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EXPERIENCE QUALITY INTEGRITY

LICHTENBURG LAFARGE CEMENT PLANT AND TSWANA QUARRY

STORMWATER INFRASTRUCTURE AND POLLUTION CONTROL DAMS PRELIMINARY DESIGN REPORT

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LAFARGE

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SYNOPSIS

Preliminary design details and assumptions for the Stormwater Management Infrastructure for the Lafarge Tswana Quarry and the Lafarge Cement Plant, and Pollution Controls Dams for the Lafarge Cement Plant.

KEY WORDS:

Lafarge Cement Plant, Quarry, National Water Act 36 of 1998, General Notice 704, Best Practice Guidelines-A1, Stormwater, Channels, PCD, Pump, Waste

QUALITY VERIFICATION

This report has been prepared under the controls established by a quality management system that meets the requirements of ISO9001: 2008 which has been independently certified by DEKRA Certification under certificate number 90906882

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LAFARGE CEMENT PLANT AND TSWANA QUARRY STORMWATER INFRASTRUCTURE AND POLLUTION CONTROL DAMS PRELIMINARY DESIGN REPORT

EXECUTIVE SUMMARY

JG Afrika Pty Ltd (JG Afrika) were appointed by Lafarge Industries South Africa (PTY) Ltd (Lafarge) to provide a preliminary design of the stormwater infrastructure to manage the dirty water from the Lafarge Cement Plant (LCP) and the Lafarge Tswana Lime Quarry (LTQ) for the purposes of a Water Use Licence Application (WULA). The stormwater management infrastructure is designed to ensure these two facilities are compliant with GN704 as per the findings of the audit undertaken by JG Afrika in 2019 and the most recent stormwater management plans by JG Afrika (2022).

The LTQ stormwater infrastructure includes four interconnected channels (A to D) and one isolated channel (E) which discharges into an existing dam as shown in **Table 1**. The channels are designed to accommodate 1 in 50 year flood peaks ranging from 0.14 m^3/s to 0.5 m^3/s. The interconnected channels are concrete lined trapezoidal channels with 1V:1.5H side slopes, 600 mm wide bases and longitudinal slopes at a minimum of 0.25% due to the flat terrain of the Lichtenburg area. The side slopes for earth and reno mattress lined channels are 1V:3H.

Table 1: Tswana Quarry Channel Dimensions and Design Flood Peaks

Channel	Shape	Channel Slope (m/m)	1:50 Year Peak Discharge (m^3/s)	Bottom Width (m)	Depth (m)	Lining Material
A	Trapezoidal	0.0025	0.18	0.60	0.30	Concrete
B	Trapezoidal	0.0025	0.14	0.60	0.30	Concrete
C	Trapezoidal	0.0025	0.20	0.60	0.30	Concrete
D	Trapezoidal	0.0025	0.50	0.60	0.50	Concrete
E (Section 1)	Trapezoidal	0.0065	0.42	0.60	0.45	Concrete
E (Section 2)	Trapezoidal	0.0065	0.44	0.60	0.70	Reno mattress
E (Section 3)	Trapezoidal	0.0065	0.44	0.60	0.50	Earth
E (Section 4)	Trapezoidal	0.0433	0.44	0.60	0.70	Reno mattress

For the purposes of road crossings five culverts were designed of which four are box-shaped culverts and one is pipe-shaped. The culverts were designed to accommodate 1 in 50 year flood peaks ranging from 0.14 m^3/s to 0.5 m^3/s similar to the flood peaks accommodated by the channels.

The preliminary design drawings for the stormwater infrastructure for the LTQ have been included in **Annexure B** and the estimated cost of the LTQ Stormwater Infrastructure is approximately **R 7.38 million** including 15% contingencies and excluding VAT.

For the LCP Stormwater Infrastructure, five stormwater management areas were proposed with interconnecting channels. The LCP has existing channels and only three of these areas (A, B and E) required new infrastructure to be designed. Two areas required the inclusion of new Pollution Control Dams (PCD's) which are the Coal Stockyard (CSY) PCD and the Additives (Add) PCD.

Multiple channels were proposed for stormwater management areas A, B and E of the Lafarge Cement Plant (LCP). The channels' cross-sectional shapes are either trapezoidal or triangular and are concrete lined with slopes ranging from 0.25% to 1% with 1V:1.5H side slopes. Only one channel is grass lined which is trapezoidal in shape with 1V:3H side slopes and basin width of 600 mm with a longitudinal slope of 0.5%. The channels will accommodate 1 in 50 year flood peaks ranging from 0.03 m^3/s to 0.9 m^3/s. The road and railway crossings of the channels in the LCP were designed as culverts, as opposed to open channels, due to heavy machinery navigating around the site. The culverts are all box-shaped and accommodate flood peaks ranging from 0.15 m^3/s to 1.96 m^3/s.

The preliminary design drawings for the stormwater infrastructure for the LCP have been included in **Annexure B** and the estimated cost of the LCP Stormwater Infrastructure is approximately **R 10.83 million** including 15% contingencies and excluding VAT.

Although the waste categorization is still being finalized, it is expected that both PCDs' dirty water will be categorized as Type 3 waste. According to the National Waste Management: Waste Act, Regulation 636, Type 3 waste requires a Class C or GLB+ liner system. The Class C liner was the preferred lining system for both PCD's and requires two 150 mm of compacted clay layers. A high-level review of material availability was undertaken using an auger on-site, the available geotechnical information ("Lafarge Lichtenburg Kiln 4 and Associated Structures Geotechnical Investigation", SRK Consulting Engineers (Pty) Ltd, February 2006), and geological maps. From the material availability review it was found that there will be insufficient clay material on the site to form the 300 mm of compacted clay required for the Class C liner. Alternative materials had to be considered for this project to eliminate the risk of delays and additional costs during the construction phase should the amount of available clay be insufficient. The most commonly used alternative to normal clay material is a Geosynthetic Clay Liner (GCL). However, it is a requirement to prove the equivalence of the alternative material to the Regulator through submission of site-specific swell tests. Additionally, the use of

a GCL requires that a minimum confining pressure of 5 kPa be placed on top of the lining system. The confining pressure will be in the form of 250 mm soilcrete filled geocell layer and shall also act as a protection layer to the HDPE liner, which forms part of the Class C liner. The 250 mm soilcrete will also limit thermal and UV exposure to the HDPE liner since heat can influence the service life of the HDPE liner especially in a hot climate such as Lichtenburg. The service life of the HDPE liner would be 106 years based on an average liner temperature of 35˚C, which is considered to be a conservative estimate as described within the report.

Both the CSY and Additives PCD's have at least one embankment sloping at 1V:3H and access ramps sloping at 1V:12H. Slope stability analysis was carried out for both PCD's using the critical design slope of 1V:3H. The properties of the material within the proposed PCD's locations were obtained from Lafarge Lichtenburg Kiln 4 and Associated Structures Geotechnical Investigation Report (SRK, 2006), the Lafarge Lichtenburg Cement Plant and Tswana Quarry Geohydrological Report (Tucana Solutions, 2017) and geological maps. Using the information found from the mentioned sources both the Additives and CSY PCD's met the minimum required Factor of Safety of 1.3 for end of construction, 1.5 for steady-state seepage and 1.3 for rapid drawdown. Analysis conducted on both PCD's indicated stable slope conditions over all three of the scenarios considered.

Both the Additives and CSY PCD's do not require registration with the Dam Safety Officer since they do not meet the minimum threshold criteria. This is because the dams will not store more than 50 000 m^3 of water and do not have free-standing walls of at least 5 m in height, primarily due to the flat terrain and the invert levels of the stormwater channels feeding into the PCD's being below the NGL. The PCD's are, therefore, exclusively in excavation.

The Additives PCD's required storage is **20 000 m^3**, which has been achieved within the designed footprint at an average depth of 5.15 m from NGL and 3.2 m below the Full Supply Level (FSL). Beneath the basin of the PCD there will be a subsoil drainage system in a herringbone fashion with lateral drains at 15 m intervals. These drains are connected to a manhole where the subsoil drain daylights. The subsoil drainage system helps to monitor the behaviour of the PCD as a leakage detection system, prevent pollution of the groundwater system in the case of leakages from the PCD, and assists to alleviate buoyant pressures due to possible high water table levels on site.

The Additives PCD features an access ramp sloping at 1V:12H with a minimum width of 3.5 m and lined, in addition to the Class C liner described above, with a 30 kN x 30 kN PP Geogrid to provide additional protection. Because of the size of the access ramp and the limits around the PCD's site, the access ramp was placed on the eastern side of the PCD, which also has sufficiently low ground levels to allow for spillway

discharge. The access ramp has, therefore, been built in conjunction with the spillway. The spillway is trapezoidal in shape, with a base with of 5 m and side slopes of 1V:3H. The spillway is able to discharge a 1 in 50 years flood peak of 2.29 m^3/s at the depth of 0.41 m and has freeboard of 0.8 m. The spillway can discharge approximately 7.09 m^3/s prior to overtopping of the design Non-Overspill Crest (NOC). The preliminary design drawings of the additives PCD have been included in **Annexure B** and the estimated cost of the PCD is **R 33.49 million** including 15% contingencies and excluding VAT.

The second PCD which is collecting dirty water from the Coal Stockyard has a minimum storage requirement of **4 000 m^3**. This was achieved within the design footprint of the PCD at a depth of 4.28 m deep below the start of the access ramp and 3.08 m deep below the FSL. The CSY PCD had to be designed within a confined triangular area which is between three existing railways and a road. Due to the target storage, available footprint, the access ramp and the invert level of the stormwater channel discharging into the PCD, it was found that the PCD could not be an embankment dam with side slopes of 1V:3H as it would not provide the minimum required storage capacity. To meet the storage requirements a reinforced concrete retaining wall around the dam's perimeter was designed. This allowed for maximum utilization of the available space and the PCD being able to store the targeted volumes.

The CSY PCD has an access ramp sloping at 1V:12H with a minimum width of 3.5 m, lined by a concrete geocell protection layer of 250 mm thickness over the liner and a 30 kN x 30 kN PP Geogrid to provide additional protection. The PCD has an internal embankment sloping down to the floor of the basin at 1V:3H on the southern side of the ramp. The spillway has a crest level (FSL) of 1488.8 mamsl and is 2 m wide with 1V:1.5H side slopes and the spillway channel connects to an existing culvert on the southern side of the PCD. The spillway is able to discharge a 1 in 50 year flood peak of 0.52 m^3/s at the depth of 0.29 m and has a freeboard of 1.15 m. The spillway can discharge approximately 5.62 m^3/s prior to overtopping the design NOC. The preliminary design drawings of the CSY PCD have been included in **Annexure B** and the estimated cost of the PCD is approximately **R 16.22 million** including 15% contingencies and excluding VAT.

The overall estimated costs of the stormwater infrastructure and PCD's was approximately **R 67.9 million** including 15% contingencies and excluding VAT. The rates used to calculate estimated costs were based on recent project experience and tendered rates but may vary from project to project due to market volatility.

It should be emphasized that the dirty water from both PCDs should not spill more than once in 50 years in order to prevent polluted water impacting on downstream water resources and environmentally sensitive areas. The water balances used to determine the sizing of the PCD's and the operational requirements of the

PCD's in order to ensure they do not spill more than once in 50 years have been detailed within the Lichtenburg Lafarge Cement Plant – Water Balance Study (JG Afrika, March 2022) and should be used as a guide for the operating requirements of the PCD's.

Following the waste classification, the project's next step is to complete the Department of Water and Sanitation's (DWS) liner checklist. JG Afrika will complete the checklist based on previous project experience in attempt to speed up the process and reduce costs where possible, however more testing may be required. Further geotechnical investigations will be required on site during the detailed design phase, as this is necessary for the selection of subsoil drain filter materials, determining the hydraulic conductivity of the insitu material, the confirmation of slope stabilities and the factor of safety achieved for the embankment slopes, and the detailed design of the retaining wall.

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ACRONYMNS AND ABBREVIATIONS

Add	Additives (or the Additives Area of the Lafarge Cement Plant)
CSY	Coal Stockyard (or the Coal Stockyard Area of the Lafarge Cement Plant)
DWS	Department of Water and Sanitation
EMP	Environmental Management Plan
FSL	Full Supply Level
GN704	Regulation 704 of the National Water Act (Act 36 of 1998)
IWUL	Integrated Water Use License
LCP	Lafarge Cement Plant
LTQ	Lafarge Tswana Quarry
NEM:WA	National Environmental Management : Waste Act
NOC	Non-Overspill Crest
NWA	National Water Act (Act 36 of 1998)
PCD	Pollution Control Dam
RDF	Recommended Design Flood
RMF	Regional Maximum Flood
SANCOLD	South African Committee on Large Dams
SEF	Safety Evaluation Flood
SW	Stormwater
SWMP	Stormwater Management Plan
WUL	Water Use Licence

1 INTRODUCTION

1.1 Background

JG Afrika (Pty) Ltd (JG Afrika) were appointed by Lafarge Industries South Africa (Pty) Ltd (Lafarge) to undertake the preliminary design of the stormwater management infrastructure and two pollution control dams (PCD) for their Lichtenburg Cement Plant (referred to herein as the Lafarge Cement Plant, or LCP) and the stormwater management infrastructure at their Tswana Lime Quarry (referred to as Lafarge Tswana Quarry, or LTQ). This infrastructure has been identified as a requirement in order for the LCP and LTQ to achieve full compliance with regards to GN704 of the Water Act (NWA) (Act 36 of 1998), the details of which and requirements have been detailed in the most recent stormwater management plans (Lichtenburg Lafarge Cement Plant and Tswana Quarry Stormwater Management Plan and General Notice 704 Audit – Rev02, JG Afrika, April 2022 and Tswana Quarry Stormwater Management Plan – Rev00, JG Afrika, April 2022), which provides sizing guidelines for both the stormwater infrastructure and the PCD's.

1.2 Purpose of this Report

The intention of this report is to provide details of considerations made for the preliminary design of the infrastructure relevant to the stormwater management and the PCD's. The report provides references and assumptions used in the design and also identifies further recommendations and the outstanding design detailing which will be undertaken during the detailed design phase of the project. This report also, in the form of annexures, presents the preliminary design drawings of the infrastructure included and a preliminary design level cost estimation and bill of quantities (BoQ) for all of the infrastructure.

1.3 Locality

The Lafarge Cement Plant is located just outside Lichtenburg Town on Portion 61 of Lichtenburg Town Farm No 27, whilst the Tswana Quarry is located on Portion 0 of Driefontein Farm No 46 near Itsoseng, approximately 35 km from Lichtenburg. Within the Tswana Quarry the stormwater management infrastructure is concentrated around the workshop and processing areas, not in the actual quarry. Whilst at the Cement Plant, the new stormwater infrastructure covers areas in the east, north and west of the plant. The two PCD's required are to be located in the south-east of the plant to contain water from the additives area and the other in the north of the plant to contain water from the coal stockyard. As such, the two PCD's are referred to as the Additives PCD (Add PCD) and the Coal Stockyard PCD (CSY PCD).

2 STORMWATER INFRASTRUCTURE PRELIMINARY DESIGN REQUIREMENTS

2.1 Stormwater Management Plan

JG Afrika were appointed to update the stormwater management plan (SWMP) for the Tswana Quarry and the Cement Plant for the purposes of a Water Use Licence Application (WULA), and provide engineering drawings of stormwater infrastructure proposed. The stormwater management plan (JG Afrika, 2022a) is therefore largely based on the findings of the General Notice 704 audit and previous SWMP study undertaken in 2019.

This updated SWMP has provided guidance on the sizing and horizontal alignments for the stormwater infrastructure contained within this report. Therefore, summary maps, tables and design requirements (such as design flood peaks) from the SWMP will also be presented in this report, where necessary, for ease of reference.

2.2 Design Assumptions

A number of assumptions and decisions have been made in order to undertake the design of the stormwater infrastructure. These have been detailed below, along with the reasons behind the decision or assumption.

2.2.1 Shape of Stormwater Channels

In order to maintain consistency across the site, and for ease of construction, the cross-sectional shape of the stormwater channels has been kept consistent (for each type of channel lining), with the exception of the concrete lined channels where two cross-sectional profiles have been recommended. For all concrete lined channels, apart from those within the coal stockyard itself, a trapezoidal channel with side slopes of 1V:1.5H has been used. This shape is close to the most hydraulically efficient shape for a channel and provides practical side slopes for construction purposes (with steeper slopes becoming more difficult to construct. For channels within the coal stockyard, a triangular channel with side slopes 1V:6H has been considered. The alternate cross-sectional shape for these channels allows for light vehicle traffic, such as a bobcat, to travel across the channels. The range of vehicle traffic required to cross the channels within the coal stockyard will be confirmed during detailed design. The cross-sectional profile and steel reinforcing required for these channels will then be re-considered and modified accordingly. It is also understood that additional upgrades to the CSY itself may occur in future and it is important that the stormwater infrastructure is compatible with these upgrades.

For grass lined channels, the channels have also been designed in a trapezoidal shape, with side slopes of 1V:3H being used. This is typically the maximum side slope used for grass lined channels, as recommended by the Drainage Manual (SANRAL, 2013). With side steeper than 1V:3H there is increased possibility for erosion and slope instability.

Some sections of the grass lined channels on the Tswana Quarry are lined with reno-mattresses. This is to provide erosion protection and typically the profile of the reno-mattress lined sections follows that of the grass lined sections of channels.

2.2.2 Minimum Design Slopes

As per the Drainage Manual (SANRAL, 2013), the minimum allowable slope for a concrete lined channel is 0.25%. This is recognised as being an extremely gradual slope for a channel and has only been used where completely necessary. As the Lichtenburg area is particularly flat, this slope has been used for a number of the channels. Typically, a slope of 0.5% and steeper has been targeted for the concrete lined channels.

As a guideline, stormwater channels can increase in slope along the length of the channel, but it is preferred for the channels slopes not to decrease as this can lead to non-uniform flow and potentially a build-up of sediment. This principle has been followed in almost all cases, except where it becomes impractical or cannot be achieved due to limitations in the sites' topography.

2.2.3 Road Crossings

Due to the large plant and trucks travelling in and around the two sites, all road crossings have been designed as culverts. Open channels are typically preferred as they are easier to monitor and maintain, however, as a result of the depth of the channels crossing the roads and the required vertical alignments to ensure no issues are encountered by the vehicles, the channels would become excessively wide and lose their cost efficiency.

Therefore, culverts have been used instead. These are typically box culverts which require less cover above the culvert, and therefore (at least in this case), prevent unnecessary changes in the slope of the channels.

As per the Department of Transport typical sections and guidelines, a minimum cover of 300 mm has been maintained as an absolute minimum above all box culverts on the site. Generally, this minimum is well surpassed.

It is anticipated that openings for culverts under existing dirt roads would be done by conventional trenching ('open excavation') and existing concrete road surfaces would be saw cut prior to excavation for culvert pipes/ box culvert units. Allowances have been made within the preliminary design costing for construction of all required culverts. Detailed specifications, construction level detailing and further refined costing for culverts will be done during detailed design.

2.2.4 Cost Estimation

For the purposes of cost estimation at this the preliminary design phase of the project, the Preliminary and General component of the works has been estimated to be approximately 30% of the cost of the rest of the construction. For the calculation of the remainder of the works, quantity estimations have been taken from the design model and calculated based on the depths of the channels and required material volumes for the construction of the infrastructure. The estimation of rates has been based on recent projects undertaken by JG Afrika and provide an estimation of what is expected to be received when the project goes out to tender. It should be noted, however, that these rates do change from project to project and with the volatility in the market (seen particularly for items such as the cost of steel) and increasing fuel prices, some allowance should be made for changes in these rates. At this stage of the project is it typical to allow a 15% continency to the overall cost to account for this volatility.

2.2.5 Survey Data

Anomalies between the survey point data/ surface model and the orthophotographs have been identified, for example, regarding the alignment of the existing road and rail to the north of the CSY PCD. In such cases, design judgements have been made taking into account information available. Confirmation of key areas within the project footprint, through ground-truthing and/ or further survey, will be required during detailed design to ensure that the level of accuracy required for detailed design and construction is attained.

2.3 LTQ Stormwater Infrastructure Preliminary Design

2.3.1 Proposed Infrastructure Layouts and Sizing

The SWMP proposed the inclusion of five stormwater channels for the Lafarge Tswana Quarry (LTQ) site, channels A through to E. Four of the five channels are interconnected (channels A to D), whereas channel E is independent and discharges into an existing dam. The proposed layout of the channels can be seen in **Figure 2-1**, as taken from the SWMP.

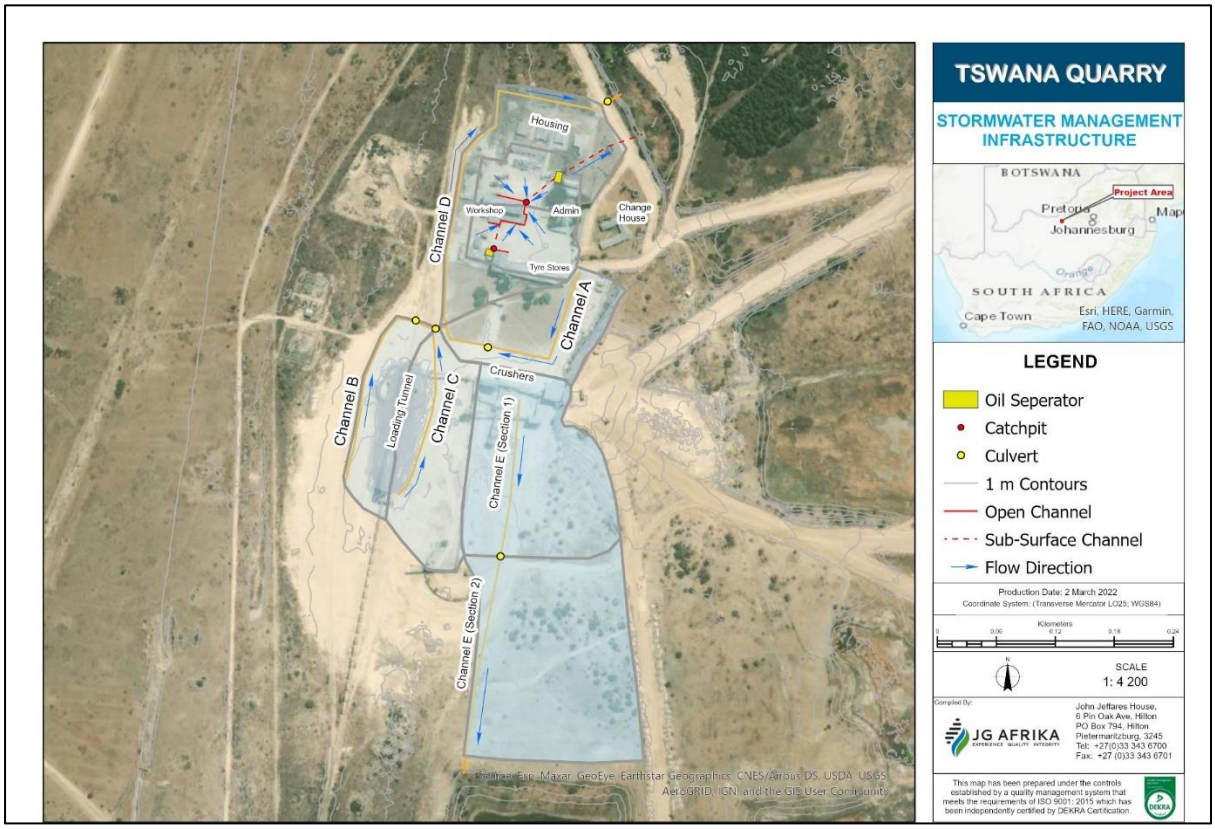

Figure 2-1: LTQ Proposed Stormwater Management Infrastructure

The contributing catchment areas (also indicated in **Figure 2-1**), design rainfall depths and required capacity, based on the 1:50 year return period flood peak, for the channels as taken from the SWMP are presented in **Table 2-1** below.

Table 2-1: Tswana Quarry Stormwater Channel Design Flood Calculation Results

Channel	Catchment Area (km^2)	1:50 Year Design Rainfall (mm)	1:50 Year Peak Discharge (m^3/s)
Channel A	0.0130	135	0.18
Channel B	0.0083	135	0.14
Channel C	0.0120	135	0.20

Channel	Catchment Area (km^2)	1:50 Year Design Rainfall (mm)	1:50 Year Peak Discharge (m^3/s)
Channel D	0.0150	135	0.50
Channel E (Section 1)	0.024	135	0.42
Channel E (Section 2)	0.034	135	0.44

Based on the required design discharges for each of the channels, the achievable slopes based on site topography and the manner in which the channels are required to interconnect, **Table 2-2** below presented the design slopes, shapes and dimensions for the stormwater infrastructure. This table presents the top widths of the channels based on the side slopes (as presented in **Section 2.2.1**) and the design channel depths (shown in **Table 2-2**). Following this, the design culvert sizing for all culverts on the site have been indicated in **Table 2-3**.

Table 2-2: Tswana Quarry Recommended Stormwater Channel Dimensions

Channel	Shape	Channel Slope (m/m)	Top Width (m)	Bottom Width (m)	Depth (m)	Lining Material
A	Trapezoidal	0.0025	1.50	0.60	0.30	Concrete
B	Trapezoidal	0.0025	1.50	0.60	0.30	Concrete
C	Trapezoidal	0.0025	1.50	0.60	0.30	Concrete
D	Trapezoidal	0.0025	2.10	0.60	0.50	Concrete
E (Section 1)	Trapezoidal	0.0065	1.95	0.60	0.45	Concrete
E (Section 2)	Trapezoidal	0.0065	4.80	0.60	0.70	Reno mattress
E (Section 3)	Trapezoidal	0.0065	3.60	0.60	0.50	Earth
E (Section 4)	Trapezoidal	0.0433	4.80	0.60	0.70	Reno mattress

Table 2-3: Proposed Culvert Sizing

Culvert	Shape	Span (m)	Rise (m)	Deck Height (m)	Openings	Capacity (m^3/s)	Required Peak (m^3/s)
A	Box	0.60	0.45	0.75	1	0.37	0.18
B1-1	Box	0.45	0.30	0.50	1	0.15	0.14
B1-2	Box	0.45	0.30	0.35	3	0.55	0.43
D	Pipe	0.75	0.70	2.55	1	0.55	0.50
E	Box	0.45	0.30	0.32	3	0.46	0.42

2.3.2 Preliminary Design Drawings

The preliminary design drawings for the stormwater infrastructure for the LTQ have been included in **Annexure B**. These drawings provide the channel sizing, setting out points and layout.

2.3.3 Cost Estimation

With the proposed channels presented above and on the preliminary design drawings, a cost estimation (at a preliminary design level) for the construction of the infrastructure, has been calculated. This estimated that the total construction cost (excluding VAT) of the LTQ stormwater infrastructure will be approximately R 7.38 million. A summary table of the cost estimation has been included as below, with the full preliminary design BoQ included in **Annexure A**.

Table 2-4: LTQ Stormwater Infrastructure Construction Cost Estimate Summary

No.	Description	Amount
1	R 1 589 154.00	R 1 580 424.00
2	R 4 827 180.00	R 4 798 080.00
Subtotal A		**R 6 416 334.00**
Contingencies (15%)		R 962 450.10
TOTAL (Excl. VAT)		**R 7 378 784.10**

2.4 LCP Stormwater Infrastructure Preliminary Design

2.4.1 Proposed Infrastructure Layouts and Sizing

The SWMP for the Lafarge Cement Plant (LCP) proposed the inclusion of five stormwater management areas A through to E, with interconnecting channels. The proposed layout of the channels can be seen in **Figure 2-2**, as taken from the SWMP. Some of these channels are existing and will remain in place as is.

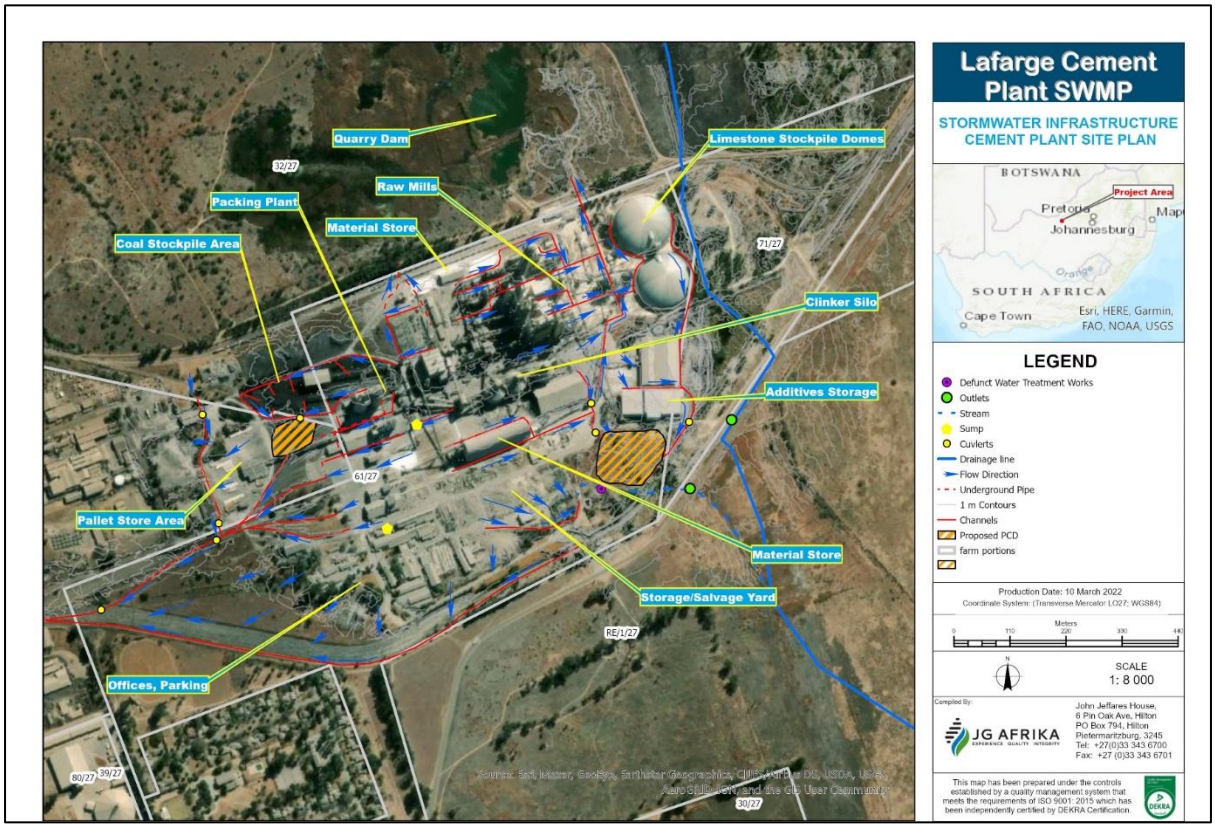

Figure 2-2: LCP Proposed Stormwater Management Infrastructure

Figure 2-3 presents the numbering of the channels as well as the delineated catchment areas for each stormwater management area. As noted, not all areas require new infrastructure to be designed, therefore, for the purposes of this preliminary design report only areas A, B and E will be discussed as these are the areas requiring new infrastructure. The PCD's required to be constructed in area B (Coal Stockyard PCD) and area E (Additives PCD) are covered later in this report and do not form a part of this section.

