change Report (ECR), "Modification of Chimney Compensator and Nozzles, and Addition of Coating to the 316L Stainless Flue Liners" [9]; corrective action has been recommended for the Kusile Power Station site, consisting of replacement of nozzles and components of the compensator made from 316 L material; and the coating of all exposed 316 L flue liner plate and hatches. The original chimney design did not fully account for the low pH levels and high chloride design conditions downstream of the wet FGD, considering the design life of the plant. This ECR concluded that C276 material should have been used for the exposed steel components rather than 316 L stainless steel. A study should be carried out to determine the schedule impacts and cost impacts for the coating, lining, and/or replacement with C276 material of the items currently made of 316L material, and to recommend whether the modifications should be made while the Medupi Power Station is under construction, after power station startup but prior to the FGD Retrofit Project work, or as part of the FGD Retrofit Project scope.

Condensation calculations and flow modelling will need to be performed during detailed design to assure duct-stack system is favourable for wet operation and to review the need for additional liquid collection facilities in the breeching and flue.

Modifications to the chimney drain piping and the chimney drain system are necessary to return collected condensation to the Gypsum Bleed Tanks is described in the Stack Water Collection Study, attached.

Refer to the following documents (attached) for additional information on the Chimney.

Document	SPF File Number	Document / File Number
Chimney Analysis	200-55812	178771.41.0101
Stack Water Collection Study	200-106540	006265-T-STD-230

3.5.3.5 FGD Makeup Water and Process Water Supply

Makeup water for the FGD system will be supplied from the existing raw water reservoir. The reservoir has two compartments to supply water from either the Crocodile West or the Mokolo water supplies. A backwashable strainer pretreatment system will provide treatment of the makeup water for the FGD equipment.

FGD makeup water will be supplied by two of the low-pressure raw water pumps drawing water from either of the two basins at the water reservoir. Three 50 percent capacity low-pressure raw water pumps

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

will be provided to secure the necessary backup in water supply. After pretreatment, the majority of water is sent to the Process Water Tanks for utilization in the FGD process. The makeup water is also used for the FGD Closed Cycle Cooling Water System cooling tower makeup and the FGD ZLD Treatment System uses. The backwash water from the backwashable strainers will be discharged into the existing dirty water drains system.

Condensate polisher plant (CPP) waste stream from the existing water treatment plant (WTP) was evaluated for use as makeup water to the FGD system as described in the FGD System Water Supply/Wastewater Disposal Study (178771.41.0107, SPF file 200-55817). The average flow is 4.57 cubic metres per hour with an instantaneous flow of 100 cubic metres per hour. The routing of the CPP waste stream from the WTP to the FGD would require extensive work (due to this plant area being constructed with most pipelines below ground). Prediction of the waste stream quality would also be difficult due to unknowns regarding the chemicals required for the cleaning process around the membrane systems at the WTP. Therefore the CPP waste stream will follow its current process, i.e., flowing into the effluent neutralisation sump (ENS) and being pumped by the concentrate pumps at the ENS to Dirty Water Tank 1.

The three Process Water Tanks (two in operation and one spare) have a storage capacity of 8 hours of full load operation, supplying all FGD plant water demands. Six process water pumps each will provide 100 percent redundancy, with one spare pump for each tank, to secure the necessary backup in water supply. Water will be delivered from these pumps to all systems needing clean process water.

The makeup water will be used to replace evaporation losses in the absorbers. This will be done primarily via mist eliminator washing. Other uses for this water will be washing the gypsum and preparing fresh limestone suspension.

Makeup water will be consumed completely in the FGD process plant; no water will be returned to the existing plant, with the exception that the water effluent from the FGD makeup water pretreatment plant will be returned to the dirty water drains system.

Refer to the following documents (attached) for additional information on the Makeup Water and Wash Water Supply.

Document	SPF File Number	Document / File Number
Water Supply / Waste Water Disposal Study	200-55817	178771.41.0107
FGD Makeup Water Supply System Description	200-58478	178771.43.6607
FGD Makeup Water Supply P&ID	0.84/30078	178771-CHTQ-M2667A
System Description Process Water Supply, Filtrate and Reclaim Water	200-58506	006265-T-HBU-503
P&ID Process Water Tanks	0.84/29764	006265-R-PID-070
P&ID Process Water Distribution	0.84/36057	006265-R-PID-075
General Arrangement, FGD Makeup Water Pretreatment Area	0.84/36244	178771-CUGA-G2003
General Arrangement, Raw Water Pump Building	0.84/36385	178771-CUGA-G2011
General Arrangement, FGD Makeup Water Pretreatment Building	0.84/36795	178771-CUGA-G2004

3.5.3.6 Limestone Handling and Limestone Preparation Systems

New limestone material handling systems will receive limestone arriving via rail cars and trucks, sampled automatically with one online elemental analyser[3], stock out the material, and reclaim and convey it to

[3] If technically feasible at the time the project is implemented. Note that as of today, online elemental analyser is not an established, widely-used application for power plants.

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

the limestone silos located in the Limestone Preparation Area. The limestone stockpile will provide 30 days' worth of limestone storage for use in the FGD system and is equipped with dust suppression sprays.

Depending on the outcome of negotiations with Transnet Freight Rail (TFR), three alternative limestone transportation scenarios are possible. Under scenario 1, limestone will be transported to the station on flatbed rail wagons in bottom discharge containers. The containers will be offloaded from the trains via a gantry crane which will move the container above the underground hopper (HPR-2), where the limestone will be discharged directly into the hopper (HPR -2). Under scenario 2, limestone will be transported to the station via bottom discharge wagons. These rail wagons will run on rail tracks above the underground hopper (HPR-1), where the wagons will discharge limestone directly into the hopper (HPR-1). Under scenario 3, limestone will be delivered to the station by means of side tipper trucks, which will tip limestone directly into the underground hopper (HPR-2).

Limestone in the hopper will be extracted with a belt feeder and fed onto the underground link conveyor. The underground link conveyor will feed the limestone stockout conveyor with a traveling tripper that will feed the limestone stacker.

The limestone pile will be reclaimed using a portal scraper reclaimer to feed the limestone reclaim conveyor, which will transfer limestone to three limestone storage silos (day bins) located in the Limestone Preparation Area. From the reclaim conveyor, material will be transferred to a reversible shuttle conveyor. The centre bin will be fed directly from the reclaim conveyor. The outer bins will be fed by the reversible shuttle conveyor.

The system will include an emergency offloading facility for limestone delivered via side tripper truck at both the limestone receiving underground hopper and at the limestone stockpile. Emergency reclaim from the stockpile will be possible using a scraper chain feeder that will directly feed the limestone reclaim conveyor.

Each of the three limestone silos will have a storage capacity which will serve half the station requirements for 24 hours, according to the design consumption indicated in the PDM (178771.22.0000, SPF file 200–61989), attached.

From the three limestone silos, the limestone will be fed into the wet ball mills by weigh belt feeders. These ball mills will be constructed as overflow ball mills. The mill itself will primarily consist of a rotating drum containing steel balls. The total mill feed flow will be composed of water and new limestone feed, which will pass through the grinding chamber and be reduced in size. The ground slurry will be collected in the ball mill circulation tank and classified by means of pumps and a hydrocyclone station. The final product will flow from the hydrocyclone overflow by gravity to the limestone slurry feed tanks, with oversize particles being recycled to the mill inlet for additional grinding.

Refer to the following documents (attached) for additional information on the Limestone Handling and Limestone Preparation Systems.

Document	SPF File Number	Document / File Number
System Description Limestone	200-58340	178771.43.1004
Limestone Handling Plant Process Flow Diagram	0.84/37821	
System Description Limestone Mill and Slurry Preparation	200-57985	006265-T-HBU-502
P&ID Limestone Slurry Preparation Line 1	0.84/36056	006265-R-PID-061
P&ID Limestone Slurry Preparation Line 2	0.84/38971	006265-R-PID-062
P&ID Limestone Slurry Preparation Line 3	0.84/38972	006265-R-PID-063
P&ID Limestone Slurry Feed	0.84/29758	006265-R-PID-020
FGD Limestone Rec Str Reclaim Conveyor Arrangement	0.84/37789	
FGD Limestone Rec Str Reclaim Conveyor Arrangement	0.84/37790	
FGD Limestone Rec Str Reclaim Conveyor Arrangement	0.84/37791	

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Document	SPF File Number	Document / File Number
General Arrangement, Limestone Unloading and Receiving Area	0.84/37961	178771-CUVD-G2025
General Arrangement, Limestone Unloading and Receiving Building	0.84/37962	178771-CUVD-G2026
Limestone Prep Bldg Conveyor Arrangement LCVY-3	0.84/37756	
Limestone Prep Bldg Conveyor Arrangement LCVY-4	0.84/37757	
General Arrangement, Limestone Preparation Area	0.84/36532	178771-CHTJ-G2005
General Arrangement, Limestone Preparation Building	0.84/36531	178771-CHTJ-G2006A

3.5.3.7 Gypsum Refinement and Dewatering System

Gypsum will be produced as a byproduct of the wet scrubbing process. The gypsum crystals will be contained in a slurry consisting primarily of gypsum, a mixture of salts (magnesium sulphate [$MgSO_4$], calcium chloride [$CaCl_2$]), limestone, calcium fluoride (CaF_2), and dust particles. Refinement is necessary to separate the gypsum from the unwanted material and produce a material that is suitable for commercial re-use (i.e., cement, wallboard, etc.).

Refinement of gypsum will proceed in two steps: separation and dewatering. Separation will be done by means of gypsum hydrocyclones, followed by a second dewatering stage using horizontal vacuum belt filters.

Slurry from the absorber will be fed via the absorber bleed pumps to gypsum bleed tanks. From the gypsum bleed tanks, the slurry will be fed into the gypsum hydrocyclone station. The overflow from the hydrocyclone station, primarily containing the finer portion of solid particles (fine gypsum particles, fresh limestone, insoluble impurities of limestone and fly ash), will be fed into the reclaim water tanks. A small amount of the gypsum hydrocyclone overflow must be bled off from the system into the wastewater treatment plant to avoid concentration of fine particulate and dissolved chlorides. This portion of the overflow will be sent to the wastewater hydrocyclones feed tank. From there, the wastewater (now containing only a small amount of very fine particles) will be pumped into another hydrocyclone battery, which will separate even finer particles from the wastewater. The overflow from these wastewater hydrocyclones will be sent to the wastewater treatment system, while the underflow (containing most of the remaining particles) will be directed to the reclaim tanks.

The underflow from the gypsum hydrocyclones, containing primarily coarse gypsum particles, will enter directly onto the horizontal vacuum belt filters. The gypsum slurry will be deposited onto the belt filter cloth in a layer of definite thickness to ensure constant parameters and dewatering performance. This gypsum solids layer will be dewatered by applying vacuum to the back side of the belt filter cloth. The extracted liquid will be recycled to the FGD reclaim water system.

To produce commercial-grade gypsum, it is necessary to keep the chloride content of the gypsum under a certain limit. Therefore, during the dewatering process the filter cake will be washed with FGD makeup water to decrease the chloride content to the level acceptable for the commercial-grade gypsum product.

The gypsum being discharged from the horizontal vacuum belt filter will be dropped onto one of two collecting conveyors by means of bifurcated chutes. An online monitoring system installed within the gypsum production process will be used to indicate the gypsum quality. The collecting conveyor will take the gypsum to a transfer house where the gypsum will be transferred to one of two gypsum link conveyors which feed a series of gypsum conveyors. The gypsum conveyors will either feed material to the overland ash conveyors for co-disposal of the gypsum with the ash, or alternatively will feed material to an elevated mobile tripper car at the gypsum storage facility[4]. The elevated tripper car will be able to

[4] Note that the possibility of co-disposal will be confirmed with the current waste classification study [12], and thereafter the competent authority.

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

stack gypsum in three different piles or into one continuous pile. The elongated pile will allow sampling while a portion is being reclaimed. The gypsum storage facility will be required to accommodate 100 percent of the total gypsum production for three days; however it is anticipated that only 20 percent of gypsum will be required for commercial sale purposes.

Acceptable commercial grade gypsum will be reclaimed from the storage pile using mobile equipment and mobile belt (apron) feeders, and conveyed to a load out system. Acceptable material can also be loaded via mobile equipment into trucks.

The remaining gypsum will be reclaimed using mobile equipment and a mobile belt (apron) feeder and conveyed to either of the two overland ash conveyors, and combined with the ash for disposal in the on-site ash landfill.

Refer to the following documents (attached) for additional information on the Gypsum Refinement and Dewatering System.

Document	SPF File Number	Document / File Number
Byproduct Disposal Study	200-55816	178771.41.0106
System Description Gypsum Dewatering System	200-59838	006265-T-HBU-507
P&ID Gypsum Bleed/Emergency Drain Tank 1	0.84/29757	006265-R-PID-010
P&ID Gypsum Bleed/Emergency Drain Tank 2	0.84/38966	006265-R-PID-015
P&ID Gypsum Dewatering Line 1	0.84/36054	006265-R-PID-031
P&ID Gypsum Dewatering Line 2	0.84/38967	006265-R-PID-032
P&ID Gypsum Dewatering Line 3	0.84/38968	006265-R-PID-033
P&ID Gypsum Dewatering Line 4	0.84/38969	006265-R-PID-034
P&ID Gypsum Dewatering Line 5	0.84/38970	006265-R-PID-035
P&ID Filtrate Tanks	0.84/36055	006265-R-PID-037
P&ID Waste Water HC Feed Tanks	0.84/29760	006265-R-PID-040
P&ID Waste Water HC Stations	0.84/29761	006265-R-PID-050
P&ID Reclaim Tanks	0.84/29762	006265-R-PID-055
General Arrangement, Gypsum Dewatering Area	0.84/36527	178771-CHTL-G2007
General Arrangement, Gypsum Dewatering Building Ground Floor EL 902.4	0.84/36520	178771-CUGQ-G2008A
General Arrangement, Gypsum Dewatering Building EL 911.4	0.84/36521	178771-CUGQ-G2008B
General Arrangement, Gypsum Dewatering Building EL 918.4	0.84/36522	178771-CUGQ-G2008C
General Arrangement, Gypsum Dewatering Building EL 924.4	0.84/36523	178771-CUGQ-G2008D
General Arrangement, Gypsum Storage Area	0.84/37881	178771-CUGE-G2023
General Arrangement, Gypsum Storage Building	0.84/37993	178771-CUGE-G2024
System Description Gypsum	200-58339	
Gypsum Handling Plant Process Flow Diagram	0.84/37820	
FGD Solids Conveying and Storage Arrangement GCVY-1&2	0.84/37780	
FGD Solids Conveying and Storage Arrangement GCVY-3&4	0.84/37781	
FGD Solids Conveying and Storage Arrangement GCVY-5&6	0.84/37782	
FGD Solids Conveying and Storage Arrangement GCVY-7&8	0.84/37783	
FGD Solids Conveying and Storage Arrangement GCVY-9	0.84/37784	
FGD Solids Conveying and Storage Arrangement GCVY-10	0.84/37785	
FGD Solids Conveying and Storage Arrangement GCVY-11	0.84/37786	

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Document	SPF File Number	Document / File Number
FGD Solids Conveying and Storage Arrangement GCVY-12	0.84/37787	
FGD Solids Conveying and Storage Arrangement GCVY-13	0.84/37788	

3.5.3.8 FGD ZLD Treatment System

A new FGD ZLD Treatment System will treat the FGD system chloride bleed stream, the total organic carbon (TOC) scavenger regeneration wastewater from the existing plant, and FGD cooling tower blowdown streams. The FGD ZLD pretreatment equipment will consist of two 100 percent trains. Each 100 percent train will be capable of treating 103 cubic metres per hour (m^3/h). The brine concentrator/crystallizer equipment will receive the treated effluent from the FGD ZLD pretreatment equipment and will consist of four 50 percent trains. Each 50 percent train will be capable of treating 52 m^3/h.

The FGD chloride bleed and FGD cooling tower blowdown streams will first be directed to one FGD ZLD Pretreatment Holding Tank and two 100 percent capacity FGD ZLD Pretreatment Holding Tank Forwarding Pumps. In addition to the FGD chloride bleed stream and FGD cooling tower blowdown, the tank will receive filter press filtrate and off-spec recirculation from the FGD ZLD pretreatment process. Due to the high pH of the TOC scavenger wastewater which could cause precipitation of solids in the ZLD Pretreatment Holding Tank, it will be transferred directly to the FGD ZLD pretreatment process. The TOC scavenger regeneration wastewater quality will not be fully known until the system is operating within the existing plant, however a preliminary estimate of the quality indicates that additional treatment is not expected. Once the existing water treatment plant system is operational, the TOC scavenger wastewater stream will need to be monitored to establish the typical concentrations, types of organics, and variability. The eventual FGD ZLD pretreatment and brine concentrator/crystallizer equipment supplier will need to determine if the established concentrations and types of organics are acceptable. If not, it may be necessary to treat the stream for organics before it is sent to the FGD ZLD pretreatment process or provide a slip stream off of the brine concentrator to dispose of the organics separately. Depending on the type and concentration of organics, problems with foaming and solids dewatering could result in the FGD ZLD Treatment System. If the FGD ZLD Treatment System distillate is sent to the FGD system as makeup, then similar issues could occur in the FGD system.

The cooling tower blowdown from the FGD closed cycle cooling water system is currently planned to be sent to the FGD ZLD Treatment System; however, based on the expected quality of the blowdown, it could be recycled as makeup to the FGD.

The wastewater streams will be pretreated to convert hardness to sodium and remove the suspended solids and heavy metals prior to the brine concentrator/crystallizer process. The FGD ZLD pretreatment process will include physical/chemical treatment of the water to precipitate solids and heavy metals from the water. Lime and soda ash are used to convert the dissolved calcium and magnesium to sodium so that the water can be effectively treated in the downstream brine concentrators and crystallizers. The FGD ZLD pretreatment equipment will use large amounts of lime and soda ash; therefore, it is important to confirm the necessary quantity and quality of lime and soda ash that can be obtained. Using trucks with an 18,000 kg capacity and plant operation with 85 percent limestone purity, approximately one truck of lime is required every 8 hours and one truck of soda ash every 5 hours. After chemical treatment, the precipitates are settled out in clarifiers as solids slurry, which is sent to a filter press dewatering system. The water is recovered from the solids slurry and returned back to the clarifier. Slurry from the clarifier will be sent to filter presses. The filter press filtrate will be returned back to the FGD ZLD Pretreatment Holding Tank. The physical/chemical treatment system will be sized to handle the incoming flows plus the filtrate from the filter presses and any other process recycle streams. The solids will be collected in a concrete bunker or dumpsters placed underneath the presses.

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Flow from the FGD ZLD pretreatment process will be directed to a brine concentrator feed tank. Chemicals will be fed to this tank as required for feed to the brine concentrator. The water from this tank will then be pumped through the brine concentrator influent heat exchangers and into the deaerator. The brine concentrators will utilize a seeded slurry process.

The brine concentrator portion of the system operates by using mechanical vapour compression. The brine concentrators will be designed to produce a distillate product stream and a concentrated brine waste stream from the treated wastewater. The distillate product will be combined with distillate from the crystallizer portion of the system and directed to the plant for reuse. Two independent waste blowdown streams will be utilized to maintain close control of the recirculating brine chemistry. A seed recycle system recovers and recycles seed from the waste brine stream back to the recirculating brine. The concentrated brine waste stream will be fed to the crystallizer feed tanks for intermediate storage. Steam will be sparged into the tank to maintain the tank contents at a predetermined temperature, to prevent corrosion to downstream equipment and quenching of the crystallizer recirculating brine (which may lead to foaming). The steam driven crystallizers will then remove the balance of the recoverable water, and a stream of wet solids will be discharged from each centrifuge. Within the crystallizer, water will be continuously evaporated while a small purge stream is circulated through the centrifuge to remove the waste for disposal. Excess liquid from the centrifuge will be returned for further concentration. The brine concentrator will have a foam detection system to detect any excess amount of foaming in the brine concentrator. Steam may be used for brine concentrator startup steam and deaerator steam.