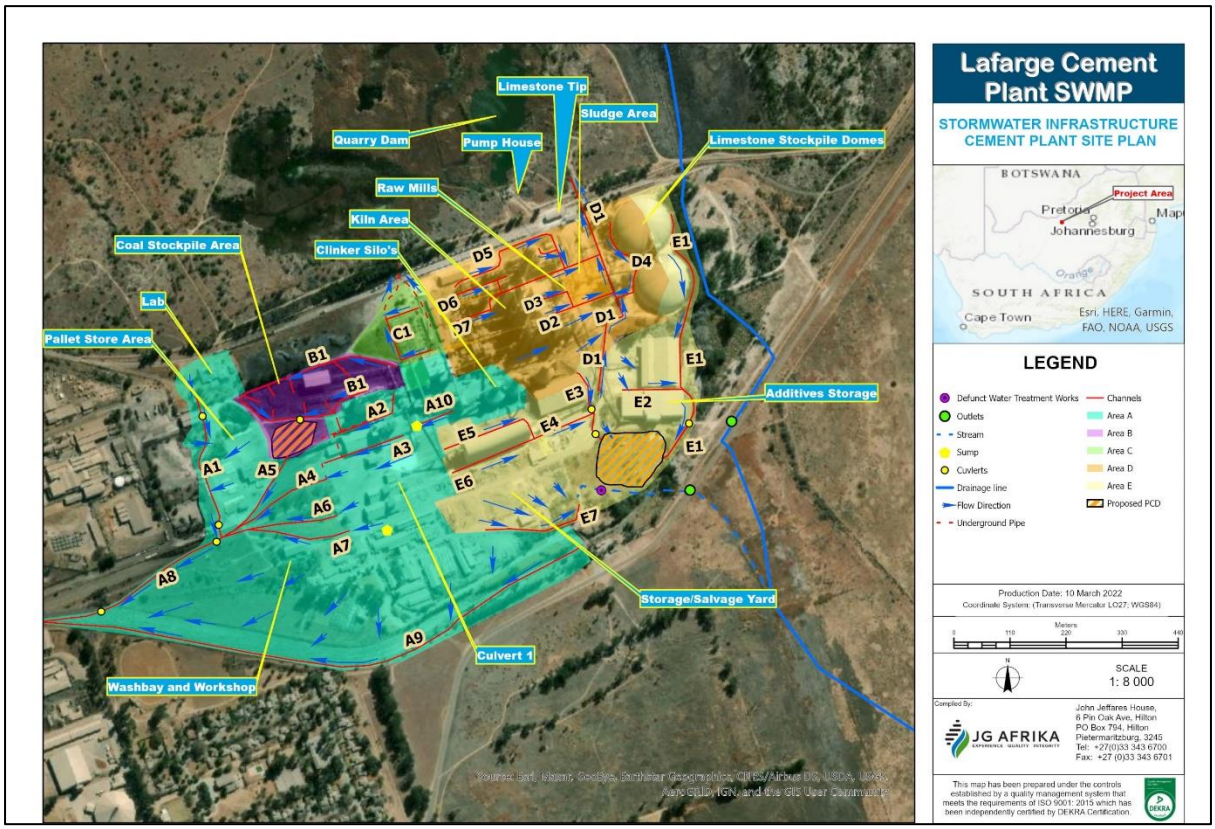

Figure 2-3: LCP Proposed Stormwater Management Infrastructure and Catchment Areas

2.4.2 Stormwater Management Area A

The stormwater management in Area A includes several channels and culverts, the locations of which can be seen in **Figure 2-4**.

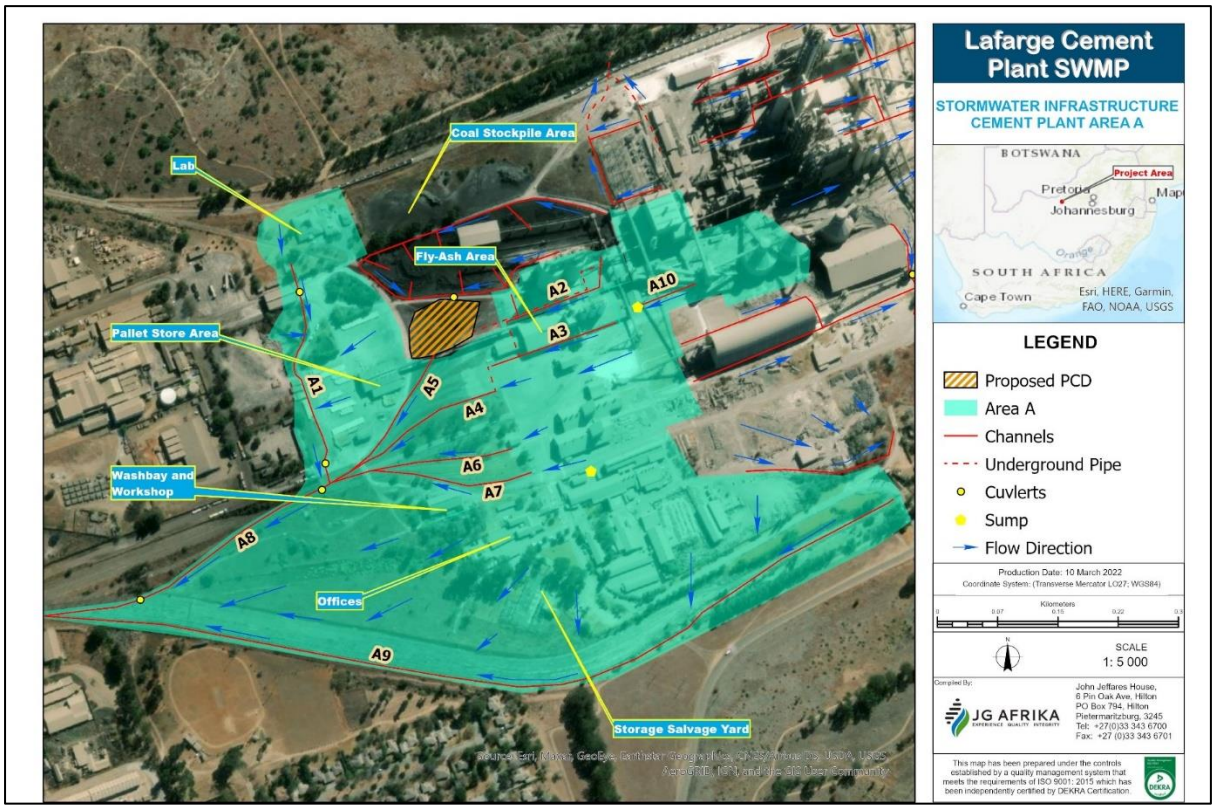

Figure 2-4: LCP Area A Proposed Stormwater Management Infrastructure and Catchment Area

The contributing catchment areas (also indicated in **Figure 2-4**), design rainfall depths and required capacity, based on the 1:50 year return period flood peak, for the channels as taken from the SWMP are presented in **Table 2-5** below.

Table 2-5: LCP Area A Stormwater Channel Design Flood Calculation Results

Channel	Catchment Area (km^2)	1:50 Year Design Rainfall (mm)	1:50 Year Peak Discharge (m^3/s)
A1	0.04	47	0.52
A5	0.04	94	0.42
A8	0.16	63	1.70

Based on the required design discharges for each of the channels, the achievable slopes based on site topography and the manner in which the channels are required to interconnect, **Table 2-6** below presented the design slopes, shapes and dimensions for the stormwater infrastructure. This table presents the top widths of the channels based on the side slopes (as presented in **Section 2.2.1**) and the design channel depths (shown in **Table 2-6**). Following this, the design culvert sizing for all culverts on the site have been indicated in **Table 2-7**.

Table 2-6: LCP Area A Recommended Stormwater Channel Dimensions

Channel	Shape	Channel Slope (m/m)	Top Width (m)	Bottom Width (m)	Depth (m)	Lining Material
A1	Trapezoidal	0.007	2.10	0.6	0.50	Concrete
A5	Trapezoidal	0.01	2.10	0.6	0.50	Concrete
A8	Trapezoidal	0.005	6.00	0.6	0.90	Earth (Grass)

Table 2-7: LCP Area A Proposed Culvert Sizing

Culvert	Shape	Span (m)	Rise (m)	Deck Height (m)	Openings	Capacity (m^3/s)
A1-1 (Upstream road crossing)	Box	0.45	0.30	0.7	1	0.15
A1-2 (Downstream road crossing)	Box	0.60	0.60	1.1	1	0.56
A8-1 (Railway crossing)	Box	0.45	0.60	0.7	3	1.12
A8-2 (Downstream railway crossing)	Box	0.45	0.90	1.0	3	1.96

2.4.3 Stormwater Management Area B

The stormwater management in Area B includes several channels and culverts, the locations of which can be seen in **Figure 2-5**.

Figure 2-5: LCP Area B Proposed Stormwater Management Infrastructure and Catchment Area

The contributing catchment areas (also indicated in **Figure 2-5**), design rainfall depths and required capacity, based on the 1:50 year return period flood peak, for the channels as taken from the SWMP are presented in **Table 2-8** below.

Table 2-8: LCP Area B Stormwater Channel Design Flood Calculation Results

Channel	Catchment Area (km^2)	1:50 Year Design Rainfall (mm)	1:50 Year Peak Discharge (m^3/s)
B1	0.05	57.41	0.10
B2	0.013	70.57	0.18
B3	0.001	45.48	0.03

Based on the required design discharges for each of the channels, the achievable slopes based on site topography and the manner in which the channels are required to interconnect, **Table 2-9** below presented the design slopes, shapes and dimensions for the stormwater infrastructure. This table presents the top widths of the channels based on the side slopes (as presented in **Section 2.2.1**) and the design channel depths (shown in **Table 2-9**).

Table 2-9: LCP Area B Recommended Stormwater Channel Dimensions

Channel	Shape	Channel Slope (m/m)	Top Width (m)	Bottom Width (m)	Depth (m)	Lining Material
B1a	Trapezoidal	0.0061	1.80	0.60	0.40	Concrete
B1b	Trapezoidal	0.005	2.10	0.60	0.50	Concrete
B1c	Trapezoidal	0.0036	5.00	0.60	0.50	Concrete
B2a	Trapezoidal	0.0061	1.65	0.60	0.35	Concrete
B2b	Trapezoidal	0.0025	1.65	0.60	0.35	Concrete
B3a	Triangular	0.0061	4.20	-	0.35	Concrete
B3b	Triangular	0.0061	4.20	-	0.35	Concrete
B3c	Triangular	0.0061	4.20	-	0.35	Concrete
B3d	Triangular	0.0025	4.20	-	0.35	Concrete
B3e	Triangular	0.0025	4.20	-	0.35	Concrete
B3f	Triangular	0.0025	4.20	-	0.35	Concrete
B3g	Triangular	0.0025	4.20	-	0.35	Concrete

Channels B3a-g include channels within the coal stockyard to direct surface water into the CSY PCD (via inter-connected channels B1 and B2) to avoid standing water within the stockyard area. In order to allow for frequent silt-up anticipated due to their location within the coal stockyard itself, additional freeboard depth has been accommodated for these channels (viz. channels B3a-g). Although currently unlined, it is necessary that the coal stockyard surface will ultimately be concrete lined to prevent groundwater contamination. With this eventuality in mind, concrete lined channels have been used within the coal stockyard (viz. B3a-g). It is recommended that these channels within the coal stockyard area be constructed as earth channels in the interim, and concrete lined concurrently with concrete lining of the coal stockyard surface.

Details regarding traffic movements and vehicle types that traverse the coal stockyard will be required for analysis during detailed design towards optimisation of the channel layout within the coal stockyard area. That is, to minimise possible effects of the stormwater channel layout on operational requirements within the coal stockyard.

The design culvert sizing for all culverts on the site have been indicated in **Table 2-10**.

Table 2-10: LCP Area B Proposed Culvert Sizing

Culvert	Shape	Span (m)	Rise (m)	Deck Height (m)	Openings	Capacity (m^3/s)
B1-1 (road crossing)	Box	0.45	0.45	0.8	2	0.55
B1-2 (rail crossing)	Box	0.45	0.45	0.6	2	0.55

2.4.4 Stormwater Management Area E

The stormwater management in Area E includes several channels and culverts, the locations of which can be seen in **Figure 2-6**.

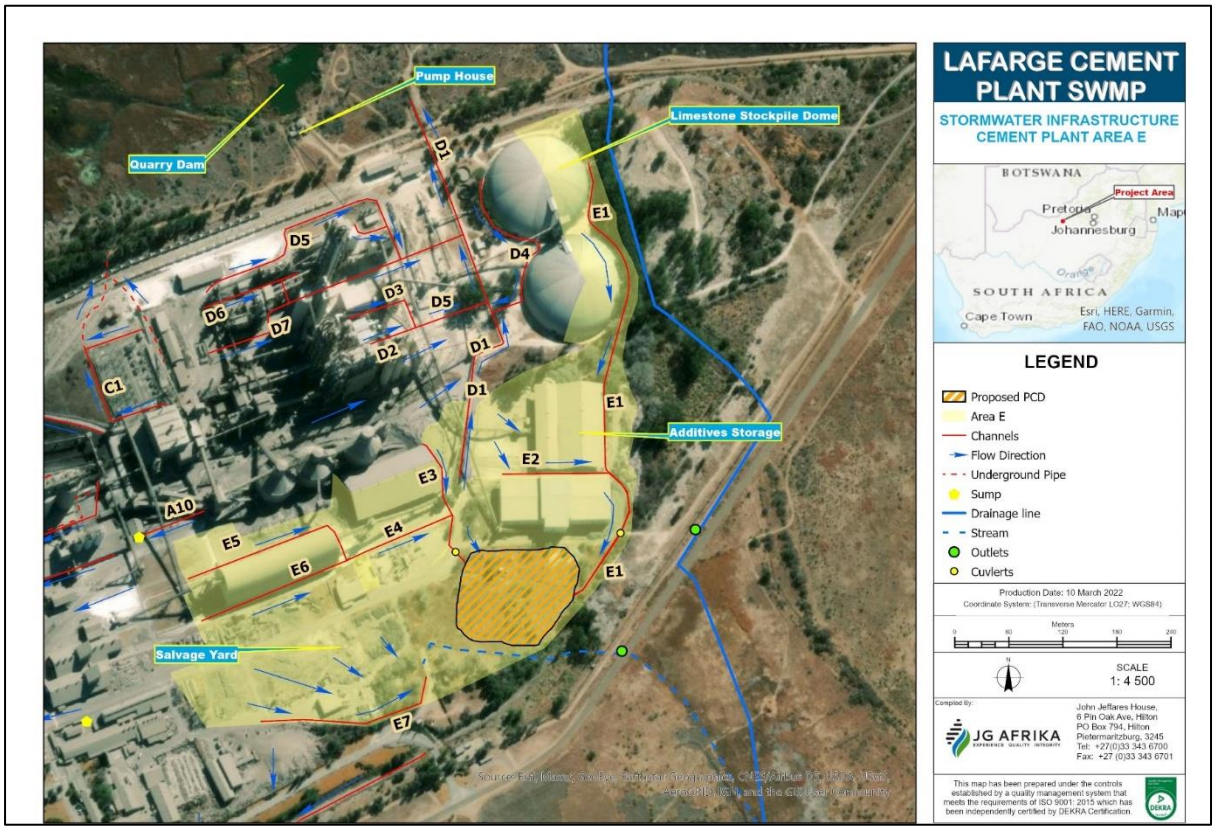

Figure 2-6: LCP Area E Proposed Stormwater Management Infrastructure and Catchment Area

The contributing catchment areas (also indicated in **Figure 2-5**), design rainfall depths and required capacity, based on the 1:50 year return period flood peak, for the channels as taken from the SWMP are presented in **Table 2-11** below.

Table 2-11: LCP Area E Stormwater Channel Design Flood Calculation Results

Channel	Catchment Area (km^2)	1:50 Year Design Rainfall (mm)	1:50 Year Peak Discharge (m^3/s)
E1	0.03	39.75	0.25
E2	0.03	42.59	0.37
E3	0.03	43.39	0.11

As shown in **Figure 2-6**, channel E1 passes adjacent to an additives storage structure. It is assumed that any excess material excavated along the western edge will be spoiled or used along the eastern bank of the channel, within a freehaul distance of 1 km.

Based on the required design discharges for each of the channels and the achievable slopes based on site topography and the manner in which the channels are required to interconnect, **Table 2-12** below presented the design slopes, shapes and dimensions for the stormwater infrastructure. The top widths of the channels are determined based on the side slopes (as presented in **Section 2.2.1**) and the design channel depths (shown in **Table 2-12**).

Table 2-12: LCP Area E Recommended Stormwater Channel Dimensions

Channel	Shape	Channel Slope (m/m)	Top Width (m)	Bottom Width (m)	Depth (m)	Lining Material
E1a	Trapezoidal	0.0056	1.50	0.60	0.3	Concrete
E1b	Trapezoidal	0.0025	2.40	0.60	0.6	Concrete
E2	Trapezoidal	0.005	1.80	0.60	0.4	Concrete
E3a	Trapezoidal	0.0489	1.50	0.60	0.3	Concrete
E3a	Trapezoidal	0.005	1.50	0.60	0.3	Concrete
E3b	Trapezoidal	0.005	1.80	0.60	0.4	Concrete
E3c	Trapezoidal	0.005	1.80	0.60	0.4	Concrete

Based on the survey point elevations, it appears that the first portion (approximately 20 m long) of channel E3 passes through large heaps of discarded material. It is assumed that this discarded material will be excavated prior to commencement with construction of the channels. For preliminary design, an estimate of the actual natural ground level has been extrapolated based on elevations of nearby points. Further investigation and confirmation of the actual natural ground levels along the first portion of channel E3 will be required during detailed design, and amendments to the channel design will be made accordingly, if required.

Channel E2 passes between an additives storage structure to the north and another structure along the south side of it. Based on site investigation findings, it is noted that there have been vehicles passing between the two structures in the past. However, no allowance has been made for vehicles to pass over channel E2 between structures. It has been assumed that after construction of the channels, vehicle traffic between these two structures will utilise the existing access road on the western side of channel E, and not drive over the channel.

The design culvert sizing for all culverts within LCP area E have been indicated in **Table 2-13**.

Table 2-13: LCP Area E Proposed Culvert Sizing

Culvert	Shape	Span (m)	Rise (m)	Deck Height (m)	Openings	Capacity (m^3/s)
E1-1 (road crossing)	Box	0.90	0.60	1.4	1	0.56
E3-1 (road crossing)	Box	0.45	0.30	0.6	1	0.15
E3-2 (road crossing)	Box	0.60	0.60	1.0	1	0.56

2.4.5 Preliminary Design Drawings

The preliminary design drawings for the stormwater infrastructure for the LCP have been included in **Annexure B**. These drawings provide the channel sizing, setting out points and layout.

2.4.6 Cost Estimation

With the proposed channels presented above and on the preliminary design drawings, a cost estimation (at a preliminary design level) for the construction of the infrastructure, has been calculated. This estimated that the total construction cost (excluding VAT) of the LCP stormwater infrastructure will be approximately R 10.83 million. A summary table of the cost estimation has been included in **Table 2-14** below, with the full preliminary design BoQ included in **Annexure A**.

Table 2-14: LCP Stormwater Infrastructure Construction Cost Estimate Summary

No.	Description	Amount
1	Preliminary & General	R 2 350 042.00
2	Stormwater Management Area A	R 2 658 301.33
3	Stormwater Management Area B	R 1 900 392.00
4	Stormwater Management Area E	R 2 504 780.00
Subtotal A		**R 9 413 515.33**
Contingencies (15%)		R 1 412 027.30
TOTAL (excluding VAT)		**R 10 825 542.63**

3 PRELIMINARY DESIGN REQUIREMENTS OF PCD'S

3.1 Introduction

At the Lafarge Cement Plant (LCP), two areas have been identified to require new PCD's to be constructed as per the Stormwater Management Plan and General Notice 704 Audit Report (JG Afrika, 2021). This section of the report presents the preliminary design considerations for those PCD's and provides information necessary to complete the DWS checklist (NATIONAL ENVIRONMENTAL MANAGEMENT WASTE ACT REGULATIONS 2013: BASAL BARRIER SYSTEM CHECKLIST FOR THE LEAD AUTHORITY (NATIONAL OR PROVINCIAL GOVERNMENT) IN ADVANCE OF DOCUMENT SUBMISSION TO COMMENTING AUTHORITY) which is required to be presented to the Regulator for approval.

The primary purpose of the PCD's is to store the contaminated stormwater runoff passing through the additives area and the coal stockyard area. A pumpstation footprint has been included at each PCD (the pump station design does not form a part of the scope of works for this project), for the ultimate inclusion of a return water pump which recycles the water from the PCD back to the factory for re-use. The PCD forms part of a complex stormwater management system and will accept all contaminated run-off during storm events. The PCD's are suitably sized to accommodate the entire volume of the 1 in 50 year storm event which aligns them with the GN704 requirements in that the facility and greater stormwater system will not spill contaminated water to the downstream environment more than once in a 50 year return period. The level at which the PCD's are operated, will naturally determine the storage capacity available for storm events and as such it is recommended that the PCD's be operated at as low a level as is feasibly possible to allow for the capturing of as much runoff from storm events as possible to prevent the overflow of stormwater into the downstream environment. The operation of the PCD's is to be guided by the principles of the Lichtenburg Lafarge Cement Plant Water Balance Study (JG Afrika, 2022c)

3.2 Location of PCD's

One of the PCD's is required to contain dirty water from the additives area of the factory, whilst the other is required to capture runoff from the coal stockyard. The locations identified for the PCD's have been indicated in **Figure 3-1** below.

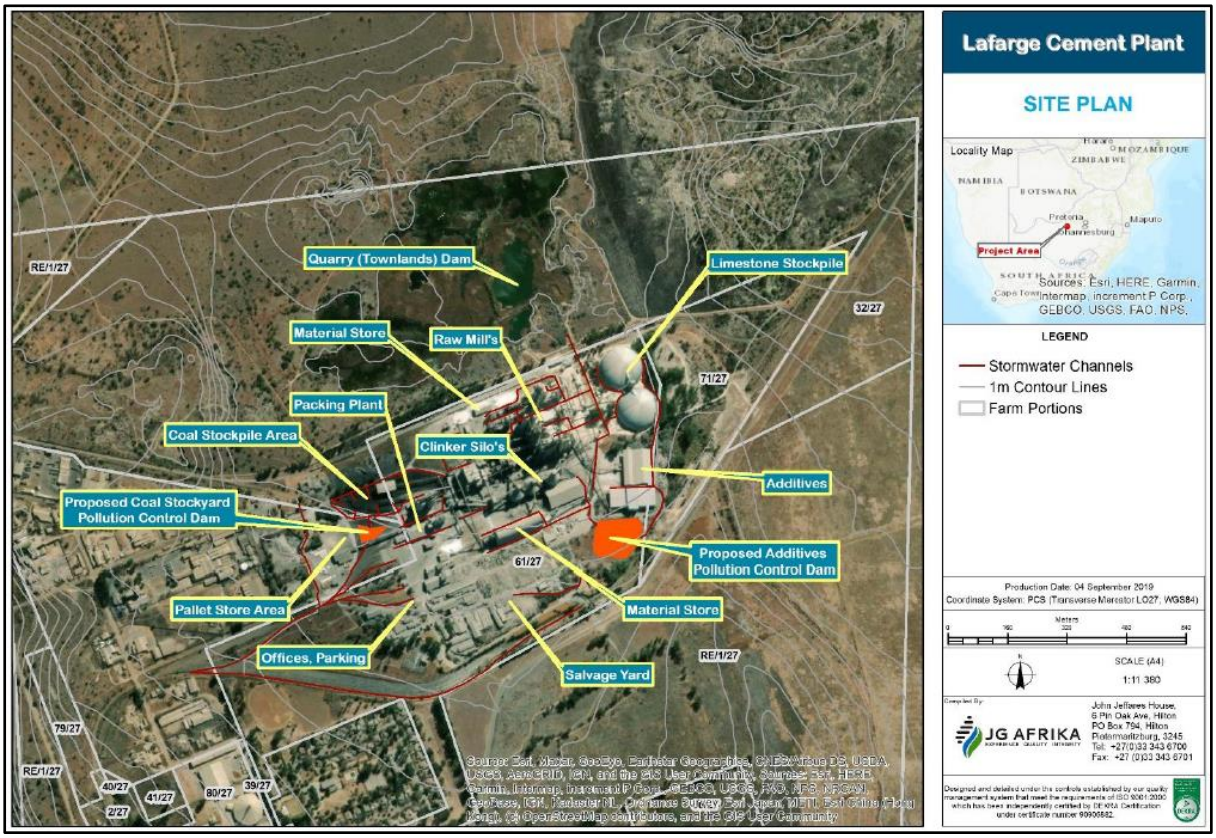

Figure 3-1: Locality Map of Lafarge Cement Factory PCD's

3.3 PCD Sizing Requirements

A water balance study has been undertaken by JG Afrika in order to determine the required sizing of the two PCD's. This information is contained within the Lichtenburg Lafarge Cement Plant Water Balance Study (JG Afrika, 2022c). In summary, the required sizes for the two PCD's are as follows:

- Additives PCD: 20 000 m³
- Coal Stockyard PCD: 4 000 m³

3.4 Waste Classification

A waste classification was, at the time of writing, in the process of being undertaken by Lafarge and the final findings of this had not yet been determined. In order to proceed with the preliminary design phase of the PCD's and based on the type of waste present and experience at previous projects with similar waste types, the assumption was made that the type of waste would be a Type 3 waste.

3.5 Design of Liner

3.5.1 Liner Requirements

Based on the assumed findings of the waste classification being undertaken on samples obtained from the Lafarge factory, the resulting waste terminating in both of the PCD's is anticipated to be classified as a Type 3 waste. Type 3 waste according to the National Environmental Management: Waste Act, Regulation 636 (NEM:WA, Reg 636) of 23 August 2013, National Norms and Standards for Disposal of Waste to Landfill, requires a Class C liner or a historical GLB+ liner system, as detailed in the Minimum Requirements 2nd Edition, (**Figure 3-2** and **Figure 3-3**) to be installed.

Type 3 Waste	Type 3 waste may only be disposed of at a **Class C** landfill designed in accordance with section 3(1) and (2) of these Norms and Standards, or, subject to section 3(4) of these Norms and Standards, may be disposed of at a landfill site designed in accordance with the requirements for a **GLB+ landfill** as specified in the Minimum Requirements for Waste Disposal by Landfill (2nd Ed., DWAF, 1998).

Figure 3-2: Type 3 Waste Liner Requirement According to NEM:WA, Reg. 636

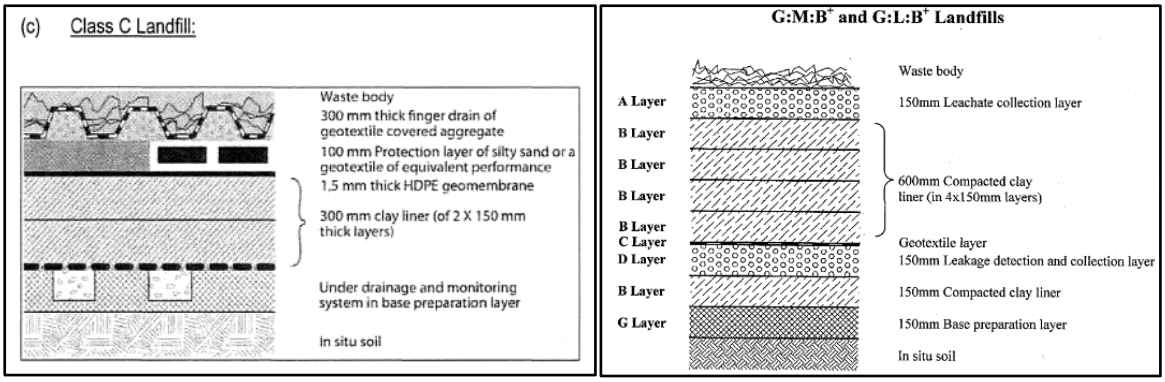

Figure 3-3: Class C and GLB+ Liner detail as per NEM:WA Reg.636 & MR2

3.5.2 Material Availability

The standard design guidelines for a Class C liner includes two 150 mm compacted clay layers, therefore one of the first steps in considering the design of the liner system was to review the availability of clay on the site. A high-level review of material availability was undertaken through the use of an auger, the available geotechnical information ("Lafarge Lichtenburg Kiln 4 and Associated Structures Geotechnical Investigation", SRK Consulting Engineers (Pty) Ltd, February 2006), and geological maps.

Coal Stock Yard PCD:

At the site of the CSY PCD the auger encountered coal, layers of pebbles and some waste material which made it difficult to obtain any meaningful information. The auger went to a depth of 470 mm before refusal. The findings did accurately mimic what could be seen in a soil profile through the existing channel (**Figure 3-4**). Another auger hole was dug in the channel, but met refusal at a fairly shallow level of 300 mm (**Figure 3-5**), likely due to another pebble layer. No clay was encountered in any of the auger holes on this site.

Figure 3-4: Soil Profile from Existing Channel (Left) and Material from First Auger Hole (Right)

Figure 3-5: Auger Hole in Existing Channel

Additives PCD:

At the site of the Additives PCD three auger holes were drilled. The first, in the south-eastern portion of the site encountered rock at surface level. This rock would need to be excavated for the basin construction.

Figure 3-6: First Auger Location of Additives PCD (Left) with Rock Layer Shown (Right)

The second was drilled in the middle of the incoming stormwater channel, as shown in **Figure 3-7**. This channel is approximately 0.9 m below the external NGL in the PCD area. A soil profile from inside the

channel is also shown in **Figure 3-7**. This hole was met with refusal almost immediately and it appeared as though it was on a rock layer.

Figure 3-7: Auger Hole in Stormwater Channel (Left) and Soil Profile of Channel Side Wall (Right)

The third auger hole was drilled on the north-eastern side of the PCD footprint and was able to reach a total depth of 1.9 m as shown in **Figure 3-8**, with the water table encountered at a depth of 0.75 m.

Figure 3-8: Third Auger Hole in the Additives PCD Area

The material extracted from the hole varied, as shown in **Figure 3-9**, but included a number of clayey layers and sandy clays. However, based on the locations of the three holes and assumed materials

between the holes it is anticipated that there will be insufficient clay available on the site to form the 300 mm of compacted clay required for the Class C liner. Therefore, to prevent additional costs and time delays which might be incurred through attempting to source clay material from off-site a commonly used alternative approach was considered, that being the use of a geosynthetic clay liner or GCL in place of the 300 mm of compacted clay.

Figure 3-9: Material Extracted from Third Auger Hole at Additives PCD Area

3.5.3 Geosynthetic Clay Liner Requirements

A GCL is a manufactured hydraulic barrier and typically consists of a layer of bentonite clay supported by geotextiles and geomembranes held together by needle punching, stitching or chemical adhesives (Rowe, 2005). The use of a GCL eliminates several risks associated with the availability and quality of natural clay, which is a key consideration with a Class C liner system. Furthermore, the construction period of the PCD's could be reduced due to the placement of a GCL, being faster than that of a standard compacted clay liner and likely to incur less delays due to any inclement weather. As such, in this case – primarily due to the limited quantity of clay available on the site – a GCL has been selected to form part of the Class C liner system and is to replace the two 150 mm compacted clay layers shown in a typical liner design.

The use of the GCL, however, requires that a minimum confining pressure of 5 kPa be placed onto the lining system to both ensure intimate contact between the HDPE and GCL and to apply sufficient normal force to the GCL to ensure optimal operation. Therefore, a 250 mm soilcrete filled geocell layer is to be placed on a non-woven protection geotextile above the HDPE liner. The soilcrete layer shall act as both a protection layer to the HDPE liner and provide the minimum confining pressure required over the GCL. Additionally, this soilcrete layer allows for access into the PCD basin for small plant such as a bobcat/skidsteer and means that during the low rainfall months the PCD could be cleared of silt and sediment build-up. It is required that the maximum stone/particle size in the soilcrete layer be less than 5 mm. Soilcrete has the added advantage of being placed in a flowable mix which allows for easy placement in the geocell, without requiring any mechanical compactive effort which could damage the liners beneath it.

The use of a GCL to replace the two 150 mm compacted clay layers included in a Class C liner is considered a deviation from the normal Class C liner, and as such equivalence must be proved to the Regulator for approval. JG Afrika have through previous projects experience and testing proven GCL equivalence (i.e., that a specified GCL can perform as well as or better than the two 150 mm compacted clay layers it is set to replace). It should however be noted that no project specific testing, such as swell indicator tests with water sampled from the existing factory have yet been undertaken due to timing constraints (the chemical composition of the wastewater being contained may have adverse effects on the ability of the bentonite in the GCL to swell and thereby increase the permeability of the barrier system. This can only be quantified by swell indicator tests). These tests are scheduled to be undertaken as part of the detailed design phase of the project. The lack of this

project specific testing does increase the potential of the Regulator requesting that additional testing be undertaken in order to prove the equivalence of the alternative liner recommended.

3.5.4 HDPE Liner

As part of the Class C liner requirements, an HDPE geomembrane layer with a thickness of 1.5 mm is required.

It is well known that heat can influence the service life of a HDPE liner especially in landfill basal systems where exothermic reactions can produce significant heat to the detriment of the HDPE liner. The same can occur to exposed liner systems found in a hot climate such as Lichtenburg. The inclusion of a relatively thick 250 mm soilcrete layer (described above) will not only act as a protection layer and provide confining stress to the GCL but will also limit thermal and UV exposure to the HDPE liner. A rise in liner temperature will cause antioxidant depletion in a geomembrane, potential dehydration of the GCL beneath a geomembrane, and increase diffusion and/or moisture movement through liners (Yoshida & Rowe, 2003). Increased liner temperatures have been shown to have significant impact on the useful service life of geosynthetic barrier lining systems (Rowe, 2005). The lifespan of a geomembrane liner is defined by three stages (Koerner et al. 2005):

- Stage A: Antioxidant Depletion Time
- Stage B: Induction Time to the Onset of Degradation
- Stage C: Time to Reach 50% Degradation (Half-life, considered to be end of service life)

Based on literature by Koerner et. al 2005 assuming an average liner temperature of 35˚C is achieved and maintained through the majority of the PCD's service life, the adjusted service life of the HDPE liner would be in the order of 106 years (as shown in **Table 3-1**). This however is a conservative approach given that the general overnight drop in temperature will see the temperature on the liner reduce significantly. Therefore, thermal influence and UV degradation (given that the liner will not be exposed to UV apart from during construction) on the overall liner service life is not expected to be of concern for the HDPE liner used in the proposed application.

Table 3-1: Service Life Estimations of HDPE Membranes Exposed to Elevated Temperatures (Koerner et. al, 2005)

In Service Temperature (°C)	Stage "A" (years)			Stage "B" (years)	Stage "C" (years)	Total Prediction* (years)
	Standard OIT	High Press. OIT	Average OIT			
20	200	215	207	30	208	445
25	135	144	140	25	100	265
30	95	98	97	20	49	166
35	65	67	66	15	25	106
40	45	47	46	10	13	69

* Total = Stage A (average) + Stage B + Stage C

3.5.5 Nonwoven Protection Geotextile

Needle-punched nonwoven geotextiles are made by taking a large number of small fibre fibres and using a barbed needle to interlock the fibres together (Layfield Group, 2019). The nonwoven fabric can be used in almost any stabilization, separation or cushioning application, and they are most commonly used in areas that also require filtration. The geotextile provides an effective and low cost protection to the HDPE membrane from damage by sharp objects. The ease and speed to which a nonwoven geotextile can be installed compared to a protective sand layer is also an advantage.

The recommended non-woven geotextile protection layer to be utilised for the PCD's is a 600 g/m².

3.5.6 Geocell Protection Layer

Due to a high silt and sediment content anticipated in the stormwater entering the two PCD's and the lack of sufficient space to include an adequate silt trap, allowance has been made for access into the PCD basins. This is achieved through the inclusion of a 250 mm soilcrete filled geocell layer. Various options for this layer were considered including reinforced concrete panels, concrete filled geocells, stabilised earthfill and soilcrete filled geocells.

Due to the inclusion of a GCL in the liner a minimum confining pressure of 5 kPa is required to be maintained over the GCL. This means that should concrete have been used a minimum layer thickness of approximately 200 mm would be required, with stabilised earthfill a thickness of 300 mm and with the soilcrete a thickness of 250 mm. Cost comparisons undertaken in previous projects have resulted in the following findings, that considering the additional excavation depth required to achieve the additional thickness and offsetting that against the cost of the various geocell layers and materials, the soilcrete layer was found to cost a similar amount to the stabilised earthfill, but to offer a far better

and more durable solution – with less risk posed to the HDPE liner beneath it due to the compaction effort required on the stabilised earth. The soilcrete was found to be notably cheaper than the concrete options, whilst still providing an acceptable level of durability.

3.5.7 Final Liner Design

Based on the sections detailing the various elements of the liner, the final design includes the following layers from top to bottom (shown in **Figure 3-10**):

- 250 mm soilcrete filled geocell layer,
- 600 g/m² non-woven geotextile protection layer.
- 1.5 mm HDPE liner (smooth-smooth on basin and smooth-textured on slopes),
- Geosynthetic clay layer (GCL),
- 100 mm layer of selected cohesive material below GCL,
- 150 mm in-situ base preparation layer compacted to 95% std. proctor at ±2% OMC.

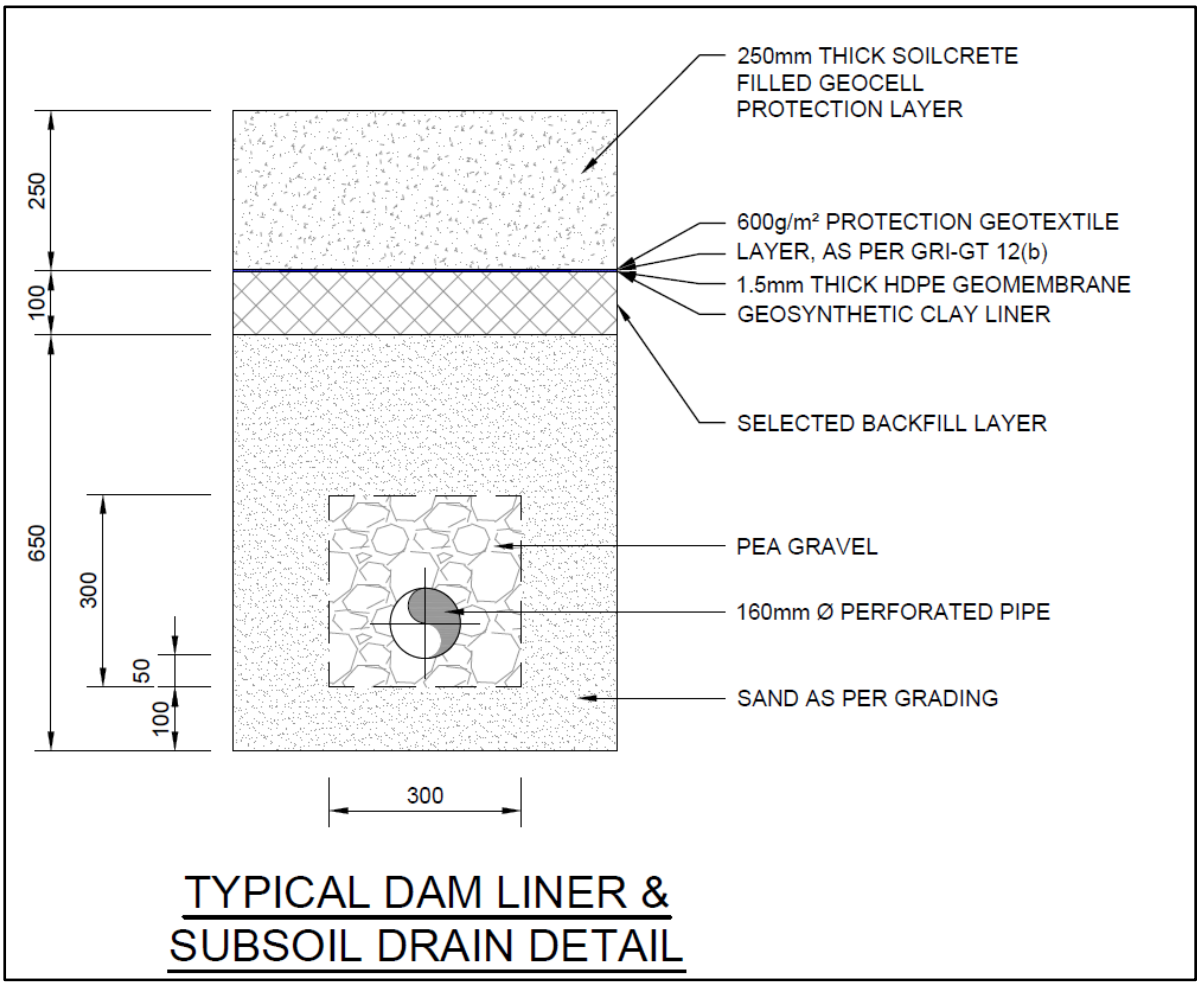

Figure 3-10: PCD Liner Components

For the access ramp based on the sections detailing the various elements of the liner and the additional requirements of additional loading from traffic, the final design liner for the access ramp includes the following layers from top to bottom:

- 250 mm 10 MPa concrete filled geocell layer,
- 30 kN x 30 kN PP geogrid,
- 600 g/m² non-woven geotextile protection layer.
- 1.5 mm HDPE liner (smooth-smooth on basin and smooth-textured on slopes),
- Geosynthetic clay layer (GCL),
- 50 mm layer of selected cohesive material below GCL,
- 150 mm in-situ base preparation layer compacted to 95% std. proctor at ±2% OMC.
- Access ramp constructed from fill material in layers not exceeding 150 mm and compacted to 95% std. proctor, where required.

3.6 Slope Stability Modelling

3.6.1 Introduction

Slope stability analyses were undertaken on the Coal Stockyard (CSY) PCD and Additives (Add) PCD as part of the preliminary design. Information for the material properties were primarily based on the findings of the Lafarge Lichtenburg Kiln 4 and Associated Structures Geotechnical Investigation Report (SRK, 2006). Other references were made to the Lafarge Lichtenburg Cement Plant and Tswana Quarry Geohydrological Report (Tucana Solutions, 2017) and geological maps.

A map of the surface geology from the Geohydrological Report has been included as Figure 3-11 below. As noted in the geotechnical report, based on the published 1:250 000 scale geological map (Sheet 2626) the site is underlain by the Dwyka Group of the Karoo supergroup, with calcrete occurring in the upper 6 m to 8 m of the soil profile across most of the site. The Dwyka shale beneath the calcrete is usually partly calcretised in its upper few metres, becoming less weathered with depth and often has a varied horizon near the base.

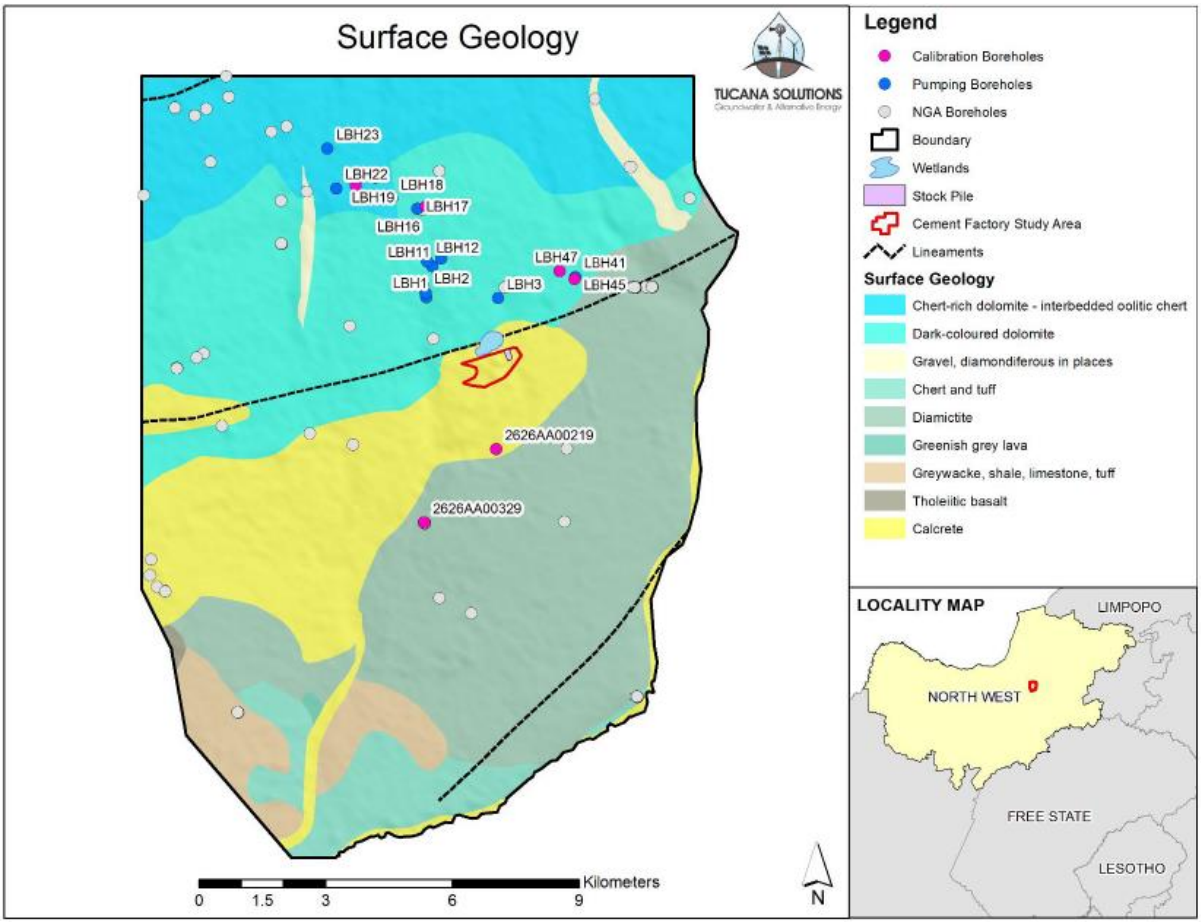

Figure 3-11: Surface Geology Map (Tucana Solutions, 2017)

Importantly for the design of the PCD's, the groundwater table is noted within the Geotech report as being between 2.5 m and 4 m below the natural ground level (NGL).

3.6.2 Material Properties and Baseline Models

Geological information from boreholes LBH1, LBH2, LBH3 and LBH4 (SRK, 2006) were used to construct the baseline models, which were then modelled at the design configuration (with slopes of 1V:3H). The parameters used during slope stability analyses have been summarized in **Table 3-2**.

Table 3-2: Geotechnical Material Properties

Zone	Bulk Unit Weight	Shear Strength		Permeability *(k)*
PCD Founding Material - Hard pan calcrete (in-situ)	*19.2 kN/m^3	*UCS = 10 MPa		*1 x 10^{-5} m/s
Embankment Fill Material - Fine to coarse angular to sub-angular gravel (calcrete, quartzite, chert)	*19.7 kN/m^3	*c' = 0 kPa	*ϕ' = 32°	*1 x 10^{-4} m/s

Zone	Bulk Unit Weight	Shear Strength	Permeability *(k)*
* Empirical values based on engineering soil descriptions in borehole LBH1, LBH2, LBH3 and LBH4.			

It is assumed that both the Coal Stockyard PCD and Additives PCD are underlain by calcrete which extends to a depth in the order of 8.0 m below ground level. It is assumed that the *in-situ* calcrete within the PCD basin will be used as embankment material. The material properties of the calcrete (minor quartzite and chert) have been determined using the engineering geological descriptions provided in borehole logs combined with the literature of Looke (2007). The geological conditions at the Coal Stockyard PCD and Additives PCD will need to be more accurately investigated during the detailed design stage to confirm founding conditions and material suitability for construction purposes.

3.6.3 Coal Stockyard PCD Slope Stability Analyses

Figure 3-12 shows the layout of the model used for analysis, material parameters and modelled slope configuration.

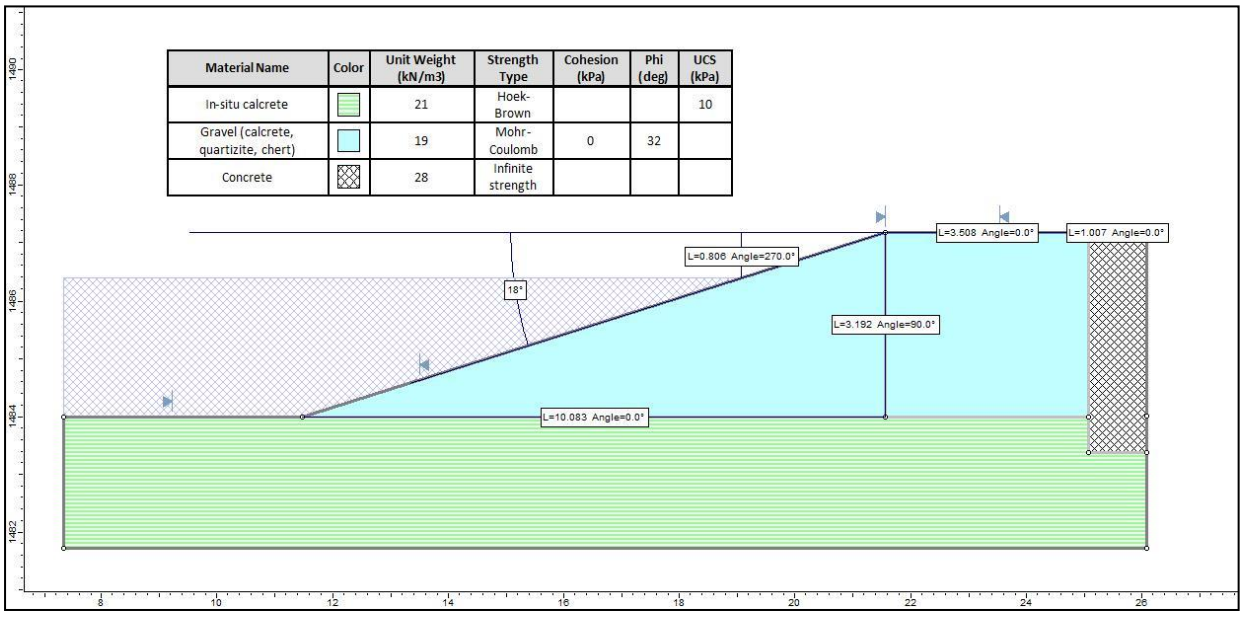

Figure 3-12: Coal Stockyard PCD, Slope Configuration

Results Summary:

The findings of the slope stability analyses are summarised in **Table 3-3** with the minimum FOS requirements noted per scenario. The critical failure surface which returned the lowest FOS value is

highlighted in green in the various diagrams. Analyses conducted on the Coal Stockyard PCD indicates stable slope conditions over the three scenarios considered.

Table 3-3: Summary of the FOS results for the Coal Stockyard PCD

Design Condition	Minimum Required FOS	Achieved FOS (1V:3H)
End of Construction	1.30	**1.69**
Steady-state Seepage	1.50	**3.08**
Rapid Drawdown	1.30	**1.97**

The model output for these critical slopes have been included in **Figure 3-13**, **Figure 3-14** and **Figure 3-15**.

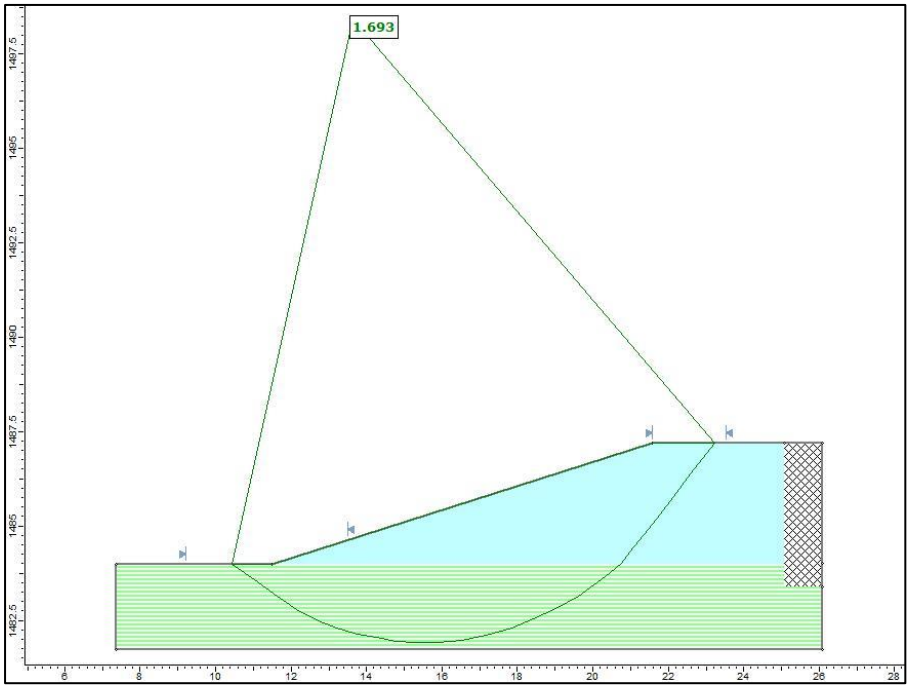

Figure 3-13: Coal Stockyard PCD, End of Construction

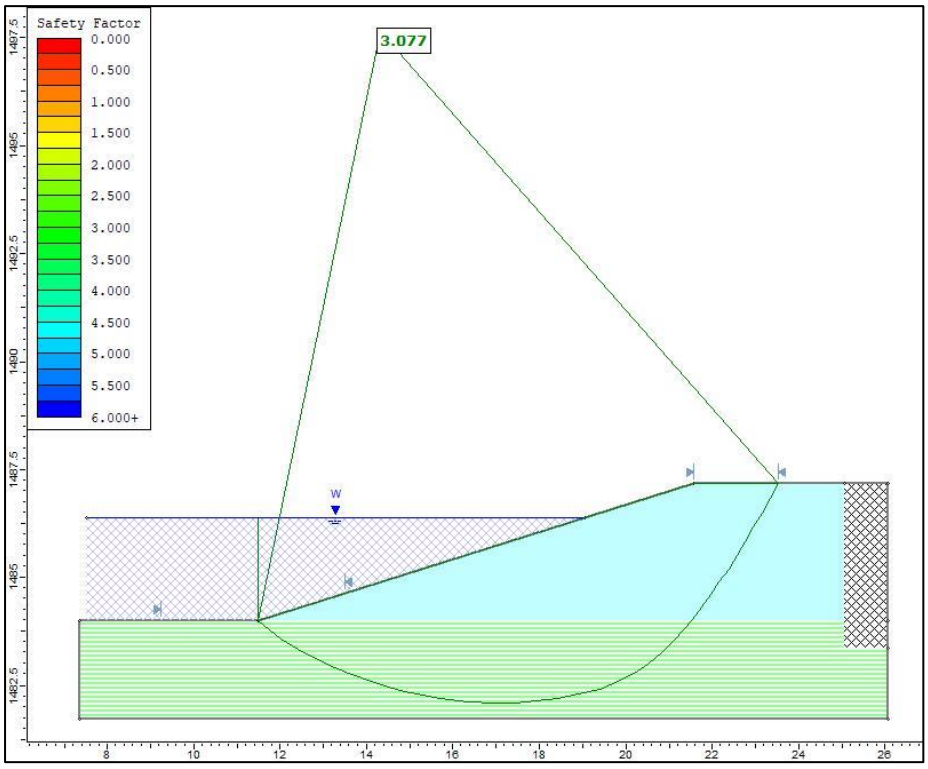

Figure 3-14: Coal Stockyard PCD, Steady-state Conditions

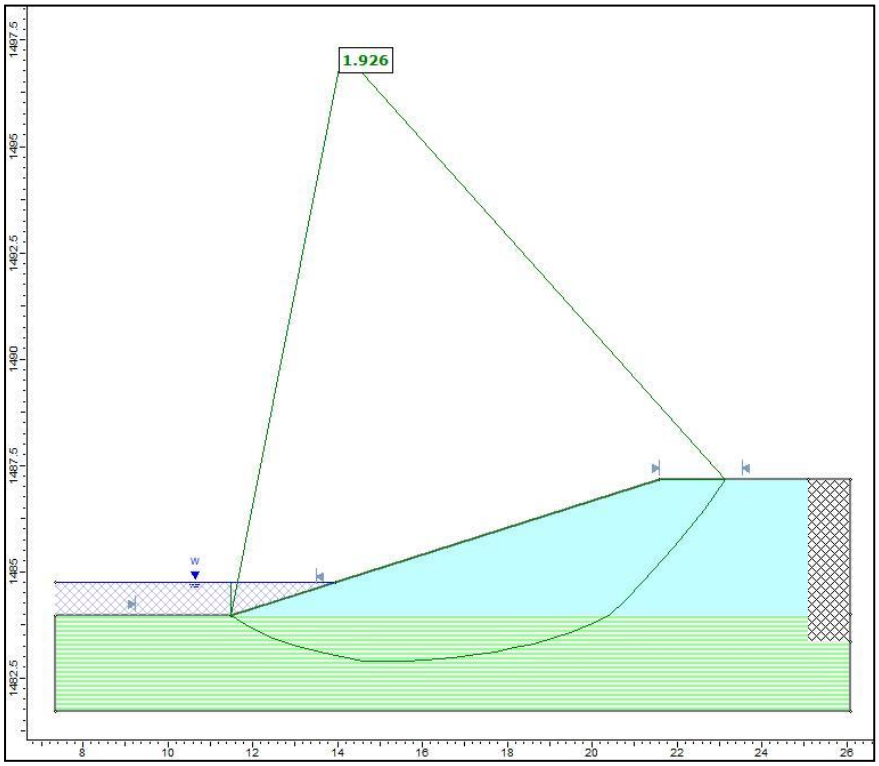

Figure 3-15: Coal Stockyard PCD, Rapid Drawdown Conditions

3.6.4 Additives PCD Slope Stability Analyses

Figure 3-16 shows the layout of the model used for analysis, material parameters and modelled slope configuration for the Additives PCD. It is understood that this structure will be constructed entirely below the existing ground level.

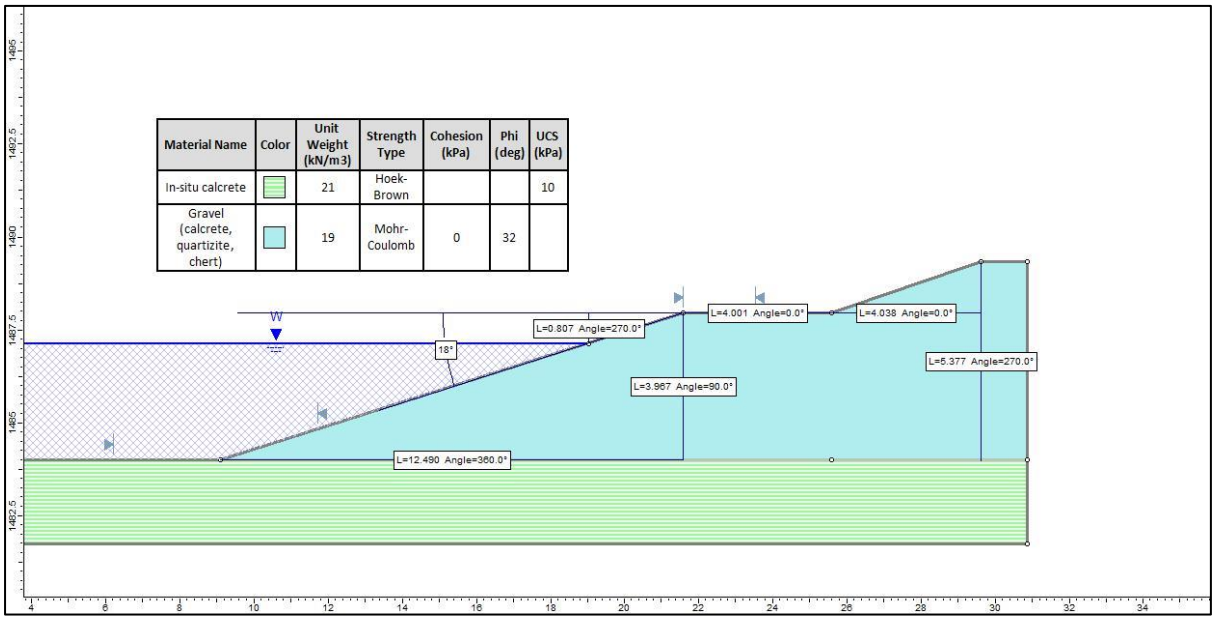

Figure 3-16: Additives PCD, Slope Configuration

Results Summary:

The findings of the slope stability analyses are summarised in **Table 3-3** with the minimum FOS requirements noted per scenario. The critical failure surface which returned the lowest FOS value is highlighted in green in the various diagrams. Analyses conducted on the additives PCD indicate stable slope conditions over the three scenarios considered.

Table 3-4: Summary of the FOS Results for the Additives PCD

Design Condition	Minimum Required FOS	Achieved FOS (1V:3H)
End of Construction	1.30	**1.67**
Steady-state Seepage	1.50	**3.30**
Rapid Drawdown	1.30	**1.88**

The model output for these critical slopes which were analysed have been included in **Figure 3-17**, **Figure 3-18** and **Figure 3-19**.

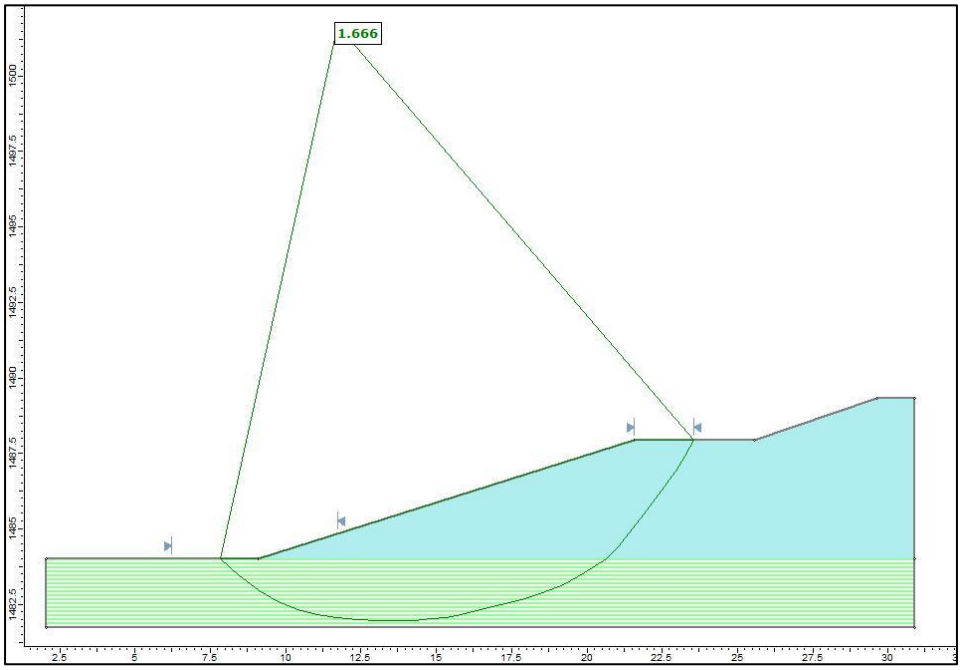

Figure 3-17: Additives PCD, End of Construction

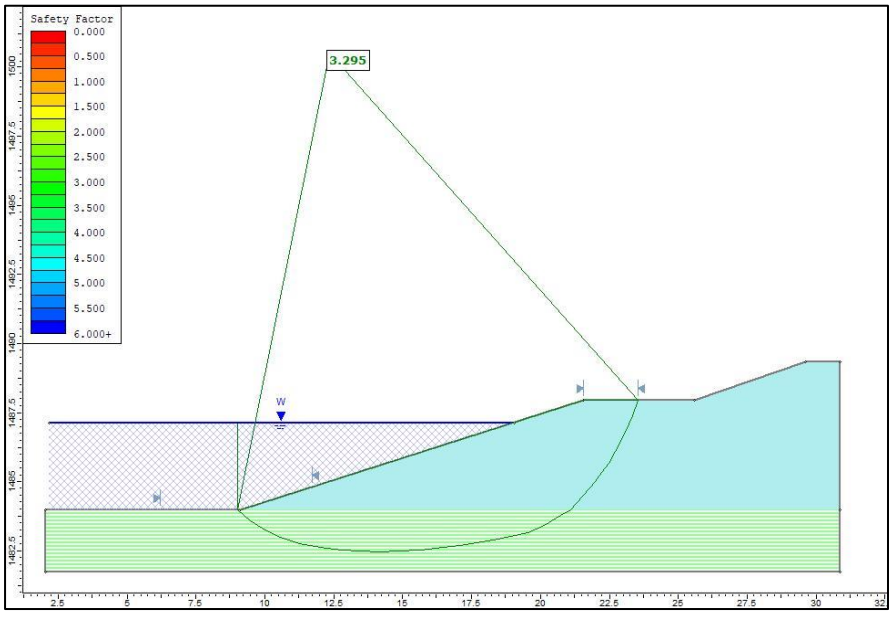

Figure 3-18: Additives PCD, Steady-state Seepage

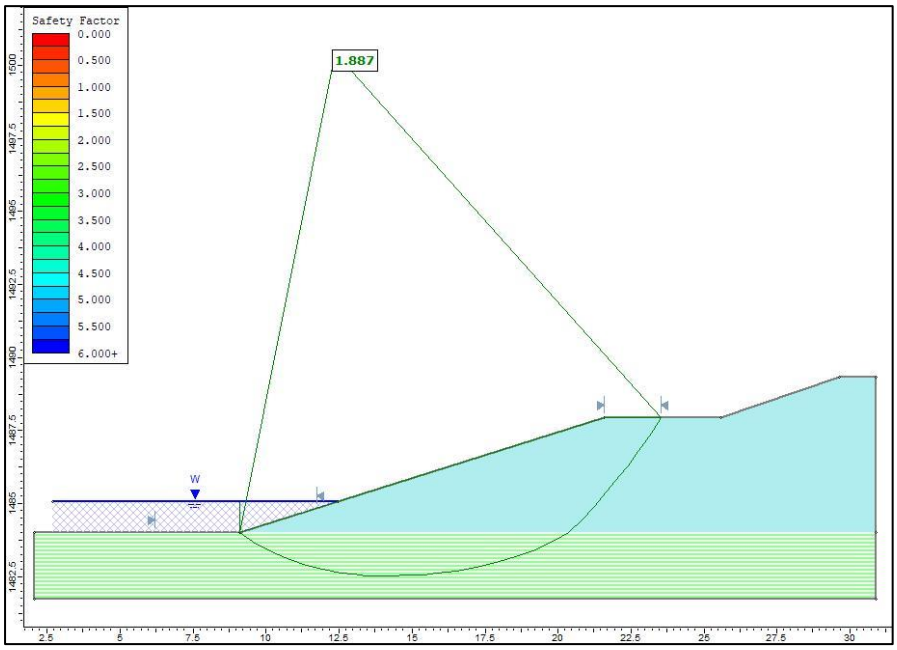

Figure 3-19: Additives PCD, Rapid Drawdown

4 PRELIMINARY DESIGN OF ADDITIVES PCD

4.1 Dam Safety Classification

Based on the required sizes of the PCD it will not store more than 50 000 m³ of water. Given the generally flat topography of the natural ground and the fact that the PCD is required to received water from stormwater channels which are all below the NGL with relatively flat gradients, the PCD is exclusively in excavation and as a result has no freestanding walls or embankments.