If the TOC content in the effluent from the FGD Zero Liquid Discharge Treatment System (the “ZLD distillate”) is low (≤29 ppm), it would be suitable for use as makeup water to the FGD plant, which would offset some of the fresh water demand of the FGD. It is anticipated that ZLD distillate may also be suitable for other uses within the Medupi Power Station. To provide operational flexibility, the Basic Design includes provisions for the ZLD distillate to be directed to either the Reclaim Tanks or existing Medupi Water Treatment Plant RO Feed Tank. Dewatered sludge will be disposed of using trucks to transport to onsite or offsite dumps, and dewatered brine will also be disposed of using trucks to transport to onsite or offsite dumps[5].

Refer to the following documents (attached) for additional information on the FGD ZLD Treatment System.

Document	SPF File Number	Document / File Number
Water Supply / Waste Water Disposal Study	200-55817	178771.41.0107
FGD Zero Liquid Discharge (ZLD) Treatment System Description	200-58476	178771.43.6405
P&ID FGD ZLD Treatment	0.84/30077	178771-CGNG-M2645
Byproduct Disposal Study	200-55816	178771.41.0106
General Arrangement, FGD ZLD Treatment Area	0.84/37792	178771-CGNR-G2009
General Arrangement, FGD ZLD Treatment Building	0.84/37689	178771-CGNR-G2010

3.5.3.9 Auxiliary Steam System

The FGD Auxiliary Steam System will be designed to distribute auxiliary steam to the wastewater treatment area to be used for the FGD zero liquid discharge treatment system. The FGD Auxiliary Steam System connects the plant Units 1-3 and Units 4-6 auxiliary steam header to the FGD ZLD treatment system area auxiliary steam header. The FGD Auxiliary Steam System will continuously supply the auxiliary steam requirements for the FGD ZLD Treatment System during normal operation, startup, and shutdown.

[5] Note that disposal of the ZLD and pretreatment waste disposal will be confirmed with the current waste classification study [12], and thereafter the competent authority.

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Auxiliary steam is provided to the brine concentrator deaerator equipment within the FGD ZLD Treatment System, where it is used to heat the brine (wastewater) solution. The steam is mixed within the treatment process and recovered with the ZLD distillate, and therefore there is not a return stream for steam or steam distillate. Auxiliary steam flow requirements herein are estimated and will require confirmation by the FGD ZLD Treatment System supplier.

Refer to the following documents (attached) for additional information on the Auxiliary Steam System.

Document	SPF File Number	Document / File Number
FGD Auxiliary Steam System Description	200-58353	178771. 43.0601
P&ID Auxiliary Steam System	0.84/30083	178771-CLBG-M2061

3.5.3.10 FGD Closed Cycle Cooling Water

A new, stand-alone closed cycle cooling water (CCCW) system will provide heat rejection for the heat exchangers associated with FGD equipment that requires water cooling. The heat rejection requirement for this equipment is generally larger than for other equipment that is air cooled.

The CCCW system will provide cooling water to the following equipment.

- Limestone ball mill lubrication system
- FGD system air compressors
- Brine concentrator/crystallizer equipment in the FGD ZLD Treatment area

Cooling water for the CCCW system will be of condensate quality and supplied by the existing plant through a 50 mm pipeline to the CCCW Expansion Tank. The tank is elevated to provide sufficient suction head for the closed cycle cooling water pumps and to fill the system by gravity. Once filled, the expansion tank will only require small amounts of water to maintain level in the tank and keep the system filled. A minimum tie-in pressure of 496 kPa is sufficient to fill the system during commissioning at a rate of 189 lpm. Two 100 percent closed cycle cooling water pumps will be designed to supply cooling water to the FGD equipment heat exchangers. The CCCW heat exchangers will transfer heat from the circulating cooling water to the auxiliary cooling water. The open cycle cooling water pumps will take suction from a multi-cell wet cooling tower and pump the auxiliary cooling water through the CCCW heat exchangers and to the wet cooling tower. The wet cooling tower will reject heat from the auxiliary cooling water to atmosphere and return it to the system at a specified design temperature. Makeup water due to evaporation and blowdown will be provided from the FGD Makeup Water Supply System Blowdown from the cooling tower will be directed to the FGD ZLD Pretreatment Holding tank. An acid feed system including a storage tote and feed skid will feed acid to condition the open cycle circulating water.

Refer to the following documents (attached) for additional information on the FGD Closed Cycle Cooling Water System.

Document	SPF File Number	Document / File Number
FGD and Wastewater Treatment Closed Cycle Cooling Water System Description	200-58471	178771. 43.3202
P&ID FGD and Wastewater Treatment Closed Cycle Cooling Water System	0.84/30084	178771-CPGB-M2322
General Arrangement, FGD ZLD Treatment Area	0.84/37792	178771-CGNR-G2009

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

3.5.3.11 Fire Protection

The existing fire protection system will be extended to supply fire water for both automatic and manual firefighting at locations in the FGD area. Existing fire water pumps will provide pressure for FGD fire protection. New fire water booster pumps will be used to maintain fire water pressure at elevated points within the system.

Refer to the following documents (attached) for additional information on the FGD fire protection.

Document	SPF File Number	Document / File Number
Fire Protection/Detection Assessment Report	474-9699	
FGD Fire Protection System Description	200-58473	178771.43.3621
P&ID FGD Fire Protection	0.84/30086	178771-CSGA-M2361
Conceptual Fire Hydrant Locations	0.84/37851	178771-SK-M0003
General Arrangement, Common Pump Building	0.84/38747	178771-CGKC-G2027

3.5.3.12 Compressed Air

The compressed air system will supply dry air for all the service and instrument air users in the FGD area. Two 100 percent FGD air compressors and two 100 percent filter / air dryers will be designed to provide compressed, oil-free air at the required capacity and pressure to meet the compressed air requirements. Air receivers located in the FGD Common Pump Building, Absorber Pump Buildings, FGD ZLD Treatment Building, Limestone Preparation Building, Gypsum Dewatering Building, and FGD Makeup Water Pretreatment Building will provide surge capacity and maintain a relatively constant air supply flow and pressure to the FGD area users.

Refer to the following documents (attached) for additional information on the Compressed Air System.

Document	SPF File Number	Document / File Number
FGD Compressed Air System Description	200-58467	178771.43.1802
P&ID FGD Compressed Air	0.84/30085	178771-CQFB-M2182

3.5.3.13 Potable Water

The existing plant potable water system will be extended to supply potable water to the safety shower/eyewash stations, washdown hose connections, ablution facilities, HVAC equipment, lab faucets, and other potable water users in the FGD area. Two 100 percent potable water booster pumps will ensure adequate flow and pressure to meet system demands. The pumps will be tied into the Essential Services Substation and the Emergency Diesel Generator so that potable water is available when the plant is without power. Backflow preventers will be provided as required to prevent contamination into the potable water system and backpressure regulators will be used to isolate the nonessential water users in the event of low system pressure.

Refer to the following documents (attached) for additional information on the Potable Water System.

Document	SPF File Number	Document / File Number
FGD Potable Water System Description	200-58477	178771.43.6604
P&ID FGD Potable Water	0.84/30075	178771-CGKC-M2664

3.5.3.14 FGD Blowdown System

The FGD blowdown system collects and conveys process waste fluids by means of drain trenches, sumps and sump pumps. The sumps and trenches will be below grade, reinforced concrete structures

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

located in the Absorber Pump Buildings, FGD Common Pump Building, FGD makeup water pretreatment area, absorber drain and gypsum bleed tank area, FGD ZLD Treatment Building and area, Limestone Preparation Building and area, and Gypsum Dewatering Building and area. Process wastewaters and slurries in these buildings/areas will discharge into the trenches, which are sloped to drain by gravity into the associated sumps. Sumps which receive slurry will have agitators to maintain solids suspension. Each sump will contain two 100 percent sump pumps to transfer the sump contents to the appropriate discharge location. Sump level measurement will start and stop the sump pumps in an alternating mode that automatically cycles between pumps to ensure even run time. Sump pumps and pipelines that transfer slurry include flushing with process water upon pump shutdown.

Refer to the following documents (attached) for additional information on the FGD Blowdown System.

Document	SPF File Number	Document / File Number
FGD Blowdown System Description	200-58469	178771.43.2819
P&ID FGD Limestone Preparation Building Sumps	0.84/30079	178771-CHTT-M2281A
P&ID FGD Gypsum Dewatering Building Sumps	0.84/30080	178771-CHTT-M2281B
P&ID FGD Limestone Preparation Area Sumps	0.84/30081	178771-CHTT-M2281C
P&ID FGD Makeup Water Pretreatment Sump	0.84/30082	178771-CHTT-M2281D
P&ID FGD ZLD Treatment Area Sumps	0.84/38020	178771-CHTT-M2281E
P&ID Absorber Drain and Gypsum Bleed Tank Area Sumps	0.84/38021	178771-CHTT-M2281F
P&ID FGD ZLD Treatment Building Sumps	0.84/38022	178771-CHTT-M2281G
P&ID FGD Gypsum Dewatering Area Sumps	0.84/38023	178771-CHTT-M2281H
P&ID FGD Common Pump Building Sump	0.84/38024	178771-CHTT-M2281J
P&ID Unit 1 Absorber Pump Building Sumps	0.84/38025	178771-1HTT-M2281
P&ID Unit 2 Absorber Pump Building Sumps	0.84/38026	178771-2HTT-M2281
P&ID Unit 3 Absorber Pump Building Sumps	0.84/38027	178771-3HTT-M2281
P&ID Unit 4 Absorber Pump Building Sumps	0.84/38028	178771-4HTT-M2281
P&ID Unit 5 Absorber Pump Building Sumps	0.84/38029	178771-5HTT-M2281
P&ID Unit 6 Absorber Pump Building Sumps	0.84/38030	178771-6HTT-M2281

3.5.3.15 FGD Auxiliary Electric Power System

3.5.3.15.1 High Voltage Power Supply

A new 132 kilovolt (kV) power supply will be installed at the 132 kV switchyard to provide back-up power to the FGD Common system. A new 132/12 kV transformer will step-down voltage for a new 11 kV FGD Common board switchgear which will supply the FGD Fire Water Electric Pump and an 11/6.9 kV FGD Back-up transformer. The 11/6.9 kV FGD Back-Up Transformer supplies a new 6.6 kV FGD Common Plant Back-Up Supply Board.

This back-up power supply is required to maintain 100 percent redundancy in the FGD Common power system as required by the User Requirements Specification [4] due to capacity limitations on Medupi Station Transformer 1 and 2. Extension of the 132 kV busbar and installation of the 132/12kV transformer will be the responsibility of Eskom transmission.

Refer to the following documents (attached) for additional information on the High Voltage Auxiliary Electric System.

Document	SPF File Number	Document / File Number
Medupi FGD Retrofit Evaluation (load flow, fault and motor start-up studies)	200-62087	
Single Line Diagram FGD Common MV & LV BRD	0.84/28751 – Sheet 8	178771-CBCG-E1008
Single Line Diagram FGD Common Back-Up Supply MV & LV BRD	0.84/28751 – Sheet 12	178771-CBCG-E1012

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Document	SPF File Number	Document / File Number
Medupi Project FGD Electrical Load List	0.84/39020	178771-DE-1001

3.5.3.15.2 Medium Voltage Power Supply

New FGD auxiliary transformers will transform 11 kV three-phase power supplied from the existing 11 kV system to 6900 volt (V) three-phase power. The FGD auxiliary transformers will supply 6900 V, three-phase power to the FGD plant and absorber board switchgear buses through main breakers. The switchgear buses for similar service will be connected through a tiebreaker. For instance, the 6.6 kV Unit 1 FGD Plant Board 1 and the 6.6 kV Unit 1 FGD Plant Board 2 will be connected through a tiebreaker. The main breakers and the tiebreaker make it possible for a switchgear bus to be fed from two separate sources. This configuration will be used for all 6.6 kV switchgear with the exception of the 6.6kV FGD Common Plant BRD 1 and 6.6kV FGD Common Plant BRD 2 which will be connected to the 6.6kV FGD Common Plant Back-Up Supply BRD.

The switchgear buses will distribute power through feeder breakers to 6.6 kV FGD loads. These 6.6 kV loads will consist of large 6600 V motors, variable speed drives associated with 6.6 kV loads (such as for the limestone conveyors), 6.6 kV switchboards, and FGD load centre transformers.

Refer to the following documents (attached) for additional information on the Medium Voltage Auxiliary Electric System.

Document	SPF File Number	Document / File Number
Medupi FGD Retrofit Evaluation (load flow, fault and motor start-up studies)	200-62087	
AC Power Supply (6600V) System Description	200-58166	178771.43.0404
Single Line Diagram Unit 6 Absorber MV & LV BRD	0.84/28751 – Sheet 2	178771-6BCG-E1002
Single Line Diagram Unit 5 Absorber MV & LV BRD	0.84/28751 – Sheet 3	178771-5BCG-E1003
Single Line Diagram Unit 4 Absorber MV & LV BRD	0.84/28751 – Sheet 4	178771-4BCG-E1004
Single Line Diagram Unit 3 Absorber MV & LV BRD	0.84/28751 – Sheet 5	178771-3BCG-E1005
Single Line Diagram Unit 2 Absorber MV & LV BRD	0.84/28751 – Sheet 6	178771-2BCG-E1006
Single Line Diagram Unit 1 Absorber MV & LV BRD	0.84/28751 – Sheet 7	178771-1BCG-E1007
Single Line Diagram FGD Common MV & LV BRD	0.84/28751 – Sheet 8	178771-CBCG-E1008
Single Line Diagram FGD ZLD Treatment MV & LV BRD	0.84/28751 – Sheet 9	178771-CBCG-E1009
Single Line Diagram FGD Essential MV & LV BRD	0.84/28751 – Sheet 10	178771-CBCG-E1010
Single Line Diagram FGD Limestone and Gypsum Handling MV & LV BRD	0.84/28751 – Sheet 11	178771-CBCG-E1011
Single Line Diagram FGD Common Back-Up Supply MV & LV BRD	0.84/28751 – Sheet 12	178771-CBCG-E1012
Medupi Project FGD Electrical Load List	0.84/39020	178771-DE-1001
General Arrangement, FGD Common Substation	0.84-36243	178771-CUBE-G2013
General Arrangement, Limestone and Gypsum Handling Substation	0.84/37960	178771-CUBV-G2014

3.5.3.15.3 Low Voltage Power Supply

The 400 V FGD auxiliary power system will consist of low-voltage (LV) switchgear, power cables, and low voltage loads. The main supply to the LV switchgear will be from the 6.6 kV switchgear through the 6.6 kV/0.42 kV dry-type transformers. The 6.6/0.42 kV dry-type transformer will be an integral part of the LV switchgear. Switchgear busbar voltage will be 400 V AC, three-phase, 50 Hz, 4-wire, and 230 V AC 2-wire is utilized for control and protection of the switchgear. The distributed control system (DCS) and the Emergency Trip Relays utilize 24V DC.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Main power supply to a board (or switchgear) is through a 6.6/0.42 kV dry-type, delta-wye transformer (except 400 V limestone unloading boards 1 and 2 which are supplied from the 400 V Limestone Handling boards). Tie-breakers connect boards of similar service. The tie-breaker and incomer breaker are equally sized. The main breakers and the tie-breaker make it possible for a switchgear bus to be fed from two separate sources.

The switchgear buses will distribute power through feeder breakers to 400 V FGD loads. These 400 V loads are 400 V motors, variable speed drives, motor operated valves, distribution panels, DC panels, motor starters, etc.

Refer to the following documents (attached) for additional information on the 400 Volt Auxiliary Electric System.

Document	SPF File Number	Document / File Number
Medupi FGD Retrofit Evaluation (load flow, fault and motor start-up studies)	200-62087	
AC Power Supply (400V) System Description	200-58141	178771.43.0403
Single Line Diagram Unit 6 Absorber MV & LV BRD	0.84/28751 – Sheet 2	178771-6BCG-E1002
Single Line Diagram Unit 5 Absorber MV & LV BRD	0.84/28751 – Sheet 3	178771-5BCG-E1003
Single Line Diagram Unit 4 Absorber MV & LV BRD	0.84/28751 – Sheet 4	178771-4BCG-E1004
Single Line Diagram Unit 3 Absorber MV & LV BRD	0.84/28751 – Sheet 5	178771-3BCG-E1005
Single Line Diagram Unit 2 Absorber MV & LV BRD	0.84/28751 – Sheet 6	178771-2BCG-E1006
Single Line Diagram Unit 1 Absorber MV & LV BRD	0.84/28751 – Sheet 7	178771-1BCG-E1007
Single Line Diagram FGD Common MV & LV BRD	0.84/28751 – Sheet 8	178771-CBCG-E1008
Single Line Diagram FGD ZLD Treatment MV & LV BRD	0.84/28751 – Sheet 9	178771-CBCG-E1009
Single Line Diagram FGD Essential MV & LV BRD	0.84/28751 – Sheet 10	178771-CBCG-E1010
Single Line Diagram FGD Limestone and Gypsum Handling MV & LV BRD	0.84/28751 – Sheet 11	178771-CBCG-E1011
Single Line Diagram FGD Common Back-Up Supply MV & LV BRD	0.84/28751 – Sheet 12	178771-CBCG-E1012
Medupi Project FGD Electrical Load List	0.84/39020	178771-DE-1001

3.5.3.15.4 Emergency Electrical Supply

A new 2000 kVA emergency diesel generator (EDG) will provide emergency shutdown power at 6.6 kV AC upon the loss of normal 6.6 kV AC power. Sizing for the EDG to support FGD loads requires a unit rated 2000kVA. The existing 2500kVA Medupi EDG's do not have this additional capacity to support these loads.

The EDG will be connected to a 6.6 kV essential switchgear and provide a backup power feed to the essential 6.6 kV pumps. The essential power will then be distributed to step-down transformers which will supply 400 V AC essential boards in each of the FGD clusters, from which it will distribute power to loads such as the valves that must operate on the loss of power to the FGD system, agitators that must be started or operated during the time when power is lost to prevent limestone slurry from solidifying, emergency lighting, and any other loads that require power on the loss of the normal 400 V AC power.

The existing EDG building is sized to accommodate only the three existing units. In addition, the existing essential reticulation system has not been configured to allow the addition of the FGD essential loads. There is not sufficient space for the new FGD EDG building and Essential Services Substation near the Medupi EDG Building due to the existing, electrical trenches, compressor house substation, and inclined coal conveyor drive house. The proposed location for the FGD EDG building is more centrally located to service the FGD loads.

Refer to the following documents (attached) for additional information on the Emergency Electrical Supply.

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Document	SPF File Number	Document / File Number
Emergency Generation System Description	200-58170	178771.43.0411
Single Line Diagram FGD Essential MV & LV BRD	0.84/28751 – Sheet 10	178771-CBCG-E1010
Medupi Project FGD Electrical Load List	0.84/39020	178771-DE-1001
General Arrangement, FGD Essential Service Substation and Emergency Generation Building	0.84/37880	178771-CUBN-G2012

3.5.3.15.5 Essential Electrical Supply

New 230 V AC uninterruptible power supply (UPS) systems with dedicated 220 V DC batteries and chargers will be provided for each Unit Absorber Pump Building Substation, FGD Common Substation, Limestone and Gypsum Handling Substation, FGD ZLD Treatment Building, FGD Emergency Generation Building and all other FGD building containing low voltage (400V) boards. These UPS systems will provide essential power for board control as well as functioning as "dip-proof" power supplies to maintain contactor position.

New 220 V DC nickel-cadmium batteries with dedicated chargers will be provided to supply essential power for control of medium voltage (11 & 6.6 kV) boards.

Refer to the following documents (attached) for additional information on the Emergency Electrical Supply.