Due to the PCD not having any free-standing walls equal to or greater than 5 m in height and not storing more than 50 000 m³ of water, the PCD is not considered to be a dam with a safety risk and therefore does not require registration with the Dam Safety Office (DSO) as it does not meet the minimum threshold criteria.

4.2 Design of PCD's Footprint and Basin

The initial stages of the PCD design required that an engineered geometric landform be developed for the two facilities. This includes engineered lines and radii and slopes to be adopted to allow for the engineering drawings of the PCD to be compiled for submission to the DWS and ultimately for the PCD to be constructed.

Using provided survey data a digital terrain model (DTM) was developed for the site utilising AutoCAD Civil 3D Software. This was used as the basis for developing the PCD's footprint and determining the basin sizing as described below.

The Additives PCD is required to capture the stormflow from the stormwater drains around the additives area of the factory. As noted in **Section 3.3**, the required storage capacity of the PCD is 20 000 m³ and the location of the PCD has been identified based on available space and the drainage lines which lead to the PCD. There is limited available space for the PCD due to the footprint of the plant within the factory and existing fences etc. A buffer of 3 m around existing infrastructure has been allowed for in determining the footprint of the dam. Additionally, a minimum of a 15 m radius for all corners of the PCD has been allowed to prevent strain being placed on the liner and to allow for easier construction. Using the above as a guide the proposed footprint of the PCD is presented in **Figure 4-1** indicating the surrounding infrastructure and confinements.

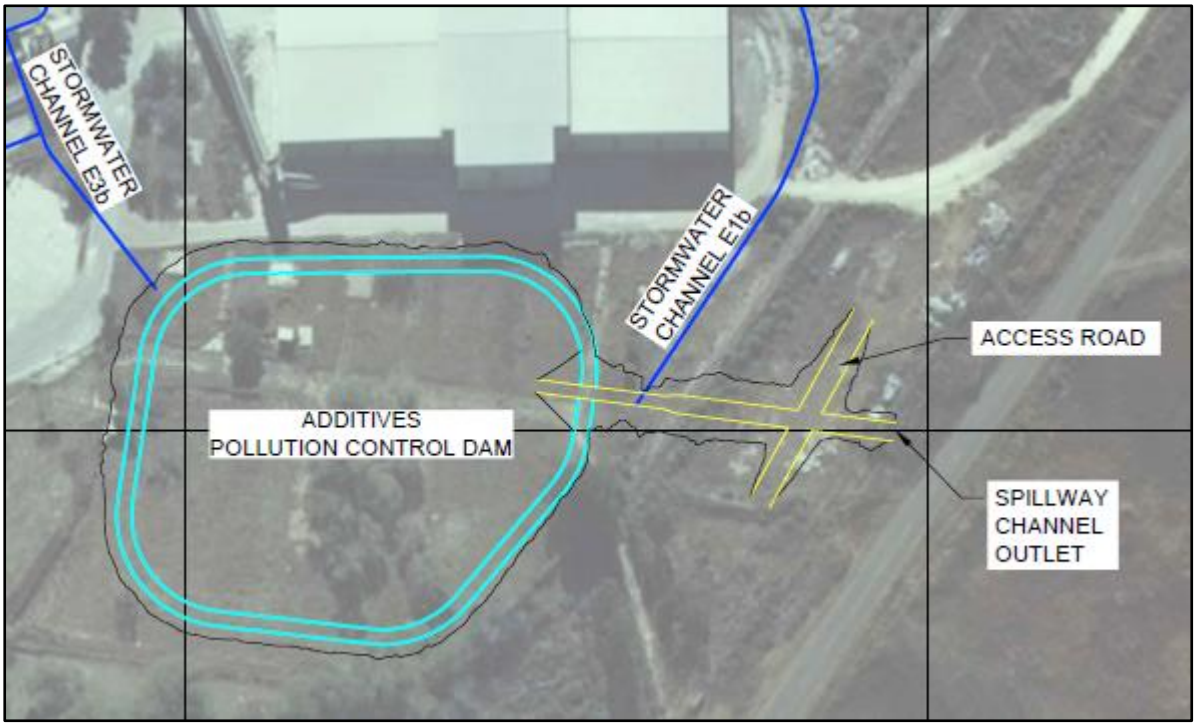

Figure 4-1: Additives PCD Footprint

Based on the footprint presented above and the required storage capacity from the water balance exercise, the basin of the PCD could be designed. Two additional considerations for the design of the basin also play an important role in the final design levels, these are the invert level of the stormwater channels discharging into the PCD and the access ramp. It is proposed that the access ramp and the stormwater inlet be combined which allows for a concrete liner to be utilised for both of these elements with a reduced overall cost.

The PCD is required to have a spillway with adequate freeboard, which is discussed **Section 4.6**, and the crest level of the spillway determines the full supply level (FSL) of the PCD. The spillway has been designed to be only slightly below the level of the stormwater channel invert which discharges into the dam. The spillway should only be active once every 50 years.

The side slopes of the PCD have been made as steep as practicably possible, with a side slope angle of 18.4˚ or 1 vertical in 3 horizontal (1V:3H), being adopted. The steeper side slopes help to limit the depth of the PCD as far as possible, however consideration of constructability, liner limitations and slope stabilities needed to be taken into consideration. The internal toe of the facility was then determined by iteratively cutting from the NOC level down to a basin level that achieved the desired storage capacity, after allowing for the inclusion of the access ramp and noting the required FSL. As

shown in **Table 4-1** to achieve the targeted storage the PCD will have an approximate depth of 3.25 m from the FSL and 5.35 m from the surrounding NGL. It should however be noted that the basin floor of the PCD slopes at 1% to allow for a low point near the return water pumpstation. A rendering with contours of the basin is shown in **Figure 4-2** below.

Table 4-1: Additives PCD Basin Sizing Details

Approx. NGL (mamsl)	Dam Crest Level (mamsl)	Full Supply Level (mamsl)	Basin Level (mamsl)	Depth From NGL to Basin (m)	Depth From FSL to Basin (m)	PCD Capacity (m^3)
1489	1487.7	1486.9	1483.65	5.35	3.25	20 736

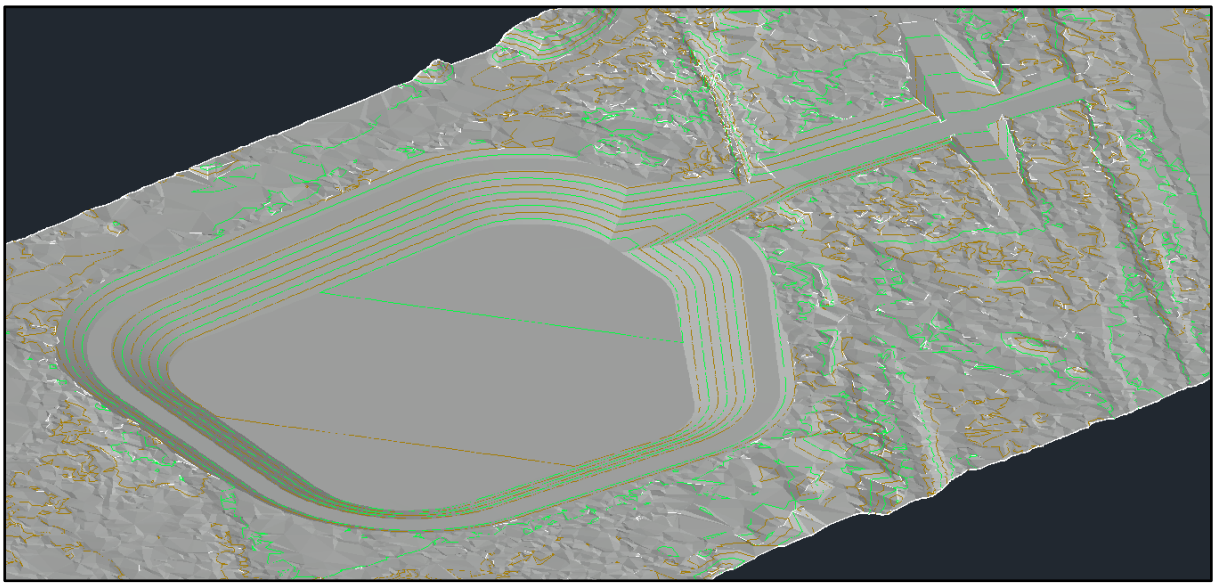

Figure 4-2: Additives PCD Basin Design

4.3 Access Ramps

The over-arching assumption regarding access and maintenance to the basin of the PCD's is that this will be undertaken with the use of a Bobcat (Skidsteer) or similar type of machinery and loading. The same principles have been applied to both of the PCD's access ramps, these are as follows:

- Maximum slope of 1V:12H, or 8.33%,
- Minimum width of access channels of 3.5 m,
- Concrete (10 MPa/13 mm) geocell protection layer of 250 mm thickness over liner, and
- Inclusion of a 30 kN x 30 kN PP Geogrid to provide additional protection.

For the Additives PCD the access ramp has been positioned on the eastern side of the PCD for several reasons as follows:

- Due to the size of the access ramp and constraints within the site, positioning it on the eastern side is the only area where the majority of the ramp can fall outside of the PCD's basin's footprint, which in turns allows for a shallower PCD.
- The eastern side of the PCD is the only side where the external; ground levels are sufficiently low to allow for a discharge point for the dam's spillway channel. Since a channel is required in any case, the access ramp has been designed in such a way as to allow it to function both as the spillway channel and the access ramp.
- The PCD has two stormwater inlets, one from the north west for the channel from the new coal stockpile and one from the east which brings stormwater from the lime stockpiles and the additives area. Since water will be flowing from these channels into the PCD the design has allowed for the geocells in these two areas to be filled with concrete and not soilcrete like the rest of the basin. With the access ramp being positioned in the east, this allows for the channel to discharge onto the slope of the access ramp. This is beneficial since the access ramp will be constructed out of geocells filled with concrete and prevents the need for additional concrete specifically for that channel.

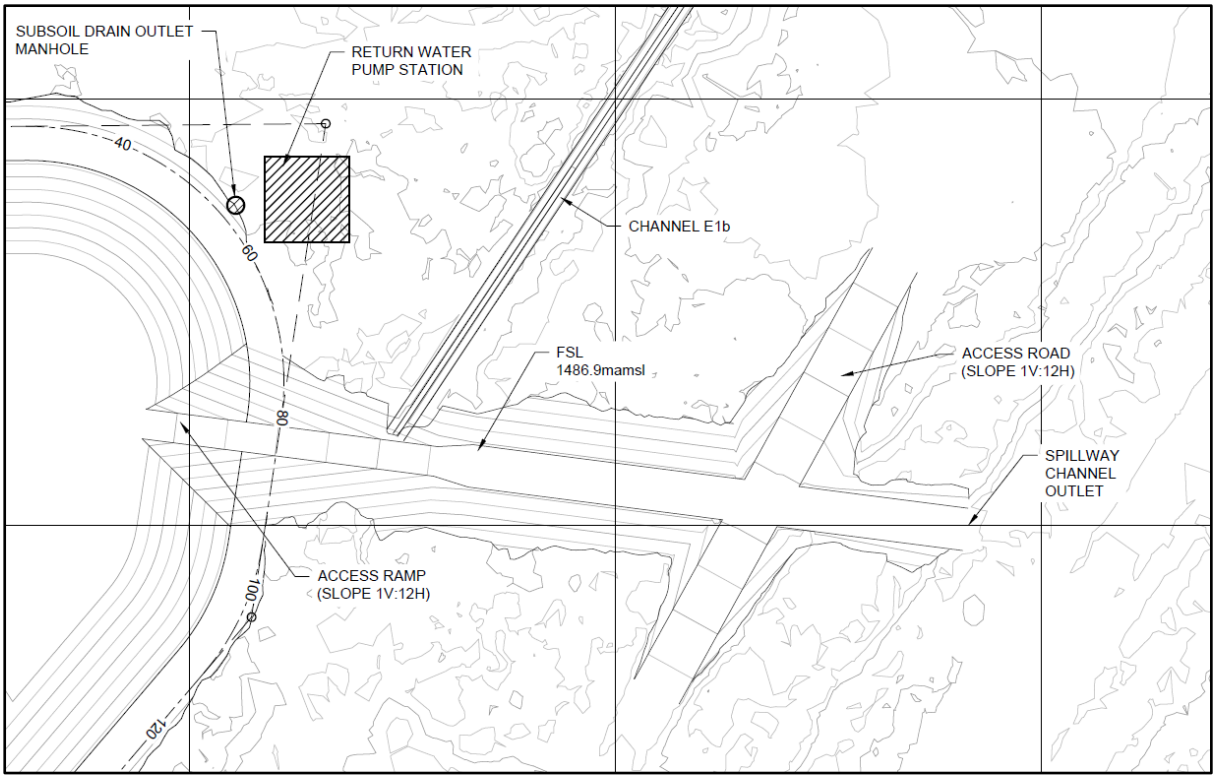

Figure 4-3: Additives PCD Access Ramp Layout

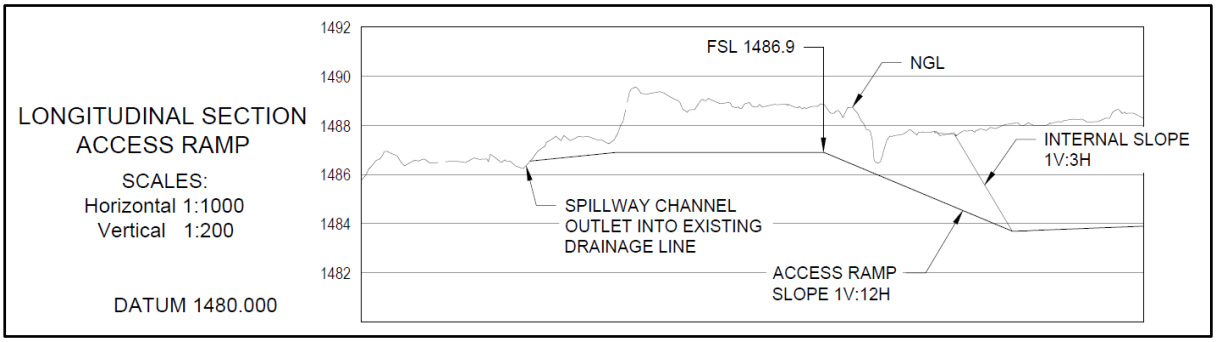

Figure 4-4: Additives PCD Section Through Access Ramp

4.4 Subsoil Drainage System/Leakage Detection System

The subsoil drainage system is required to ensure that any leakage which may occur through the liner does not then pollute the surrounding groundwater aquifer. It is also able to operate as a leakage detection system through monitoring of the amount of water collected by the drainage system. It is important that filters and drainage systems are able to conduct the seepage water into a sump (manhole) and should be designed conservatively to prevent the build-up of excessive pressure beneath the liner.

In this case, the geotechnical information available indicates that the natural ground water table is present at an elevation of between 2.5 m and 4 m below the natural ground level. This means that for both PCD's the bottom of the PCD will be lower than the water table. This raises a concern as the buoyancy force acting on the PCD's over their entire footprints will be significant and could result in ballooning or lifting of the liner. The subsoil drainage system, therefore also acts as a protection against phreatic head building up below the liner system.

In order to accommodate this phenomenon, larger laterals in the sub-surface drainage system have been allowed for and the return water pump (which returns water from the subsoil drain manhole back into the PCD) has been slightly enlarged.

4.4.1 Subsoil System Components

The subsoil drainage system is inclusive of perforated HDPE collector pipes used to drain the surrounding soil in a herringbone layout. These pipes are surrounded first by a layer of pea gravel (which is typically a 6-8 mm stone), which in turn is surrounded by a layer of filter sand. The final grading envelope of the filter sand will be determined during the detailed design phase of the project,

once accurate grading curves of the surrounding insitu soil have been obtained from samples taken at the dam site, as the particle sizing for each layer is dependent on the preceding layers particle size distribution.

The perforated HDPE pipes connect and join a solid HDPE pipe which exits the dam and daylights inside the subsoil drain manhole. The outlet of the pipe allows for monitoring of the subsoil drainage. This manhole is designed to be a 2 m diameter precast concrete manhole and allows for a sump below the outlet of the subsoil pipe for water to be returned into the PCD (since the water is considered to be dirty water and cannot be discharged into the environment) creating a closed loop. The manhole is designed to be equipped with a submersible pump with an automatic switch so that it turns on and off whenever the levels inside the sump reach their upper and lower limits.

4.4.2 Subsoil Drain Layout and Sizing

A herringbone type of layout has been used for the subsurface drainage as this type of drain can reduce a generally high water table to an acceptable level. It is used in the following cases (SANRAL, 2013):

- In areas where there is a high groundwater table which is undesirable; or
- To stabilise areas where a high water table interferes with construction.

In this case, the drainage system will assist with both of these aspects.

It is generally not practical to undertake sophisticated calculations for determining groundwater intercepted from cuts as there can be large variations in the variety of materials found in the excavation, and seasonal changes also have a big impact (SANRAL, 2013). That being said, it is likely that at the detailed designs stage some in field testing such as a double ring infiltrometer test, will be undertaken to get representative values of the hydraulic conductivity of the materials surrounding the PCD. It is recommended that a percolation test be undertaken at the dam site in order to obtain a more accurate hydraulic conductivity (K) value. For the purposes of the preliminary design, this value was determined from literature and used to estimate the required capacity and sizing of the subsoil drainage system.

The drain capacity is determined from **Equation 1** (SANRAL, 2013) and the input and results are provided in **Table 4-2**. This equation provides that for the longest lateral, a minimal pipe diameter of approximately 125 mm would suffice. However, due to typical pipe sizing and the minimum diameter

required being the internal diameter, a pipe diameter of DN 160 mm is opted for (internal diameter 137 mm). This diameter also provides a practical diameter for a pipe that can be unblocked mechanically and allows some additional capacity for the drains to better cope with a potentially high groundwater table.

$A = 26.92E6 \times d^{2.666} \times S_o^{0.5} \times 0.7/nq$ **Equation 1**

Where:

S is the spacing of the laterals;

A is the surface area to be drained in m² (A = S (L+0.5S));

d is the diameter of the pipe in m;

L is the length of the pipe in m;

q is the drainage rate in mm/day and is based on typical hydraulic conductivity rates for calcrete (1 x 10^{-5} m/s has been used in this case);

n is Manning's n in $s/m^{0.33}$; and

S_o is the slope of the pipe in m/m.

Table 4-2: Determination of Laterals Pipe Diameter

Spacing	Longest Lateral	A	n	q	S_o	Diameter Required	
m	m	m²		mm/day	m/m	m	mm
15	30	568	0.015	864	0.01	0.125	125

4.5 Spillway

The spillway has been incorporated into the access ramp and also allows for the main stormwater channel inlet to discharge down the access ramp into the PCD. The FSL of the dam is set at 1486.9 mamsl and the width at the top of the access ramp (which is the start of the spillway crest) is 5 m. The spillway is a (very long) broad crested weir, with a long flat section at the crest level leading away from the PCD until after the access road crossing. At this point the channel slopes down and passed the fence line, where the channel discharges into the channels alongside the road on the outside of the fence. The spillway is trapezoidal in shape, with a base width of 5m and side slopes of 1V:3H.

It is important to note that this dam should not spill more than once in fifty years.

The access ramp and flat portion of the spillway channel are both lined with a 250 mm concrete filled geocell layer. One the eastern side of the road, where the channel begins to slope away, the channel is lined with reno-mattresses to provide some energy dissipation and to ensure no erosion takes place.

The 1:50 year flood peak was used as the Recommended Design Flood (RDF) for the PCD. The flows entering the dam are from two channels, channel E3b which has a 1:50 year peak flow of 0.89 m^3/s and Channel E1b which has a peak discharge of 1.4 $m^3/$ at the 1:50 year recurrence interval. Combining these flows, the required design capacity of the spillway is 2.29 m^3/s. The 1:20, 1:50 and 1:100 year flood peaks for the two inlet channels and the combined flood for the PCD are shown in **Table 4-3** below. As shown in **Figure 4-5** the spillway is able to discharge this flood at a water depth of 0.411 m.

Table 4-3: Flood Peaks for Varying Recurrence Intervals for the Additives PCD

Recurrence Interval:	**1:20**	**1:50**	**1:100**
Channel E1b Peak Flows (m^3/s)	0.72	0.89	1.06
Channel E3b Peak Flows (m^3/s)	1.20	1.40	1.58
Additives PCD Peak Flows (m^3/s)	**1.92**	**2.29**	**2.64**

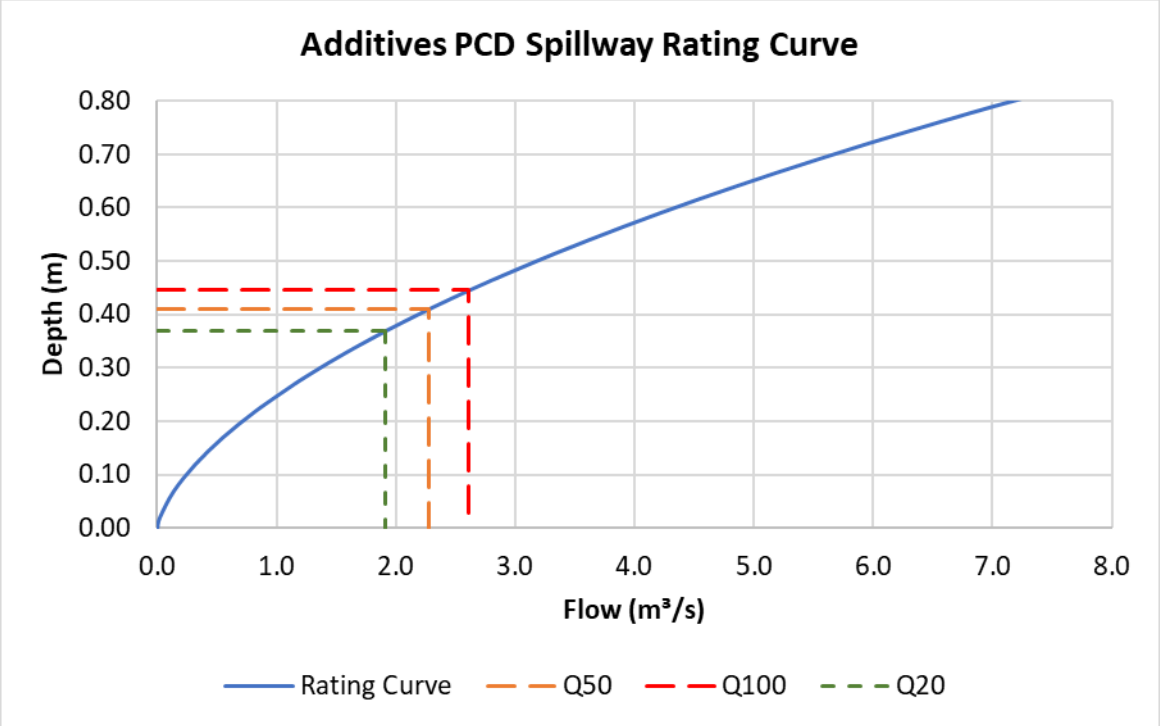

Figure 4-5: Additives PCD Spillway Rating Curve

4.6 Freeboard

Freeboard is the vertical distance above the FSL to the Non-overspill Crest (NOC) Level of the dam. Having an acceptable freeboard height is one approach to prevent the dam from overtopping during extreme events. The available freeboard protects the dam against waves washing across the crest due to wind set-up and wave run-up. It also allows for the safe spillage of water through a spillway designed to allow floods of a specific return period to pass without the dam failing.

4.6.1 Freeboard Design Criteria

The SANCOLD Interim Guidelines on Freeboard for Dams (SANCOLD, 1990) provide guidance on applicable freeboard criteria in terms of combinations of factors to be considered. These factors give minimum values which should be accounted for and include guidance on the Recommended Design Flood (RDF) in terms of recurrence intervals and the Safety Evaluation Flood (SEF) in terms of a factor of the regional maximum flood (RMF) and the Probable Maximum Flood. Given that the Additives PCD is not considered to be a dam with a safety risk, the most basic assessment has been considered for the freeboard requirements (encircled in green) on **Table 4-4**.

Table 4-4: Proposed Freeboard Design Criteria and Flood Recurrence Intervals (SANCOLD, 1990)

Dam size	Freeboard criteria and floods	Hazard rating (Category of dam in brackets)		
		Low	Significant	High
Small (H = 5-12 m)		(I)	(II)	(II)
	FB Criteria RDF SEF	1 20-50 year 0,4*RMF 0,2*PMF	1 100 year 0,7*RMF 0,5*PMF	2 100 year 1,0*RMF 0,7*PMF
Medium (H = 12-30 m)		(II)	(II)	(III)
	FB Criteria RDF SEF	2;6 100 year 0,7*RMF 0,5*PMF	2;3;6 100 year 1,0*RMF 0,7*PMF	2;3;4;5;6 200 year 1,5*RMF 1,0*PMF
Large (H > 30 m)		(III)	(III)	(III)
	FB Criteria RDF SEF	2;3;6 200 year 1,0*RMF 0,7*PMF	2;3;4;5;6 200 year 1,5*RMF 1,0*PMF	2;3;4;5;6 200 year 1,7*RMF 1,1*PMF

The proposed design combinations of freeboard conditions are presented in **Table 4-5** which has been extracted from the SANCOLD Interim Guidelines on Freeboard for Dams (SANCOLD, 1990), with the

relevant combination (Combination I), encircled in green on **Table 4-5**. This combination includes the recommended design flood (RDF), wind wave and run-up for the 25-year event (minimum) and wind set-up in the total freeboard requirements. Each of these has been discussed and computed in the following sub-sections. Also noted within the guidelines in *Table III: Simplified Practical Freeboard Guidelines* was that a Category 1 Earthfill Dam should have a minimum total freeboard of 0.8 m. This aligns with the requirements from GN704 which also notes that all dirty water dams are to have a minimum freeboard of 0.8 m.

Table 4-5: Proposed Freeboard Design Guidelines (SANCOLD, 1990)

Combination number	RDF	20-year flood	Wind wave and run-up		Wind set-up	Flood surges and seiches	Earthquake wave	Landslide wave (b)	Flood outlets (c)
			25-year event (a)	100-year event					
1	X		X		X				
2	X		X		X	X			
3		X		X	X	X			
4							X		
5	X							X	
6	X								X

4.6.2 Design Floods

Based on the indicative values presented in **Table 4-4**, a RDF of the 1:50 year recurrence interval has been selected. For this PCD this has a peak discharge of 2.29 m^3/s. The spillway is able to pass this discharge at a depth of 0.411 m.

Due to the small size of the contributing catchment area of 0.12 km^2, the RMF approach as detailed within the guidelines is not applicable. Therefore the 1:100 year flood peak of 2.64 m^3/s has been selected as the SEF. As can be seen in the spillway's rating curve, shown in **Figure 4-5**, the 1:100 year flood depth through the spillway is 0.45 m. With a minimum allowable freeboard of 0.8 m, the spillway would be able to discharge a flood peak of approximately 7.09 m^3/s before the NOC level was reached, this is a discharge of more than 2.6 times the 1:100 year flood peak.

4.6.3 Wind Wave and Run-up

Freeboard accounts for waves induced by wind and the run-up on the dam wall due to the waves (SANCOLD, 1990). The length and height of the waves, and wave run-up vary depending on the effective fetch of the dam, which is discussed later in this section. The steps taken in determining the wind wave and run-up value to be included in the freeboard are detailed below.

a. Wind Speed:

The SANCOLD freeboard guidelines require a minimum design wind speed of 1:25 year for combination 1; however, the guideline provides a map of 50-year design isopleths for hourly mean wind speeds (see **Figure 4-6**). There are correction factors applied on the 1:50 year design speed to determine design speed at other return periods. The guideline does not provide a correction factor for the 1:25 year; however, there are correction factors for 1:20 year of 0.95 and 1:50 year of 1. The decision was taken not to alter the design wind speeds (i.e. to apply a correction factor of 1), as the differences are very small, and it is more conservative to use the 1:50 year value of 20 m/s.

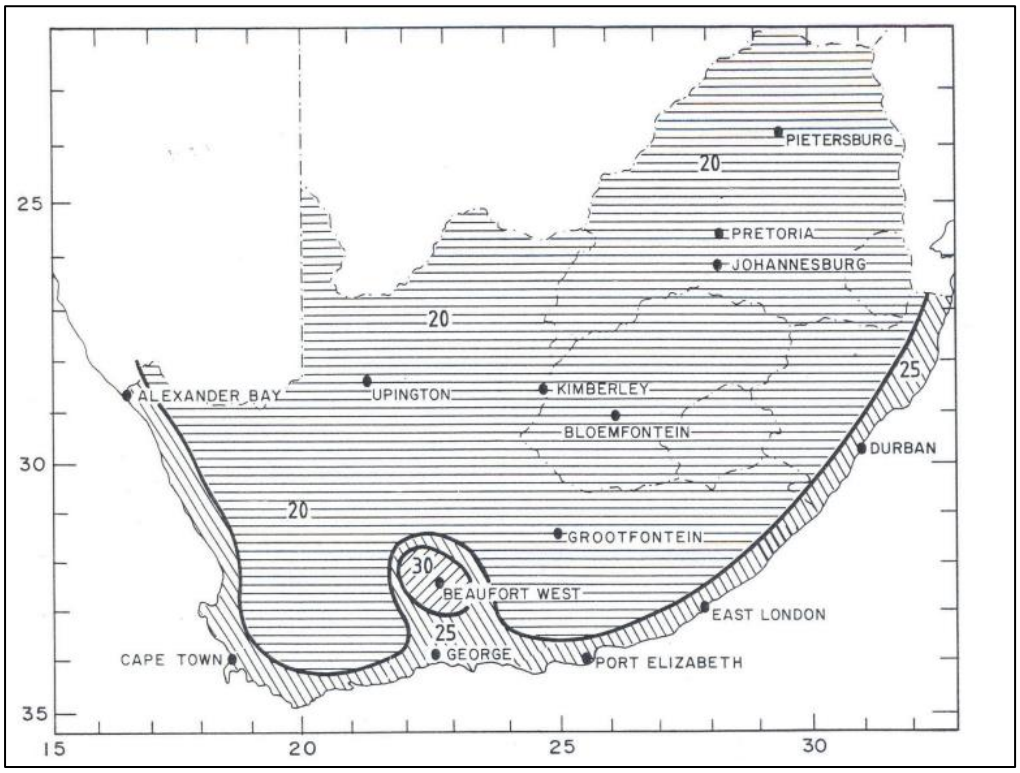

Figure 4-6: Design Wind Speed. Maximum Hourly Mean for 1:50-year return period (Milford, 1987)

b. Effective Fetch:

The effective fetch is the distance over which the wind acts to generate waves and is affected by the length and the varying width of the dams' water surface area. The effective fetch is determined by measuring the average reach over a 90° arc from a critical point on the dam wall. An example of the calculation approach from the guidelines has been included below in **Figure 4-7.**

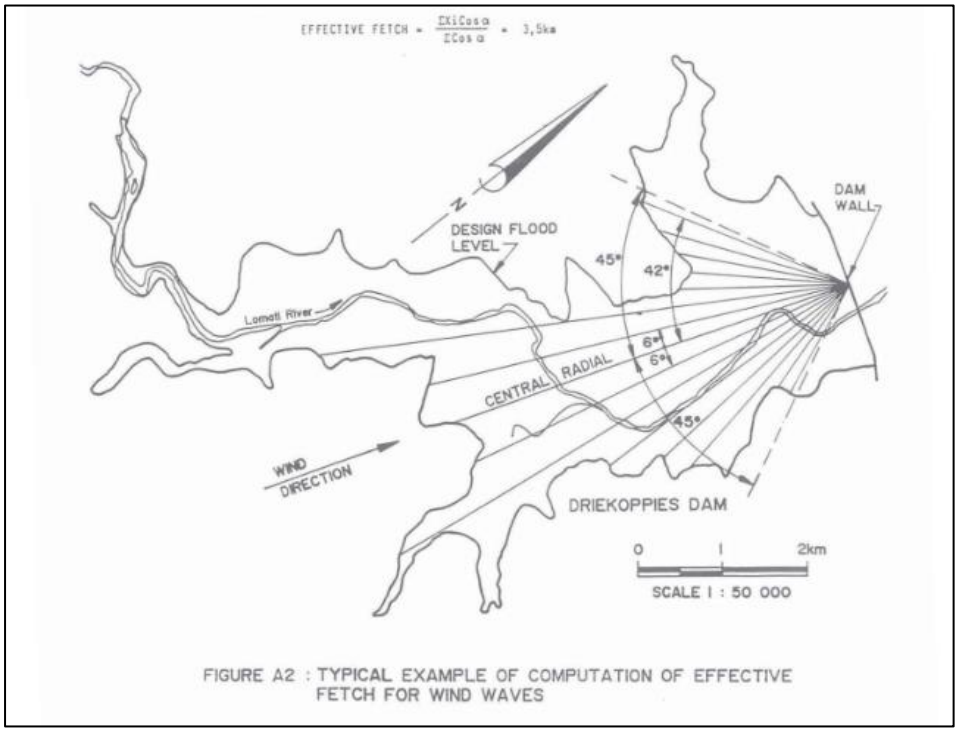

Figure 4-7: Example of Effective Fetch Computation (SANCOLD,1990)

c. Wind Speed Ratio:

The wind speed ratio is the ratio for converting wind speed over land to wind speed over water and is based on the length of the effective fetch as shown in **Table 4-6.** As can be seen by the ratios, wind speeds over water are typically higher than wind speeds over land.

Table 4-6: Wind Speed Relationship - Water to Land (SANCOLD, 1990)

Effective Fetch (km)	1	2	4	6	8 (or more)
Wind Speed Ratio $(\frac{Over\ Water}{Over\ Land})$	1.1	1.16	1.23	1.28	1.3

d. Significant Wave Height (Hs):

The significant wave height is the average wave height of the highest one-third of the waves in a spectrum or in a rectangular wave train. The selection of the significant wave height is based on **Figure 4-8** included below.

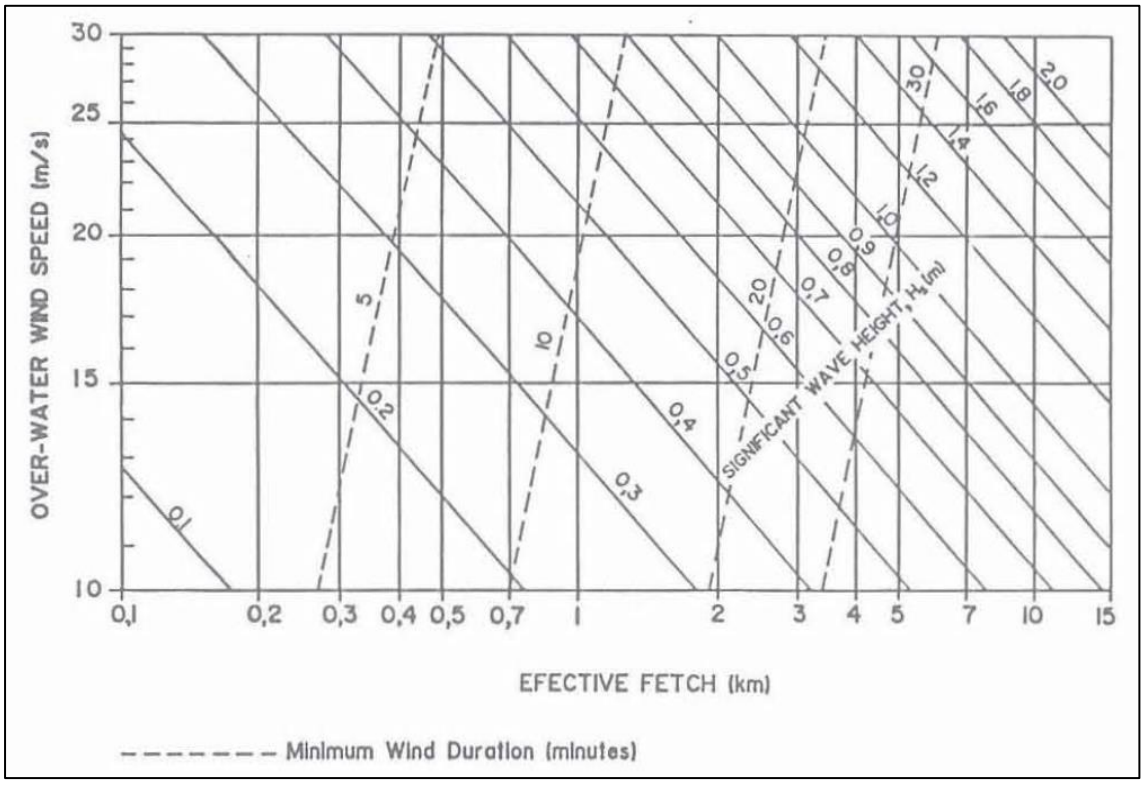

Figure 4-8: Graph for Determining Significant Wave Height from Effective Fetch and Wind Speed Over the Water (SANCOLD, 1990)

e. Design Wave Height:

The design wave heights used in the computation of wave run-up for the freeboard calculations are based on the significant wave height. Factors are provided in the guidelines to convert the significant wave height into the design wave height based on different types of dams, these are as follows:

- Concrete dam – 0.75
- Rockfill dam with road on crest – 1.0
- Earthfill dam with road on crest and selected grass on downstream slope – 1.1

f. Wave Run-up Ratio:

Wave run-up is the difference in height between the still water level of the dam and the maximum level reached by the design wave running up the dam wall. The wave run-up ratio is dependent on the

material and slope of the upstream face of the wall. Run-up ratios to the design wave height are presented in **Figure 4-9**. The wave run-up ratio is applied to the design wave height to determine the final wind wave run-up value to be included in the freeboard calculations.

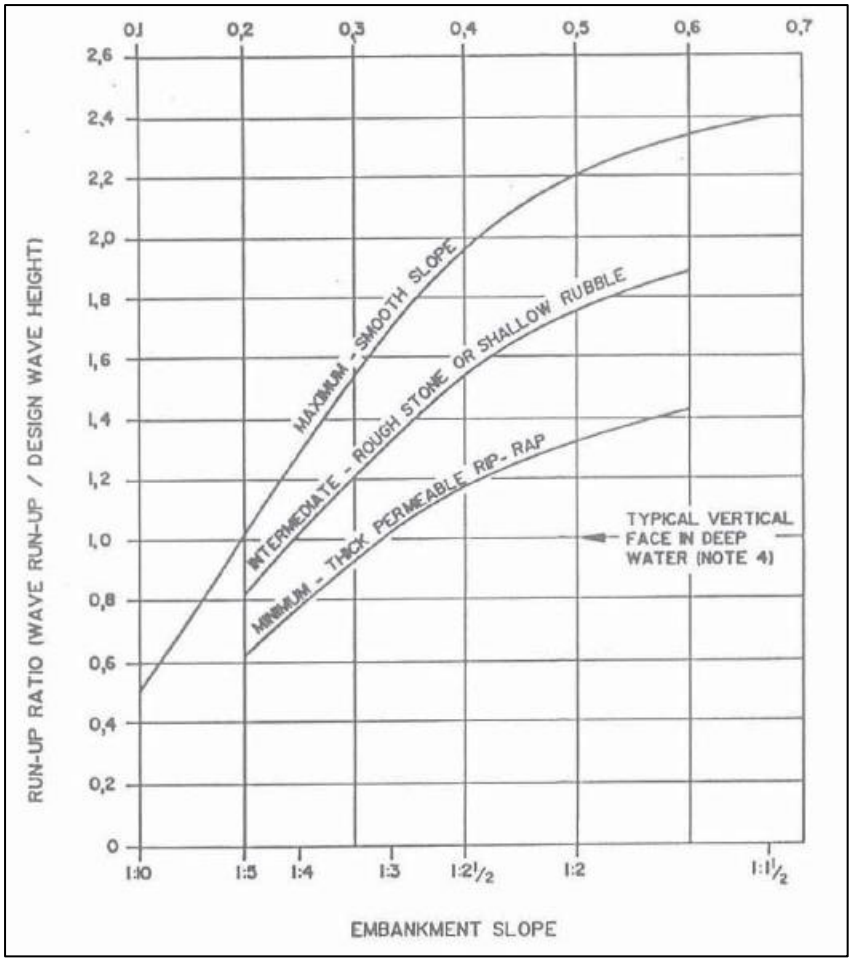

Figure 4-9: Wave Run-up to Design Wave Ratio (SANCOLD, 1990)

g. Calculation of above factors to determine wind wave run-up for Lafarge PCD:

Following the methodology and definitions detailed above, the table below (**Table 4-7**) indicates the values determined for the calculation of the wind wave run-up to be included in the final freeboard requirements for Lafarge PCD.

Table 4-7: Lafarge PCD – Wind Wave Run-up Freeboard Calculations

Description	Value	Units
1:50 year Wind Speed	20	m/s
Design Wind Speed Correction Factor Applied	1	

Description	Value	Units
Effective Fetch	95	m
Wind speed Over Land to Over Water Ratio	1.1	
Significant Wave Height (Hs)	0.19	m
Design Wave Height Factor (Earthfill Dam)	1.1	
Factored Design Wave Height (Earthfill Dam)	0.21	m
Wave Run-up Ratio to Design Wave Height (Smooth Slope)	1.7	
Wave Run-up	0.36	m

4.6.4 Wind Set-up

Wind set-up is defined by Saville et al (1962) as the resulting build-up of water at the leeward end of an enclosed body of water and a lowering of the water level at the windward end, resulting from the horizontal stress exerted on the water as a result of the wind blowing over the water surface.

It is assumed for design purposes that the design wind event will be directly at the dam wall. It should be noted that the effects of wind set-up can be transferred around significant bends, therefore the fetch lengths affecting the wind set-up could be substantially longer than the effective fetch length determined as shown in **Section 4.6.3**. Therefore, the fetch length for wind set-up computations is typically taken as two (2) times the effective fetch.

The wind set-up is calculated using the following formula from Saville et al (1962):

$$S = \frac{V^2 F}{4850 D}$$

Where:

S is the rise above the still water level (i.e., the wind set-up) in m;

V is the design wind speed in m/s;

F is the fetch in km (equal to 2 times the Effective Fetch); and

D is the average water depth in the basin, along the fetch, in m.

For the Additives PCD, **Table 4-8** details the computation of the wind set-up and presents the final value to be included in the total freeboard requirements. For the purposes of determining the average depth within the basin the value was obtained from the design model for the PCD.

Table 4-8: Lafarge PCD Wind Set-up Calculations

Description	Value	Units
Design Wind Speed (1:50 year)	20	m/s
Fetch	0.190	km
Water Surface Area at FSL	9 199	m^2
Full Supply Capacity	20 736	m^3
Average Water Depth in Basin (D)	3.25	m
Wind Set-up (S)	0.0003	m

4.6.5 Total Freeboard Requirements

There are three different considerations when setting the final freeboard amount, essentially the total required freeboard is the maximum of the following values:

- 0.8 m based on GN. 704 minimum requirements and SANCOLD guidelines minimum requirements.
- Sum of factors contributing to the minimum freeboard requirements as per the SANCOLD guidelines, for the Lafarge PCD are as follows:
    - RDF = 0.41 m
    - Wind wave run-up = 0.22 m
    - Wind set-up = 0.00 m
    - Total of Combination 1 = 0.63

Therefore, for the Additives PCD the total design freeboard of 0.8 m exceeds the physical design requirements. **Table 4-9** included below provides a summary of the critical levels for the design of the dam. It should be noted that with a freeboard of 0.8 m the spillway would be able to discharge a maximum flood equal to approximately 7.09 m^3/s prior to the overtopping of the design NOC.

Table 4-9: Design Levels for Lafarge PCD

Description	Value	Units
FSL	1486.9	Mamsl
Design NOC	1487.7	Mamsl
Design Freeboard	0.8	M

4.7 Preliminary Design Drawings

Based on the details of the design as described in the preceding sections, the Preliminary Design Drawings have been drawn up and are included in **Annexure B**. This annexure includes all of the preliminary design drawings, but those specific to the Additives PCD have been described in **Table 4-10** below. Typically, the drawing numbering includes various elements which describe the drawing, these are Project No. – Designer (Company) – Project Phase (e.g. P = Preliminary Design) – Locality (e.g. LCP = Lafarge Cement Plant) – Discipline (e.g. CI = Civil, ST = Structural) – Unique Drawing No. (which can be further separated by area or structure). Drawing revisions are typically letters for preliminary design phases and become numbers after detailed design and leading into construction.

Table 4-10: Preliminary Design Drawings for the Additives PCD

Drawing No.	Title	Revision
5707 – JGA – P – LCP – GA – 0001 Sheet 1 of 1	Lafarge Cement Plant Stormwater Management and Pollution Control Dams General Arrangement	RevA
5707 – JGA – P – LCP – CI – 2001 Sheet 1 of 1	Lafarge Cement Plant Additives Pollution Control Dam Layout Plan and Sections	RevA
5707 – JGA – P – LCP – CI – 2002 Sheet 1 of 1	Lafarge Cement Plant Additives Pollution Control Dam Subsoil Drains Layout & Setting Out Details	RevA
5707 – JGA – P – LCP – CI – 2003 Sheet 1 of 1	Lafarge Cement Plant Additives Pollution Control Dam Subsoil Drains Longitudinal Sections	RevA
5707 – JGA – P – LCP – CI – 2004 Sheet 1 of 1	Lafarge Cement Plant Additives Pollution Control Dam Subsoil Drains Manhole Details	RevA
5707 – JGA – P – LCP – CI – 2005 Sheet 1 of 1	Lafarge Cement Plant Additives Pollution Control Dam Spillway / Access Road Details	RevA
5707 – JGA – P – LCP – CI – 2006 Sheet 1 of 1	Lafarge Cement Plant Additives Pollution Control Dam Typical Sections & Details	RevA

4.8 Cost Estimation

The estimated costs for the construction of the Additives PCD are included in the summary table below. A more detailed breakdown of costing in the form of an itemised BoQ has been included in **Annexure A**. It has been assumed, for the purposes of a preliminary design cost estimation that the Preliminary and General items will amount to approximately 30% of the cost of the rest of the work. An allowance of 15% for contingencies for unforeseen items and/or fluctuations in prices of certain

items has also been included. As shown in **Table 4-11**, the anticipated cost of the Additives PCD is approximately R 32.34 million.

Table 4-11: Preliminary Design Cost Estimate Summary for the Additives PCD

Summary of Additives PCD Preliminary Design Cost Estimation		
1	PRELIMINARY AND GENERAL	R 6 820 501.00
2	SMALL EARTH DAMS	R 10 225 700.00
3	LINER AND GEOTEXTILES	R 11 201 320.00
4	GABIONS AND PITCHING	R 105 500.00
5	SUBSOIL DRAINAGE SYSTEM	R 721 650.00
6	ANCILLIARY WORKS	R 47 500.00
Subtotal A		**R 29 122 171.00**
Contingencies (15%)		R 4 368 325.65
Total (Excl. VAT)		**R 33 490 496.65**

5 PRELIMINARY DESIGN OF COAL STOCKYARD PCD

5.1 Dam Safety Classification

Based on the required size of the Coal Stockyard (CSY) PCD it will not store more than 50 000 m³ of water. Given the generally flat topography of the natural ground and the fact that the PCD is required to received water from a stormwater channel which is below the NGL with relatively flat gradients, the PCD is exclusively in excavation and as a result has limited freestanding walls (of approximately 0.5 m) and no embankments.

Due to the PCD not having any free-standing walls or embankments equal to or greater than 5 m in height and not storing more than 50 000 m³ of water, the PCD is not considered to be a dam with a safety risk and therefore does not require registration with the Dam Safety Office (DSO) as it does not meet the minimum threshold criteria.

5.2 Design of PCD's Footprint and Basin

The initial stages of the PCD design required that an engineered geometric landform be developed for the PCD. This includes engineered lines and radii and slopes to be adopted to allow for the engineering drawings of the PCD to be compiled for submission to the DWS and ultimately for the PCD to be constructed.

Using provided survey data a digital terrain model (DTM) was developed for the site utilising AutoCAD Civil 3D Software. This was used as the basis for developing the PCD's footprint and determining the basin sizing as described in the following sections.

Similarly, to the Additives PCD, the CSY PCD had to be designed within a confined area as well. In the case of the CSY PCD this area was even more restricted as the PCD is located within a triangular area between two existing railways and a road. The final footprint is shown in the layout presented in **Figure 5-1**.

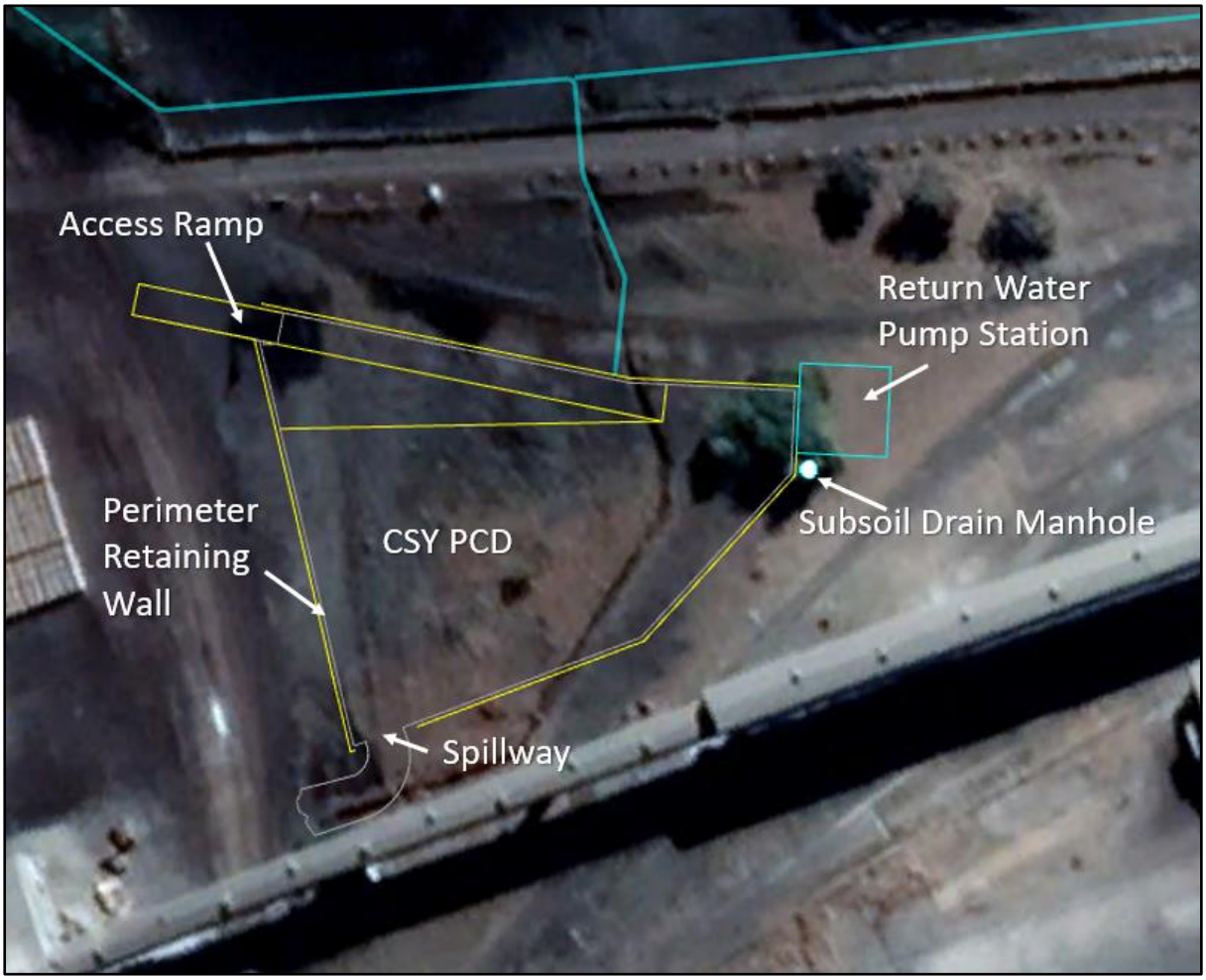

Figure 5-1: CSY PCD Footprint

The CSY PCD is required to have a minimum storage volume of 4 000 m³, and based on the available footprint, the required storage capacity, the access ramp, the invert level of the stormwater channel discharging into the PCD and the required slopes for safe excavation, it was found that the PCD could not be an embankment dam with side slopes of 1V:3H as this would not provide sufficient storage to meet the minimum requirements. Therefore, a concrete retaining wall around the perimeter of the PCD basin was designed. This allowed the available space to be maximised and reduced the depth of excavation required for the PCD. Based on the footprint shown in **Figure 5-1** the targeted storage capacity of the PCD of 4 000 m³ was achieved at a basin level (level of the top of the liner) of 1485.55 mamsl at the lowest point. As shown in **Table 5-1** this level is at a depth of approximately 4.45 m from the average NGL over the footprint and a depth of 3.25 m below the FSL of the PCD.

Table 5-1: CSY PCD Depth and Storage Details

Approx. NGL (mamsl)	Perimeter Wall Crest Level (mamsl)	Full Supply Level (mamsl)	Basin Level (mamsl)	Depth From NGL to Basin (m)	Depth From FSL to Basin (m)	PCD Capacity (m^3)
1490	1490.5	1488.8	1485.55	4.45	3.25	4266

The following (**Figure 5-2**) presents the contours for the layout of the CSY PCD basin, with design levels indicated.

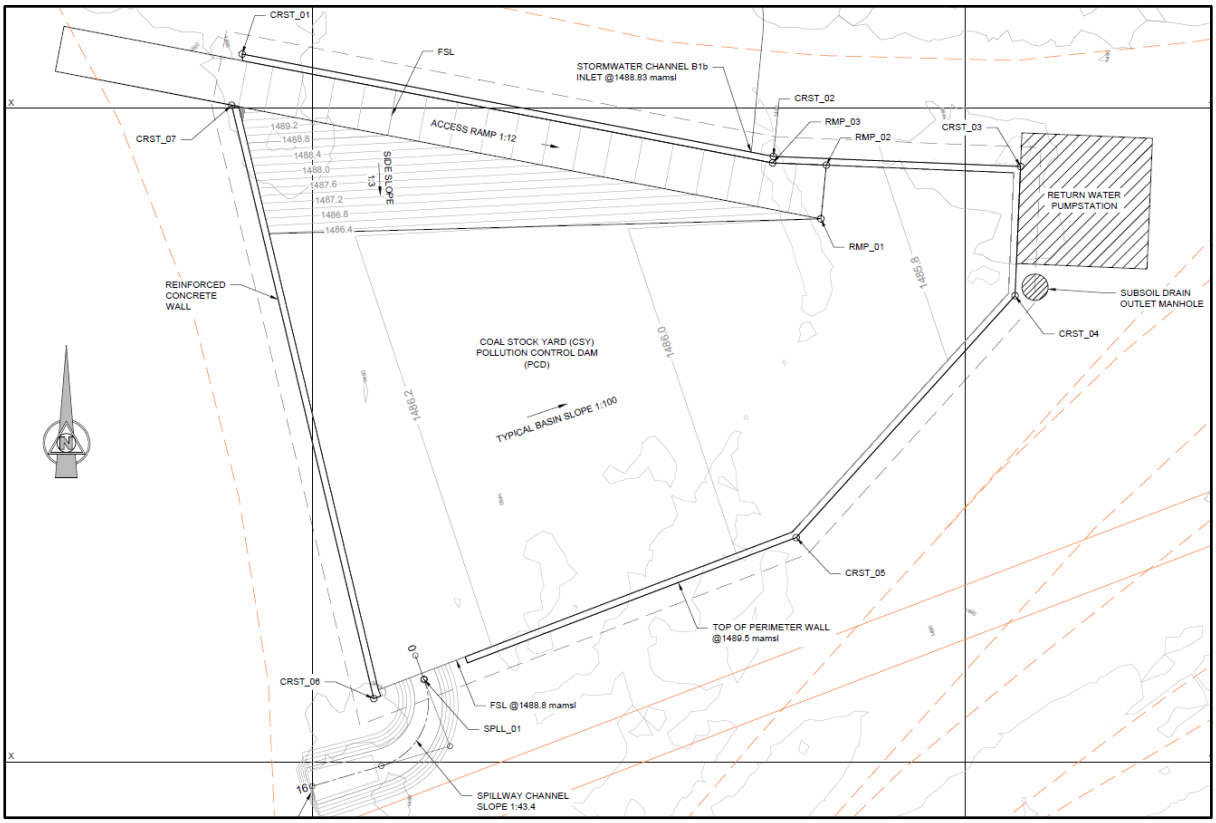

Figure 5-2: CSY PCD Basin Design

5.3 Design of Perimeter Retaining Wall

The perimeter of the CSY PCD will be a reinforced concrete retaining wall as established in **Section 5.2** above**.** The wall has been designed to withstand four failure modes of which two are stability checks listed in **Table 5-2**. Overturning and Sliding are both governed by a safety factor of 1.5. The third failure mode is called soil failure which is governed by the bearing capacity of the founding soil. The soil failure mode was checked against a conservative bearing capacity of 3 800 kPa for Calcrete obtained from

the Lafarge Lichtenburg Kiln 4 and Associated Structures Geotechnical Investigation Report (SRK, 2006). In order to make the wall more stable, a 500 mm wide key was incorporated in the design.

Table 5-2: Failure Modes of Retaining Wall and Safety Factor Requirements

Mode of Failure	Factor of Safety
Overturning	1.5
Sliding	1.5

The retaining wall's dimensions shown in **Figure 5-3** were determined based on the soil pressure behind the wall of which the soil properties are described in **Section 3.6.2**. Although the overall excavated depth to the wall's footing varies, a maximum design limit of 5.2 m was used. The CSY PCDs' excavated depth surpasses the groundwater table level, therefore, to alleviate the water pressures on the wall, strip drains were introduced at 1.8 m c/c spacing as shown in **Figure 5-3**. A perforated pipe collects the water from these strip drains and transfers it ultimately into the subsoil drain manhole.

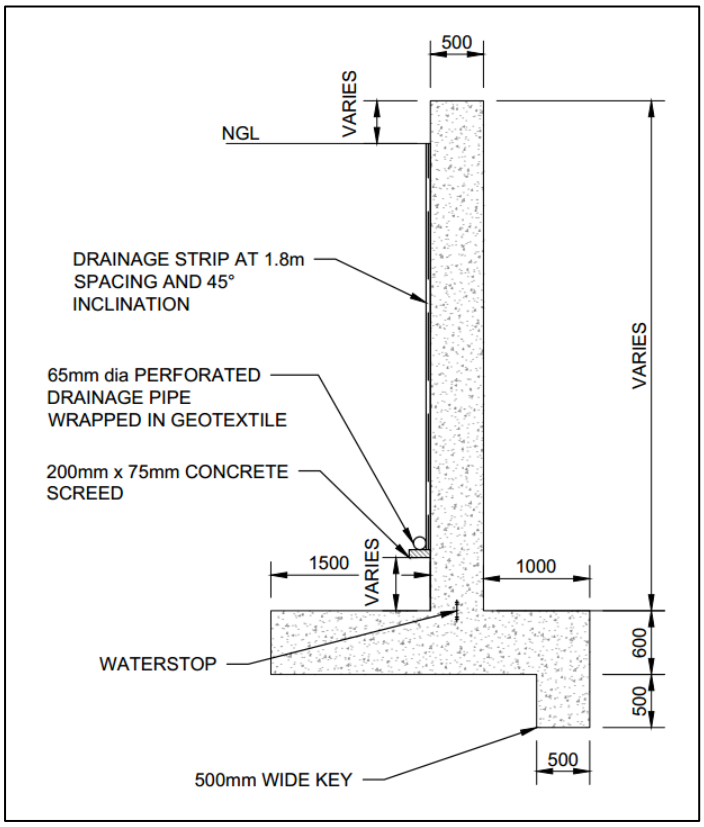

Figure 5-3: CSY PCD Section Through the Retaining Wall

For input into the design, the various materials units weights have been presented in **Table 5-3**, while the relevant load factors for the at the Ultimate Limit State (ULS) have been indicated in **Table 5-4**.

Table 5-5 shows the scenarios considered when designing the retaining wall. Scenario 3 where the dam is empty and the backfill material is saturated at a depth of 2.5 m below the natural ground level was found to be the worst-case scenario for the parameters of the wall. As can be seen in **Table 5-5** all analysed scenarios yielded high safety factors, which exceed the minimum FoS requirements, including the worst-case scenario. The ultimate design loads experienced by the wall are shown in **Table 5-6**. With the aid of additional geotechnical information at the detailed design stage the retaining wall will be optimised.

Table 5-3: Design Unit Weights of Retaining Wall

Unit Weight	kN/m^3
γ_c Unit weight of concrete	25.00
γ_s Unit weight of backfill soil	19.70
γ_{sat} Unit weight of saturated backfill soil	22.68
γ_{sc} Unit weight of cover soil	20.00

Table 5-4: Load Factors at Ultimate Limit State

Ultimate Load Factors	
Concrete	1.2
Surcharge	1.6
Soil	1.4

Table 5-5: Scenarios Considered for the Retaining Wall Design

Analysis Scenario	Overturning FOS	Sliding FOS	Factored Max Soil Pressure (kPa)
1) Dam empty, backfill unsaturated	2.22	2.67	235.5
2) Dam Full, backfill unsaturated	4.57	7.68	197.95
3) Dam empty, backfill saturated **@2.5m below NGL**	2.19	2.60	246.14
4) Dam Full, backfill saturated **@2.5m below NGL**	4.26	6.95	206.16

Table 5-6: Ultimate Design Loads on the Wall

Heel		Toe		Stem	
V (kN)	M (kNm)	V (kN)	M (kNm)	V (kN)	M (kNm)
163.2	145.53	180.02	96.87	113.39	181.42

5.4 Access Ramps

The over-arching assumption regarding access and maintenance to the basin of the PCD's is that this will be undertaken with the use of a Bobcat (Skidsteer) or similar type of machinery and loading. The same principles have been applied to both of the PCD's access ramps, these are as follows:

- Maximum slope of 1V:12H, or 8.33%,
- Minimum width of access channels of 3.5 m,
- Concrete (10 MPa/13 mm) geocell protection layer of 250 mm thickness over liner, and
- Inclusion of a 30 kN x 30 kN PP Geogrid to provide additional protection.