Document	SPF File Number	Document / File Number
FGD Essential Service AC System (UPS) Description	200-58167	178771.43.0409
Medupi Project FGD Electrical Load List	0.84/39020	178771-DE-1001
General Arrangement, Unit 1 Absorber Pump Building	(not yet assigned)	178771-1UHT-G2017
General Arrangement, Unit 2 Absorber Pump Building	(not yet assigned)	178771-2UHT-G2018
General Arrangement, Unit 3 Absorber Pump Building	(not yet assigned)	178771-3UHT-G2019
General Arrangement, Unit 4 Absorber Pump Building	(not yet assigned)	178771-4UHT-G2020
General Arrangement, Unit 5 Absorber Pump Building	(not yet assigned)	178771-5UHT-G2021
General Arrangement, Unit 6 Absorber Pump Building	0.84/36796	178771-6UHT-G2022
General Arrangement, Raw Water Pump Building	0.84/36385	178771-CUGA-G2011
General Arrangement, FGD Common Substation	0.84-36243	178771-CUBE-G2013
General Arrangement, FGD Makeup Water Pretreatment Building	0.84/36795	178771-CUGA-G2004
General Arrangement, Common Pump Building	0.84/38747	178771-CGKC-G2027
General Arrangement, Limestone and Gypsum Handling Substation	0.84/37960	178771-CUBV-G2014
General Arrangement, FGD ZLD Treatment Building	0.84/37689	178771-CGNR-G2010
General Arrangement, FGD Essential Service Substation and Emergency Generation Building	0.84/37880	178771-CUBN-G2012

3.5.3.16 Control System

The existing Medupi control and instrumentation system will be extended to include all equipment required to allow the operator to operate and monitor the FGD, limestone handling, gypsum de-watering and handling, FGD ZLD, and power plant processes and be fully informed of their status.

The existing DCS for the Medupi Power Station is an Alstom ALSPA and is configured for seven distinct networks, one network for each of the six generating units (the power islands) and one for the common plant, referred to as the balance-of-plant (BOP).

A stand-alone DCS will be added for the FGD systems and subsystems. The DCS will provide control, display, alarming, reporting, and archive capabilities for the retrofit of new FGD systems for Units 1 through 6 and their associated subsystems. These subsystems include limestone handling and byproduct disposal. The FGD system DCS network will be independent of the plant DCS networks. However, the signal interface between the FGD DCSs and plant DCS will be hardwired. Local work stations will be provided for these DCS systems and all other FGD system subsystems with the exception of the FGD ZLD Treatment System.

The FGD DCS system will be on its own network and will have a dedicated loop with dedicated controllers and network equipment. Therefore there should be little to no effect to the on the overall plant network traffic. A bi-directional loop is provided for reliability so that a break in the fibre will not affect the network.

The FGD ZLD Treatment System will be provided with a dedicated control room in the FGD ZLD Treatment Building. Monitoring of the FGD ZLD Treatment System will be available in the BOP Control Room but control will be performed in the FGD ZLD Control Room on a permanent basis.

Refer to the following documents (attached) for additional information on the Control System.

Document	SPF File Number	Document / File Number
Distributed Control System System Description....................	200-123563	178771.43.2401
I/O Study		
Local Control Philosophy..	200-114237	178771.41.0108
FGD Network Architecture Diagram	0.84/38951.....................	178771-CHYQ-K8001
FGD Instrument List...	200-58413	178771-DK-1001

3.5.4 Modifications to Existing Facilities

Several modifications to the existing facilities have been identified.

1. An Interface List (178771-DM-1006, SPF file 200-60397), attached, was developed to identify the location and design requirements for interface points with the existing plant.
2. Chimney modifications will be required as described in Section 3.5.3.4.
3. A new 132 kV power supply will be installed at the 132 kV switchyard to provide back-up power to the FGD Common system as described in Section 3.5.3.15.1.
4. Interface and isolation of the FGD and bypass ductwork is described in Section 3.5.3.2.
5. Supply of the FGD Auxiliary Steam System from the existing plant auxiliary steam supply is described in Section 3.5.3.9.
6. The new gypsum conveyor system will connect with the overland ash conveyor as described in Section 3.5.3.7.
7. Waste gypsum and water treatment solid waste will be disposed in the existing onsite ash dump, as described in Section 3.14.2.

3.6 SITING

The project scope will be located within the existing boundaries of the Medupi Power Station, with one exception (refer to the Site Arrangement, 178771-CGAU-G1001, SPF file 0.84/28836, and the Plot Plan, 178771-CGAU-G1000, SPF file 0.84/36776, attached). A new raw water pipeline will be installed from the existing Raw Water Pump Building to the new Raw Water Pretreatment Building as shown on the Conceptual Raw Water Makeup Route with Road and Rail Crossings (drawing 178771-SK-M0001, SPF file 0.84/36053), attached.

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

3.7 BUILDING FACILITY LAYOUT DESIGN

Each FGD absorber will treat the flue gas from one of the six boilers; commercial-grade saleable gypsum will be produced as a byproduct. A cluster of three absorbers will be located near each of the plant's two chimneys. Systems for makeup water, reagent preparation (limestone), FGD byproduct (gypsum) dewatering and storage/disposal, and treatment of the wastewater stream will be common to all FGD absorbers in the plant. The 3D model was used to ensure that the access requirements associated with operations, maintenance, and construction activities were maintained. The 3D model was also used to coordinate the interfaces between the FGD process and Balance of Plant equipment.

The project scope includes the addition of several new buildings. Refer to the following documents (attached) and Section 3.8.2 for additional information on the buildings and facilities.

Document	SPF File Number	Document / File Number
FGD Buildings and Structures System Description	200-101738	178771.43.0801
General Arrangement, Unit 1 Absorber Pump Building	(not yet assigned)	178771-1UHT-G2017
General Arrangement, Unit 2 Absorber Pump Building	(not yet assigned)	178771-2UHT-G2018
General Arrangement, Unit 3 Absorber Pump Building	(not yet assigned)	178771-3UHT-G2019
General Arrangement, Unit 4 Absorber Pump Building	(not yet assigned)	178771-4UHT-G2020
General Arrangement, Unit 5 Absorber Pump Building	(not yet assigned)	178771-5UHT-G2021
General Arrangement, Unit 6 Absorber Pump Building	0.84/36796	178771-6UHT-G2022
General Arrangement, Raw Water Pump Building	0.84/36385	178771-CUGA-G2011
General Arrangement, FGD Common Substation	0.84-36243	178771-CUBE-G2013
General Arrangement, FGD Makeup Water Pretreatment Building	0.84/36795	178771-CUGA-G2004
General Arrangement, Common Pump Building	0.84/38747	178771-CGKC-G2027
General Arrangement, Limestone Unloading and Receiving Building	0.84/37962	178771-CUVD-G2026
General Arrangement, Limestone and Gypsum Handling Substation	0.84/37960	178771-CUBV-G2014
General Arrangement, Limestone Preparation Building	0.84/36531	178771-CHTJ-G2006A
General Arrangement, Gypsum Dewatering Building Ground Floor EL 902.4	0.84/36520	178771-CUGQ-G2008A
General Arrangement, Gypsum Dewatering Building EL 911.4	0.84/36521	178771-CUGQ-G2008B
General Arrangement, Gypsum Dewatering Building EL 918.4	0.84/36522	178771-CUGQ-G2008C
General Arrangement, Gypsum Dewatering Building EL 924.4	0.84/36523	178771-CUGQ-G2008D
General Arrangement, Gypsum Storage Building	0.84/37993	178771-CUGE-G2024
General Arrangement, FGD ZLD Treatment Building	0.84/37689	178771-CGNR-G2010
General Arrangement, FGD Essential Service Substation and Emergency Generation Building	0.84/37880	178771-CUBN-G2012

3.8 CIVIL INFRASTRUCTURE AND BUILDING DESIGN

3.8.1 Civil Infrastructure

The following assumptions were made for the basic design phase; minimal terrace cut-and-fill would be necessary in the main FGD process area, and all ground floor building slabs and equipment and vessel foundations will be at the same top-of-concrete elevation.

Basic design and or layout of the site work including roads, storm water drainage, limited area terrace cut and fill at the limestone unloading area, and new dirty water dam was completed to provide the cost for the necessary facilities for the FGD Retrofit Project. Access roads to buildings and areas and tie-in roads to existing plant roads were developed to provide the necessary access to buildings, equipment, and areas as developed in this phase. The road construction basic design criteria including widths, radii of turns; and materials of construction were based on the Medupi Power Station roads.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Storm water drainage facilities were designed following the design example of existing work for the Medupi Power Station (refer to the FGD Stormwater Drainage Layout for Area West of Boiler to Road 09 drawing, SPF file 0.84/35608, attached), and assumes the existing system is capable of accepting the dirty storm water run-off from the main FGD process area. For estimating the costs, a new Storm Water Dirty Dam was designed and shown on the Plot Plan (178771-CGAU-G1000, SPF file 0.84/36776), attached, near the Gypsum Storage Building.

During the Basic Design phase, it was determined that additional drainage design was required for the Medupi Power Station; requiring terrace drawing 0.84/193 to be updated. Drainage in this area is being coordinated with the Medupi FGD Retrofit Project's drainage needs between Road 10 and the existing boiler area; refer to ECP 200-107457.

The assumption was made that a rail-spur connecting the Plant rail yard (by others) and the Limestone Unloading Facility would have an interface point adjacent to and 25 metres from the Limestone Unloading Facility. Beyond this interface the rail yard additions are outside the scope of the Medupi FGD Retrofit Project.

Further, it was assumed that all material handling equipment; conveyors; and transfer buildings will be furnished and erected by the material handling contractor.

3.8.2 Buildings, Structures, and Foundations

Buildings consist of foundations, superstructures, building architectural enclosures, building lighting, floor sump pits and trenches where applicable, fire protection, including the Isolation Control Valve (ICV) chamber area and the Consolidated Building Management System (CBMS) and HVAC equipment, as well as architectural commodities and finishes.

The building superstructures mainly consist of two types; cast-in-place reinforced concrete portal frames, or laterally-braced steel framing. Some elevated platforms will be concrete on metal deck, and in other locations galvanized steel grating on steel framing.

The building designs relied on the building arrangement (refer to Section 3.7) for size, height, number of floors, arrangement of platforms and stairways, maintenance and egress requirements, and location of fire-rated walls for area separation where applicable, as well as cut-outs in floors and walls for equipment access.

The mechanical loads for the process equipment were developed by the project team. The load criteria developed was based upon the PDM (178771.22.0000, SPF file 200–61989) attached, S.A.N.S. codes, and investigations of site-specific environmental conditions, with the assumption made for the Basic Design phase that wind load governed the lateral load case over the seismic lateral load case for all buildings. Geological data for the main FGD process area was not available during the Basic Design. Soil bearing capacities and modulus values were assumed after reviewing Medupi Power Station data representing a strong in-situ rock formation with moderate fracturing for foundation design. Localized subgrade variability and site-specific data may require several design cases during the detailed design phase.

Building foundations are assumed to be founded upon the in-situ rock or compacted structural backfill over in-situ rock, with shallow spread footings, pad footings, or shallow mat foundations rather than deep piling-type foundations. Due to in-situ rock being close to the surface, it was assumed that deep piling-type foundations would not be applicable. The foundations will be reinforced 35 MPa cast-in-place concrete.

Process tank foundations were designed assuming ring-beam foundations bearing on in-situ rock.

The structural calculations for buildings and equipment foundations were based upon unverified assumptions, and as such, are only for cost estimating purposes. None of the basic design phase

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

calculations are applicable to actual construction – new calculations during the detailed design phase will be required.

For the Basic Design phase, assumptions were made for unknown data or loads, and are identified in an unverified assumptions log (refer to Section 3.2.3). In support of the definitive cost estimate, simplifications were also used such as not designing structural connections for structural steel structures; using a density factor for the amount of reinforcing steel estimated per cubic metre of cast-in-place concrete structures and foundations; assumption that wind loading case governed over seismic; and setting assumed values for geotechnical variables such as soil bearing capacity; modulus of subgrade reaction; and California bearing ratio.

The physical criteria for buildings such as building footprint size and number of levels; the type of building construction such as a concrete of a steel superstructure and masonry or metal wall panelling walls; and operating and maintenance access requirements were covered in detail in the FGD Buildings and Structures System Description (178771.43.0801, SPF file 200-101738). A high level overview is given in the subsections below.

3.8.2.1 Limestone Preparation Building

The ball mill bay within the Limestone Preparation Building is a lateral portal frame/longitudinally-braced steel superstructure with an overhead bridge crane for maintenance. Access platforms are furnished with the equipment. The limestone day bin bay supports the three limestone day bins and the limestone conveyors above the day bins. Also within this bay are the bin outlets, weigh belt feeders, and the limestone classifiers (hydro-cyclones).

The Limestone Preparation Building day bin bay structure foundation was designed as a matt foundation bearing on in-situ rock and assuming the need for epoxy-grouted tension tendons (rock anchors) to carry uplift forces caused by large over-turning forces due to the high centre-of-gravity of the three day bins.

The ball mill foundations were assumed to consist of a matt foundation, isolated from the building foundation, and a pedestal for each ball mill as required by the arrangement and design of the ball mill equipment.

3.8.2.2 Gypsum Dewatering Building

The Gypsum Dewatering Building is a laterally-braced steel superstructure with multiple floors and maintenance monorails and hoists over each vacuum filter.

3.8.2.3 Substations

All substations are cast-in-place concrete portal-frame superstructures.

3.8.2.4 Absorber Pump House Buildings

The Absorber Pump House buildings are laterally-braced steel superstructures. The Pump Houses are adjacent to but independent of the cast-in-place superstructure substation buildings in all six locations.

For cost estimating purposes, the Absorber Vessel foundations were assumed to be round, reinforced concrete matt foundations; two metres thick, bearing on in-situ rock. Absorber Pump House Building columns adjacent to the vessel would also be supported on this foundation.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

3.8.2.5 Gypsum Storage Building

The Gypsum Storage Building is a large lateral portal-frame/longitudinally braced steel superstructure. The building requires roof trusses 5 metres or more in depth due to the large span distance between the side walls. A gypsum conveyor gallery runs the length of the building, and is above the building's roof.

3.8.2.6 FGD Zero Liquid Discharge Treatment Building

The FGD Zero Liquid Discharge Treatment Building is a very large building with a conventional laterally-braced steel superstructure.

3.8.2.7 Raw Water Pretreatment Building

The Raw Water Pretreatment Building houses strainers; chemical feed equipment; and the electrical/control equipment. Access platforms and stairways are provided to the elevated electrical room above the cable spreading room. The building is a single story concrete superstructure with concrete block walls, and insulated metal roof panelling. The building is supported by a concrete matt foundation. The ground floor contains trenches which drain to an outside sump pit. A sodium hypochlorite storage tank is adjacent to the building, on a separate foundation.

3.8.2.8 Utility Rack

The Utility Rack superstructures are steel frames with lateral and longitudinal bracing systems. The rack's typical ground clearance is 6.5 metres, and the typical overall height is 12.5 metres. The typical width of racks is 3 metres. The racks have three to four levels for process piping with all electrical tray on the top level. Racks with limited maintenance access from the ground have galvanized steel grating catwalk platforms.

The Utility Rack foundations were assumed to be matt foundations (in some locations for multiple frames), bearing on in-situ rock, and incorporating rock anchors for uplift forces.

3.9 MECHANICAL DESIGN

This section provides a summary of the general mechanical design for the FGD Retrofit Project. Descriptive information regarding the mechanical design for the FGD and supporting systems is provided in Section 3.5.3.

For estimating the project costs during the Basic Design, equipment sizing calculations were performed to determine approximate equipment duty sizes. Sizing calculations for pumps, compressors, heat exchangers, tanks, cooling tower, sumps, strainers and HVAC equipment were performed. A 3D model was used to plan/design the equipment arrangements for space control and to determine approximate building size requirements. This allowed maintenance and access space allocation and planning. general arrangement drawings for buildings and areas were produced as an export from the 3D model.

It was assumed that all FGD ZLD pretreatment and brine concentrator/crystallizer equipment will be furnished by the ZLD supplier. This includes piping, valves, clarifiers, pumps, tanks, filter presses, silos, brine concentrators, crystallizers and all other associated equipment. Conceptual design for this equipment was performed only to the extent to estimate flows required for the water mass balance calculations and to determine approximate sizes of equipment for space allocation and general arrangement design. Detailed design of this equipment is very supplier-specific and is performed by the suppliers.

Refer to the following documents (attached) for additional information on the mechanical design.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Document	SPF File Number	Document / File Number
FGD Buildings and Structures System Description	200-101738	178771.43.0801
FGD Zero Liquid Discharge System Description	200-58476	178771.43.6405
FGD Potable Water System Description	200-58477	178771.43.6604
Sumps System Description	200-58469	178771.43.2819
Interface List	200-60397	178771-DM-1006
FGD BOP Equipment List	200-58423	178771-DM-1005
Equipment List	200-57316	006265-S-LIS-002
Equipment Load List Absorber	200-108957	P06265-S-LIS-010
Equipment Load List Dewatering	200-108992	P06265-S-LIS-011
Equipment Load List Limestone Preparation	200-108993	P06265-S-LIS-012

3.10 PIPING DESIGN

This section provides a summary of the general piping design for the FGD Retrofit Project. Descriptive information regarding the design for the FGD and supporting systems is provided in Section 3.5.3.

For estimating the project costs during the Basic Design, pipe sizing calculations and Piping and Instrument Diagrams (P&IDs) were produced. The piping was modelled in the 3D model based on the P&ID's and general arrangements using the calculated sizes. Modelling the piping assisted in the planning/designing of pipe routing around equipment to ensure space control. Modelling the piping also allowed the extraction of piping lengths from the 3D model to be used for cost estimating purposes. All BOP large bore piping (65 mm and larger) was sized and modelled with the exception of ZLD supplier piping. BOP small bore piping (50 mm and smaller) was only modelled if necessary to support space control purposes.

With the exception of the Auxiliary Steam System, the majority of piping is considered to be "cold supported" piping and does not require pipe stress analysis. A preliminary pipe stress analysis was performed on the Eskom-provided existing plant pipe routing and the additional auxiliary steam pipe associated with the FGD Retrofit Project. The preliminary analysis indicates that the pipe routing is generally acceptable but that further refinements and analysis will be needed during detailed design.

Refer to the following documents (attached) for additional information on the piping design.

Document	SPF File Number	Document / File Number
FGD Auxiliary Steam System Description	200-58353	178771.43.0601
Pipeline List	200-58414	178771-DM-1001
FGD In-Line Components List	200-58419	178771-DM-1003
FGD Valve List	200-58416	178771-DM-1002A
FGD Relief Valve List	200-58417	178771-DM-1002B
Piping List	200-112366	006265-S-LIS-020
Valve List	200-62262	006265-S-LIS-030
Interface List	200-60397	178771-DM-1006

3.11 ELECTRICAL DESIGN

The electrical system design was performed based on information developed by the project team. Single line diagrams were developed for each unit's absorber and the FGD common system. A detailed load list was maintained, which includes cable sizing calculations. Calculations for battery and UPS systems and the emergency diesel generator were performed. Load flow, motor starting, and short circuit studies were performed by Eskom with input and review from Black & Veatch.

The electrical design allows for 100 percent redundancy in the power supply system for the FGD which allows for reliable operation and safe shut down of the system in case of loss of power. Transformers,

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

medium voltage boards, low voltage boards and all other electrical devices have been calculated and sized to carry the estimated electrical load as defined in the electrical load list. Cable sizing and routing was performed using the load list formulas, the Medupi site arrangement drawings, and model.

For detailed descriptions of the electrical design, see Subsections 3.5.3.15.1 through 3.5.3.15.4.

Refer to the following documents (attached) for additional information on the electrical design.