For the CSY PCD the access ramp was required to be on the western side of the PCD due to the north, east and southern sides being bordered by existing railway lines. The angle at which the western and northern sides of the PCD are set out at, it was possible to align the access ramp parallel to the northern perimeter wall. This brings a saving to the height of the retaining wall in this area. The southern side of the ramp slopes at 1V:3H down to the floor of the basin, this is evident in both **Figure 5-1** and **Figure 5-2**.

5.5 Subsoil Drainage System/Leakage Detection System

The requirements of the subsoil drainage system have been discussed in **Section 4.4**. Specifically for the CSY PCD, the components, sizing and system layout are described in the sub-sections below.

5.5.1 Subsoil System Components

The subsoil drainage system is inclusive of perforated HDPE pipes used to drain the surrounding soil in a herringbone layout. These pipes are surrounded first by a layer of pea gravel (which is a 6-8 mm stone), which is turn is surrounded by a layer of filter sand. The final grading envelope of the filter sand will be determined during the detailed design phase of the project, once accurate grading curves of the surrounding insitu soil have been obtained from samples taken at the dam site.

The perforated HDPE pipes connect and join a solid HDPE pipe which exits the dam and daylights inside the subsoil drain manhole located on the eastern side of the PCD. The outlet of the pipe allows for monitoring of the subsoil drainage. This manhole is designed to be a 2 m diameter precast concrete manhole and allows for a sump below the outlet of the subsoil pipe for water to be returned into the PCD (since the water is considered to be dirty water and cannot be discharged into the environment) creating a closed loop. The manhole is designed to be equipped with a submersible pump with an

automatic switch so that it turns on and off whenever the levels inside the sump reach their upper and lower limits.

5.5.2 Subsoil Drain Layout and Sizing

As the available information used to size the subsoil drains, at this the Preliminary Design Phase, is consistent for both the Additives PCD and the CSY PCD the same sizing and distance between drains for the layout has been used. For the CSY the basin also slopes at 1% towards the eastern side of the PCD and for the subsoil drain two main lines have been used along the base of the retaining wall and the access ramp side slope. Connecting to these mainlines are three laterals per line. A layout of the subsoil drainage system is shown in **Figure 5-4** below.

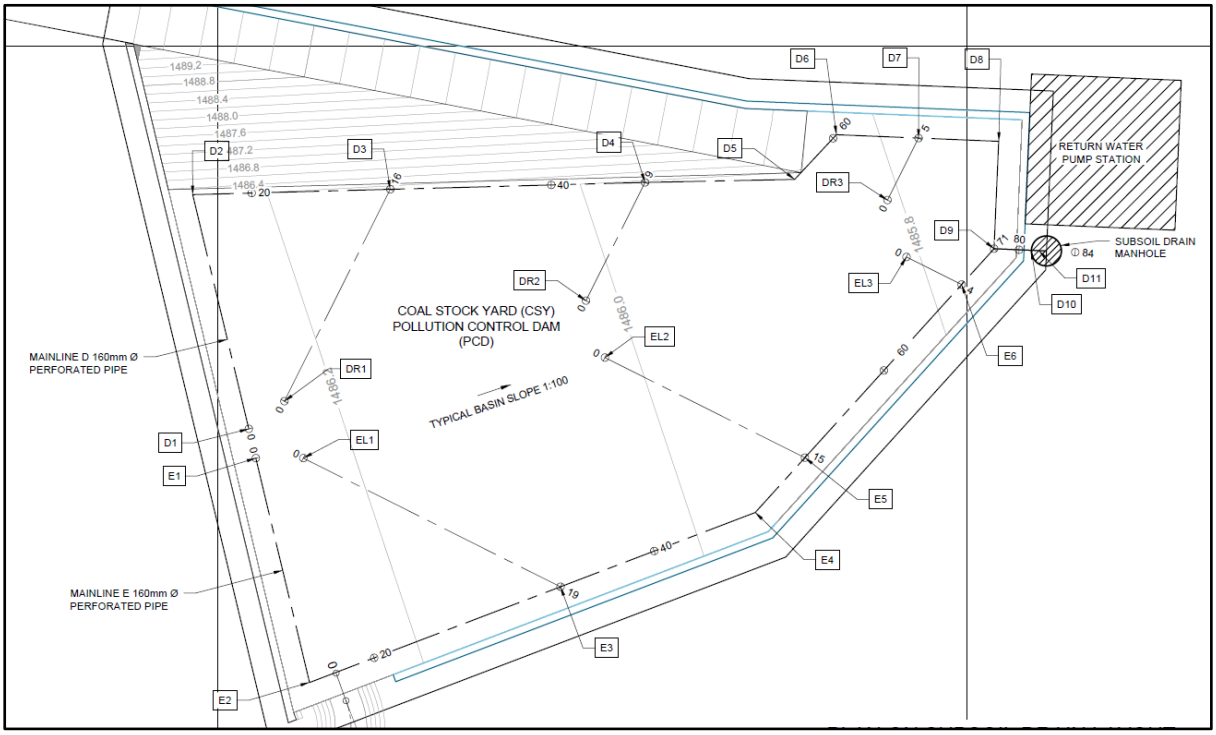

Figure 5-4: CSY PCD Subsoil Drain Arrangement

5.6 Spillway

The spillway has been connected to the existing culvert downstream of Channel B1b, to allow the dam to spill into an existing stormwater channel. The FSL of the dam is set at 1488.800 mamsl and the width of the spillway is 2 m with 1V:1.5H side slopes. The spillway is a sharp-crested weir with a channel sloping down to the culvert at 1V:43.4H and has a bend with of 5 m radius to align the flow with the culvert.

The 1:50 year flood peak was used as the RDF for the PCD. The flow entering the dam is from Channel B1b which has a 1:50 year peak flow of 0.52 m^3/s. The 1:20, 1:50 and 1:100 year flood peaks for the Coal Stockyard PCD inlet channel are shown in **Table 5-7** below. As shown in **Figure 5-5** the spillway is able to discharge the design flood at 0.29 m flow depth. It is important to note that the dam should not spill more than once in fifty years.

Table 5-7: CSY PCD Flood Peaks for Varying Recurrence Intervals

Recurrence Interval:	1:20	1:50	1:100
CSY PCD Peak Flows (m^3/s)	0.44	0.52	0.58

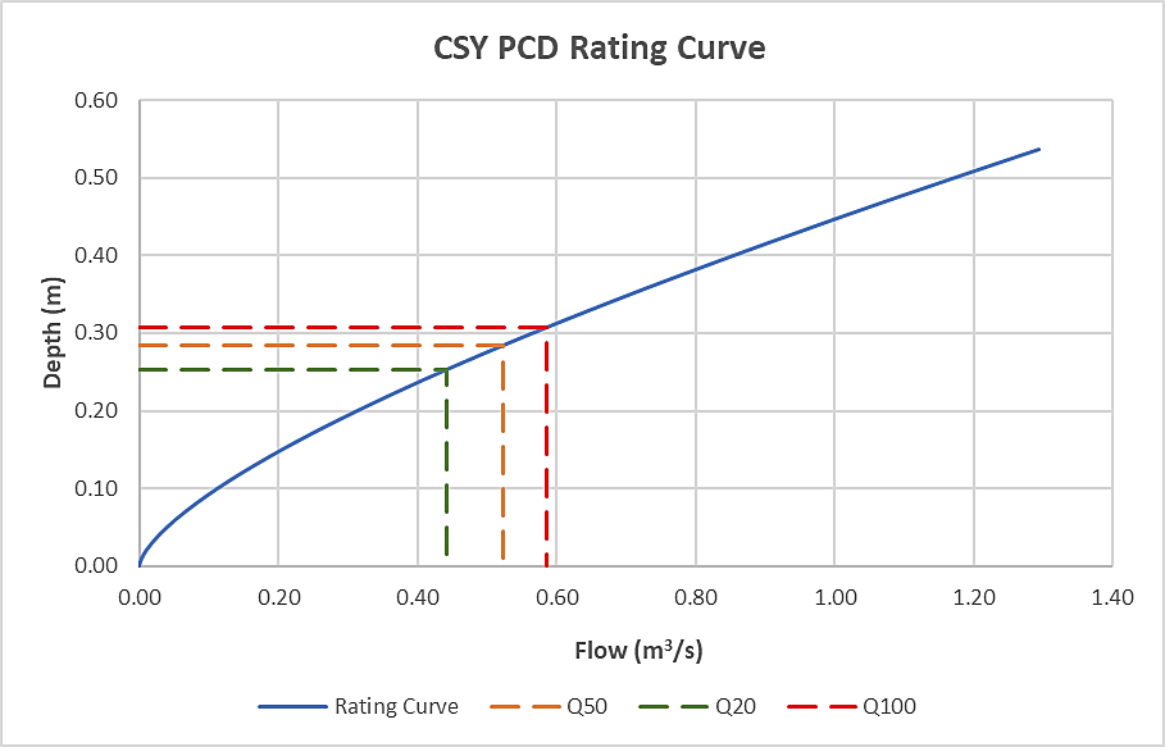

Figure 5-5: CSY PCD Spillway Rating Curve

5.7 Freeboard

Freeboard is the vertical distance above the FSL to the NOC Level of the dam. Having an acceptable freeboard height is one approach to prevent the dam from overtopping during extreme events. The available freeboard protects the dam against waves washing across the crest due to wind set-up and wave run-up. It also allows for the safe spillage of water through a spillway designed to allow floods of a specific return period to pass without the dam failing.

5.7.1 Freeboard Design Criteria

The SANCOLD Interim Guidelines on Freeboard for Dams (SANCOLD, 1990) provide guidance on applicable freeboard criteria in terms of combinations of factors to be considered. These factors give minimum values which should be accounted for and include guidance on the Recommended Design Flood (RDF) in terms of recurrence intervals and the Safety Evaluation Flood (SEF) in terms of a factor of the regional maximum flood (RMF) and the Probable Maximum Flood. Given that the Additives PCD is not considered to be a dam with a safety risk, the most basic assessment has been considered for the freeboard requirements (encircled in green) on **Table 5-8.**

Table 5-8: Proposed Freeboard Design Criteria and Flood Recurrence Intervals (SANCOLD, 1990)

Dam size	Freeboard criteria and floods	Hazard rating (Category of dam in brackets)		
		Low	Significant	High
Small (H = 5-12 m)		(I)	(II)	(II)
	FB Criteria RDF SEF	1 20-50 year 0,4*RMF 0,2*PMF	1 100 year 0,7*RMF 0,5*PMF	2 100 year 1,0*RMF 0,7*PMF
Medium (H = 12-30 m)		(II)	(II)	(III)
	FB Criteria RDF SEF	2;6 100 year 0,7*RMF 0,5*PMF	2;3;6 100 year 1,0*RMF 0,7*PMF	2;3;4;5;6 200 year 1,5*RMF 1,0*PMF
Large (H > 30 m)		(III)	(III)	(III)
	FB Criteria RDF SEF	2;3;6 200 year 1,0*RMF 0,7*PMF	2;3;4;5;6 200 year 1,5*RMF 1,0*PMF	2;3;4;5;6 200 year 1,7*RMF 1,1*PMF

The proposed design combinations of freeboard conditions are presented in **Table 5-9** which has been extracted from the SANCOLD Interim Guidelines on Freeboard for Dams (SANCOLD, 1990), with the relevant combination (Combination I), encircled in green on **Table 5-9**. This combination includes the recommended design flood (RDF), wind wave and run-up for the 25-year event (minimum) and wind set-up in the total freeboard requirements. Each of these has been discussed and computed in the following sub-sections. SANCOLD Interim Guidelines on Freeboard for Dams states that freeboard requirements for Category I and small Category II concrete dams can be relaxed depending on hazard potential and the consequences of failure, therefore a minimum total freeboard of 0.8 m has been

adopted. This aligns with the requirements from GN704 which also notes that all dirty water dams are to have a minimum freeboard of 0.8 m.

Table 5-9: Proposed Freeboard Design Guidelines (SANCOLD, 1990)

Combination number	RDF	20-year flood	Wind wave and run-up		Wind set-up	Flood surges and seiches	Earthquake wave	Landslide wave (b)	Flood outlets (c)
			25-year event (a)	100-year event					
1	X		X		X				
2	X		X		X	X			
3		X		X	X	X			
4							X		
5	X							X	
6	X								X

5.7.2 Design Floods

Based on the indicative values presented in **Table 5-8**, a RDF of the 1:50 year recurrence interval has been selected. For this PCD this has a peak discharge of 0.52 m^3/s. The spillway is able to pass this discharge at a depth of 0.290 m.

Due to the small size of the contributing catchment area of less than 0.1 km^2, the RMF approach as detailed within the guidelines is not applicable. Therefore the 1:100 year flood peak of 0.58 m^3/s has been selected as the SEF. As can be seen in the spillway's rating curve, shown in **Figure 5-5**, the 1:100 year flood depth through the spillway is 0.31 m. With a minimum allowable freeboard of 0.8 m, the spillway would be able to discharge a flood peak of approximately 2.23 m^3/s, which is more than 3.8 times the 1:100 year flood peak. However, the NOC level of the CSY PCD is effectively the top level of the access ramp, since the perimeter wall is higher than this. The top of the access ramp is at 1489.95 mamsl which is 1.15 m above FSL thus making the freeboard depth fixed at 1.15 m.

It should be noted that due to the invert level of the inlet channel the FSL of the CSY PCD could not be above 1488.83 mamsl, hence a FSL of 1488.8 mamsl was selected to minimize the chances of backflow into the channel during a spill event.

5.7.3 Wind Wave and Run-up

Freeboard accounts for waves induced by wind and the run-up on the dam wall due to the waves (SANCOLD, 1990). The length and height of the waves, and wave run-up vary depending on the effective fetch of the dam, which is discussed later in this section. The steps taken in determining the wind wave and run-up value to be included in the freeboard are detailed below.

a. Wind Speed:

The SANCOLD freeboard guidelines require a minimum design wind speed of 1:25 year for combination 1; however, the guideline provides a map of 50-year design isopleths for hourly mean wind speeds (see **Figure 5-6**). There are correction factors applied on the 1:50 year design speed to determine design speed at other return periods. The guideline does not provide a correction factor for the 1:25 year; however, there are correction factors for 1:20 year of 0.95 and 1:50 year of 1. The decision was taken not to alter the design wind speeds (i.e. to apply a correction factor of 1), as the differences are very small, and it is more conservative to use the 1:50 year value of 20 m/s.

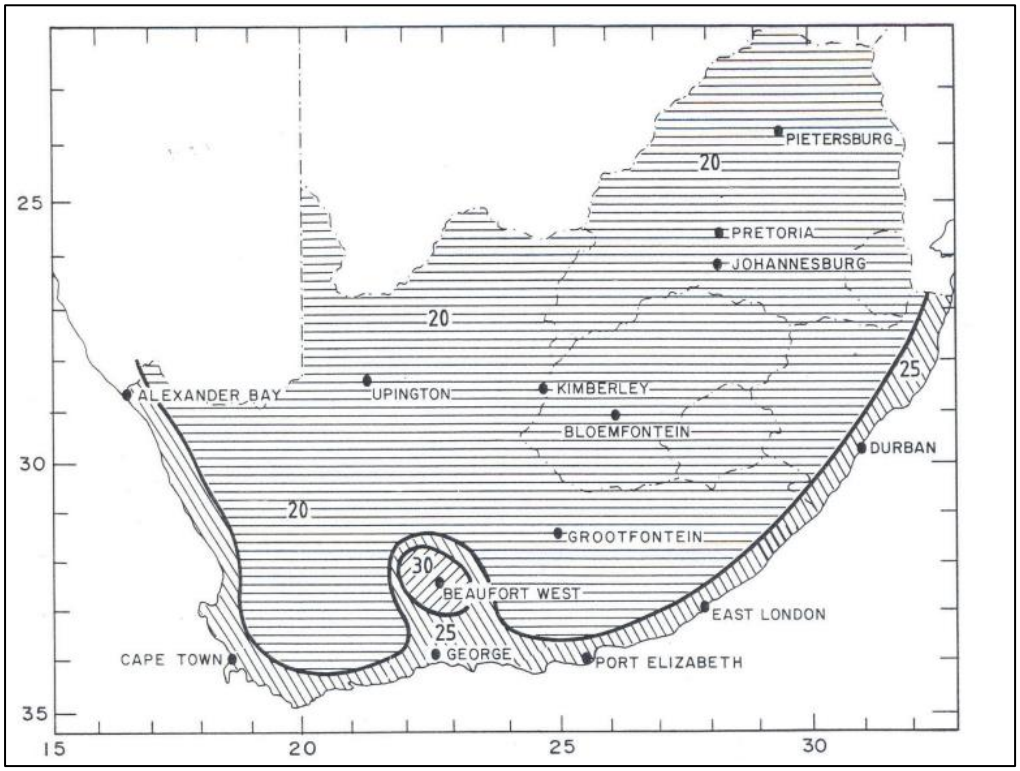

Figure 5-6: Design Wind Speed. Maximum Hourly Mean for 1:50-year return period (Milford, 1987)

b. Effective Fetch:

The effective fetch is the distance over which the wind acts to generate waves and is affected by the length and the varying width of the dams' water surface area. The effective fetch is determined by measuring the average reach over a 90° arc from a critical point on the dam wall. An example of the calculation approach from the guidelines has been included below in **Figure 5-7.**

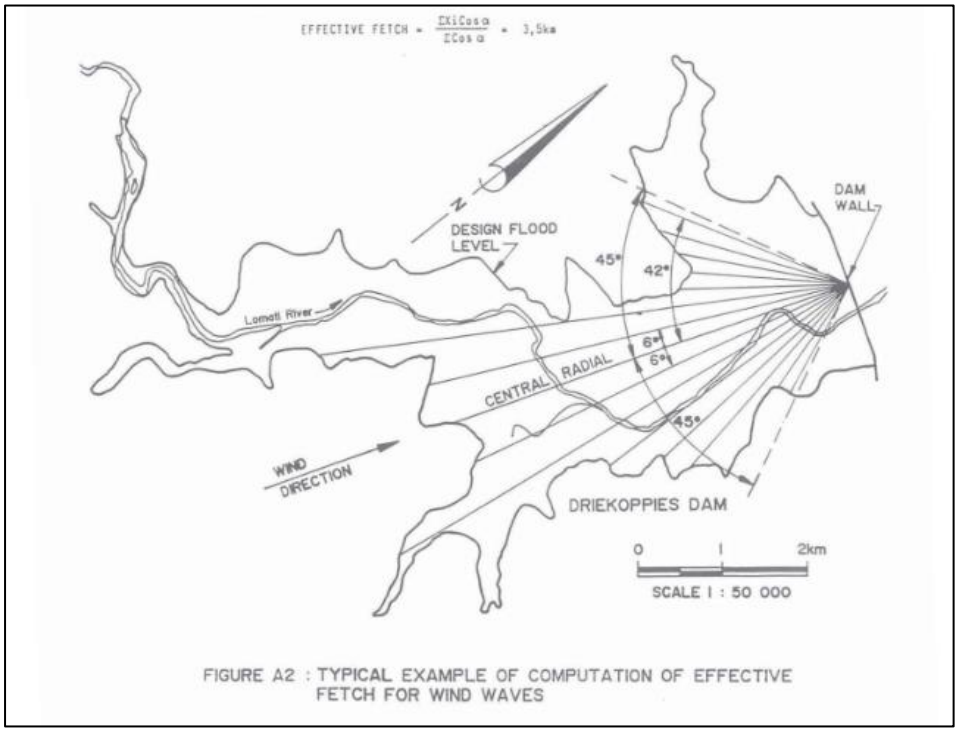

Figure 5-7: Example of Effective Fetch Computation (SANCOLD,1990)

c. Wind Speed Ratio:

The wind speed ratio is the ratio for converting wind speed over land to wind speed over water and is based on the length of the effective fetch as shown in **Table 5-10.** As can be seen by the ratios, wind speeds over water are typically higher than wind speeds over land.

Table 5-10: Wind Speed Relationship - Water to Land (SANCOLD, 1990)

Effective Fetch (km)	1	2	4	6	8 (or more)
Wind Speed Ratio $(\frac{Over\ Water}{Over\ Land})$	1.1	1.16	1.23	1.28	1.3

d. Significant Wave Height (Hs):

The significant wave height is the average wave height of the highest one-third of the waves in a spectrum or in a rectangular wave train. The selection of the significant wave height is based on **Figure 5-8** included below.

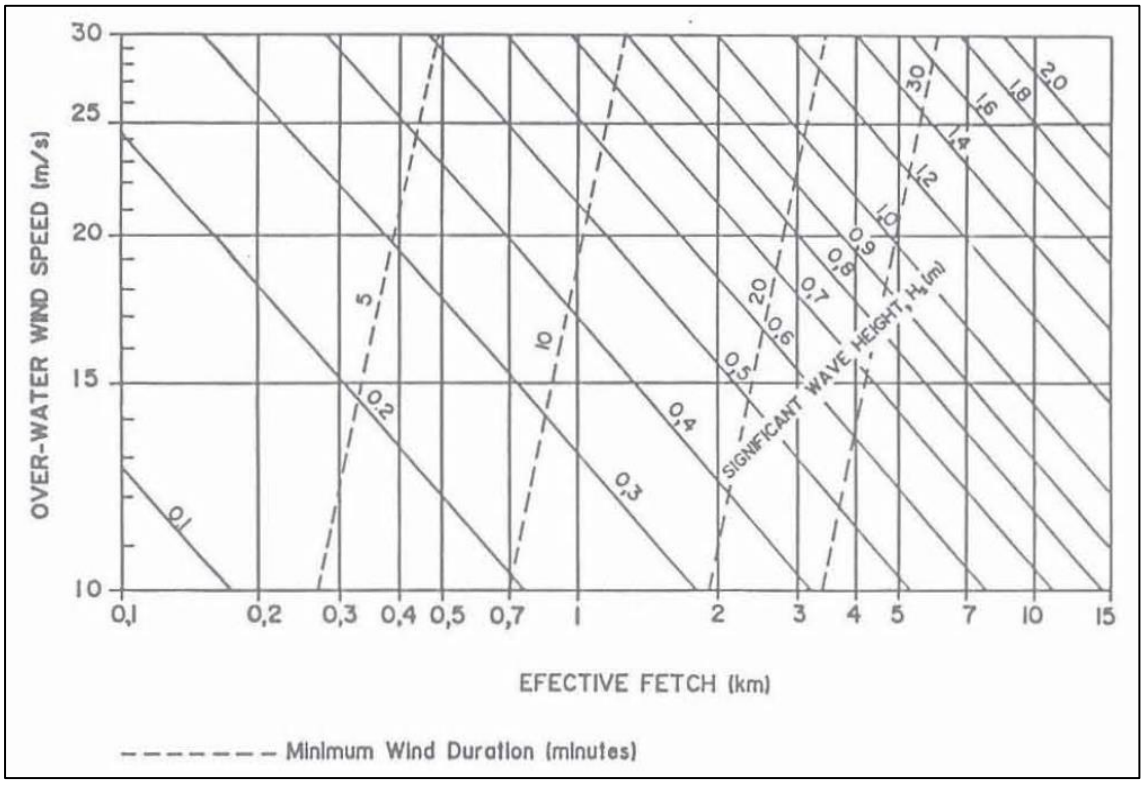

Figure 5-8: Graph for Determining Significant Wave Height from Effective Fetch and Wind Speed Over the Water (SANCOLD, 1990)

e. Design Wave Height:

The design wave heights used in the computation of wave run-up for the freeboard calculations are based on the significant wave height. Factors are provided in the guidelines to convert the significant wave height into the design wave height based on different types of dams, these are as follows:

- Concrete dam – 0.75
- Rockfill dam with road on crest – 1.0
- Earthfill dam with road on crest and selected grass on downstream slope – 1.1

f. Wave Run-up Ratio:

Wave run-up is the difference in height between the still water level of the dam and the maximum level reached by the design wave running up the dam wall. The wave run-up ratio is dependent on the

material and slope of the upstream face of the wall. Run-up ratios to the design wave height are presented in **Figure 5-9**. The wave run-up ratio is applied to the design wave height to determine the final wind wave run-up value to be included in the freeboard calculations.

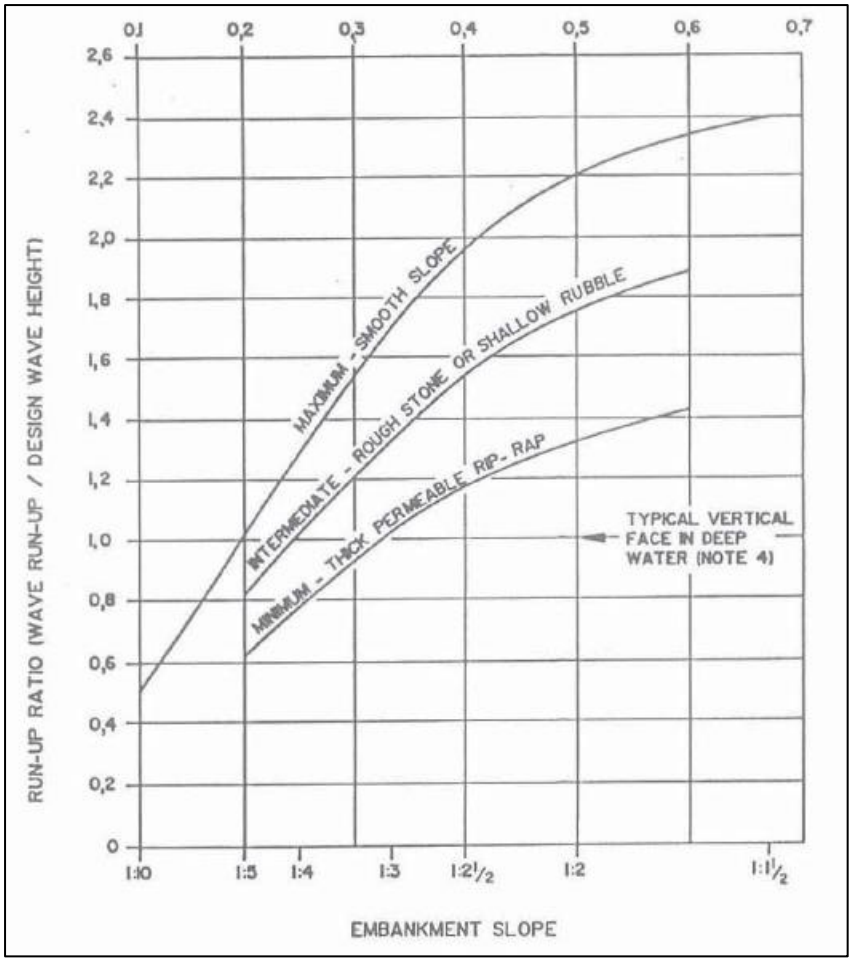

Figure 5-9: Wave Run-up to Design Wave Ratio (SANCOLD, 1990)

g. Calculation of above factors to determine wind wave run-up for Lafarge PCD:

Following the methodology and definitions detailed above, the table below (**Table 5-11**) indicates the values determined for the calculation of the wind wave run-up to be included in the final freeboard requirements for Lafarge PCD.

Table 5-11: Lafarge PCD – Wind Wave Run-up Freeboard Calculations

Description	Value	Units
1:50 year Wind Speed	20	m/s
Design Wind Speed Correction Factor Applied	1	

Description	Value	Units
Effective Fetch	39.4	m
Wind speed Over Land to Over Water Ratio	1.1	
Significant Wave Height (Hs)	0.19	m
Design Wave Height Factor (Concrete Dam)	0.75	
Factored Design Wave Height (Concrete Dam)	0.14	m
Wave Run-up Ratio to Design Wave Height (Smooth Slope)	2	
Wave Run-up	0.29	m

5.7.4 Wind Set-up

Wind set-up is defined by Saville et al (1962) as the resulting build-up of water at the leeward end of an enclosed body of water and a lowering of the water level at the windward end, resulting from the horizontal stress exerted on the water as a result of the wind blowing over the water surface.

It is assumed for design purposes that the design wind event will be directed directly at the dam wall. It should be noted that the effects of wind set-up can be transferred around significant bends, therefore the fetch lengths affecting the wind set-up could be substantially longer than the effective fetch length determined as shown in **Section 5.7.3**. Therefore, the fetch length for wind set-up computations is typically taken as two (2) times the effective fetch.

The wind set-up is calculated using the following formula from Saville et al (1962):

$$S = \frac{V^2 F}{4850 D}$$

Where:

S is the rise above the still water level (i.e., the wind set-up) in m;

V is the design wind speed in m/s;

F is the fetch in km (equal to 2 times the Effective Fetch); and

D is the average water depth in the basin, along the fetch, in m.

For the CSY PCD, **Table 5-12** details the computation of the wind set-up and presents the final value to be included in the total freeboard requirements. For the purposes of determining the average depth within the basin the value was obtained from the design model for the PCD.

Table 5-12: Lafarge PCD Wind Set-up Calculations

Description	Value	Units
Design Wind Speed (1:50 year)	20	m/s
Fetch	0.079	km
Water Surface Area at FSL	1727.4	m^2
Full Supply Capacity	4000	m^3
Average Water Depth in Basin (D)	2.32	m
Wind Set-up (S)	0.00015	m

5.7.5 Total Freeboard Requirements

There are three different considerations when setting the final freeboard amount, essentially the total required freeboard is the maximum of the following values:

- 0.8 m based on GN. 704 minimum requirements and SANCOLD guidelines minimum requirements.
- Sum of factors contributing to the minimum freeboard requirements as per the SANCOLD guidelines, for the Lafarge PCD are as follows:
    - RDF = 0.29 m
    - Wind wave run-up = 0.29 m
    - Wind set-up = 0.00 m
    - Total of Combination 1 = 0.57 m

Therefore, for the CSY PCD the total design freeboard of 1.15 m exceeds the physical design requirements. **Table 4-9** included below provides a summary of the critical levels for the design of the dam.

Table 5-13: Design Levels for Lafarge CSY PCD

Description	Value	Units
FSL	1488.8	mamsl
Design NOC (Top of Access Ramp)	1489.95	mamsl
Top of Perimeter Retaining Wall	1490.5	mamsl
Design Freeboard	1.15	m

5.8 Preliminary Design Drawings

Based on the details of the design as described in the preceding sections, the preliminary design drawings are included in **Annexure B**. This annexure includes all of the preliminary design drawings, but those specific to the CSY PCD have been described in **Table 5-14** below. Typically, the drawing numbering includes various elements which describe the drawing, these are Project No. – Designer (Company) – Project Phase (e.g. P = Preliminary Design) – Locality (e.g. LCP = Lafarge Cement Plant) – Discipline (e.g. CI = Civil, ST = Structural) – Unique Drawing No. (which can be further separated by area or structure). Drawing revisions are typically letters for preliminary design phases and become numbers after detailed design and leading into construction.

Table 5-14: Preliminary Design Drawings for the CSY PCD

Drawing No.	Title	Revision
5707 – JGA – P – LCP – GA – 0001 Sheet 1 of 1	Lafarge Cement Plant Stormwater Management and Pollution Control Dams General Arrangement	RevA
5707 – JGA – P – LCP – CI – 3001 Sheet 1 of 1	Lafarge Cement Plant Coal Stockyard Pollution Control Dam Layout Plan and Sections	RevA
5707 – JGA – P – LCP – CI – 3002 Sheet 1 of 1	Lafarge Cement Plant Coal Stockyard Pollution Control Dam Subsoil Drains Layout and Sections	RevA
5707 – JGA – P – LCP – CI – 3003 Sheet 1 of 1	Lafarge Cement Plant Coal Stockyard Pollution Control Dam Perimeter Retaining Wall Details	RevA
5707 – JGA – P – LCP – CI – 3004 Sheet 1 of 1	Lafarge Cement Plant Coal Stockyard Pollution Control Dam Subsoil Drains Manhole Details	RevA

5.9 Cost Estimation

The estimated costs for the construction of the CSY PCD are included in the summary table below. A more detailed breakdown of costing in the form of an itemised BoQ has been included in **Annexure A**. It has been assumed, for the purposes of a preliminary design cost estimation that the Preliminary and General items will amount to approximately 30% of the cost of the rest of the work. An allowance of 15% for contingencies for unforeseen items and/or fluctuations in prices of certain items has also been included. As shown in **Table 5-15**, the anticipated cost of the Coal Stockyard PCD is approximately R 16.22 million (excluding VAT).

Table 5-15: Preliminary Design Cost Estimate Summary for the CSY PCD

Summary of Coal Stockyard PCD Preliminary Design Cost Estimation		
1	PRELIMINARY AND GENERAL	R 3 354 724.00
2	SMALL EARTH DAMS	R 1 717 970.00
3	LINER AND GEOTEXTILES	R 2 081 460.00
4	CONCRETE (STUCTURAL)	R 6 005 200.00
5	STRUCTURAL STEELWORK (SUNDRY ITEMS)	R 440 000.00
6	SUBSOIL DRAINAGE SYSTEM	R 472 450.00
7	ANCILLIARY WORKS	R 32 000.00
Subtotal A		**R 14 103 804.00**
Contingencies (15%)		R 2 115 570.60
Total (Excl. VAT)		**R 16 219 374.60**

6 CONSTRUCTION COST ESTIMATION

The individual summary costings for each section of the works have been presented in the induvial sections of the design report, however, **Table 6-1** below presents the overall cost estimate summary for the preliminary design. Detailed breakdowns of each element are included in **Annexure A** which contains an itemized BoQ. It is anticipated that the cost of implementing the preliminary designs for the stormwater infrastructure and the PCD's will be approximately R 78.1 million.

Table 6-1: Stormwater Infrastructure and PCD's Cost Estimate Summary

No.	Description	Amount
1	Stormwater Infrastructure: LTQ	R 7 378 784.10
2	Stormwater Infrastructure: LCP	R 10 825 542.63
3	Additives PCD	R 33 490 496.65
4	Coal Stockyard PCD	R 16 219 374.60
Total (Excl. VAT)		**R 67 914 197.98**
VAT (@ 15%)		R 10 187 129.70
Total		**R 78 101 327.68**

7 CONCLUSIONS

JG Afrika produced a stormwater management plan for the Lafarge Tswana Quarry (LTQ) and the Lafarge Cement Plant (LCP) following a previous GN.704 audit, and as an outcome of these the quarry and plant required some interventions to be fully GN.704 compliant. These interventions included new stormwater channels to be constructed as well as two new pollution control dams (PCD's). The preliminary design of this required infrastructure has been completed and is detailed within this report. Key findings of the preliminary design as detailed within this report are discussed below.

The preliminary design of the stormwater infrastructure required at the LTQ included the design of five channels. The channels were designed to be trapezoidal concrete lined with side slopes of 1V:1.5H, with the exception of channel E which has a portion of the channel grass lined, both with side slopes of 1V:3H. The selection of concrete channel lining was in order to assist with maintenance and the transport of sediment which is often contained within the stormwater runoff. Additionally, due to the flat topography of the quarry site it was necessary to reduce the slopes of the channels to an absolute minimum of 0.25% in some areas, which was necessary in order to prevent excessive channel depths and large top widths. In total the site requires approximately 1.14 km of concrete lined channel, 189 m of grass lined channel, with a short section (32 m in total) of reno-mattress lining on the channel at the start and end of the grass lined sections to provide protection against erosion, particularly at the end of the channel where the slope increases as the channel discharges into the dam. Five culverts are required to convey the water beneath roads and railways. The anticipated cost of construction of the stormwater infrastructure at the LTQ based on the preliminary design is estimated to be approximately R 7,38 million excluding VAT.

At the LCP the stormwater infrastructure required to be upgraded can be split into three sections, the additives area which requires a new PCD in addition to the stormwater infrastructure (Area E), the coal stockyard area which also requires a new PCD (Area B), and also includes the area to the south and west of both the coal stockyard and CSY PCD (Area A). All of these channels are concrete lined trapezoidal channels with 1V:1.5H side slopes. A number of culverts, nine in total, are required to convey the water beneath roads and railways.

For Area E, the stormwater infrastructure included three new channels, the first of which conveys stormwater runoff from the lime storage silos, passed the additives storage area and to the new PCD located in the south-east of the plant. The second channel conveys runoff from the additives area and joins with the first approximately 150 m before it enters the PCD. The third channel conveys dirty

water runoff from the secondary coal stockpile in the southern portion of the plant. This channel connects with an existing channel and includes two culverts underneath the plant roads. The table below provides a summary of the channels in this area and their 1:50 year design discharges.

Table 7-1: Stormwater Channels within the Cement Plant Additives Area

Channel	Catchment Area (km^2)	1:50 Year Design Rainfall (mm)	1:50 Year Peak Discharge (m^3/s)
E1	0.03	39.75	0.25
E2	0.03	42.59	0.37
E3	0.03	43.39	0.11

In Area B, new channels are required to capture dirty water runoff from the coal stockpile area. As such, the new channel essentially encircles the stockyard area and channels all the runoff water from this area underneath the road to the south of the stockyard and then under a railway line and into the new Coal Stockyard (CSY) PCD. These channels are, in total, approximately 164 m long and have a 1:50 year design discharge of 0.03 m^3/s at the entrance to the PCD.

Stormwater management Area A includes a long channel from the north near the entrance to the plant, down to the railway line running along the south of the site. Once the channel reaches the southern side of the railway line it connects to an existing grass lined trapezoidal channel. The spillway from the CSY PCD discharges into a short trapezoidal channel which connects to an existing culvert. This culvert connects to an existing channel which, after having gone through two culverts, connects into the line running from the north before going beneath the railway and connecting to the grass channel.

For the LCP the cost of the stormwater infrastructure, excluding the PCD's, is estimated to be approximately R 10.83 million excluding VAT, based on the preliminary design contained within this report.

As noted, two PCD's have been identified to be required. Although the waste classification has not yet been completed, based on the contents of the stockpiles and areas from which the runoff is flowing from to enter the PCD's the facilities are anticipated to require a Class C liner. This has been incorporated into the design of these facilities. This liner includes a layer of selected backfill material below a GCL, which has been recommended due to their being insufficient clay available on the site. Above the GCL is a 1.5 mm thick HDPE liner, which is smooth over the basins of the two PCD's and

mono-textured on the slopes of these facilities. To protect the HDPE liner and GCL from puncture, the liner design includes a 600g/m² non-woven geofabric and above this a 250 mm thick soilcrete filled geocell. This geocell layer allows for small plant such as bobcats to drive into the PCD basin to do maintenance and silt removal. The access ramps and pump sump areas of the PCD's have concrete filled geocells instead of the soilcrete to provide additional protection and longevity to these areas which have more severe loading conditions. The footprints of the return water pump stations have been indicated on the preliminary design drawings, however, the actual design of the pump stations does not form a part of the scope of works for this project.

The Additives PCD is required to have a storage capacity of 20 000m³ based on the water balance exercise. Due to the invert level of the lowest stormwater channel which brins water into the PCD, the FSL of the PCD has been set at an elevation of 1486.89 mamsl. In order to achieve the required storage capacity, the basin of the facility at its lowest point is approximately 1483.7 mamsl. The PCD is therefore, 3.2 m deep at its lowest point (below the FSL) and approximately 5.15 m deep below the surrounding NGL. Beneath the basin of the PCD a subsoil drainage system has been included in a herringbone fashion, with lateral drains spaced at 15 m intervals. These drains connect to a manhole where the subsoil drains daylight. This manhole is equipped with a return water submersible pump with an automatic float switch to ensure the subsoil drains can always drain into the manhole sump. The spillway of the PCD is connected with the access ramp but travels straight where the ramp turns up the existing road on the eastern edge of the LCP property. The spillway slopes away after this road and the channel is lined with reno-mattresses in this area to protect the channel from erosion and provide some energy dissipation before being discharged into the existing channel on the outer edge of the property. The anticipated cost of the Additives PCD is approximately R 33.49 million excl. VAT and the preliminary design drawings have been included in **Annexure B**.

The Coal Stockyard PCD was sized to be 4 000 m³ based on the water balance exercise undertaken. Due to the existing infrastructure in the area of this PCD and the invert level of the incoming stormwater channel, of 1488.83 mamsl, this targeted storage was not achievable when using an embankment type dam with side slope of 1V:3H. Therefore, the PCD has been designed with a concrete retaining wall around the perimeter of the PCD. The basin of the PCD has the same liner as described for the Additives PCD, and the access ramp slopes into the PCD at a 1:12 slope along the northern wall of the PCD, with a side slope of 1V:3H into the basin on the southern side of the access ramp. The lowest point within the PCD is at an elevation of 1485.72 mamsl, with the FSL at 1488.8 mamsl, the top of the access ramp at 1489.95 mamsl and the top of the Retaining wall at

1490.5 mamsl, the PCD is 3.08 m deep below the FSL and 4.23 m below the NOC (top of access ramp). The CSY PCD also has a subsoil drainage system below the dam basin which drains into a manhole sump at the eastern end of the PCD, with the same operational aspects as that of the Additives PCD subsoil system. A footprint for a pump station has been allowed for on the eastern edge of the PCD and can be connected with the retaining wall, or alternatively the suction lines could pass through this wall. Preliminary design drawings of the CSY PCD have been included in **Annexure B** and it is anticipated that the total cost of the facility will be approximately R 16.22 million (excl.VAT).

Using the estimated costs presented above for each elements the total anticipated cost for the stormwater and PCD infrastructure is approximately R 67.9 million excluding VAT, or R 78.1 million including VAT.

8 RECOMMENDATIONS

In order to continue further with the project it is imperative that the waste classification for the runoff from both the Additives and CSY areas are completed to finalize the liner requirements for these facilities.

Following completion of the waste classification, the next stage of the project would be to complete the Department of Water and Sanitations (DWS) liner checklist. Some additional testing is anticipated to be required for this stage, such as a swell test of the GCL in the actual leachate anticipated to be in the PCD's. Some additional testing may also be required; however, the submission will be made using whatever information is available to JG Afrika from previous projects in an attempt to speed up the process and reduce costs wherever possible.

Some additional on site testing may also be required, such as percolations tests and/or permeability tests such as a double ring infiltrometer test. Confirmation of the depth of the water table is also important for detailed design of the subsoil drainage system.

Prior to undertaking the detailed design of the two PCD's further geotechnical information will be required, this will guide the design of subsoil drain filter materials, confirm slope stabilities and factor of safeties achieved for the embankment slopes. The material properties also impact on the design of the retaining wall.

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Annexure A – Preliminary Design Engineers Cost Estimate

			Lafarge Tswana Quarry Stormwater Infrastructure					LCP: Area A					LCP: Area B					LCP: Area E			
Item	**Pay Ref.**	**Description**	**Unit**	**Qty**	**Rate**	**Amount**		**Unit**	**Qty**	**Rate**	**Amount**		**Unit**	**Qty**	**Rate**	**Amount**		**Unit**	**Qty**	**Rate**	**Amount**
	SANS 1200A	**PRELIMINARY AND GENERAL**				R 1 448 154.00					R 797 490.40					R 570 117.60					R 751 434.00
		Fixed charge items																			
1.1	8.3.1	Contractual requirements																			
1.2	8.3.2.2	Establish facilities on site for the contractor: A. Offices, storage sheds, workshop B. Communications and telephone C. Ablution facilities (showerhouse), latrines and eating premises. D. Tools, equipment and plant E. Water supply F. Electricity supply G. Laboratory (This service may be free issue by the employer and can be removed from the scope)																			
1.3	8.3.3	General responsibilities and other fixed charge items																			
1.4		Staff Inductions, badging, and other health and safety start up requirements																			
1.5	8.3.4	Remove establishment on completion, incl of exit medicals.																			
1.6	8.3.2.1	Provide furnished office of nominal size 15 m^2 for sole use of the Engineer.																			
		Time related Items																			
1.7	8.4.1	Contractual requirements																			
1.8	8.4.2.1	Operation and maintenance of Contractor's facilities on site for the engineer																			
1.9	8.4.2.2	Operation and maintenance of Contractor's facilities on site for: A. Offices, storage sheds, workshop incl. Supervisors office. B. Communications and telephone C. Ablution facilities (showerhouse), latrines and eating premises. D. Tools, equipment and plant E. Water supply F. Electricity supply G. Survey assistants and material H. Laboratory (This service may be free issue by the Employer and can be removed from the scope)																			
1.10	8.4.3	Supervision for the duration of the contract																			
1.11	8.4.5	General responsibilities and other time related obligations																			
1.12		Management of construction regulations and Lafarge specific health and safety requirements, incl risk assessments, plant inspections, safety officer etc.																			
		Temporary Works																			
1.13	8.8.1	Construct and maintain haul roads on site.																			
1.14		Special Requirements																			
		A. Supply of survey to Engineer in approved electronic format. Survey provided at initial, after topsoil stripping, and final levels. (if required)	Sum	1	R 25 000.00	R 25 000.00		Sum	1	R 25 000.00	R 25 000.00										
	PB1.4.6.2	B. Allowance for 3rd party testing of geosynthetic materials to be used on site	PSum	1	**R 15 000.00**	**R 15 000.00**		PSum	1	**R 15 000.00**	**R 15 000.00**										
	1200 A 8.7	C. Excavate test pits or trial holes as per Engineer's request with Cat 225 excavator or similar, backfill with same.	PSum	1	R 11 000.00	R 11 000.00		PSum	1	R 11 000.00	R 11 000.00										
		D. Provisional allowance for unmeasured items and site Instructions	Psum	1	**R 90 000.00**	**R 90 000.00**		Psum	1	**R 90 000.00**	**R 90 000.00**		Psum	1	**R 90 000.00**	**R 90 000.00**					
		CARRIED TO FINAL SUMMARY				**R 1 589 154.00**					**R 938 490.40**					**R 660 117.60**					**R 751 434.00**

			Lafarge Tswana Quarry Stormwater Infrastructure				LCP: Stormwater Management Area A				LCP: Stormwater Management Area B				LCP: Stormwater Management Area E			
Item	**Pay Ref.**	**Description**	**Unit**	**Qty**	**Rate**	**Amount**	**Unit**	**Qty**	**Rate**	**Amount**	**Unit**	**Qty**	**Rate**	**Amount**	**Unit**	**Qty**	**Rate**	**Amount**
4		**Storm Water Management**																
		Site Clearance																
4.1	1200 C 8.2.1	Clear & grub to stormwater management infrastructure footprint.																
		A. Concrete Trenches	m^2	17 070	R 11.00	R 187 770.00	m^2	5 950	11.00	R 65 450.00	m^2	4 380	11.00	R 48 180.00	m^2	7 400	11.00	R 81 400.00
		B. Reno mattress and Gabion channel	m^2	230	R 11.00	R 2 530.00	m^2		11.00	R -	m^2		11.00	R -	m^2		11.00	R -
		C. Reno mattress and Gabion energy dissipation structure	m^2	10	R 11.00	R 110.00	m^2		11.00	R -	m^2		11.00	R -	m^2		11.00	R -
4.2	1200 C 8.2.10	Strip 150 mm topsoil and stockpile for reuse.	m^3	2 600	R 33.00	R 85 800.00	m^3	900	33.00	R 29 700.00	m^3	660	33.00	R 21 780.00	m^3	1 110	33.00	R 36 630.00
		Earthworks																
4.3	1200 DA 8.3.1 (b)	Excavate in all materials, for re-use in PCD upstream embankment, diversion berm or spoil locally. For:																
		A. Concrete Trapezoidal Trench	m^3	9 870	R 137.00	R 1 352 190.00	m^3	4 624	137.00	R 633 488.00	m^3	1 302	137.00	R 178 374.00	m^3	4 050	137.00	R 554 850.00
		B. Reno mattress and Gabion channel	m^3	530	R 137.00	R 72 610.00	m^3		137.00	R -	m^3		137.00	R -	m^3		137.00	R -
		C. Reno mattress and Gabion energy dissipation structure	m^3	10	R 44.00	R 440.00	m^3		44.00	R -	m^3		44.00	R -	m^3		44.00	R -
		D. Pipe/ Box Culverts	m^3	500	R 44.00	R 22 000.00	m^3	205	44.00	R 9 020.00	m^3	22	44.00	R 968.00	m^3	120	44.00	R 5 280.00
4.4	1200 DA 8.3.7	Grassing of embankments or channel, using sods	m^2	14 610	R 60.00	R 876 600.00	m^2	5 201	60.00	R 312 060.00	m^2	2 030	60.00	R 121 800.00	m^2	5 300	60.00	R 318 000.00
		Concrete																
4.5	1200 GA 8.4.3	Supply and place 25 MPa concrete for lined channel. To be constructed at falls and inverts as indicated on drawings. Price to include soft board joint and 500mm wide non-woven geofabric (GRI GT13, class 2) strip every 3 m.																
		A. New Concrete trenches	m^3	275	R 3 400.00	R 935 000.00	m^3	77	3 400.00	R 261 800.00	m^3	238	3 400.00	R 809 200.00	m^3	222	3 400.00	R 754 800.00
4.6	1200 GA 8.4.3	Supply and place 25 MPa concrete																
		A. Culvert wing walls, approach slabs, and between rectangular culvert units.	m^3	8	R 3 400.00	R 27 200.00	m^3	13	3 400.00	R 44 200.00	m^3	3	3 400.00	R 10 200.00	m^3	3	3 400.00	R 10 200.00
		B. Reinstate concrete road above culvert	m^3		R 3 400.00	R -	m^3	14	3 400.00	R 47 600.00	m^3		3 400.00	R -	m^3	6	3 400.00	R 20 400.00
4.7	1200 G 8.3.1	Steel reinforcement to above																
		A. High tensile bars (all diameters)	kg	900	R 28.00	R 25 200.00	kg	3 130	28.00	R 87 640.00	kg	350	28.00	R 9 800.00	kg	1 060	28.00	R 29 680.00
4.8	1200 GA 8.3.2	#395 steel reinforment mesh to concrete trenches	m^2	2 690	R 110.00	R 295 900.00	m^2	748	110.00	R 82 280.00	m^2	1 573	110.00	R 173 030.00	m^2	2 100	110.00	R 231 000.00
4.9	1200 GA 8.2.2	Smooth formwork (vertical):																
		A. Culvert wingwalls	m^2	32	R 100.00	R 3 200.00	m^2	72	100.00	R 7 200.00	m^2	13	100.00	R 1 300.00	m^2	19	100.00	R 1 900.00
		B. Channels	m^2	1 220	R 100.00	R 122 000.00	m^2	1 241	100.00	R 124 100.00	m^2	1 167	100.00	R 116 700.00	m^2	985	100.00	R 98 500.00
4.10		Sawing existing concrete: Road surface for culvert	m^2		R 100.00	R -	m^2	93	100.00	R 9 333.33	m^2		100.00	R -	m^2	40	100.00	R 4 000.00
		Gabions and Reno Mattress																
4.11	1200 DK 8.2.1 (a)	Surface preparation for bedding of gabions and reno mattress in solution trench, Cavities filled with approved excavated material or rock	m^2	230	R 17.00	R 3 910.00	m^2	30	17.00	R 510.00	m^2		17.00	R -	m^2	20	17.00	R 340.00
4.12	1200 DK 8.2.4	Supply and place non-woven geotextile (GRI-GT13, class 2) backing to gabion and reno mattress channels.	m^2	280	R 44.00	R 12 320.00	m^2	40	44.00	R 1 760.00	m^2		44.00	R -	m^2	20	44.00	R 880.00
4.13	1200 DK 8.2.2	Supply and place erosion protection to channel down chutes and energy dissipation structures. Supply and construct reno mattresses for channel lining. Clean rockfill of min 70 mm to max 100 mm to be placed in:																
		A. 0.3 m thick galvanised reno mattress	m^3	71	R 950.00	R 67 450.00	m^3	8	950.00	R 7 600.00	m^3		950.00	R -	m^3	8	950.00	R 7 600.00
4.14	1200 L 8.2.14	Precast concrete manhole to act as drop inlet, including excavation, mesh reinforced concrete base, grouted precast concrete rings with cast iron step irons, grid and frame, cover slab, inlet lid, including manhole cover and frame, suitable channel pipe in 1:3 cement mortar benching, required holes through sides with concrete backing and seal detail.																
		A. 1.0 m dia, of depth not exceeding 4.0 m.	No	5	R 66 000.00	R 330 000.00	No	3	66 000.00	R 198 000.00	No	5	66 000.00	R 330 000.00	No	1	66 000.00	R 66 000.00

			Lafarge Tswana Quarry Stormwater Infrastructure					LCP: Area A					LCP: Area B					LCP: Area E			
Item	**Pay Ref.**	**Description**	**Unit**	**Qty**	**Rate**	**Amount**		**Unit**	**Qty**	**Rate**	**Amount**		**Unit**	**Qty**	**Rate**	**Amount**		**Unit**	**Qty**	**Rate**	**Amount**
		Culverts																			
4.15	1200LB 8.2.2.3	Supply and place selected granular material from commercial source suitable for a Class B bedding to:																			
		A. 750 mm dia, 100D	m^3	20	R 825.00	R 16 500.00		m^3		825.00	R -		m^3		825.00	R -		m^3		825.00	R -
4.16	1200LE 8.2.1	Supply and lay concrete pipe culverts on selected Class B Bedding (bedding priced separately)																			
		A. 750 mm dia, 100D	m	25	R 1 650.00	R 41 250.00		m		1 650.00	R -		m		1 650.00	R -		m		1 650.00	R -
4.17	SANS 1200LE 8.2.2	Supply and lay concrete portal rectangular culverts including base slab on Class B bedding (bedding included in this item) of sizes and class:																			
		A. 0.3 m deep x 0.45 m wide, class 200 S	m	102	R 1 800.00	R 183 600.00		m	33	1 800.00	R 59 400.00		m		1 800.00	R -		m	53	1 800.00	R 95 400.00
		B. 0.3 m deep x 0.6 m wide, class 200 S	m		R 2 100.00	R -		m		2 100.00	R -		m		2 100.00	R -		m		2 100.00	R -
		C. 0.6 m deep x 0.6 m wide, box culvert, class 200 S	m		R 2 800.00	R -		m	26	2 800.00	R 72 800.00		m		2 800.00	R -		m		2 800.00	R -
		D. 0.6 m deep x 0.9 m wide, box culvert, class 175 S	m		R 3 300.00			m		3 300.00	R -		m		3 300.00	R -		m	14	3 300.00	R 46 200.00
		E. 0.6 m deep x 0.45 m wide, class 200 S	m		R 2 500.00	R -		m	41	2 500.00	R 102 500.00		m		2 500.00	R -		m		2 500.00	R -
		F. 0.45 m deep x 0.45 m wide, class 200 S	m		R 1 900.00	R -		m	250	1 900.00	R 475 000.00		m	30	1 900.00	R 57 000.00		m		1 900.00	R -
		G. 0.45 m deep x 0.60 m wide, class 200 S	m	30	R 2 500.00	R 75 000.00		m		2 500.00	R -		m		2 500.00	R -		m	45	2 500.00	R 112 500.00
4.18	SANS 1200 LE 8.2.3	Extra over item 4.18 for supplying end units for rectangular portal culverts (SANS 986) with a Skew of more than 20°:																			
		A. 0.3 m deep x 0.45 m wide, class 200 S	No.		R 5 000.00	R -		No.		5 000.00	R -		No.		5 000.00	R -		No.		5 000.00	R -
		B. 0.3 m deep x 0.6 m wide, class 200 S	No.		R 5 000.00	R -		No.		5 000.00	R -		No.		5 000.00	R -		No.	2	5 000.00	R 10 000.00
		C. 0.6 m deep x 0.6 m wide, box culvert, class 200 S	No.		R 5 000.00	R -		No.		5 000.00	R -		No.		5 000.00	R -		No.		5 000.00	R -
		D. 0.6 m deep x 0.9 m wide, box culvert, class 175 S	No.		R 5 000.00	R -		No.		5 000.00	R -		No.		5 000.00	R -		No.		5 000.00	R -
		E. 0.6 m deep x 0.45 m wide, class 200 S	No.		R 5 000.00	R -		No.		5 000.00	R -		No.		5 000.00	R -		No.		5 000.00	R -
		F. 0.6 m deep x 0.45 m wide, class 200 S	No.		R 5 000.00	R -		No.		5 000.00	R -		No.		5 000.00	R -		No.		5 000.00	R -
		G. 0.45 m deep x 0.45 m wide, class 200 S	No.		R 5 000.00	R -		No.		5 000.00	R -		No.	3	5 000.00	R 15 000.00		No.		5 000.00	R -
4.19	SANS 1200 LE 8.2.4	Extra over item 4.17 for cutting end units for culverts on site																			
		A. Straight cut	No.	1	R 4 000.00	R 4 000.00		No.	1	4 000.00	R 4 000.00		No.	1	4 000.00	R 4 000.00		No.		4 000.00	R -
		B. Skew cut	No.		R 5 000.00	R -		No.		5 000.00	R -		No.		5 000.00	R -		No.	1	5 000.00	R 5 000.00
4.20	1200 DM 8.3.1.6	Reinstate road layer works from excavations to gravel road above																			
		A. 750 mm dia, 100D	m^3	410	R 180.00	R 73 800.00		m^3		180.00	R -		m^3		180.00	R -		m^3		180.00	R -
		B. 0.3 m deep x 0.45 m wide, class 200 S	m^3	40	R 180.00	R 7 200.00		m^3	26	180.00	R 4 680.00		m^3		180.00	R -		m^3	21	180.00	R 3 780.00
		C. 0.3 m deep x 0.6 m wide, class 200 S	m^3		R 180.00	R -		m^3		180.00	R -		m^3		180.00	R -		m^3		180.00	R -
		D. 0.6 m deep x 0.6 m wide, box culvert, class 200 S	m^3		R 180.00	R -		m^3	31	180.00	R 5 580.00		m^3		180.00	R -		m^3		180.00	R -
		E. 0.6 m deep x 0.9 m wide, box culvert, class 175 S	m^3		R 180.00	R -		m^3		180.00	R -		m^3		180.00	R -		m^3	30	180.00	R 5 400.00
		F. 0.6 m deep x 0.45 m wide, class 200 S	m^3		R 180.00	R -		m^3	14	180.00	R 2 520.00		m^3		180.00	R -		m^3		180.00	R -
		G. 0.45 m deep x 0.45 m wide, class 200 S	m^3		R 180.00	R -		m^3	56	180.00	R 10 080.00		m^3	17	180.00	R 3 060.00		m^3		180.00	R -
		H. 0.45 m deep x 0.60 m wide, class 200 S	m^3	20	R 180.00	R 3 600.00		m^3		180.00	R -		m^3		180.00	R -		m^3	28	180.00	R 5 040.00
		CARRIED TO FINAL SUMMARY				**R 4 827 180.00**					**R 2 658 301.33**					**R 1 900 392.00**					**R 2 504 780.00**

Stormwater Management Infrastructure						
Cost Estimate Summary		**Lafarge Tswana Quarry**	**LCP: Area A**	**LCP: Area B**	**LCP: Area E**	**Total**
No.	**Description**	**Amount**	**Amount**	**Amount**	**Amount**	**Amount**
1	Preliminary & General	R 1 589 154.00	R 938 490.40	R 660 117.60	R 751 434.00	R 3 939 196.00
2	Stormwater Management	R 4 827 180.00	R 2 658 301.33	R 1 900 392.00	R 2 504 780.00	R 11 890 653.33
Subtotal A		**R 6 416 334.00**	**R 3 596 791.73**	**R 2 560 509.60**	**R 3 256 214.00**	**R 15 829 849.33**
Contingencies (15%)		R 962 450.10	R 539 518.76	R 384 076.44	R 488 432.10	R 2 374 477.40
Subtotal B		**R 7 378 784.10**	**R 4 136 310.49**	**R 2 944 586.04**	**R 3 744 646.10**	**R 18 204 326.73**
VAT		R 1 106 817.62	R 620 446.57	R 441 687.91	R 561 696.92	R 2 730 649.01
TOTAL		**R 8 485 601.72**	**R 4 756 757.07**	**R 3 386 273.95**	**R 4 306 343.02**	**R 20 934 975.74**

PRELIMINARY DESIGN COST ESTIMATION FOR THE ADDITIVES PCD

Item	Pay Ref.	Description	Unit	Qty	Rate	Amount
100	SANS 1200A	**PRELIMINARY AND GENERAL**				R 6 690 501.00
101		Fixed Charge Items				
101.1	8.3.1	Contractual requirements	Sum	1		
101.2	8.3.2.1	Facilities for the Engineer:				
a		Provide furnished office of nominal size 15 m^2 for sole use of the Engineer.	Sum	1		
101.3	8.3.2.2	Establish facilities on site for the contractor:	Sum	1		
a		Offices, storage sheds, workshop	Sum	1		
b		Communications and telephone	Sum	1		
c		Ablution facilities (showerhouse), latrines and eating premises.	Sum	1		
d		Tools, equipment and plant	Sum	1		
e		Water supply	Sum	1		
f		Electricity supply	Sum	1		
g		Laboratory (This service may be free issue by the employer and can be removed from the scope)	Sum	1		
101.4	8.3.3	General responsibilities and other fixed charge items	Sum	1		
101.5		Staff Inductions, badging, and other health and safety start up requirements	Sum	1		
101.6	8.3.4	Remove establishment on completion, incl of exit medicals.	Sum	1		
102		Time Related Items				
102.1	8.4.1	Contractual requirements	Sum	1		
102.2	8.4.2.1	Operation and maintenance of Contractor's facilities on site for the engineer	Sum	1		
102.3	8.4.2.2	Operation and maintenance of Contractor's facilities on site for:				
a		Offices, storage sheds incl. Supervisors office.	Sum	1		
b		Workshops	Sum	1		
c		Laboratory	Sum	1		
d		Ablution facilities (showerhouse), latrines and eating premises	Sum	1		
f		Tools, equipment and plant	Sum	1		
g		Water supplies, electric power and communication	Sum	1		
102.4	8.4.3	Supervision for the duration of the contract	Sum	1		
102.5	8.4.5	General responsibilities and other time related obligations	Sum	1		
103	8.8	Temporary Works				
103.1	8.8.1	Construct and maintain haul roads on site.	Sum	1		
103.2	8.8.4	Protection and Discovery of Existing Services	Sum	1		
103.3	8.8.6	Allowance for Ongoing Water Management during the construction	PSum	1	R 50 000.00	R 50 000.00
104		Special Requirements				
a		Supply of survey to Engineer in approved electronic format. Survey provided at initial, after topsoil stripping, and final (as-built) levels.	Sum	1	R 50 000.00	R 50 000.00
b	PB1.4.6.2	Allowance for 3rd party testing of geosynthetic materials to be used on site	Psum	1	R 15 000.00	R 15 000.00
c	8.7	Excavate test pits or trial holes as per Engineer's request with Cat 225 excavator or similar, backfill with same.	hours	10	R 1 500.00	R 15 000.00
d	8.5	Provisional allowance for unmeasured items and site Instructions	Psum	1		R -
		CARRIED TO FINAL SUMMARY			**R**	**6 820 501.00**