Document	SPF File Number	Document / File Number
Medupi FGD Retrofit Evaluation (load flow, fault and motor start-up studies)	200-62087	
AC Power Supply (400V) System Description	200-58141	174330.43.0403
AC Power Supply (660V) System Description	200-58166	174330.43.0404
24V DC Power Supply System Description	200-58165	174330.43.0407
DC Switchgear (110/220 V) System Description	200-58133	174330.43.0408
Essential Service AC System Description	200-58167	178771.43.0409
Emergency Generation System Description	200-58170	174330.43.0411
Index FGD MV & LV Single Line Diagrams	0.84/28751	178771-CBCG-E1000
Single Line Diagram Unit 1 Absorber MV & LV Board	0.84/28751	178771-1BCG-E1007
Single Line Diagram Unit 2 Absorber MV & LV Board	0.84/28751	178771-2BCG-E1006
Single Line Diagram Unit 3 Absorber MV & LV Board	0.84/28751	178771-3BCG-E1005
Single Line Diagram Unit 4 Absorber MV & LV Board	0.84/28751	178771-4BCG-E1004
Single Line Diagram Unit 5 Absorber MV & LV Board	0.84/28751	178771-5BCG-E1003
Single Line Diagram Unit 6 Absorber MV & LV Board	0.84/28751	178771-6BCG-E1002
Single Line Diagram FGD Common MV & LV Board	0.84/28751	178771-CBCG-E1008
Single Line Diagram ZLD Treatment MV & LV Board	0.84/28751	178771-CBCG-E1009
Single Line Diagram Essential MV & LV Board	0.84/28751	178771-CBCG-E1010
Single Line Diagram Limestone And Gypsum Handling MV & LV Board	0.84/28751	178771-CBCG-E1011
Single Line Diagram FGD Common Back-Up MV Board	0.84/28751	178771-CBCG-E1012
FGD Electrical Load List	0.84/39020	178771-DE-1001
Interface List	200-60397	178771-DM-1006

3.12 CONTROL AND INSTRUMENTATION DESIGN

The control and instrumentation system design was performed based on information developed by the project team. Input/output (I/O) and instrument lists were maintained based on this information. The stand-alone DCS was designed for FGD system operation based on the requirements of the instrument and I/O lists.

The FGD system DCS network will be independent of the plant DCS networks. However, the signal interface between the FGD DCSs and plant DCS will be hardwired.

For detailed descriptions of the control and instrumentation design, see Subsection 3.5.3.16.

Refer to the following documents (attached) for additional information on the Control and Instrumentation Design.

Document	SPF File Number	Document / File Number
Distributed Control System System Description	200-123563	178771.43.2401
Local Control Philosophy	200-114237	178771.41.0108
DCS Architecture Diagram	0.84/38951	178771-CHYQ-K8001
Process Control System Philosophy	200-109912	006265-T-HBU-508
System Description, FGD Process Control Concept	200-58278	006265-T-HBU-509
Functional Description Absorber	200-111269	006265-T-HBU-540
Functional Description Absorber Bleed System	200-112494	006265-T-HBU-541

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Document	SPF File Number	Document / File Number
Functional Description Mist Eliminator Flushing	200-112499	006265-T-HBU-542
Functional Description Flue Gas Path	200-110087	006265-T-HBU-510
Functional Description Wet Ball Mill	200-112362	006265-T-HBU-630
Functional Description Limestone Slurry Feed	200-110747	006265-T-HBU-640
Functional Description Bleed/Emergency Drain System	200-112486	006265-T-HBU-660
Functional Description Dewatering System	200-113405	006265-T-HBU-670
Functional Description Gypsum Dewatering Line	200-112364	006265-T-HBU-671
Functional Description Waste Water System	200-113408	006265-T-HBU-672
Functional Description Reclaim Water System	200-111980	006265-T-HBU-673
Functional Description Process Water	200-110227	006265-T-HBU-610
Logic Diagram Absorber	200-111720	006265-D-DIA-540
Logic Diagram Absorber Bleed	200-112374	006265-D-DIA-541
Logic Diagram Mist Eliminator	200-112704	006265-D-DIA-542
Logic Diagram Flue Gas Path	200-110758	006265-D-DIA-510
Logic Diagram Limestone Slurry Feed	200-112092	006265-D-DIA-640
Logic Diagram Gypsum Bleed/Drain System	200-113119	006265-D-DIA-660
Logic Diagram Dewatering System	200-113481	006265-D-DIA-670
Logic Diagram Waste Water System	200-113682	006265-D-DIA-672
Logic Diagram Reclaim System	200-112385	006265-D-DIA-673
Logic Diagram Process Water	0.84/38056	006265-D-DIA-010
Signal and Alarm List Absorber Mist Eliminator Flushing and Oxidation	200-114401	006265-S-LIS-263
Signal and Alarm List Flue Gas Path	200-112711	006265-S-LIS-261
Signal and Alarm List Limestone Preparation	200-115861	006265-S-LIS-265
Signal and Alarm List Limestone Slurry Feed	200-113439	006265-S-LIS-262
Signal and Alarm List Gypsum Bleed and Drain	200-110785	006265-S-LIS-267
Signal and Alarm List Dewatering System	200-117087	006265-S-LIS-268
Signal and Alarm List Waste Water System	200-117080	006265-S-LIS-266
Signal and Alarm List Reclaim System	200-114673	006265-S-LIS-264
Signal and Alarm List Process Water	200-109384	006265-S-LIS-260
Hook Ups	200-112554	006265-A-SKI-010
FGD Instrument List	200-58413	178771-DK-1001
Measuring Point List	200-102532	006265-S-LIS-250
Interface List	200-60397	178771-DM-1006

3.13 UTILITIES REQUIRED

Table 5 lists the annual consumption rates for the utilities and consumables for the FGD Retrofit project.

Table 5: Consumption and Production Rates

Description	For 85 Percent $CaCO_3$ Limestone	For 96 Percent $CaCO_3$ Limestone
Reagent (Limestone)		
Hourly consumption, kg / hr	143,236	125,735
Consumption per year[1], tonnes	1,129,272	991,295
Byproduct for Disposal (Gypsum)		
Hourly generation, kg / hr	247,537	233,250
Total generation per year1, tonnes	1,951,581	1,838,940

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Description	For 85 Percent $CaCO_3$ Limestone	For 96 Percent $CaCO_3$ Limestone
Steam		
Hourly consumption, kg / hr	21,000	21,000
Total consumption per year[2], kg	124,173,000	124,173,000
Water		
Hourly generation, 1,000 L / hr	1157.5	1179.5
Total generation per year[1], 1,000 L	9,125,730	9,299,178
Auxiliary Power		
Hourly consumption, MWh / hr	40.87	40.87
Total consumption per year[3], MWh	322,186	322,186
Hydrated Lime (Ca Hydroxide)		
Hourly consumption, kg / hr	2,297	3
Total consumption per year[2], kg	13,582,161	17,739
Soda Ash (Sodium Carbonate)		
Hourly consumption, kg / hr	3,331	3,035
Total consumption per year[2], kg	19,696,203	17,945,955
Sodium Sulphate, 50% solution		
Hourly consumption, kg / hr	546	602
Total consumption per year[2], kg	3,228,498	3,559,626
Caustic, 50% solution		
Hourly consumption, kg / hr	202	212
Total consumption per year[2], kg	1,194,426	1,253,556
Sulphuric Acid, 66 Baume		
Hourly consumption, kg / hr	75	81
Total consumption per year[2], kg	443,475	478,953
Ferric Chloride, 50% solution		
Hourly consumption, kg / hr	11	10
Total consumption per year[2], kg	65,043	59,130
Antiscalant, 100% solution		
Hourly consumption, kg / hr	4.6	4.6
Total consumption per year[2], kg	27,200	27,200
Antifoam, 100% solution		
Hourly consumption, kg / hr	5.4	5.4
Total consumption per year[2], kg	31,930	31,930
Polymer, 100% solution		
Hourly consumption, kg / hr	3	2
Total consumption per year[2], kg	17,739	11,826
FGD ZLD Pretreatment Solids Waste (Clarifier Solids for Disposal)		
Hourly discharge, kg / hr	20,330	10,132
Total discharge per year[2], tonnes	120,211	59,911

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Description	For 85 Percent $CaCO_3$ Limestone	For 96 Percent $CaCO_3$ Limestone
FGD ZLD Treatment Solids Waste (Brine Concentrator/Crystallizer Solidsfor Disposal)		
Hourly discharge, kg / hr	5,288	5,302
Total discharge per year[2], tonnes	31,268	31,351

[1]*Based on a capacity factor of 90% of 8760 hours of equivalent full load operation per year.*

[2]*Based on a capacity factor of 90%, a utilization factor of 75%, and 8760 hours of equivalent full load operation per year.*

[3]*Based on a combination of a capacity factor of 90%, a ZLD utilization factor of 75%, a common utilization factor of 60%, a process utilization factor of 90%, and 8760 hours of equivalent full load operation per year.*

[4]*All cases based on Worst Coal, except Water is based on Worst Coal + Attemperating Air.*

3.14 WASTE MANAGEMENT

3.14.1 Water Purification

As identified in Section 3.5.3.8, a new FGD ZLD Treatment System will treat the FGD system chloride bleed stream, the TOC scavenger rejects from the existing plant, and FGD cooling tower blowdown streams.

The FGD chloride bleed stream is pre-treated as described in Section 3.5.3.8 to remove the suspended solids and heavy metals prior to the brine concentrator/crystallizer equipment. The FGD ZLD pretreatment process will include chemical treatment of the water to precipitate solids and heavy metals from the water. The precipitates are settled out in a clarifier as sludge, which is sent to a filter press or similar dewatering system. The water is recovered from the sludge and returned back to the clarifier. The de-watered solids will be directed to a storage bin for disposal.

As described in Section 3.5.3.8, the FGD ZLD Treatment System distillate will be directed to either the Reclaim Tanks or existing Medupi Water Treatment Plant. The dewatered solids and dewatered brine will be disposed of either on or off-site in an area designed for the FGD ZLD pretreatment and brine concentrator/crystallizer wastes.

Document	SPF File Number	Document / File Number
Water Supply / Wastewater Disposal Study	200-55817	178771.41.0107
FGD Makeup Water Supply System Description	200-58478	178771-43-6607
FGD Zero Liquid Discharge System Description....................	200-58476	178771.43.6405

3.14.2 Waste Storage and Transportation

Solid waste streams from the Medupi FGD Retrofit Project consist of gypsum from the Gypsum Refinement and Dewatering System described in Section 3.5.3.7, and sludge from the FGD ZLD Treatment System described in Section 3.5.3.8.

As the basis for the Basic Design it was assumed that under normal operating circumstances, up to 20 percent of the gypsum would be sent to market. Gypsum that is not able to meet commercial-grade specifications or is chosen not to be sold would be treated as a waste stream and combined with the ash

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

for disposal in the onsite ash dump[6]. Eskom requested the existing ash dump designers (Jones and Wagener, Engineering and Environmental Consultants) to evaluate the existing ash dump for co-disposal of ash and gypsum in terms of capacities (both with and without the excess coal stockyard currently designed to be located on the west end of the northern ash dump), liner applicability, and slope stability. The gypsum characteristics and details provided to the designers were based on data from the Basic Design and it was requested that the assessment be performed for the 100 percent and 80 percent (20 percent saleable) disposal of gypsum. Jones and Wagener advised that there is sufficient space in the existing ash dump for the co-disposal of ash and gypsum (under the worst case, i.e., 100 percent gypsum disposal) provided that the excess coal stockyard is removed. This result together with the rest of the response from the designers can be found under SPF document no. 257-185172, "For Information Only: Medupi Power Station, FGD, Jones and Wagener Letters for Co-Disposal of Ash and Gypsum" [10]. Eskom Engineering has developed a Scope of Works [12] document to be issued to the already appointed Environmental Impact Assessment (EIA) consultant to execute development and assessment of alternatives for the disposal of gypsum produced, together with conceptual design of the preferred and back up alternatives for presentation to the competent authority. The waste classification study to be executed by the EIA consultant will inform the preferred and back up alternatives.

From the dewatering process, gypsum will drop from vacuum filters onto one of two side-by-side collecting conveyors by means of bifurcated chutes. Gypsum will be transported via a series of gypsum conveyors. The gypsum conveyors will either feed non-saleable gypsum to the overland ash conveyors for co-disposal with the ash[7], or alternatively will feed saleable gypsum to the gypsum storage facility. At the gypsum storage facility, gypsum will be stacked out in three different piles or into one continuous pile. Gypsum which does not meet commercial-grade specifications will be reclaimed via mobile equipment and a mobile belt (apron) feeder and conveyed to the overland ash conveyors for co-disposal with the ash.

The chloride bleed stream and cooling tower blowdown stream from the Medupi FGD Retrofit Project and the TOC scavenger rejects from the existing plant will be pre-treated in a clarifier to remove suspended solids and heavy-metals. The solids and heavy-metals that precipitate out of the chloride bleed stream in the clarifier will be collected as sludge. The sludge (solids) will be collected in a concrete bunker or dumpsters placed underneath filter presses. In the FGD ZLD Treatment System, a brine concentrator/crystallizer will be utilized to concentrate solids of the wastewater. A guideline report was undertaken by Eskom for the Medupi Power Station, presenting various possible options of disposing the FGD chemical wastes. The guideline report together with all supporting documentation, recorded meeting minutes and e-mail communications can be found under SPF document no, 200-128401, “Guideline: Possible alternatives for the disposal of chemical wastes produced by the FGD process” [11]. For the Basic Design, it was assumed that the collected sludge from the FGD ZLD pretreatment and the concentrated and dewatered brine solids from the FGD ZLD Treatment System will be disposed of using trucks to transport to onsite or offsite dumps. It should be noted that the guideline report has now been converted into a Scope of Works [12] document to be issued to the already appointed EIA consultant to execute development and assessment of alternatives for the disposal of chemical sludge and chemical solids (salts) produced, together with conceptual design of the preferred and back up alternatives for presentation to the competent authority. The waste classification study to be executed by the EIA consultant will inform the preferred and back up alternatives.

---

[6] Note that the possibility of co-disposal will be confirmed with the current waste classification study [12], and thereafter the competent authority.

[7] Note that the possibility of co-disposal will be confirmed with the current waste classification study [12], and thereafter the competent authority.

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Document	SPF File Number	Document / File Number
Byproduct Disposal Study	200-55816	178771.41.0106
Water Supply / Waste Water Disposal Study	200-55817	178771.41.0107
Gypsum Handling Plant Process Flow Diagram	0.84/37820	
FGD Solids Conveying and Storage Arrangement GCVY-1&2	0.84/37780	
FGD Solids Conveying and Storage Arrangement GCVY-3&4	0.84/37781	
FGD Solids Conveying and Storage Arrangement GCVY-5&6	0.84/37782	
FGD Solids Conveying and Storage Arrangement GCVY-7&8	0.84/37783	
FGD Solids Conveying and Storage Arrangement GCVY-9	0.84/37784	
FGD Solids Conveying and Storage Arrangement GCVY-10	0.84/37785	
FGD Solids Conveying and Storage Arrangement GCVY-11	0.84/37786	
FGD Solids Conveying and Storage Arrangement GCVY-12	0.84/37787	
FGD Solids Conveying and Storage Arrangement GCVY-13	0.84/37788	
FGD Zero Liquid Discharge (ZLD) Treatment System Description	200-58476	178771.43.6405

3.15 MAINTENANCE REQUIREMENTS

The plant design and layout was reviewed in accordance with the Medupi Power Station User Requirements Specification Revision 4 [4] to ensure that the plant included sufficient features to ensure safe and efficient maintenance can be carried out. The following aspects were reviewed for all plant areas:

- Access to plant item from normally provided floors and platforms or special access provisions, such as permanently installed ladders and local platforms.
- Adequacy of lifting and handling devices.
- Area available for in-situ work.
- Adequacy of lighting to allow inspections and maintenance to be performed.
- Interference with the operation and maintenance of other structures and systems.
- Adequacy of the maintenance and storage facilities.
- Electrical and mechanical isolation devices, including devices which are lockable to enable the application of Permits to Work as per ESKOM standards.
- Draining and venting facilities on active systems.
- Adequacy of spare parts.
- Suitable electrical and compressed air supply points are included to ensure that portable tools can be used to perform maintenance activities.

Refer to the following documents (attached) for additional information on the maintenance requirements.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Document	SPF File Number	Document / File Number
Maintenance and Access Diagram FGD Medupi	200-110120	006265-T-STD-400
Maintenance and Access Drawing Pumphouse	0.84/38274	006265-Z4010-611
Maintenance Staffing Plan	200-103917	006265-S-TAB-020
Maintenance and Access Drawing Gypsum Dewatering Building +0.000M	0.84/38263	006265-Z4020-601
Maintenance and Access Drawing Gypsum Dewatering Building +9.000M	0.84/38264	006265-Z4020-602
Maintenance and Access Drawing Gypsum Dewatering Building +16.000M	0.84/38265	006265-Z4020-603
Maintenance and Access Drawing Limestone Building 0.00M	0.84/38260	006265-Z4320-601
Maintenance and Access Drawing Limestone Building +20.0M	0.84/38261	006265-Z4320-602
Maintenance and Access Drawing Gypsum Bleed Tank Area	0.84/38262	006265-Z4330-601
Evaluation of Access Equipment for Maintenance of Top Entry Agitators	200-114243	006265-T-STD-410
Mobile Equipment Plan	200-120679	178771.43.1007

3.16 DESIGN ASSESSMENT

3.16.1 Compliance with Stakeholder Requirements

The URS compliance evaluation shown in Table 6 is based on adherence to Medupi Power Station User Requirements Specification Revision 4 [4], Section 8.1.34.

Table 6: URS Compliance Evaluation

URS Section	Specification	Adhered to Yes/No	Comments
8.1.34.1	SO_2 Removal Efficiency	Yes	Complies to the SA Government Minimum Emission standards effective April 2010 and Eskom's Air Quality Strategy Doc no. 31-1143
8.1.34.2	Water Consumption	Yes	The FGD water Consumption is within the projected allocation
8.1.34.3	Sorbent	Yes	Compliant
8.1.34.4	Computational Fluid Dynamic (CFD) Modeling	Yes	CFD modelling was performed
8.1.34.5	Control and Instrumentation Interface	Yes	Compliant
8.1.34.6	Power Consumption	Yes	Based on Basic Design Estimate
8.1.34.7	Pressure Drop	Yes	Within the ID fan limits
8.1.34.8	Stack and Exit Temperature	No	This requirement is no longer applicable based on the dispersion model results performed by Eskom Environmental. Formal Engineering change to be lodged with ECP committee

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

URS Section	Specification	Adhered to Yes/No	Comments
8.1.34.9	Corrosion and Erosion Protection	Yes	Compliant
8.1.34.10	Waste Product	Yes	Provision made to dispose or store Gypsum for salability[8].
8.1.34.11	Stacks	Yes	Chimney modifications are required, refer to Section 3.5.3.4.

Please note that adherence to the URS is based on information available at the completion of the Basic Design Phase.

3.16.2 Operability Assessment

The plant design and layout was reviewed in accordance with the Medupi Power Station User Requirements Specification Revision 4 [4] to ensure that the plant included sufficient features to ensure safe and efficient operation can be carried out. A description of the operational process was developed to ensure that the plant functions according to the design requirements under normal and abnormal conditions, and how the human interface would be achieved.

Refer to the following documents (attached) for additional information on operability.

Document	SPF File Number	Document / File Number
Operability Study	200-92095	006265-T-STD-100
FGD Startup and Shutdown Concept	200-99436	006265-T-STD-200
Local Control Philosophy	200-114237	178771.41.0108
Process Control System Philosophy	200-109912	006265-T-HBU-508
System Description, FGD Process Control Concept	200-58278	006265-T-HBU-509

3.16.3 Reliability, Maintainability, Availability Assessment

A Reliability, Availability, and Maintainability (RAM) Assessment (SPF Doc No 474-9289) was performed at the conclusion of the Concept phase for the Medupi FGD Retrofit Project. This evaluation was considered as input to the Basic Design.

RAM analysis was also performed during the Basic Design in accordance with the Medupi Power Station User Requirements Specification Revision 4 [4] to evaluate decisions made during design, such as levels of redundancy, general equipment types, and general equipment configurations. The team review issue of the report identified two main component types which affect the unavailability and recommended improvements in the oxidation air absorber motor and its agitator. Team review comments have not been incorporated at this time.

A Failure Modes, Effects, and Criticality Analysis (FMECA) was performed during the Basic Design to identify potential failure modes, failure causes and subsequent failure effects on system performance.

Refer to the following documents (attached) for additional information on these analyses.

Document	SPF File Number	Document / File Number
RAM Analysis	200-127168	
FMECA Analysis	200-122279	178771.41.0201

[8] Note that the possibility of co-disposal will be confirmed with the current waste classification study [12], and thereafter the competent authority.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

3.16.4 Procurability Assessment

All equipment and materials required for the Medupi FGD Retrofit Project are available in the international market. To assist in the identification of equipment and materials available within South Africa, it was intended to issue a contractor questionnaire, however this could not be accomplished during Basic Design. Information from the Kusile FGD installation was reviewed to identify potential local suppliers for equipment and materials (Table 7) and fabrication and construction contractors (Table 8).

Table 7: Local Supply Capability for Equipment and Materials

Commodity/Scope	On Shore	Off Shore	Country	Comments
MV Motors	X		South Africa	Full local capability - design, supply and install
Grounding & Lightning System, Lighting & Small Power, I&C Installation	X		South Africa	Full local capability - design, supply and install
Variable Speed Drive	X	X	Partial	Local suppliers available, critical components are imported
On-Off Recycle Valves	X		South Africa	Full local capability - design, supply and install
On-Off Actuated Motorized & Pneumatic Valves	X		South Africa	Full local capability - design, supply and install
Control Valves	X		South Africa	Full local capability - design, supply and install
Instrumentations		X		
Flue Gas Analysers		X		
Oxidation Air Blowers		X		
Sump Pumps		X		
Mist Eliminator		X		
Agitators		X		Local agents, equipment is imported
Absorber Spray Nozzles		X		
Flake Lining	X			
Suction Strainer		X		
Ball Mills	X	X	Partial	Shared scope and capability, main contractor offshore
Dewatering System	X	X	Partial	Shared scope and capability, main contractor offshore
Recirculation Pumps	X	X	Partial	Shared scope and capability, main contractor offshore
Water Pumps	X		South Africa	Full local capability - design, supply and install
Horizontal Slurry Pumps	X		South Africa	Full local capability - design, supply and install
Bridge Cranes	X		South Africa	Full local capability - design, supply and install

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Commodity/Scope	On Shore	Off Shore	Country	Comments
Elevators	X		South Africa	Full local capability - design, supply and install
Hoist	X		South Africa	Full local capability - design, supply and install
Dedusting System	X		South Africa	Full local capability - design, supply and install
Heating & Ventilation (HVAC) - Package	X		South Africa	Full local capability - design, supply and install
BoP FRP Piping	X		South Africa	Full local capability - design, supply and install
Recycle Pipes (FRP)	X	X	Partial	Shared scope and capability, main contractor offshore
GRP Spray headers	X	X	Partial	Shared scope and capability, main contractor offshore
Piping Insulation	X			Full local capability - design, supply and install
Expansion Joint - Piping	X			Full local capability - design, supply and install
Absorber Modules Alloy Material		X		High alloy material not readily available locally
Lances Material (SMO254)		X		Lances material (SMO254) not readily available
Duct Works (FRP)	X	X		Shared scope and capability, main contractor offshore
Expansion Joint - Ducts	X		South Africa	Full local capability - design, supply and install
Buildings - Architectural Enclosures and Finishes	X		South Africa	Full local capability - design, supply and install
Cable - Control & Instrumentation (All Sizes)	X		South Africa	Full local capability - design, supply and install
Cable - Low & Medium Voltage	X		South Africa	Full local capability - design, supply and install
Cooling Tower	X		South Africa	Full local capability - design, supply and install
Fire Protection Equipment	X		South Africa	Full local capability - design, supply and install
Materials Handling Equipment	X		South Africa	Full local capability - design, supply and install
Metal Wiring Channels	X		South Africa	Full local capability - design, supply and install
Panel Boards	X		South Africa	Full local capability - design, supply and install
Pipe Supports	X		South Africa	Full local capability - design, supply and install
Piping (CS, SS)	X		South Africa	Full local capability - design, supply and install

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Commodity/Scope	On Shore	Off Shore	Country	Comments
Raceway (Cable Tray)	X		South Africa	Full local capability - design, supply and install
Transformers Various Sizes	X		South Africa	Full local capability - design, supply and install
Structural Steel (Steel, Grating, Handrails, Access Platforms, Utility Rack)	X		South Africa	Full local capability - design, supply and install
Water Treatment System	X		South Africa	Full local capability - design, supply and install
Waste Water Treatment System (ZLD)	X		South Africa	Full local capability - design, supply and install
Surveying and Geotech	X		South Africa	Full planning capabilities and execution
Spray Nozzles		X		Potential to develop local capability specific for FGD application
Switchgear	X	X		Shared scope and capability - breakers imported
Compressed Air Equipment	X		South Africa	Full local capability - design, supply and install

Table 8: Local Supply Capability for Fabrication and Construction Contractors

Scope	On Shore	Off Shore	Country	Comments
Absorber- Grinding and C276 Welding -Erection	X		South Africa	Full local capability
Absorber Tower Preassembly and Assembly	X		South Africa	Full local capability
All Tanks/Silos Erection	X		South Africa	Full local capability
Structural Steel- Erection	X		South Africa	Full local capability
Absorber Pre-Assembling	X		South Africa	Full local capability
Ducting Installation and Installation	X		South Africa	Full local capability
Steel and Profile Fabrication	X		South Africa	Full local capability
Absorber/Tanks/Silos - Field Erected Tanks	X		South Africa	Full local capability
Grouting	X		South Africa	Full local capability
Metal Decking	X		South Africa	Full local capability
Concrete Slab	X		South Africa	Full local capability
Scaffolding	X		South Africa	Full local capability
C276 Inlet Duct Alloy Fabrication	X		South Africa	Full local capability
Tanks Secondary Structure- Fabrication	X		South Africa	Full local capability

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Scope	On Shore	Off Shore	Country	Comments
Absorber Blasting and Rubber Lining	X	X	South Africa	Shared scope and Capability, Main Contractor offshore
Mechanical Package	X		South Africa	Full local capability
Lighting	X		South Africa	Full local capability
Insulation and Lagging	X		South Africa	Full local capability
Foundation (Excavation, Backfill, Reinforcing, etc.)	X		South Africa	Full local capability
Piping	X		South Africa	Full local capability
Tanks Secondary Structure-Fabrication	X		South Africa	Full local capability
Terrance Construction(Site Earthworks, Grading, Drainage, Roads and Surfacing, Erosion Control, Landfill)	X		South Africa	Full local capability
Abs Module-Loading - Transport-Lifting Package	X		South Africa	Full local capability

3.16.5 Constructability Assessment

As a retrofit project, constructability of the design was evaluated during the review of each project deliverable.

The Construction Execution Plan (178771.41.0111, SPF file 200-60812), attached, evaluated the conceptual design for constructability and access and made recommendations to be considered during detailed design and construction. Demolition and relocation requirements are shown on FGD Area Demolition and Relocation Plan (178771-CGAU-S3002, SPF file 0.84/36017), attached. The conceptual construction area and lay down site arrangement are shown on the Construction Facilities Drawing (178771-DS-1003, SPF file 0.84/36018), attached.

The content of the Construction Execution Plan is based upon a multi-contract EpCM approach in line with the Project Definition planning. This approach is under review and may be revised to a multi-package EPC (or hybrid) approach at a later stage. Changes to the contracting approach will affect the construction management approach presented therein.

3.16.6 Inspectability and Testability Assessment

The plant design and layout was reviewed in accordance with the Medupi Power Station User Requirements Specification Revision 4 [4] to confirm that sufficient features, such as test ports, sample connections, access platforms, instrumentation, redundant equipment, etc. were included to enable in-service inspections and/or tests to be performed to the respective system to verify that the system meets the design requirements/specifications (i.e., a field performance test or inspection of a pump).

3.16.7 Sustainability Assessment

Per the User Requirements Specification [4], the design life of the FGD plant supports the overall plant life requirement of 200,000 hours over 50 years. The Basic Design of the Medupi FGD Retrofit includes standby spare equipment to support the ongoing maintenance of the plant to support continued operations throughout the plant life. Refer to the RAM Analysis in Section 3.16.3 for additional details regarding the suitability of the plant standby equipment.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Limestone sourcing will not be completed during the Basic Design phase; however it is recommended that a minimum of two sources be developed so that plant operation is not subject to interruption based on disruption of a single limestone supply.

3.16.8 Expandability Assessment

The FGD retrofit will consume considerable land area to the west of the main power block and would limit the physical space available for plant expansion. The FGD plant and associated auxiliaries have been designed to meet the required performance on a variety of fuel and operating scenarios (refer to the FGD Design Controlling Cases, P06259-S-TAB-015, SPF file 200-92546, attached).

Provisions have been included in the Basic Design to allow the future installation of gas cooling heat exchangers upstream of the FGD absorber modules, to reduce the water consumption of the FGD system. Refer to the Technical Evaluation of flue Gas Cooling options (006265-T-STD-260, SPF file 200-110410), attached, for additional information on this process.

As described in Section 3.5.3.7, the FGD system is designed to produce a saleable byproduct, however as described in Section 3.14.2, it is anticipated that only 20 percent of the gypsum would be sent to market. If market demand for the gypsum byproduct develops to a level where sale of greater than 20 percent of the gypsum production capacity of the FGD plant is economically viable, modification of the material handling systems would be required to increase the loadout capacity of the system.

The capability for future expansion of the FGD plant to achieve greater removal efficiency or to treat higher sulphur fuels was not a design objective; however the FGD is designed to achieve SO_2 emissions according to the Eskom Air Quality Strategy [6], i.e. 400 mg/Nm³ at 6 percent O_2. The emissions standard of South Africa only requires a SO_2 reduction below 500 mg/Nm³ referred to an O_2 content of 10 percent. Therefore, the necessity of a future expansion of the FGD plant to achieve greater removal efficiency is not expected. If required to further increase the removal efficiency, each absorber possesses a redundant spray bank which can also be operated in parallel with the other spray banks, or adipic acid can be added to the absorber.

3.16.9 Project Development Readiness Assessment Review

An end-of-phase Project Development Readiness Assessment (PDRA) will be conducted for the project after the conclusion of the Basic Design. The following Table 9 provides the locations within this report for supporting information related to PDRA assessment elements. For those items where Table 9 indicates "None," the information related to those elements is outside the scope of this report.

Table 9: PDRA Element References

PDRA Element		Basic Design Document Reference(s)
I. Basis of Project Decision		
	Manufacturing Objectives/Criteria	
A1	Reliability Philosophy	• User Requirements Specification [4], Section 1.5 • Basic Design Report, Section 3.16.3 Reliability, Maintainability, Availability Assessment
A2	Maintenance Philosophy	• User Requirements Specification [4], Section 4.5 • Basic Design Report, Section 3.15 Maintenance Requirements

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

PDRA Element		Basic Design Document Reference(s)
A3	Operating Philosophy	• User Requirements Specification [4], Section 4.4 • Basic Design Report, Section 3.16.2 Operability Assessment
	Business Objectives	
B1	Products	• Basic Design Report, Section 3.5.3.7 Gypsum Refinement and Dewatering System
B2	Business Need and Purpose	• Basic Design Report, Section 2.2.2 Informative
B3	Project Strategy	• Basic Design Report, Section 0 • Introduction (project charter)
B4	Affordability and Life-Cycle-Cost Drivers	• None
B5	Capacities	• Basic Design Report, Section 3.2.4 Design Criteria
B6	Future Expansion	• Basic Design Report, Section 3.16.8 Expandability Assessment
B7	Expected Project Life Cycle	• Basic Design Report, Section 3.2.4 Design Criteria • Basic Design Report, Section 3.14 Waste Management
B8	Social and Economic Development Planning	• Eskom procurement and contracting strategy
	Basic Data R & D	
C1	Technology Selection	• Medupi FGD Retrofit Technology Selection Study (200-55815)
C2	Processes	• Basic Design Report, Section 3.5.3.1 FGD System
	Project Scope	
D1	Project Objective Statement	• Basic Design Report, Section 1 • Introduction (project charter)
D2	Design Philosophy	• Basic Design Report, Section 3.2.4 Design Criteria
D3	Site Characteristics Available vs. Required	• System Descriptions • Basic Design Report, Section 3.9 Mechanical Design (interface table) • Basic Design Report, Section 3.2.4 Design Criteria
D4	Dismantling/Demolition Requirements	• Basic Design Report, Section 3.16.5 Constructability Assessment
D5	Lead/Discipline Scope of Work	• Basic Design Report, Section 3.5.1 Project Breakdown Structure • Basic Design Report, Section 3.20 Scheduling
D6	Project Schedule	• Basic Design Report, Section 3.20 Scheduling
	Value Engineering	
E1	Process Simplifications	• FGD Redundancy & Size Evaluation (006265-S-TAB-010, SPF file 200-92612) • Balance of Plant System Sizing Criteria Study (178771.41.0103, SPF file 200-55814)

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

PDRA Element		Basic Design Document Reference(s)
E2	Value Engineering Process	• List of Attachments (Volume II) (Duct material, absorber insulation, and piping materials etc. studies)
E3	Design for Constructability	• Basic Design Report, Section 3.16.5 Constructability Assessment
II. FRONT END DEFINITION		
	Site Information	
F1	Site Location	• Basic Design Report, Section 3.6 Siting
F2	Surveys and Soil Tests	• Basic Design Report, Section 3.2.4 Design Criteria
F3	Environmental Assessment	• None
F4	Permit Requirements	• None
F5	Utility Sources/Supply Conditions	• Basic Design Report, Section 3.9 Mechanical Design (interface table)
F6	Fire Protection/Safety Considerations	• Basic Design Report, Section 3.17.2 Fire Safety Assessment • Basic Design Report, Section 3.9 Mechanical Design
	Process/Mechanical	
G1	Process Flow Sheets	• List of Attachments (Volume II) (P&IDs, Flow Sheets etc.)
G2	Heat and Material Balances	• Basic Design Report, Section 3.5.3.1 FGD System • Basic Design Report, Section 3.14.1 Water Purification (Water balance in attached study)
G3	Piping and Instrument Diagrams	• List of Attachments (Volume II) (P&IDs, Flow Sheets etc.)
G4	Process Safety Management	• Basic Design Report, Section 3.16 Design Assessment • Basic Design Report, Section 3.17 Safety Assessment • Basic Design Report, Section 3.23 Risk Register
G5	Utility Flow Diagrams	
G6	Project Specifications	• Basic Design Report, Section 3.2.4 Design Criteria (WIPs under development)
G7	Piping/Cabling/Conveying System Requirements	• Basic Design Report, Section 3.2.4 Design Criteria (WIPs under development)
G8	Plot Plan	• Basic Design Report, Section 3.6 Siting
G9	Equipment Lists	• Basic Design Report, Section 3.9 Mechanical Design • Basic Design Report, Section 3.11 Electrical Design
G10	Line List	• Basic Design Report, Section 3.10 Piping Design
G11	Tie-In List	• Basic Design Report, Section 3.9 Mechanical Design (interface table)
G12	Specialty Items Lists	• Basic Design Report, Section 3.10 Piping Design

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

PDRA Element		Basic Design Document Reference(s)
G13	Instrument Index	• Basic Design Report, Section 3.12 Control and Instrumentation Design (Instrument list)
	Equipment Scope	
H1	Equipment Status	• Basic Design Report, Section 3.4 Procurement Strategy
H2	Equipment Location	• List of Attachments (Volume II) (Plot Plan, Site Arrangement, General Arrangements)
H3	Equipment Utility	• Basic Design Report, Section 3.13 Utilities Required
	Civil/Structural/Architectural	
I1	Civil/Structural Requirements	• Basic Design Report, Section 3.2.4 Design Criteria • Basic Design Report, Section 3.8 Civil Infrastructure and Building Design • List of Referenced Documents (calcs, steel drawings, etc.)
I2	Architectural Requirements	• Basic Design Report, Section 3.2.4 Design Criteria • Basic Design Report, Section 3.8 Civil Infrastructure and Building Design • List of Referenced Documents (architectural drawings, etc.)
	Infrastructure	
J1	Water Treatment	• Basic Design Report, Section 3.5.3.5 FGD Makeup Water and Process Water Supply • Basic Design Report, Section 3.5.3.8 FGD ZLD Treatment System • Basic Design Report, Section 3.14.1 Water Purification • List of Attachments (Volume II) (site drainage, system descriptions)
J2	Loading/Unloading/Storage Facilities Requirements	• Basic Design Report, Section 3.5.3.6 Limestone Handling and Limestone Preparation Systems • Basic Design Report, Section 3.5.3.7 Gypsum Refinement and Dewatering System
J3	Transportation Requirements	• Basic Design Report, Section 3.6 Siting (Plot plan - roads) • Basic Design Report, Section 3.16.5 Constructability Assessment • Logistics study is part of Rail Yard Project
	Instrument & Electrical	
K1	Control Philosophy	• Basic Design Report, Section 3.12 Control and Instrumentation Design
K2	Logic Diagrams	• Basic Design Report, Section 3.12 Control and Instrumentation Design
K3	Electrical Area Class	• None
K4	Substation Requirements	• Basic Design Report, Section 3.11 Electrical Design

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

PDRA Element		Basic Design Document Reference(s)
K5	Elect One Line Diagrams	• Basic Design Report, Section 3.11 Electrical Design
K6	Instrumentation and Electrical Specifications	• Basic Design Report, Section 3.11 Electrical Design • Basic Design Report, Section 3.12 Control and Instrumentation Design
III. EXECUTION APPROACH		
	Procurement Strategy	
L1	Identify Long Lead/Critical Items	• Basic Design Report, Section 3.4 Procurement Strategy • Basic Design Report, Section 3.20 Scheduling
L2	Procurement Procedures/Plans	• Eskom procurement and contracting strategy
L3	Procurement Responsibilities	• Eskom procurement and contracting strategy
	Deliverables	
M1	CADD/Model Requirements	• List of Attachments (Volume II) (in Project Execution Plan; IT tools plan)
M2	Deliverables Defined	• (Project Deliverables Register)
M3	Distribution Matrix	• None
	Project Control	
N1	Project Control Requirements	• None
N2	Project Accounting Requirements	• None
N3	Risk Analysis	• None
	Execution Plan	
P1	Owner Approval Requirements	• None
P2	Engineering/Construction Plan/Approach	• None
P3	Shut/Turnaround Requirements	• None
P4	Pre-Commissioning/Turnover Sequence	• None
P5	Startup Requirements	• None
P6	Training Requirements	• None

3.17 SAFETY ASSESSMENT

Each building and area layout associated with the Basic Design of the Medupi FGD Retrofit was reviewed using the 3D Model and 2D drawings to ensure that the plant design and layout included life-safety considerations in accordance with the Fire Protection and Life Safety Design Standards (240-56737448 and 240-54937450) per subsection 1.11 “Fire Protection” of the PDM (178771.22.0000, SPF file 200–61989), attached.

3.17.1 Industrial Safety Assessment

A Hazard and Operability analysis (also known as HAZOP study or HAZOP) was performed during the Basic Design (SPF file 200-135697) to identify potential hazards in the system and to identify potential operability problems with the system. The preliminary (team review) version of the report is included with the final Basic Design Report.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

3.17.2 Fire Safety Assessment

A Plant Fire Protection/Detection Assessment (SPF file 474-9699), attached, for the new FGD plant was performed by Eskom. The assessment was carried out to define and analyse all fire risks associated with the plant in view of the plant-specific considerations regarding design, layout and anticipated operating requirements.

3.18 INVESTMENT PROTECTION

The primary FGD subsystem which requires special protective measures is the absorber internals. In the event of a unit trip with loss of electrical power, hot gas would pass through the ductwork and absorber as the boiler is ventilated and cools down. It is possible for this hot gas to damage the rubber lining and mist eliminator within the absorber, and may cause a fire. To protect the absorber internals, a flue gas bypass is included as described in Section 3.5.3.2. The bypass isolation dampers are powered from the Emergency Electrical Supply as described in Section 3.5.3.15.4.

3.19 SECURITY

The FGD retrofit will not adversely affect the plant's security requirements.

3.20 SCHEDULING

Three documents were created and reviewed by the team to develop the Level 3 ERA schedule. The first document was the system matrix (178771.24.2010.20, SPF file 200-106694). The system matrix identifies the systems and associated engineering deliverable that will be utilized during the execution phase. The second document was the procurement matrix (refer to Section 3.4). The procurement matrix was used to establish how the equipment would be packaged to be purchased and the construction contracting strategy. The third document is the schedule fragnets. The fragnet shows the sequence of activities from start of a work process to the completion of a work process. Once the system and procurement matrix's were reviewed, typical fragnets (fragments of a network) (refer to the list of referenced Basic Design documents) were developed for each system and deliverable.

A Work Break Down Structure (WBS) was created in the schedule using the KKS systems that will be used for this project (refer to Section 3.5.1 herein). The WBS was used to develop the planning document known as the system matrix.

Long lead equipment and critical items were taken into consideration when developing the detailed level 3 schedule. It is important to get the long lead equipment awarded early in order to receive vendor information to support engineering deliverables, construction installation and commissioning. The long lead equipment for this project are considered to be the FGD absorbers, oxidation air blowers, absorber spray (recycle) pumps, material handling system, gypsum dewatering system, Limestone Preparation System, FGD station service transformer and FGD wastewater treatment (ZLD).

A level 3 ERA schedule (178771.24.2010.26, SPF file 200-117150) was developed using the fragnets to show detailed logic relationship between engineering, procurement, construction and commissioning.

A level 2 ERA Schedule (178771.24.2010.21, SPF file 200-117133), attached, was developed to show summary bars for engineering by system and deliverable, procurement and construction. The level 2 schedule was derived from the construction planning areas and packaging plan. The level 2 schedule was a roll up of activities produced directly from the Primavera level 3 schedule

The level 1 ERA schedule (178771.24.2010.20, SPF file 200-117132), attached, that was developed during the Concept Phase was updated to reflect changes from the level 3 logic driven schedule. The level 1 Microsoft Visio indicates the timelines for bid and award, vendor engineering, fabrication and

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

delivery, construction, and pre commissioning for the first unit's FGD and the common equipment. It is planned that subsequent units are to be completed at six month intervals.

The start of the ERA phase was based on a start date of October 2016 due to funding constraints. The commercial operation of the first FGD system is planned to be complete by January 2022. The remaining units are planned to be completed at six month intervals. It was assumed that 60-day outage dates will be selected based on the ideal construction sequence, rather than as dictated by the dates for the first Mini General Overhaul (MGO). Therefore at this time the tie-in outages may not align with other work at the Power Station. Actual outage dates will be coordinated with Eskom Generation during execution of the project.

These schedules are based upon a multi-contract EpCM approach in line with the Project Definition planning. This approach is under review and may be revised to a multi-package EPC (or hybrid) approach at a later stage. Changes to the project design basis, project scope, execution plan, or contracting approach will impact the time for completion and activity relationships and durations.

The critical path begins with the bid and award of major long lead equipment. The critical path continues through construction of the foundations, followed by building erection so the equipment, piping, electrical and controls can be installed prior to commissioning of the FGD system and balance of plant equipment. It is anticipated that an outage will occur to tie in the new FGD ductwork to the existing operating ductwork.

3.21 LIFE CYCLE COST ANALYSIS

The life cycle cost analysis presented in this section includes the levelized annual fixed charges on capital and levelized annual operating costs (consumables, labour, and maintenance) associated with the FGD retrofit to the Medupi Power Station.

The capital cost estimates include the cost for FGD and ancillary systems, auxiliary electric, structural, mechanical and other required balance-of-plant system upgrades. The operating cost estimates were based on operation at full-load conditions.

3.21.1 Capital Cost Estimate

A preliminary Capital Cost Estimate (178771.25.2000, SPF file 200-128137), attached, was developed for the equipment and materials, construction, and engineering costs to implement the Medupi FGD Retrofit Project. This estimate was developed from historical pricing and quantities and includes escalation and contingency, but excludes Owner's costs (such as project development, Owner personnel for engineering, startup, and construction management, taxes, financing, or Owner contingency for these items). A summary of the capital costs are provided in Table 10.

The Capital Cost Estimate is based upon a multi-contract EpCM approach in line with the Project Definition planning. This approach is under review and may be revised to a multi-package EPC (or hybrid) approach at a later stage. Changes to the contracting approach will affect the cost and schedule for the project.

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Table 10: Capital Cost Estimate Summary

Description	Cost, ZAR
Civil / Structural Purchase Contracts	723,714,300
Mechanical Purchase Contracts	350,301,400
Electrical Purchase Contracts	258,531,500
Environmental Purchase Contracts	2,657,483,600
Subtotal Purchase Contracts	**3,990,030,800**
Civil / Structural Construction Contracts	2,655,178,000
Mechanical Construction Contracts	3,940,802,000
Electrical Construction Contracts	1,320,101,500
Control and Instrumentation Construction Contracts	411,185,900
Construction Service Contracts	1,318,016,900
Subtotal Construction Contracts	**9,645,284,300**
Indirect Costs	2,326,516,300
Contingency	1,715,900,400
Escalation	Included
Total Capital Requirements	**17,677,731,800**

3.21.1.1 Estimate Basis

The capital cost estimate is a definitive-level (±10 to 15 percent accuracy) estimate presented in 2014 South African Rand (ZAR) based on information obtained from the following sources:

- Steinmüller in-house database.
- Black & Veatch in-house database.
- Publicly available cost data.

Direct costs consist of purchased equipment and its installation, as well as miscellaneous costs. Purchased equipment and material costs include the cost for purchasing equipment and construction materials from multiple subcontractors in accordance with the Project Procurement Plan (178771.23.1110, SPF file 200-92430), attached. The installation costs also consider retrofit-related issues, based on the existing site configuration. Finally, miscellaneous costs account for the costs for additional items such as site preparation, buildings, and other structures. The direct costs estimates were based on the following assumptions:

- A regular supply of construction craft labor and equipment is available.
- Normal lead-times for equipment deliveries.
- Construction utilities (power, water, air) would be readily available.

3.21.1.2 Estimate Exclusions

The capital cost estimate does not include the following:

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

- Testing for environmental hazards, including remediation, removal or disposal of, but not limited to: asbestos, lead paint, underground contamination, and PCBs.
- Labor and material costs resulting from underground interferences.
- Salvaging or storage of equipment or structures.
- Scrap values.
- Upgrade or repairs to off-site roads, bridges and foundations, if required.
- Owner's costs such as project development, Owner personnel for engineering, startup, and construction management, taxes, financing, or Owner contingency for these items.
- Operational spares.
- Local taxes.

3.21.1.3 Indirect Costs

Indirect costs are those costs that are not related to the equipment purchased, but are associated with any engineering project such as the retrofit of a new control technology. Indirect costs include the following:

- Contingency.
- Engineering (contractor engineering and Owner's Engineer).
- Construction management.
- Contractor indirect costs.
- Project insurance.
- Performance bond.
- Contractor overhead and profit.

3.21.1.4 Contingency

Contingency accounts for unpredictable events and costs that could not be anticipated during the normal cost development of a project. The contingency cost category includes items such as possible redesign and equipment modifications, errors in estimation, unforeseen weather-related delays, strikes and labour shortages, escalation increases in equipment costs, increases in labour costs, delays encountered in start-up, etc.

3.21.1.5 Escalation

Escalation costs account for changes in cost from the date of estimate (today) until the date of actual expenditure. Escalation was based on 3 percent average escalation from April 2014 to the midpoint of construction, which yielded an overall escalation rate 12.6 percent. This escalation rate was applied to all labour and material costs included in the estimate and is included in the estimate line items.

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

3.21.2 Operations and Maintenance Cost Estimate

An preliminary Operations and Maintenance (O&M) Cost Estimate (178771.25.2000, SPF file 200-128137), attached, was developed to show incremental O&M costs associated with the addition of FGD to the Medupi Power Station.

A summary of the O&M costs are provided in Table 11.

Table 11: Operations and Maintenance Cost Estimate Summary

Description	Annual Station Cost For 85 Percent $CaCO_3$ Limestone (2014 ZAR)	Annual Station Cost For 96 Percent $CaCO_3$ Limestone (2014 ZAR)
Scrubber Reagent	429,123,000	470,865,000
Auxiliary Power	135,640,000	135,640,000
Water	143,265,000	145,988,000
Steam	11,300,000	11,300,000
FGD ZLD Pretreatment and Treatment System Chemicals		
Hydrated Lime (Ca Hydroxide)	37,549,000	49,000
Soda Ash (Sodium Carbonate)	86,214,000	78,553,000
Sodium Sulphate, 50% solution	4,463,000	4,920,000
Caustic, 50% solution	9,631,000	10,108,000
Sulfuric Acid, 66 Baume	2,452,000	2,648,000
Ferric Chloride, 50% solution	275,000	250,000
Antiscalant, 100% solution	1,880,000	1,880,000
Antifoam, 100% solution	124,000	124,000
Polymer, 100% solution	548,000	365,000
FGD ZLD Pretreatment Solids Waste (Clarifier Solids for Disposal)	3,606,000	1,797,000
FGD ZLD Treatment Solids Waste (Brine Concentrator/Crystallizer Solids for Disposal)	938,000	941,000
Byproduct Disposal (Gypsum)	58,547,000	55,168,000
Maintenance	220,972,000	220,972,000
Permanent Plant Personnel	44,429,000	44,429,000
Total Annual Operations and Maintenance Cost (2014 ZAR)	**1,190,956,000**	**1,185,997,000**

3.21.3 Total Levelized Annual Cost Analysis

This section provides a lifecycle costs analysis consisting of a total levelized annual cost and a cumulative present worth analysis for retrofitting an FGD system at the Medupi Station. Economic criteria used in the lifecycle cost analysis were developed collaboratively between Eskom and Black & Veatch. Economic inputs to the lifecycle cost analysis are described below and summarized in Table 12.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

- Evaluation period -- The economic life of the project was assumed to be 40 years.
- General escalation rate -- The general escalation rate was used to escalate the costs capital to the date of commercial operation and escalate O&M cost for future years.
- Present Worth Discount Rate (PWDR) -- The PWDR is used to discount future cash flow values to a present values.
- Levelized Fixed Charge Rate (LFCR) -- The LFCR is the single rate which, when applied to the total capital cost of a project, determines the levelized annual revenue requirements needed to recover all fixed costs associated with the capital of the project and provide the necessary return to meet an originations weighted average cost of capital.
- The lifecycle cost analysis includes the cost of capital and the cost of annual O&M expenses.
- The lifecycle cost analysis does not include any debt issuance fees, debt reserve fund costs, payment in lieu of taxes, annual insurance premiums, profit, etc.
- All analyses are pre-tax.

Table 12: Lifecycle Cost Analysis Economic Criteria

Description	Value
First Year of Operation, year	2022
Evaluation Period, years	40
Present Worth Discount Rate, percent	8.9
Levelized Fixed Charge Rate, percent	10
General Escalation Rate, percent	6

A levelized annual cost consisting of annual levelized fixed charges on capital and annual levelized O&M costs is summarized in Table 13. The annual levelized fixed charges on capital are the product of total capital cost, as reported in Table 10, and the LFCR. Annual levelized O&M costs consist of levelized annual costs for consumables, maintenance, and plant personnel.

Table 13: Total Levelized Annual Costs

Description	Annual Cost, For 85 Percent $CaCO_3$ Limestone ZAR	Annual Cost, For 96 Percent $CaCO_3$ Limestone ZAR
Levelized Fixed Charges on Capital	1,767,773,000	1,767,773,000
Levelized Annual O&M Costs		
Scrubber Reagent	899,268,000	986,742,000
Auxiliary Power	284,247,000	284,247,000
Water	300,225,000	305,931,000
Steam	23,680,000	23,680,000
ZLD Pretreatment Solids Disposal Cost	7,557,000	3,766,000
ZLD Treatment Solids Disposal Cost	1,966,000	1,971,000

CONTROLLED DISCLOSURE

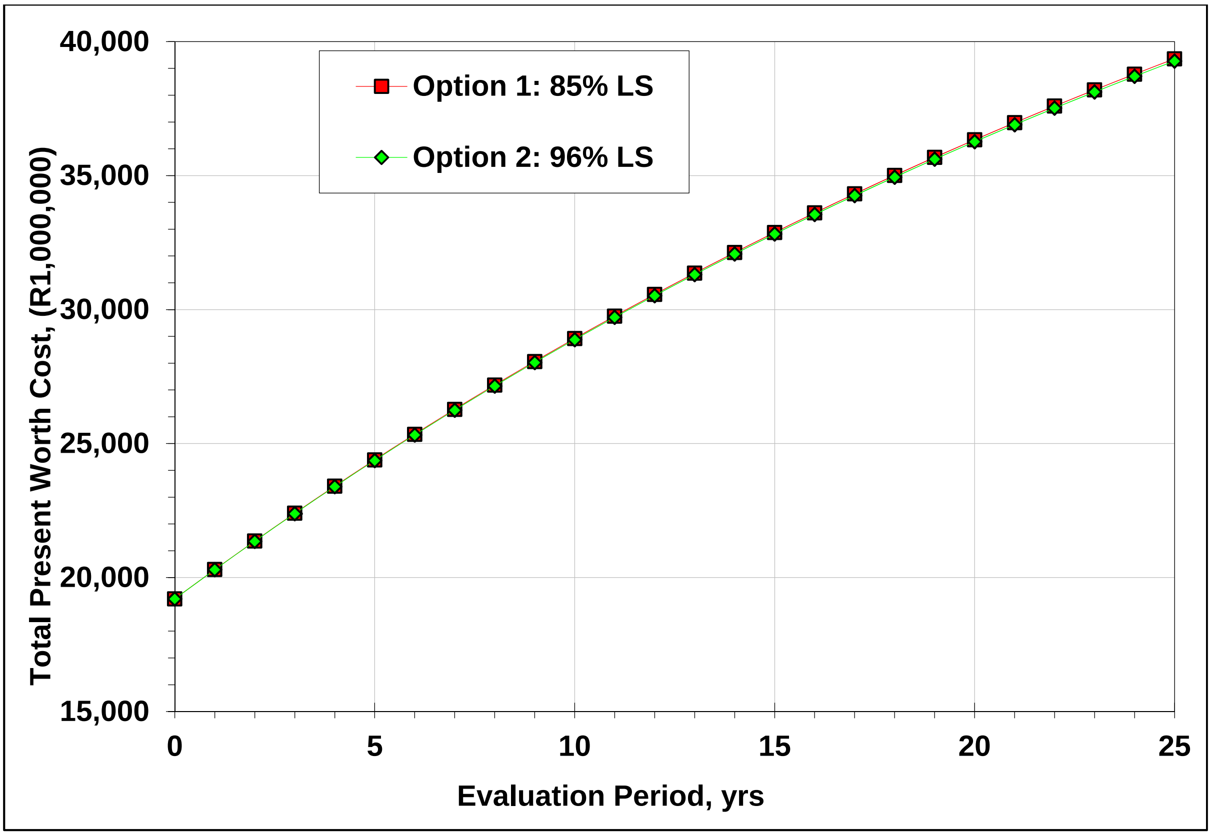
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Description	Annual Cost, For 85 Percent $CaCO_3$ Limestone ZAR	Annual Cost, For 96 Percent $CaCO_3$ Limestone ZAR
ZLD Pretreatment/Treatment Chemicals Cost	299,955,000	207,251,000
Byproduct Disposal	122,692,000	115,610,000
Maintenance	463,067,000	463,067,000
Permanent Plant Personnel	93,105,000	93,105,000
Total Levelized Annual O&M Costs	2,495,761,000	2,485,370,000
Total Levelized Annual Costs	**4,263,534,000**	**4,253,143,000**

3.21.3.1 Cumulative Present Worth

The cumulative present worth consist of a cumulative summation of present worth total annual costs comprised of the annual fixed charges on capital and present worth operating costs. Figure 1 presents the cumulative present worth costs for the FGD retrofit at the Medupi Power Station over a 25 year period.

Figure 1: Cumulative Present Worth Analysis



CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

3.22 TESTING AND COMMISSIONING

The sequence for turnover of the project for pre-commissioning and start-up were included in the Construction Execution Plan (178771.41.0111, SPF file 200-60812). The Construction Execution Plan also outlined the methodology to test the systems/plant design to prove that all requirements are met; validate the integrity of the installation; and ensure the system operates as intended, such that it may be put in service.

3.23 RISK REGISTER

A Risk Analysis was performed to identify major risks associated with executing the Medupi FGD retrofit project, and document the plans and strategies to manage and mitigate those risks. At this stage of project development, identifiable risks are generally those that arise based upon the planned project execution strategy or are typical for large projects of this nature. As project development continues, it is anticipated that the risk mitigation plans identified herein will be refined, and additional risks will be identified and appropriate mitigation strategies developed.

The content of this analysis is based upon a multi-contract EpCM approach in line with the Project Definition planning. This approach is under review and may be revised to a multi-package EPC or hybrid EPC approach at a later stage. Changes to the contracting approach may affect the risks, costs, and schedule addressed herein.

3.23.1 Risk Analysis

This document addresses risks for the Medupi FGD Retrofit Project in the following areas.

- Cost
- Schedule
- Change
- Quality
- Commercial
- Technical/Performance
- Labour Resources
- Procurement
- Information Technology (IT) Tools
- Safety
- Construction Execution

Each area is considered individually, and the key risk mitigation activities are summarized in Section 3.23.2.

3.23.1.1 Cost Risk

Cost risks are those items which have the potential to increase the project costs beyond the budgeted or projected costs for the project.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Table 14: Project Cost Risk Analysis

Potential Cost Risk	Analysis	Mitigation
Accuracy of project cost estimate	The project cost estimate may be subject to inaccuracies in equipment and material prices, labor costs, and labor productivity. Vendor quotations for major equipment used to support the project estimated developed during the Basic Design were limited to approximately 10 percent of the equipment and material costs.	Use historical prices, costs, and productivities, and include appropriate levels of escalation and contingency.
Incomplete scope of cost estimate	Design information for many procurement packages depends on receipt of design information from earlier packages and subsequent engineering design. Incomplete information development at the time of procurement may be addressed through conservative assumptions in material quantity.	Include allowances for conservative design in the project budget.
Changes in design	The input of new information or new requirements to the project during execution can result in design changes and possible rework.	See change risk analysis below.
Cost escalation, pricing volatility	The long duration of the project exposes the project to increases in the cost of equipment, materials, and labor due to inflation, worldwide demand, and other world events.	Escalation and contingency estimates in the project budget address escalation uncertainty. Transfer escalation risk to the contractors through firm pricing covering delivery and services for the duration of the project.
Scope growth	During project execution, identification of additional scope which was inadvertently omitted during conceptual design but required for the project can result in increased project costs.	1. Identification and resolution of project scope issues during basic design. 2. Include contingency for design evolution. 3. Limit project scope exclusively as needed to implement the FGD retrofit.
Construction productivity	Experience at the Medupi and Kusile construction sites has shown that contractor performance can delay the project schedule which increases project costs.	See labor resource risk below.
Availability of skilled labour resources	Experience at the Medupi and Kusile construction sites has shown that the availability of skilled laborers can increase project costs.	See labor resource risk below
Craft labour strikes	Experience at the Medupi and Kusile construction sites have proven that a strike can delay the project which leads to increased costs to the project.	Execute the project as planned. Work additional hours to recover lost time to the schedule.

3.23.1.2 Schedule Risk

Schedule risks are those items which could cause project delays which would impact the commercial operation of the FGD systems.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Table 15: Project Schedule Risk Analysis

Potential Schedule Risk	Analysis	Mitigation
Project initiation	The schedule from the start of engineering and procurement activities until operation of the first FGD system is 68 months. This time is necessary to support procurement, engineering, fabrication, delivery, and construction of the Unit 6 FGD and common systems.	ERA approval by the end of second quarter 2015 and full project release by the third quarter 2016 is needed to achieve operation of the first FGD unit by January 2022.
Overall schedule duration	Sufficient time is needed to develop the design prior to releasing procurement packages, to establish firm quantities and to coordinate design inputs from other packages. The current project schedule supports limited design input from early packages.	1. Execute the project as planned to support timely information exchange. 2. Utilize any change in project schedule duration to delay later packages and maximize information availability from earlier packages.
Open design issues	A list of open design issues at the conclusion of the Basic Design has been maintained and is included in the Basic Design Report. Timely resolution of these issues will be necessary to maintain the overall project schedule.	1. Pursue resolution of design input issues (e.g., geotechnical investigation) prior to release for execution phase engineering. 2. Review open issues list at the outset of execution phase, establish milestones for resolution, and monitor progress toward resolution.
Schedule coordination	The project schedule spans 10 years and affects multiple generating units. There is a high potential for external events to arise which would impact the schedule.	Conduct regular planning and coordination meetings with the various project stakeholders, including plant management to discuss overall schedule and upcoming events.
Procurement bid/award cycle duration	The long period of time necessary to bid, evaluate, and award procurement packages prevents the timely receipt of design information from earlier packages as input in developing subsequent procurement packages.	1. Establish high quality estimates where possible, using material takeoffs developed during Basic Design. 2. Execute the project as planned to support timely information exchange. 3. Utilize any change in project schedule duration to delay later packages and maximize information availability from earlier packages.
Changes in design	The input of new information or new requirements to the project during execution can result in design changes and possible rework. Design changes can also result in the delay of accurate information from earlier awarded packages.	See change risk analysis below
Changes in procurement packaging	The project schedule presumes that engineering information will be provided from certain packages as design input for other packages. Changes to the packaging plan could affect the project schedule if information is not available in a timely manner.	Include schedule impacts as an evaluation criterion when considering potential changes to the packaging plan.

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Potential Schedule Risk	Analysis	Mitigation
Construction productivity	Experience at the Medupi and Kusile construction sites has shown that contractor performance can delay the project schedule which increases project costs.	See labor resource risk below
Craft labour strikes	Experience at the Medupi and Kusile construction sites have proven that a strike can delay the project which leads to increased costs to the project.	Execute the project as planned. Work additional hours to recover lost time to the schedule.
Overwhelming the capacity of equipment suppliers	The FGD wastewater treatment system is relatively large and potentially may be problematic for equipment suppliers to meet a typical schedule. The risk is even higher for the brine concentrator and crystallizer equipment which uses more exotic metallurgy.	Assess vendor capabilities during the supplier prequalification process.

3.23.1.3 Change Risk

Change risks are those items arising from the input of new information or new requirements to the project during execution. Most often, change risks ultimately impact the project cost, schedule, or both.

Table 16: Project Change Risk Analysis

Potential Change Risk	Analysis	Mitigation
Change management	A defined change identification and approval process is needed to ensure that potential changes are screened for approval and information is provided to the affected parties.	1. Document the change management process as part of project execution plan early in the project. 2. Communicate the plan to the project participants.
Design interface	Design information for many procurement packages depends on receipt of design information from earlier packages and subsequent engineering design. Incomplete information development at the time of procurement creates the risk for design changes and contractor change orders. Design changes can also affect the flow of information from the earlier procurement packages.	1. To the extent possible, schedule procurement package development following the scheduled receipt of vendor engineering information from prior packages. 2. Make conservative design assumptions to develop preliminary information that is needed prior to confirmation by receipt of vendor information.

3.23.1.4 Quality Risk

Quality risks are those items which can negatively influence the quality of the installation, with associated impacts on the safety, operability, maintainability, or life of the operating facility.

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Table 17: Project Quality Risk Analysis

Potential Quality Risk	Analysis	Mitigation
Quality assurance reviews	The scope of work for the Medupi FGD Retrofit Project may require engaging new suppliers who do not have a demonstrated quality track record.	1. Establish a Quality Assurance Plan as part of the project execution plan. 2. Assess and screen vendor capabilities during prequalification.
Field quality management	While responsibility for quality belongs to the individual contractor, centralized quality management is necessary to provide accountability.	1. Implement a project-specific Field Quality Management program to verify quality. 2. Provide quality training to project field staff.
Design interface	Incomplete or inaccurate engineering interface among procurement packages could result in design coordination errors.	See Change Risk analysis above.
Poor familiarity with Eskom requirements	The scope of work for the Medupi FGD Retrofit Project may require engaging new suppliers who do not have prior experience with Eskom, and are not familiar with Eskom processes, procedures, and unique requirements.	1. Identify potential issues early through specification review. 2. Provide early notice during supplier prequalification. 3. Allow sufficient time in the procurement and contract performance periods for corrective action by contractors.

3.23.1.5 Commercial Risk

Commercial risks are those items related to supplier and contractor terms and conditions which can influence project risks described in this report.

Table 18: Project Commercial Risk Analysis

Potential Commercial Risk	Analysis	Mitigation
Schedule coordination	Timely, accurate, and compatible schedule information is needed from the contractors to facilitate overall project coordination.	Include provisions to require regular updates to contractor schedules to be provided in Primavera format.
Warranty	The typical “OEM” scope for the FGD system is planned to be broken into multiple packages. Overall performance risk arising from the coordination of the design and performance requirements is transferred to Eskom in this execution model.	Utilize Process Design and Engineering Management Partners who have experience with the design and performance coordination associated with the supply of FGD equipment.

3.23.1.6 Technical / Performance Risk

Technical and performance risks are design-related items which can impact the utility of the facility for the end user.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Table 19: Project Technical / Performance Risk Analysis

Potential Technical / Performance Risk	Analysis	Mitigation
FGD process design	FGD process design is new to Eskom. The absence of design experience could result in design errors.	Utilize experienced Process Design Partner to develop the Medupi FGD process design and mentor Eskom engineers during the design process. Utilize experienced Engineering Management Partner to review the design based on prior experience.
Operational training	Eskom has limited experience with wet FGD system operation. Proper operation will require skilled operators.	1. Plan for thorough vendor training as well as process training by Process Design Partner. 2. Begin training process early, so that a number of trained operators are available during startup for "on-the-job" training in FGD system operation. 3. Ensure that adequate technical support field services are included in the FGD-related packages.
Limestone availability and suitability	The quality, chemical reactivity, and availability to the Medupi site of limestone in sufficient quantities will not be known until the limestone procurement contract is established.	1. Limestone Sourcing Study was performed as input to the Basic Design to establish the likely values and variation for important limestone characteristics. 2. Develop a procedure for limestone specification development, testing, and evaluation as a basis for establishing a contract. 3. Solicit limestone supplier qualifications as to the availability, cost, and quality of limestone. 4. Verify that mass and water balances are within ranges once final limestone qualities have been established.
Waste gypsum disposal	It is assumed that up to 20 percent of the gypsum produced by the FGD system will be sold. The remaining quantity of gypsum is assumed to be disposed in the existing ash dump. The physical and regulatory capability to accept the gypsum produced during the life of the plant should be verified.	1. The physical capability has been assessed by Jones & Wagener (refer to For Information Only: Medupi Power Station, FGD, Jones and Wagener Letters for Co-Disposal of Ash and Gypsum [10]) which concluded that there is sufficient space provided that the excess coal stockyard is removed. 2. Complete regulatory review [12].
Water quality	The design basis water quality for the Mokolo and Crocodile West water supplies is based on prior sampling and may not be representative of the water quality available to the plant in 2020.	1. Raw water pretreatment and wastewater treatment design provides operating flexibility to address some variation in the inlet composition. 2. Routinely monitor the as-delivered water quality to establish typical values and variability for the key constituents.

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Potential Technical / Performance Risk	Analysis	Mitigation
Organics in the TOC scavenger wastewater	The TOC scavenger wastewater is sent to the FGD wastewater treatment system. A high level of organics could result in foaming, solids dewatering issues, and high levels of organics in the distillate recovered from the treatment system. High levels of organics in the distillate could cause similar problems in the FGD if it is recycled back to the FGD. The TOC scavenger wastewater quality will not be fully known until the system is operating within the existing plant.	1. Routinely monitor the concentrations and types of organics in the TOC scavenger wastewater stream to establish typical levels and variability. 2. A specific operating plan to handle the organics in the stream needs to be created. It may be necessary to treat the stream for organics prior to sending it to the FGD wastewater treatment system. It may also be necessary to take a slip stream off of the brine concentrator and dispose of it separately.
FGD wastewater treatment plant turndown	During early operations there will only be one out of six FGDs in operation and the potential exists that the FGD could operate at a high turndown in terms of flue gas flow and chlorine in the coal. This would result in a very high turndown with respect to the FGD wastewater that must be treated. The brine concentrator and crystallizer portions of the FGD wastewater treatment system have limited turndown capability.	1. The train configuration for the FGD wastewater treatment system was established to mitigate this issue. 2. Assess vendor capabilities during the supplier prequalification process and contract negotiations.
Chemical availability	The FGD wastewater treatment system will use a large amount of lime and soda ash. The availability to the Medupi site in sufficient quantities should be verified.	Confirm that current contracts in place are sufficient to meet the quality and large quantities of lime and soda ash that will be required.
FGD wastewater treatment solids disposal	The FGD wastewater treatment will generate a large amount of solids. Two different types of solids will be generated with one being fairly insoluble while the other being fairly soluble. The disposal method for these solids has not been identified.	A disposal plan should be identified to determine if there are any modifications that need to be made to the Basic Design to accommodate the disposal method. Refer to Guideline: Possible alternatives for the disposal of chemical wastes produced by the Flue Gas Desulphurisation process [11]. Complete regulatory review of disposal alternatives [12].
Chlorine demand of raw water supply	The chlorine demand of the Mokolo and Crocodile West raw water supplies has not been identified. The chlorine demand directly affects the amount of sodium hypochlorite that must be fed to the raw water supply to mitigate biological growth issues in the downstream equipment. The sodium hypochlorite feed system has the potential of being undersized depending on the chlorine demand of the raw waters.	The as-delivered water quality of the Mokolo and Crocodile West raw water supply should be monitored so that the chlorine demand can be verified.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

3.23.1.7 Labour Resources Risk

Labour resources risks are related to the availability of the engineering, manufacturing, and construction labour needed to implement the project.

Table 20: Project Labour Resources Risk Analysis

Potential Labour Resources Risk	Analysis	Mitigation
Engineering staff availability	Project implementation will require significant engineering staff levels.	1. Early identification of the required staffing levels during the Basic Design. 2. Staff levels supplemented by Process Design and Engineering Management Partners.
Engineering staff experience	Eskom has limited experience with wet FGD system engineering and design.	1. Early identification of the required staffing levels during the Basic Design. 2. Key staff positions filled with experienced engineers from Process Design and Engineering Management Partners. 3. Ensure that Eskom staff with otherwise high experience levels participate to guide and mentor third party engineering staff regarding Eskom standards and practices.
Specialized artisan labour	The Medupi FGD Retrofit Project work scope includes a significant amount of welding/joining, in particular for the Field Erected Tank package and fiberglass reinforced plastic (FRP) piping. Adequate numbers of skilled artisan welders will be needed to execute the work in a timely manner.	1. Assess vendor capabilities during the supplier prequalification process. 2. Establish a training program (if needed) in advance of the need for artisan labor onsite.
General construction labour availability	Project implementation will require significant construction staff levels over an extended period of time. It is assumed that union and expat labor will be utilized during construction, with an average manpower of approximately 1,250 workers.	Develop a craft recruiting and retention program to be implemented onsite which addresses long term craft retention strategies such as longevity bonuses, advanced training courses and certifications resulting in promotion or pay increases, etc.
Construction labour productivity	Construction labor productivity will vary based upon the overall demand for construction labor in the region. Greater demands for skilled labor may result in lower productivity from the available work force.	1. Estimate development incorporates productivity experience for the Kusile and Medupi Power Station construction projects. 2. Estimate includes contingency for labor productivity uncertainty.

3.23.1.8 Procurement Risk

Procurement risks are those items related to obtaining and delivering the needed equipment and materials for the project.

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Table 21: Project Procurement Risk Analysis

Potential Procurement Risk	Analysis	Mitigation
Contract bid / award duration	Design information for many procurement packages depends on receipt of design information from earlier packages and subsequent engineering design. The long contract award cycle inhibits information availability development at the time of procurement, increasing the risk for design changes and contractor change orders. Late award of the early packages would prevent the inclusion of accurate information in later packages.	Schedule allows 12 months for bid, evaluation, and award of all packages. Contract award should be made as early as possible to improve the availability of engineering information for subsequent packages.
Long lead times for certain items	Recently, the lead times for some common commodity items and engineered equipment have increased over historical values, primarily due to global demand.	Appropriate lead times based on recent experience have been factored into the Project Execution Schedule.
Local purchase objectives	The scope of work for the Medupi FGD Retrofit Project may require items that are not currently readily available in South Africa.	1. Assess vendor capabilities utilizing Eskom's established qualification process during the supplier prequalification process engaging all pertinent Medupi FGD Retrofit Project cross team members. 2. Organize procurement packages to allow local suppliers to aggregate materials or equipment which are sourced from outside South Africa with other, locally available items.
Experience with suppliers	The scope of work for the Medupi FGD Retrofit Project may require engaging new suppliers who do not have prior experience with Eskom, and are not familiar with Eskom processes, procedures, and unique requirements.	See quality risk analysis above
Project procurement team turnover	Continuity of procurement team and contract administration support personnel is necessary for the accurate and timely administration of the process.	Assign dedicated staff from start to finish (Works Information development through Contract Closeout) with detailed knowledge of the awarded contract.
Procurement document control	Concurrent access by the project team to the current revisions of all contract documents is necessary for accurate and consistent contract management.	Establish a central filing system that retains all documents throughout the project. Documents may only be stored on personal computers for individual reference and use.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Potential Procurement Risk	Analysis	Mitigation
Consistent and complete contract structure	Consistency of document content and structure minimizes the potential for scope gaps and supports fair and consistent contract management.	Establish a set of uniform procurement document guides with documented format that defines (but not limited to): 1. Full complete drawings. 2. Agreed-upon schedule based upon early completion with multiple milestones that show / ensure confirmation of progress. 3. Engineering information complete. Reference contract bid/award duration mitigation above – engineering information for subsequent packages. Include not-to-exceed quantities to compensate information to come from later packages.

3.23.1.9 IT and Tools Risk

IT and tools risks are risks related to the technology used for engineering and information management during project engineering and construction.

Table 22: Project IT and Tools Risk Analysis

Potential IT and Tools Risk	Analysis	Mitigation
3D model	The 3D model developed during the basic design must be converted for use in SmartPlant during project execution.	Conversion and testing of the 3D model should be performed in advance of execution release.
Document review	Timely availability of and access to review comments to project documents is needed to support smooth progress of the design work.	1. Eskom to provide user access and training for Process Design and Engineering Management Partners to access documents via SPF platform. 2. Project management to ensure that deadlines for document review are reasonable and are understood by the team and enforced.
SmartPlant design suite availability and functionality	Eskom, Process Design and Engineering Management Partners may utilize different engineering platforms. During design execution the full team must operate within a single, unified design environment. The Eskom platform does not currently support real time, remote, third party collaboration.	1. Develop a detailed IT and tools plan, indicating the tools, functionality, and processes to be implemented during design. 2. Conduct configuration validation testing with third-party engineering partners before commencing design engineering.

3.23.1.10 Safety Risk

Safety risks are related to the prevention of physical harm or injury from the activities associated with the design, construction, or operation and maintenance of the project.

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Table 23: Project Safety Risk Analysis

Potential Safety Risk	Analysis	Mitigation
Overall site safety	It is anticipated that the normal risks associated with construction activities will be present for the Medupi FGD Retrofit Project.	Develop and implement a site safety program addressing safety-related training and orientation, injury management, general safety procedures, reporting requirements, and environmental protection issues needed to provide a safe working environment.
Workforce coordination	The Medupi FGD Retrofit Project will be executed within the confines of an operating power generation facility. Safe execution of the project will require close coordination with plant operations and any ongoing construction activities at the site.	Conduct regular planning and coordination meetings with the operations and construction management at the plant site to discuss upcoming construction activities.
Congested areas	Much of the workforce will be working in close proximity to one another. Many overhead crane lifts will be occur with workers in and around the cranes.	Conduct regular coordination meetings to discuss the dangers of the close working conditions and overhead work.

3.23.1.11 Construction Execution Risk

Construction execution risks are related to activities which could cause project delays which would impact the commercial operation of the FGD systems.

Table 24: Construction Execution Risk Analysis

Potential Construction Execution Risk	Analysis	Mitigation
Improper erection sequence	Some of the Medupi FGD Retrofit Project structures are located in congested areas. FGD erection sequence must be defined in detail and closely followed to provide cost effective installation.	1. Develop and implement a detailed Construction Execution Plan for the work. 2. Generate work packages for critical work activities such as major component lifts that require heavy haul and major rigging, outage tasks that require close coordination with adjacent activities and are time restrained, or work scope that requires a very specific erection sequence, to establish detailed lift plans, level III break out schedules, step-by-step execution sequences, detailed inspection and acceptance criteria, etc..

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Potential Construction Execution Risk	Analysis	Mitigation
Lack of coordination between contractors	FGD Project work scope will be divided between multiple contractors. Individual contractor work scope execution must be coordinated into a seamless project execution plan to provide cost effective installation.	1. Develop scope in sufficient detail to identify and assign interface responsibility before contract award. 2. Ensure adequate construction management staff is provided to oversee the work. 3. Generate a detailed division of work (DOW) for each contractor to minimize scope gap. 4. Conduct frequent project coordination meetings with the contractors. 5. Share resources between contractors whenever possible. 6. Project contract managers must be pro-active, oversee field work continually, and address issues impacting work immediately.
Temporary construction facilities not available when needed	The FGD project will be executed over an extended period of time in an operating generation facility. Areas reserved for temporary construction facilities will be constantly re-assigned as needed to support various plant projects during this time. Adequate facilities must be properly allocated for FGD project use throughout project execution.	1. Develop a detailed construction facility, utility, and services plan for the life of the FGD project. 2. Develop contingency plans which provide alternate construction facilities in case emergency plant operations seize reserved facility areas.

3.23.2 Key Risk Management Activities Summary

The key risk management activities identified above are summarized below by area of primary responsibility.

3.23.2.1 Project Development

- ERA approval by the end of second quarter 2015 and full project release by the third quarter 2016 is needed to achieve operation of the first FGD unit by January 2022.
- A disposal plan for the waste gypsum and the wastewater treatment system byproduct should be identified to determine if there are any modifications that need to be made to the Basic Design to accommodate the disposal method.

3.23.2.2 Project Management

- Conduct regular planning and coordination meetings with the various project stakeholders, including plant management to discuss overall schedule and upcoming events.
- Ensure that Eskom staff with otherwise high experience levels participate to guide and mentor third party engineering staff regarding Eskom standards and practices.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

- Develop a detailed IT and tools plan, indicating the tools, functionality, and processes to be utilized during design and project execution.
- Begin operational training program early, so that a number of trained operators are available during startup for "on-the-job" training in FGD system operation.

3.23.2.3 Engineering

- Conversion to SmartPlant and testing of the 3D model developed during the Basic Design should be performed in advance of execution release.
- Initiate geotechnical and as-built site surveys following project funding approval, in advance of detailed design.
- Document the change management process as part of project execution plan.
- Establish a Quality Assurance Plan as part of the project execution plan.
- Ensure that adequate technical support field services are included in the FGD-related packages.
- Verify that mass and water balances are within ranges once limestone qualities have been verified.
- A specific operating plan to handle the organics in the stream needs to be created. It may be necessary to treat the stream for organics prior to sending it to the FGD wastewater treatment system. It may also be necessary to take a slip stream off of the brine concentrator and dispose of it separately.
- Conduct SmartPlant configuration validation testing with third-party engineering partners before commencing design engineering.

3.23.2.4 Procurement

- Utilize any change in project schedule duration to delay later packages and maximize information availability from earlier packages.
- Supplier prequalification should include assessments of the following.
    - Supplier demonstrated quality track record.
    - Supplier capability to supply the required work volume.
    - Specialty system design capability and experience (e.g., wastewater treatment).
    - Availability of specialized artisan labor.
    - Capability to supply local content.
- Address Eskom processes and procedures and quality requirements during the supplier prequalification process.
- Solicit limestone supplier qualifications as to the availability, cost, and quality of limestone.
- Transfer escalation risk to the contractors through firm pricing covering delivery and services for the duration of the project.
- Include provisions to require regular updates to contractor schedules to be provided in Primavera format.

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

- Include requirements for adequate field technical support and thorough training of Eskom personnel.
- Schedule allows 12 months for bid, evaluation, and award of all packages. Contract award should be made as early as possible to improve the availability of engineering information for subsequent packages.
- Perform a lime and soda ash sourcing study during detailed design. Solicit supplier qualifications as to the availability, cost, and quality of lime and soda ash
- Assign dedicated staff from start to finish (Works Information development through Contract Closeout) with detailed knowledge of the awarded contract.
- Establish a central filing system that retains all documents throughout the project. Documents may only be stored on personal computers for individual reference and use.
- Establish a set of uniform procurement document guides with documented format.

3.23.2.5 Construction

- Develop and implement a detailed Construction Execution Plan for the work.
- Implement a project-specific Field Quality Management program to verify quality.
- Provide quality training to project field staff.
- Establish a training program (if needed) in advance of the need for artisan labor onsite.
- Develop a craft recruiting and retention program to be implemented onsite.
- Develop and implement a site safety program addressing safety-related training and orientation, injury management, general safety procedures, reporting requirements, and environmental protection issues needed to provide a safe working environment.
- Conduct regular coordination meetings to discuss the dangers of the close working conditions and overhead work.
- Conduct regular planning and coordination meetings with the operations and construction management at the plant site to discuss upcoming construction activities.
- Conduct frequent project coordination meetings with the contractors.
- Generate work packages for critical work activities such as major component lifts that require heavy haul and major rigging, outage tasks that require close coordination with adjacent activities and are time restrained, or work scope that requires a very specific erection sequence, to establish detailed lift plans, level III break out schedules, step-by-step execution sequences, detailed inspection and acceptance criteria, etc..
- Develop a detailed construction facility, utility, and services plan for the life of the FGD project. Develop contingency plans which provide alternate construction facilities in case emergency plant operations seize reserved facility areas.
- Integrate operator trainees into the startup and commissioning phases of construction to enhance seamless turnover of FGD systems to plant operations.
- Assign discipline Field Engineers to coordinate OEM FGD technical advisor schedules to ensure their field hours are efficiently utilized to resolve FGD installation issues and educate construction personnel.

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

3.23.2.6 Operations

- Plan for thorough vendor training as well as process training by Process Design Partner.
- Begin training process early, so that a number of trained operators are available during startup for "on-the-job" training in FGD system operation.
- Integrate operator trainees into the startup and commissioning phases of construction to enhance seamless turnover of FGD systems to plant operations.
- Routinely monitor the as-delivered water quality for the Mokolo and Crocodile West water supplies to establish typical values and variability for the key constituents.
- Routinely monitor the concentrations and types of organics in the TOC scavenger wastewater stream to establish typical levels and variability.

3.24 OTHER DESIGN ISSUES

3.24.1 Unresolved Issues from Basic Design

The following issues were identified during the development of the basic design which will require resolution or completion during or in some cases, prior to the execution phase of the project.

1. Perform condensation calculations and flow modeling to assure duct-stack system is favorable for wet operation and to review the need for additional liquid collection facilities in the breeching and flue.
2. Third party review of flue discharge velocities and buoyancy to determine if exit modifications are necessary for adequate dispersion and elimination of possible plume downwash which may be caused by the wake formed on the downwind side of the flue and stack shell (such as a choke; reduction in diameter at flue exit). Updated stack exit conditions were developed during Basic Design.
3. Execute a geotechnical investigation; including soil borings, test pit samples, and laboratory testing with report of results, to furnish applicable criteria to be used to define foundation design parameters during the detailed design phase, and to determine site-specific seismic design criteria for all structures.
4. Execute an as-built survey of the foundations and structures in the areas affected by the FGD Retrofit Project in advance of detailed design.
5. Resolve clash between absorber piping and the roof, and its support structure, for all six absorber pump houses.
6. Perform design for the oxidation air quench system (refer to Section 3.5.3.1).
7. Decide whether the absorber should be insulated (refer to Section 3.5.3.1).
8. Evaluate eliminating the bypass ductwork and dampers and demolition of the existing ductwork to avoid maintenance of these components for the duration of the plant life. Would require revisiting the issues raised in Section 3.5.3.2.
9. Resolve clash between existing Hitachi ductwork support foundations and new FGD process tank foundations. The proposed solution will be to reduce the diameter of the emergency Drain Tanks and raise the side wall height to maintain tank capacity.
10. Decide whether to include the gas cooling heat exchanger (refer to Section 3.5.3.2) to reduce water consumption.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

11. Determine the schedule impacts and cost impacts for the coating, lining, and/or replacement with C276 material of the items currently made of 316L material, and recommend whether the modifications should be made while the Medupi Power Station is under construction, after power station startup but prior to the FGD Retrofit Project work, or as part of the FGD Retrofit Project scope (refer to Section 3.5.3.4).
12. Determine environmental criteria which may impact storm water runoff and retention design, new dirty water dam, and FGD blowdown system discharges to the existing storm water drainage system and existing dams. The determination of whether a new dirty water dam is needed will not be determined until the detailed design phase of the project. The need for a new dirty water dam was assumed during the Basic Design phase to capture the cost.
13. Coordinate the grade elevations and location and number of catch basins shown on the FGD Stormwater Drainage Layout for Area West of Boiler to Road 09 (SPF file 0.84/35608), attached, with the as-built Medupi Power Station grading and drainage (SPF file 0.84/193). The Medupi Power Station Project (Gibb Consulting) is updating the Power Station plan based on the attached input from the Medupi FGD Retrofit Project team.
14. Further investigate the existing ash dump for the additional tonnage of gypsum to be deposited there and complete regulatory review [12]. Must verify against existing design for size and stability.
15. Develop an implementation plan for the necessary modifications to the overland ash conveyor to facilitate co-disposal of ash and gypsum[9]. Coordinate with Medupi Power Station Operations staff regarding outage requirements for tie-in.
16. Confirm or correct the unverified assumptions described in Section 3.2.3.
17. Confirm the water qualities for the Mokolo and Crocodile West waters by routinely monitoring the water sources to establish typical values and variability.
18. Determine the chlorine demand for the Mokolo and Crocodile West waters so the hypochlorite feed to the FGD Makeup Water System can be accurately estimated.
19. Verify the FGD wastewater expected chemistry and quantity once the quality, chemical reactivity, and availability of limestone to the Medupi site is finalized.
20. Once the Medupi Power Station water treatment plant system is operational, monitor the concentrations and types of organics in the TOC scavenger wastewater stream to establish typical levels and variability.
21. Consult FGD ZLD treatment equipment suppliers to determine if the established concentrations and types of organics are acceptable and determine if additional treatment of the TOC scavenger wastewater stream will be necessary based on established operating data. It may be necessary to treat the stream for organics prior to sending it to the FGD ZLD Treatment System or provide a slip stream off of the brine concentrator to dispose of the organics separately.
22. Consult FGD ZLD treatment equipment suppliers to determine the type and quantity of organics that will pass into the distillate stream.
23. Revise the CCCW and FGD ZLD Treatment Systems design to implement sending the open cycle cooling water blowdown to the Reclaim Water Tanks in lieu of the FGD ZLD Treatment System.
24. Confirm that current contracts in place are sufficient to meet the quality and large quantities of lime and soda ash that will be required for the FGD ZLD Treatment System.

[9] Note that the possibility of co-disposal will be confirmed with the current waste classification study [12], and thereafter the competent authority.

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

25. The FGD ZLD Treatment System will generate a large amount of solids. Develop a disposal plan to determine the detailed solids disposal method[10].
26. Review redundancy requirements of FGD ZLD Pretreatment Holding Tank.
27. The Basic Design assumes that a stand-alone DCS will be added for control of the additional FGD-related scope. A decision whether to extend the existing DCS or design, procure, and install a stand-alone system has not been made at this time.
28. Evaluate the recommendations arising from the FMECA Study Report (178771.41.0201, SPF file 200-122279) for possible implementation in the design.
    a. Implement oxidation air cooling (refer to item 6 above and Section 3.5.3.1).
    b. Implement spray bank drain nozzle.
    c. Consider compressed air backup to dampers.
    d. Consider modular diesel generators.
    e. Consider revising CCCW strainers from Y-type to duplex basket type if there is chance of high airborne debris.
    f. Provide possibility for visual inspection of hydrocyclone underflow for the wastewater hydrocyclone and gypsum hydrocyclone stations.
29. Resolve Team Review comments on deliverables which could not be resolved during the Design Basic phase.
30. Eskom requested to change the format of KKS codes as follows (for example): 1 0HTD20 AM001, meaning to incorporate a blank (space) between the particular groups. Steinmüller indicated that is a lot of additional work and hard to update all drawings and studies within the remaining short period. Steinmüller proposed to change the format of KKS code prior to start and during the detail design phase. Eskom agreed. In the AGENDA (usually created by Carel) of the Eskom – Steinmüller internal process meeting 02nd April, item 16. Indicates: “KKS formatting hard to implement – implement in Detail design – find space in Basic Design Report”.
31. Resolve the means for support of the dampers at the Hitachi interface points as described in Section 3.5.3.2.
32. The following interferences discovered during 3D Model reviews will be resolved during detailed design. Interferences between piping will need to be resolved during detailed design during which time all of the design partners will be using the same 3D model. The 3D model will also be updated during detailed design to incorporate vendor specific information.
    a. Absorber Pump Houses: Absorber recycle pump discharge pipe clashes with roof structure.
    b. Absorber Pump Houses 1-5: Duct clashes with building.
    c. Absorber 5 Pump House: Pipe out of position, pipes terminate in fresh air, pipes interfere with pull space and walkway.
    d. Absorber 4 Pump House: Pipe runs into concrete base and clashes with absorber. Pipes clash with rack. Nozzle in incorrect position.
    e. Utility Rack Intersection at Absorber 6 Drain Tank: Pipes clash with cable trays, Pipes clash.
    f. Utility Rack Intersection at Absorber 4: Pipes clash with each other and with cable trays.

---

[10] Note that disposal of the ZLD and pretreatment waste disposal will be confirmed with the current waste classification study [12], and thereafter the competent authority.

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

g. Limestone Slurry Feed Tanks: Pipes run through one another.

h. Utility Rack Intersection at Limestone Slurry Feed Tank West: Pipes clash.

i. Process Water Tank: Misalignment of pipe and nozzle. Reclaim Tanks: Pipes terminate in fresh air.

j. Utility Racks at Reclaim Tanks: Pipes clash with Utility Rack and other pipes, pipework incomplete, clashes with Utility Rack.

k. ZLD Holding Tanks: Pipes terminate in fresh air.

l. Utility Racks between Reclaim Tanks and Limestone Slurry Feed Tanks: Firewater pipe clashes with other pipes.

m. Emergency Drain Tank: Foundation for Units 4-6 and 1-3 clashes with existing ductwork foundation. A possible resolution would be to reduce the diameter/increase the height of the tank to reduce the size of the foundation.

n. Absorbers: Vertical steelwork clash with Absorber.

o. Ductwork Access Doors: Ductwork access doors to be added to the 3D Model

p. Utility Rack: Investigate the possibility of adding a small utility rack between the two clusters for cable tray, air, water, and auxiliary steam piping to reduce the cost associated with routing these utilities through the Unit 6, 5, 4 cluster.

q. Gypsum Dewatering: Two of the hydrocyclones were relocated to avoid a clash between the hydrocyclone and the support steel below the hydrocyclone. The steel will be modified to allow a straight run of pipe.

r. Gypsum Dewatering Building: Roof is lower. Clashes with walkways.

s. Access to valves: Access to all valves to be provided for operation and maintenance purposes in accordance with URS requirements. Platforms to be added as needed.

3.25 LESSONS LEARNED

1. Equipment and building layouts developed during Conceptual Design should be conservatively sized so that access for operations and maintenance can be maintained as the scope is more fully developed during Basic Design and project execution and equipment support subsystems (such as ball mill lubrication skids) are identified and included in the design.
2. Test data which are required as inputs to the Conceptual and Basic Design phases must be identified early so that budget and schedule can be allocated to conducting the tests in advance of commencing the design, so that design progress is not affected by the time required to execute and deliver these design inputs.
3. The detailed (Level 3) schedule for each phase of the project should be developed, reviewed by the relevant stakeholders (including discipline resource managers), and finalized prior to the start of engineering for that phase. Prerequisites for schedule finalization include scope of work, deliverables, and division of work.
4. Resource planning (i.e., manpower requirements by discipline) is required to ensure that deliverables are completed according to the engineering schedule.
5. Consumables quality (e.g., limestone) which have a significant influence on system and/or process design should be identified and defined prior to the start of engineering for a particular phase of project development.

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

6. The schedule for the completion of the relevant RAM, HAZOP, and FMECA analyses should take cognizance of the time it takes to complete these complex analyses for any future projects.
7. End-of-phase review and baselining process should identify specific documents and/or aspects of the design for design freeze, which are then subject to the change management process. It was not clear to the project team which aspects of the Concept Phase design are subject to change management, as compared to documents which are expected to evolve during the Basic Design. Since the design is expected to mature during Basic Design, it would be cumbersome for every document produced during Basic Design to be subject to change management. For example, it would be expected that the FGD Mass Balances/Process Flow Diagrams from the Concept Phase would be frozen (aside from changes to the design basis, such as the limestone quality) but the P&IDs would continue to be refined during Basic Design. Likewise at the conclusion of the Basic Design it is anticipated that the number and general location of the buildings would be fixed, but the exact dimensions will be established when dimensions are established using contractor data. However, efficient execution of the Basic Design (and later, Detail Design) requires that the design proceed from a fixed baseline, with significant changes documented and reviewed for any cost or schedule impacts to the project prior to approval.

4. AUTHORISATION

This document has been seen and accepted by:

Project Engineering Manager

Name	Designation
Justice Bore	Project Engineering Manager
Frans Sithole	Senior Project Engineering Manager

Lead Discipline Engineers

Name	Discipline	Role
Carel van Heerden		EDWL
Carel van Heerden	Boiler – Auxiliary	LDE
Denise Govender	Civil/Structural	LDE
Tseliso Msimanga	C&I	LDE
Eugene Kisten	Electrical	LDE
Godwin Fuhnwi	System Integration	LDE
Omry Makgoale	Low Pressure Services	LDE
Eugene Pininski	Systems Design, Reliability, and Safety Engineering	LDE
Tiyani Khosa	Bulk Material Handling	LDE
Renisha Lutchminarain	Chemical	LDE
Anthony Haupt	Systems Design,. Arrangement Design	LDE
Phillip van Heerden	Roads and Rail	Support

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Discipline Managers

Name	Discipline
Anton Hart	Boiler
Yokesh Singh	Boiler
Dieter Huppe	C&I
Lungile Malaza	Electrical
Ismail Atiya	Bulk Material Handling
Nkosi Ndika (Acting)	Low Pressure Services
Nalini Moodley	Chemical
Riaan Venter	Civil/Structural, Roads and Rail
Terrance Mavunda	Civil Dams, Waterways and Geotech
Petunia Serekwa	System Integration – Configuration Management
Siyabonga Ndlovu (Acting)	System Integration – System Design

Senior Discipline Managers

Name	Discipline
Titus Mathe	Power Plant
Galia Dudenska	Civil Structures and Civil Design
Louis Fernandez	System Integration
Vasanie Pather	Auxiliary Plant
Prudence Madiba	Electrical & C&I

Medupi Project Engineering

Name	Designation
Riem De Beer	Site Engineering Manager
Philip Steyn	Medupi EDWL

Medupi Generation

Name	Designation
Johan Prinsloo	Power Station Manager
Prince Khumalo	Engineering Manager

External Partners

Name	Designation	Company
David Harris	Project Manager	Black & Veatch
John Wortman	Engineering Manager	Black & Veatch
Shannon Adams	Project Mechanical Engineer	Black & Veatch
Dan Geilman	Project Control/Electrical Engineer	Black & Veatch

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Name	Designation	Company
James Guthrie	Project Civil/Structural Engineer	Black & Veatch
Preston Tempero	AQC Engineer	Black & Veatch
Wolfgang Bloss	Project Manager	Steinmüller Engineering
Stefan Binkowski	Department Manager FGD	Steinmüller Engineering
Uwe Schadow	Department Manager Construction	Steinmüller Engineering

5. REVISIONS

Date	Rev.	Compiler	Remarks
March 2014	DRAFT 0.0	David Harris Black & Veatch	Initial Draft Report.
March 2014	DRAFT 0.1	David Harris Black & Veatch	Revised based on team comments.
August 2014	DRAFT 0.2	David Harris Black & Veatch	Revised based on team comments. Confirmatory review issue.
September 2014	0	David Harris Black & Veatch	Team Review comments incorporated.

6. DEVELOPMENT TEAM

The following people were involved in the development of this document:

Name	Discipline	Company
Justice Bore	Project Engineering	Eskom
Zubair Moola	C&I	Eskom
Tiyani Khosa	Bulk Material Handling	Eskom
Renisha Lutchminarain	Chemical	Eskom
Denise Govender	Civil/Structural	Eskom
Eugene Kisten	Electrical	Eskom
Omry Makgoale	Low Pressure Services	Eskom
Godwin Fuhnwi	System Integration	Eskom
Solly Masina	Configuration Management	Eskom
Carel van Heerden	Boiler Auxiliary - FGD	Eskom
Annikie Moganelwa	Boiler Auxiliary - FGD	Eskom
Candice Stephen	Boiler Auxiliary - FGD	Eskom
Puseletso Godana	Boiler Auxiliary - FGD	Eskom
David Harris	Project Management	Black & Veatch
John Wortman	Engineering Management	Black & Veatch
Kevin Bogner	Project Controls	Black & Veatch
Shannon Adams	Mechanical	Black & Veatch

CONTROLLED DISCLOSURE
When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.

Name	Discipline	Company
Stan Shilling	Control/Electrical	Black & Veatch
Dan Geilman	Control/Electrical	Black & Veatch
Roger Goodlet	Construction	Black & Veatch
James Guthrie	Civil/Structural	Black & Veatch
Todd Pfennig	Estimating	Black & Veatch
Preston Tempero	Air Quality Control	Black & Veatch
Wolfgang Bloss	Project and Engineering Manager	Steinmüller Engineering
Stefan Binkowski	Process Design Department Manager	Steinmüller Engineering
Uwe Schadow	Product Design Department Manager	Steinmüller Engineering
Sabrina Schäfer	Process Design Engineering	Steinmüller Engineering
Louisa Schmeken	Process Design Engineering	Steinmüller Engineering
Sven Kaiser	Process Design Engineering	Steinmüller Engineering
Stefan Uhlig	Process Design Engineering	Steinmüller Engineering
Christian Unger	Process Design Engineering	Steinmüller Engineering
Jürgen Pöhler	Control/Electrical	Steinmüller Engineering
Klaus Winn	Product Design Engineering	Steinmüller Engineering
Walter Cyrkel	Product Design Engineering	Steinmüller Engineering
Jörg Etzler	Product Design Engineering	Steinmüller Engineering
Klaus Lingenberg	Product Design Engineering	Steinmüller Engineering
Dirk Winkelmann	Product Design Engineering	Steinmüller Engineering
Petra Leng	Product Design Engineering	Steinmüller Engineering
Michael Machnik	Mechanical Engineering	Steinmüller Engineering
Michael van Kerkom	Mechanical Engineering	Steinmüller Engineering
Richard Binienda	Structural Engineering	Steinmüller Engineering

7. ACKNOWLEDGEMENTS

Bernard Pelei Petlane – Project Manager - PDD

Frans Sithole – Senior Project Engineering Manager

Titus Mathe – Senior Engineering Manager

Danie Odendaal – General Manager Engineering

CONTROLLED DISCLOSURE

When downloaded from the EDMS, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorised version on the system.