Item	Pay Ref.	Description	Unit	Qty	Rate	Amount
200	SANS 1200DE	**SMALL EARTH DAMS**				
201	8.3.1	Site Clearance				
201.1	8.3.1.1	Clear & strip site to Pollution Control Dam, access ramp and spillway footprint. Rate to include disposal.	m^2	16 500	R 15.00	R 247 500.00
201.2	8.3.1.2 a	Remove and grub large trees and tree stumps of girth in excess of 1 m and up to and including 2 m	No.		R 1 000.00	R -
201.3	8.3.1.4	Remove and recover existing fence as required and reinstate at end	m	30	R 50.00	R 1 500.00
201.4	8.3.1.6	Load, haul and spoil carbonaceous silt within PCD basin to designated disposal area, to be confirmed by Lafarge, within 1 km free haul distance.	m^3	Rate Only	R 50.00	
201.5	8.3.8	Allowance for overhaul, beyond 1 km free haul distance to Items as required.	m^3.km	Rate Only	R 10.00	
202	8.3.2	Remove Topsoil to Nominal Depth of 150 mm, Stockpile and Maintain	m^3	2 470	R 50.00	R 123 500.00
203	8.3.3	Excavation				
203.1	8.3.3 a	Excavate in all materials not suitable for use in the PCD embankment and spoil in designated area to be confirmed by Lafarge. Allow for 1km fee haul	m^3	42 320	R 80.00	R 3 385 600.00
203.2	8.3.3 b	Excavate in all materials and stockpile for reuse in PCD embankment or backfill	m^3	4 710	R 80.00	R 376 800.00
203.3	8.3.3 c	Extra over for excavation in:				
a		Intermediate material	m^3	38 790	R 90.00	R 3 491 100.00
b		Hard rock material	m^3	5 180	R 450.00	R 2 331 000.00
203.4	8.3.5 a	Selected backfill to be placed in layers not exceeding 150mm to final levels and compacted to 95% std. proctor at -2% to +2% OMC.				
a		Spillway channel	m^3	130	R 100.00	R 13 000.00
b		Crest	m^3	160	R 100.00	R 16 000.00
203.5	8.3.5 a	Allowance for 100 mm layer of selected material to be placed within PCD basin to allow for over-blast and achieve final levels and suitable surface for GCL. Material to be compacted to 98% Std. Proctor @ -2% to +2% OMC in layers not exceeding 150mm	m^3	1 100	R 120.00	R 132 000.00
203.6	8.3.5 h	Load, haul, place and compact 150mm wearing course layer of selected ferricrete (or specified by the Engineer), compacted to 93 % Mod AASHTO density to the crest.	m^3	240	R 75.00	R 18 000.00
203.7	8.3.9 a	Apply topsoil from stockpile, grass seeding and watering to:				
a		Crest and excavated area around crest	m^2	2 220	R 10.00	R 22 200.00
b		Excavations above spillway channel	m^2	770	R 10.00	R 7 700.00
203.8	8.3.9 b	Apply suitable seed to topsoiled area:				
a		Crest and excavated area around crest	m^2	2 220	R 10.00	R 22 200.00
b		Excavations above spillway channel	m^2	770	R 10.00	R 7 700.00
203.9	8.3.9 c	Watering to topsoiled and seeded areas:				
a		Crest and excavated area around crest	m^2	2 220	R 10.00	R 22 200.00
b		Excavations above spillway channel	m^2	770	R 10.00	R 7 700.00
NS 1200	SMALL EARTH DAMS	**CARRIED TO FINAL SUMMARY**			**R**	**10 225 700.00**

Item	Pay Ref.	Description	Unit	Qty	Rate	Amount
300	PB XX	**LINER AND GEOTEXTILES**				
301		Geosynthetic Clay Liner				
301.1		Supply and deliver to site Geosynthetic Clay Liner (GCL) as per specification. Measurement includes anchor trenches but excludes wastage and overlaps.	m^2	12 750	R 75.00	R 956 250.00
301.2		Installation of GCL to PCD. Measurement excludes wastage, overlaps and bentonite paste requirements.	m^2	12 750	R 15.00	R 191 250.00
302		HDPE Liner				
302.1		Supply and deliver to site 1.5 mm smooth HDPE liner as per specification for PCD base. Measurement includes anchor trenches but excludes wastage and overlaps.				
a		Foreign Currency component.	m^2	6 430	R 85.00	R 546 550.00
b		Local Currency component.	m^2	6 430	R 15.00	R 96 450.00
c		Extra over for forward cover bank charges etc. for fixing of tender prices against currency fluctuations.	Sum	1	R 64 300.00	R 64 300.00
302.2		Supply and deliver to site 1.5 mm single textured HDPE liner as per specification for PCD base. Measurement includes anchor trenches but excludes wastage and overlaps.				
a		Foreign Currency component.	m^2	6 320	R 90.00	R 568 800.00
b		Local Currency component.	m^2	6 320	R 20.00	R 126 400.00
c		Extra over for forward cover bank charges etc. for fixing of tender prices against currency fluctuations.	Sum	1	R 69 520.00	R 69 520.00
302.3		Installation of 1.5 mm HDPE geomembrane liner to PCD. Measurement excludes wastage and overlaps.	m^2	12 750	R 15.00	R 191 250.00
302.4		Supply and install 316 stainless steel batten detail, including butyl rubber gaskets, approved epoxy anchors and adhesive sealant to all concrete-HDPE connections.	m		R 1 250.00	R -
303		Protection Geotextiles				
303.1		Supply and install 250 mm high geocell within PCD, Access Ramp, Spillway. Cells to be filled with soilcrete to both basin and side slopes. Material to receive nominal compaction. Rate to include all non-destructive anchoring	m^2	14 260	R 100.00	R 1 426 000.00
303.2		Supply and place 5MPa soilcrete as geocell infill to basin and side slopes. Material to be placed from the basin upwards and to receive nominal compaction.	m^3	2 930	R 1 800.00	R 5 274 000.00
303.3		Supply and place 10MPa concrete as geocell infill to basin pump sump area.	m^3	460	R 2 000.00	R 920 000.00
303.4		Supply, deliver and install 600g/m² non-woven protection geotextile as per specification for PCD. Measurement excludes wastage and overlaps.	m^2	12 750	R 50.00	R 637 500.00
304		Access Ramp				
304.1		Supply, deliver and install 30/30 geogrid to site as per specification. Measurement includes anchor trenches but excludes wastage and overlaps.	m^2	710	R 110.00	R 78 100.00
305		Anchor Trenches				
305.1		Backfill with selected material to anchor trenches and compact by hand to 90% Mod. AASHTO at 0 - +2% OMC	m^3	170	R 75.00	R 12 750.00
305.2		Backfill of anchor trench below external spillway (after road crossing) with Soilcrete to anchor trench and compact by hand.	m^3	4	R 1 800.00	R 7 200.00
305.3		Allowance for temporary sandbags (UV stable filled with approved sand) to prevent wind damage.	PSum	1	R 35 000.00	R 35 000.00
PB XX	LINER AND GEOTEXTILES	**CARRIED TO FINAL SUMMARY**			**R**	**11 201 320.00**

Item	Pay Ref.	Description	Unit	Qty	Rate	Amount
400	SANS 1200 DK	**GABIONS AND PITCHING**				
401	8.2.1	Surface Preparation for Bedding of Gabions				
401.1		Cavities filled with approved excavated material or rock	m^2	190	R 50.00	R 9 500.00
402	8.2.2	Gabions				
402.1		Reno-mattresses of PVC Coated Double Twisted Woven Heaxagonal Mesh of Steel Wire Galvanised, 2m Long by 1m Wide by 0.3m deep; Packed with stones of size 70-120mm	m^3	57	R 1 500.00	R 85 500.00
403	8.2.4	Geotextile				
403.1		Non-woven geotextile (GRI-GT13, class 2) backing to Spillway Reno Mattress energy dissipation	m^2	210	R 50.00	R 10 500.00
SANS 1200 DK	GABIONS AND PITCHING	**CARRIED TO FINAL SUMMARY**			**R**	**105 500.00**

Item	Pay Ref.	Description	Unit	Qty	Rate	Amount
500	SANS 1200 L	**SUBSOIL DRAINAGE SYSTEM**				
501	8.2.1	Supply Lay and Bed Pipes Complete with Couplings				
501.1		Supply and install 160 mm slotted HDPE Drainex pipes with solid base facing down to toe drain mainlines.	m	470	R 150.00	R 70 500.00
501.2		Supply and install 160 mm slotted HDPE Drainex pipes with solid base facing down to toe drain laterals.	m	370	R 150.00	R 55 500.00
501.3		Supply and install 160 mm solid HDPE pipes from junction to manhole.	m	21	R 150.00	R 3 150.00
501.4	PC 2.7.1.1	Supply and fit 50 mm dia HDPE PE100 PN16 outlet pipe from subsoil sump pump to nominated point on dam wall. Pricing to include butt welding.	m	26	R 150.00	R 3 900.00
501.5	PC 2.7.1.2	Pressure testing of HDPE piping, including supply of all temporary fittings, water, and removal thereof, to 50 mm dia HDPE PN16, sub-soil return pipe.	Sum	1	R 3 500.00	R 3 500.00
502	8.2.14	Manholes				
502.1		Precast concrete manholes to detail, including excavation, mesh reinforced concrete base, grouted precast concrete rings with cast iron step irons, cover slab with grating lid, locking device suitable for and including manhole cover and frame, suitable channel pipe in 1:3 cement mortar benching, required holes through sides with concrete backing and seal detail.	No	1	R 200 000.00	R 200 000.00
502.2	1200 A 8.5 a	Provisional sum for contractor to purchase, install and commission submersible pump(s) in subsoil manhole (1 x KSB Amadrainer B 80-40 S or similar approved pump). Price to include control valve, level sensor(s), control box, duty pump and standby pump. Exact pump requirements to be confirmed prior to placing order.	Psum	1	R 160 000.00	R 160 000.00
503		Toe-Drain Bedding and Filter				
503.1	PC 3.6.1.3	Supply and place clean washed filter sand from commercial source per approved gradings to toe drain.	m^3	260	R 675.00	R 175 500.00
503.2		Supply and place pea gravel from commercial source per approved gradings to toe drain.	m^3	62	R 800.00	R 49 600.00
SANS 1200 L	SUBSOIL DRAINAGE SYSTEM	**CARRIED TO FINAL SUMMARY**			**R**	**721 650.00**

Item	Pay Ref.	Description	Unit	Qty	Rate	Amount
600	SANS 1200 MM	**ANCILLIARY WORKS**				
601	8.3.1	Warning signs supplied and erected complete, including supports, excavation, concreting and backfilling: min size 600mm x 600mm steel backing on steel frame.				
601.1		Sump contents & hazard rating	No	2	R 2 000.00	R 4 000.00
601.2		"No Entry Without Permit"	No	2	R 2 000.00	R 4 000.00
602		Lifebouys / floats mounted in UV stable protective boxes mounted on steel posts.	No	4	R 6 000.00	R 24 000.00
603		20 m long UV stable safety ropes knotted at 300 mm centres connected to 0.5 x 0.5 x 0.5m concrete ballast block on top and base of dam.	No	5	R 3 100.00	R 15 500.00
SANS 1200 MM	ANCILLIARY WORKS	**CARRIED TO FINAL SUMMARY**			**R**	**47 500.00**

PRELIMINARY DESIGN COST ESTIMATION FOR THE ADDITIVES PCD

Final Summary		**Additives PCD**	
1	PRELIMINARY AND GENERAL	R	6 820 501.00
2	SMALL EARTH DAMS	R	10 225 700.00
3	LINER AND GEOTEXTILES	R	11 201 320.00
4	GABIONS AND PITCHING	R	105 500.00
5	SUBSOIL DRAINAGE SYSTEM	R	721 650.00
6	ANCILLIARY WORKS	R	47 500.00
Subtotal A		R	29 122 171.00
Contingencies (15%)		R	4 368 325.65
Subtotal B		R	33 490 496.65
VAT		R	4 368 325.65
TOTAL		**R**	**37 858 822.30**

PRELIMINARY DESIGN COST ESTIMATION FOR THE COAL STOCKYARD PCD

Item	Pay Ref.	Description	Unit	Qty	Rate	Amount
100	SANS 1200A	**PRELIMINARY AND GENERAL**				R 3 224 724.00
101		Fixed Charge Items				
101.1	8.3.1	Contractual requirements	Sum	1		
101.2	8.3.2.1	Facilities for the Engineer:				
a		Provide furnished office of nominal size 15 m^2 for sole use of the Engineer.	Sum	1		
101.3	8.3.2.2	Establish facilities on site for the contractor:	Sum	1		
a		Offices, storage sheds, workshop	Sum	1		
b		Communications and telephone	Sum	1		
c		Ablution facilities (showerhouse), latrines and eating premises.	Sum	1		
d		Tools, equipment and plant	Sum	1		
e		Water supply	Sum	1		
f		Electricity supply	Sum	1		
g		Laboratory (This service may be free issue by the employer and can be removed from the scope)	Sum	1		
101.4	8.3.3	General responsibilities and other fixed charge items	Sum	1		
101.5		Staff Inductions, badging, and other health and safety start up requirements	Sum	1		
101.6	8.3.4	Remove establishment on completion, incl of exit medicals.	Sum	1		
102		Time Related Items				
102.1	8.4.1	Contractual requirements	Sum	1		
102.2	8.4.2.1	Operation and maintenance of Contractor's facilities on site for the engineer	Sum	1		
102.3	8.4.2.2	Operation and maintenance of Contractor's facilities on site for:				
a		Offices, storage sheds incl. Supervisors office.	Sum	1		
b		Workshops	Sum	1		
c		Laboratory	Sum	1		
d		Ablution facilities (showerhouse), latrines and eating premises	Sum	1		
f		Tools, equipment and plant	Sum	1		
g		Water supplies, electric power and communication	Sum	1		
102.4	8.4.3	Supervision for the duration of the contract	Sum	1		
102.5	8.4.5	General responsibilities and other time related obligations	Sum	1		
103	8.8	Temporary Works				
103.1	8.8.1	Construct and maintain haul roads on site.	Sum	1		
103.2	8.8.4	Protection and Discovery of Existing Services	Sum	1		
103.3	8.8.6	Allowance for Ongoing Water Management during the construction	PSum	1	R 50 000.00	R 50 000.00
104		Special Requirements				
a		Supply of survey to Engineer in approved electronic format. Survey provided at initial, after topsoil stripping, and final (as-built) levels.	Sum	1	R 50 000.00	R 50 000.00
b	PB1.4.6.2	Allowance for 3rd party testing of geosynthetic materials to be used on site	Psum	1	R 15 000.00	R 15 000.00
c	8.7	Excavate test pits or trial holes as per Engineer's request with Cat 225 excavator or similar, backfill with same.	hours	10	R 1 500.00	R 15 000.00
d	8.5	Provisional allowance for unmeasured items and site Instructions	Psum	1		R -
		CARRIED TO FINAL SUMMARY			**R**	**3 354 724.00**

Item	Pay Ref.	Description	Unit	Qty	Rate	Amount
200	SANS 1200DE	**SMALL EARTH DAMS**				
201	8.3.1	Site Clearance				
201.1	8.3.1.1	Clear & strip site to Pollution Control Dam, access ramp and spillway footprint. Rate to include disposal.	m^2	3 410	R 15.00	R 51 150.00
201.2	8.3.1.2 a	Remove and grub large trees and tree stumps of girth in excess of 1 m and up to and including 2 m	No.	0	R 1 000.00	R -
201.3	8.3.1.4	Remove and recover existing fence as required and reinstate at end	m	60	R 50.00	R 3 000.00
201.4	8.3.1.6	Load, haul and spoil carbonaceous silt within PCD basin to designated disposal area, to be confirmed by Lafarge, within 1 km free haul distance.	m^3	Rate Only	R 50.00	
201.5	8.3.8	Allowance for overhaul, beyond 1 km free haul distance to Items as required.	$m^3.km$	Rate Only	R 10.00	
202	8.3.2	Remove Topsoil to Nominal Depth of 150 mm, Stockpile and Maintain	m^3	520	R 50.00	R 26 000.00
203	8.3.3	Excavation				
203.1	8.3.3 a	Excavate in all materials not suitable for use in the PCD embankment and spoil in designated area to be confirmed by Lafarge. Allow for 1km fee haul	m^3	10 090	R 80.00	R 807 200.00
203.2	8.3.3 b	Excavate in all materials and stockpile for reuse in PCD embankment or backfill	m^3	3 950	R 80.00	R 316 000.00
203.3	8.3.3 c	Extra over for excavation in:				
a		Intermediate material	m^3	2 963	R 90.00	R 266 670.00
b		Hard rock material	m^3	395	R 450.00	R 177 750.00
203.4	8.3.5 a	Selected backfill to be placed in layers not exceeding 150mm to final levels and compacted to 95% std. proctor at -2% to +2% OMC.				
a		Upstream embankment and access ramp	m^3	9	R 100.00	R 900.00
b		Crest	m^3	0	R 100.00	R -
c		Spillway channel	m^3	12	R 100.00	R 1 200.00
203.5	8.3.5 a	Allowance for 100 mm layer of selected material to be placed within PCD basin to allow for over-blast and achieve final levels and suitable surface for GCL. Material to be compacted to 98% Std. Proctor @ -2% to +2% OMC in layers not exceeding 150mm	m^3	210	R 120.00	R 25 200.00
203.6	8.3.5 h	Load, haul, place and compact 150mm wearing course layer of selected ferricrete (or specified by the Engineer), compacted to 93 % Mod AASHTO density to the crest.	m^3	0	R 75.00	R -
203.7	8.3.9 a	Apply topsoil from stockpile, grass seeding and watering to:				
a		Excavated area around crest	m^2	1 390	R 10.00	R 13 900.00
b		Excavations above spillway channel	m^2	40	R 10.00	R 400.00
203.8	8.3.9 b	Apply suitable seed to topsoiled area:				
a		Crest and excavated area around crest	m^2	1 390	R 10.00	R 13 900.00
b		Excavations above spillway channel	m^2	40	R 10.00	R 400.00
203.9	8.3.9 c	Watering to topsoiled and seeded areas:				
a		Crest and excavated area around crest	m^2	1 390	R 10.00	R 13 900.00
b		Excavations above spillway channel	m^2	40	R 10.00	R 400.00
ANS 1200I	SMALL EARTH DAMS	**CARRIED TO FINAL SUMMARY**			**R**	**1 717 970.00**

Item	Pay Ref.	Description	Unit	Qty	Rate	Amount
300	PB XX	**LINER AND GEOTEXTILES**				
301		Geosynthetic Clay Liner				
301.1		Supply and deliver to site Geosynthetic Clay Liner (GCL) as per specification. Measurement includes anchor trenches but excludes wastage and overlaps.	m^2	2 030	R 75.00	R 152 250.00
301.2		Installation of GCL to PCD. Measurement excludes wastage, overlaps and bentonite paste requirements.	m^2	2 030	R 15.00	R 30 450.00
302		HDPE Liner				
302.1		Supply and deliver to site 1.5 mm smooth HDPE liner as per specification for PCD base. Measurement includes anchor trenches but excludes wastage and overlaps.				
a		Foreign Currency component.	m^2	1 520	R 85.00	R 129 200.00
b		Local Currency component.	m^2	1 520	R 15.00	R 22 800.00
c		Extra over for forward cover bank charges etc. for fixing of tender prices against currency fluctuations.	Sum	1	R 15 200.00	R 15 200.00
302.2		Supply and deliver to site 1.5 mm single textured HDPE liner as per specification for PCD base. Measurement includes anchor trenches but excludes wastage and overlaps.				
a		Foreign Currency component.	m^2	510	R 90.00	R 45 900.00
b		Local Currency component.	m^2	510	R 20.00	R 10 200.00
c		Extra over for forward cover bank charges etc. for fixing of tender prices against currency fluctuations.	Sum	1	R 5 610.00	R 5 610.00
302.3		Installation of 1.5 mm HDPE geomembrane liner to PCD. Measurement excludes wastage and overlaps.	m^2	2 030	R 15.00	R 30 450.00
302.4		Supply and install 316 stainless steel batten detail, including butyl rubber gaskets, approved epoxy anchors and adhesive sealant to all concrete-HDPE connections.	m	200	R 1 250.00	R 250 000.00
303		Protection Geotextiles				
303.1		Supply and install 250 mm high geocell within PCD. Cells to be filled with soilcrete to both basin and side slopes. Material to receive nominal compaction. Rate to include all non-destructive anchoring	m^2	2 090	R 100.00	R 209 000.00
303.2		Supply and place 5MPa soilcrete as geocell infill to basin and side slopes. Material to be placed from the basin upwards and to receive nominal compaction.	m^3	450	R 1 800.00	R 810 000.00
303.3		Supply and place 10MPa concrete as geocell infill to basin pump sump area.	m^3	90	R 2 000.00	R 180 000.00
303.4		Supply, deliver and install 600g/m² non-woven protection geotextile as per specification for PCD. Measurement excludes wastage and overlaps.	m²	2 030	R 50.00	R 101 500.00
303.5		Securing geocell to base of retaining wall all inclusive (bitumen, anchor rods, etc.) as per detail	m	200	R 100.00	R 20 000.00
304		Access Ramp				
304.1		Supply, deliver and install 30/30 geogrid to site as per specification. Measurement includes anchor trenches but excludes wastage and overlaps.	m^2	240	R 110.00	R 26 400.00
305		Anchor Trenches				
305.1		Backfill with selected material to anchor trenches and compact by hand to 90% Mod. AASHTO at 0 - +2% OMC	m^3	4	R 75.00	R 300.00
305.2		Backfill of anchor trench at start of access ramp with Soilcrete to anchor trench and compact by hand.	m^3	4	R 1 800.00	R 7 200.00
305.3		Allowance for temporary sandbags (UV stable filled with approved sand) to prevent wind damage.	PSum	1	R 35 000.00	R 35 000.00
PB XX	LINER AND GEOTEXTILES	**CARRIED TO FINAL SUMMARY**			**R**	**2 081 460.00**

Item	Pay Ref.	Description	Unit	Qty	Rate	Amount
400	SANS 1200 G	**CONCRETE (STUCTURAL)**				
401	8.2	Scheduled Formwork Items				
401.1	8.2.2	Vertical formwork to:				
a		Base slab of retaining wall	m^2	340	R 350.00	R 119 000.00
b		Retaining wall vertical faces	m^2	1 790	R 350.00	R 626 500.00
402	8.3	Scheduled Reinforcement Items				
402.1	8.3.1	High Tensile Steel Bars	t	114	R 21 000.00	R 2 394 000.00
403	8.4	Scheduled Concrete Items				
403.1	8.4.2	Blinding layer (50mm thick, 5 Mpa Concrete)	m^2	600	R 100.00	R 60 000.00
403.2	8.4.3	Strength Concrete Grade 30 Mpa/19mm	m^3	860	R 3 000.00	R 2 580 000.00
403.3	8.4.4	Unformed surface finishes				
a		Wood floated finish	m^2	500	R 50.00	R 25 000.00
b		Steel floated finish	m^2	100	R 50.00	R 5 000.00
404	8.5	Joints				
404.1		Movement (Contraction/Expansion) Joints (Including waterstops all in)	m	270	R 150.00	R 40 500.00
404.2		Construction Joints (Including waterstops all in)	m	200	R 150.00	R 30 000.00
405		Drainage Behind Retaining Wall				
405.1		Drainage Strips: 300mm wide "Netlon drainage flownet DN1" Core completely enveloped in a Grade 2 geotextile jacket	m	630	R 130.00	R 81 900.00
405.2		65mm Dia Perforated Piping to Subsoil - Wrapped in Grade B filter fabric	m	200	R 95.00	R 19 000.00
405.3		Synthetic filter fabric: Grade B	m^2	900	R 27.00	R 24 300.00
SANS 1200 G	CONCRETE (STUCTURAL)	**CARRIED TO FINAL SUMMARY**			**R**	**6 005 200.00**

Item	Pay Ref.	Description	Unit	Qty	Rate	Amount
500	SANS 1200 HA	**STRUCTURAL STEELWORK (SUNDRY ITEMS)**				
501	8.3.2 a	Handrails:				
501.1		Install complete 3CR12 handrails around perimeter of PCD on top of retaining wall with kickplate	m	200	R 1 000.00	R 200 000.00
403	8.3.3	Ladders, Complete and Installed				
403.1		Install complete stainless steel cat ladders into PCD (4.5 m height)	No.	4	R 60 000.00	R 240 000.00
SANS 1200 HA	STRUCTURAL STEELWORK (SUNDRY ITEMS)	**CARRIED TO FINAL SUMMARY**			**R**	**440 000.00**

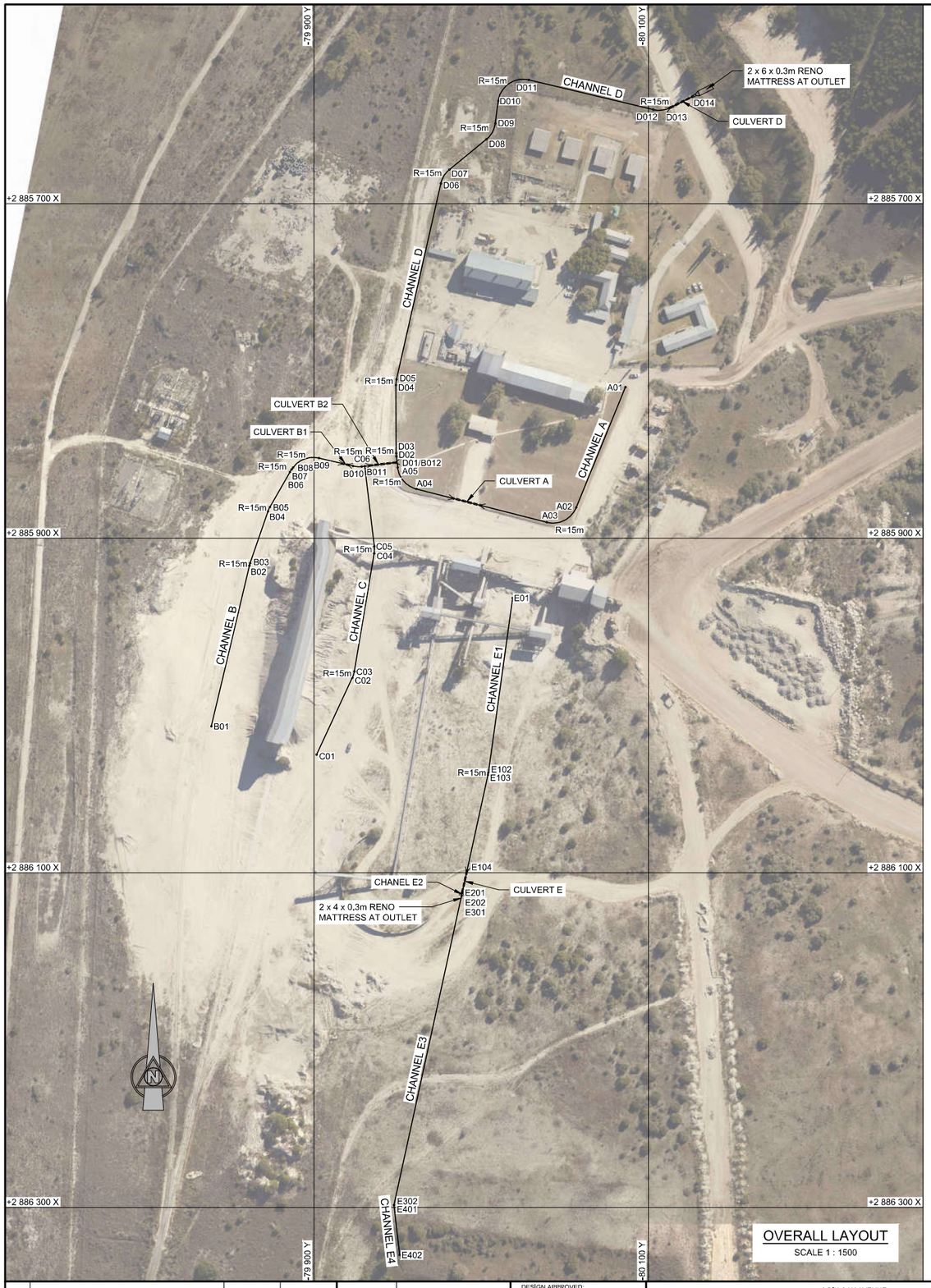
Item	Pay Ref.	Description	Unit	Qty	Rate	Amount
600	SANS 1200 L	**SUBSOIL DRAINAGE SYSTEM**				
601	8.2.1	Supply Lay and Bed Pipes Complete with Couplings				
601.1		Supply and install 160 mm slotted HDPE Drainex pipes with solid base facing down to toe drain mainlines.	m	170	R 150.00	R 25 500.00
601.2		Supply and install 160 mm slotted HDPE Drainex pipes with solid base facing down to toe drain laterals.	m	76	R 150.00	R 11 400.00
601.3		Supply and install 160 mm solid HDPE pipes from junction to manhole.	m	4	R 150.00	R 600.00
601.4	PC 2.7.1.1	Supply and fit 50 mm dia HDPE PE100 PN16 outlet pipe from subsoil sump pump to nominated point on dam wall. Pricing to include butt welding.	m	15	R 150.00	R 2 250.00
601.5	PC 2.7.1.2	Pressure testing of HDPE piping, including supply of all temporary fittings, water, and removal thereof, to 50 mm dia HDPE PN16, sub-soil return pipe.	Sum	1	R 3 500.00	R 3 500.00
602	8.2.14	Manholes				
602.1		Precast concrete manholes to detail, including excavation, mesh reinforced concrete base, grouted precast concrete rings with cast iron step irons, cover slab with grating lid, locking device suitable for and including manhole cover and frame, suitable channel pipe in 1:3 cement mortar benching, required holes through sides with concrete backing and seal detail.	No	1	R 200 000.00	R 200 000.00
602.2	1200 A 8.5 a	Provisional sum for contractor to purchase, install and commission submersible pump(s) in subsoil manhole (1 x KSB Amadrainer B 80-40 S or similar approved pump). Price to include control valve, level sensor(s), control box, duty pump and standby pump. Exact pump requirements to be confirmed prior to placing order.	Psum	1	R 160 000.00	R 160 000.00
603		Toe-Drain Bedding and Filter				
603.1	PC 3.6.1.3	Supply and place clean washed filter sand from commercial source per approved gradings to toe drain.	m^3	80	R 675.00	R 54 000.00
603.2		Supply and place pea gravel from commercial source per approved gradings to toe drain.	m^3	19	R 800.00	R 15 200.00
SANS 1200 L	SUBSOIL DRAINAGE SYSTEM	**CARRIED TO FINAL SUMMARY**			**R**	**472 450.00**

Item	Pay Ref.	Description	Unit	Qty	Rate	Amount
700	SANS 1200 MM	**ANCILLIARY WORKS**				
701	8.3.1	Warning signs supplied and erected complete, including supports, excavation, concreting and backfilling: min size 600mm x 600mm steel backing on steel frame.				
701.1		Sump contents & hazard rating	No	2	R 2 000.00	R 4 000.00
701.2		"No Entry Without Permit"	No	2	R 2 000.00	R 4 000.00
702		Lifebouys / floats mounted in UV stable protective boxes mounted on steel posts.	No	4	R 6 000.00	R 24 000.00
703		30 m long UV stable safety ropes knotted at 300 mm centres connected to 0.5 x0.5 x 0.5m concrete ballast block on top and base of dam.	No	0	R 3 100.00	R -
SANS 1200 MM	ANCILLIARY WORKS	**CARRIED TO FINAL SUMMARY**			**R**	**32 000.00**

PRELIMINARY DESIGN COST ESTIMATION FOR THE COAL STOCKYARD PCD

Final Summary		**Coal Stockyard PCD**	
1	PRELIMINARY AND GENERAL	R	3 354 724.00
2	SMALL EARTH DAMS	R	1 717 970.00
3	LINER AND GEOTEXTILES	R	2 081 460.00
4	CONCRETE (STUCTURAL)	R	6 005 200.00
5	STRUCTURAL STEELWORK (SUNDRY ITEMS)	R	440 000.00
6	SUBSOIL DRAINAGE SYSTEM	R	472 450.00
7	ANCILLIARY WORKS	R	32 000.00
Subtotal A		R	14 103 804.00
Contingencies (15%)		R	2 115 570.60
Subtotal B		R	16 219 374.60
VAT		R	2 115 570.60
TOTAL		**R**	**18 334 945.20**

Annexure B – Preliminary Design Drawings



OVERALL LAYOUT
SCALE 1 : 1500

CHANNEL A					
WGS 84 - Lo 25					
POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
A01	START	0,000	-80 086,190	+2 885 809,639	1441,400
A02	BC	77,749	-80 056,754	+2 885 881,601	1441,206
A03	EC	99,248	-80 039,149	+2 885 890,453	1441,152
A04	BC	179,722	-79 961,192	+2 885 870,485	1440,951
A05	EC	197,737	-79 950,020	+2 885 857,736	1440,905
A06	END	200,854	-79 949,649	+2 885 854,641	1440,900

CHANNEL B					
POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
B01	START	0,000	-79 838,621	+2 886 012,416	1441,470
B02	BC	98,710	-79 861,379	+2 885 916,366	1441,223
B03	EC	100,196	-79 861,792	+2 885 914,939	1441,220
B04	BC	132,949	-79 872,459	+2 885 883,971	1441,138
B05	EC	135,768	-79 873,621	+2 885 881,408	1441,131
B06	BC	159,937	-79 885,623	+2 885 860,429	1441,070
B07	EC	161,805	-79 886,649	+2 885 858,869	1441,066
B08	BC	163,309	-79 887,552	+2 885 857,666	1441,062
B09	EC	180,669	-79 902,977	+2 885 852,072	1441,018
B10	BC	201,556	-79 923,310	+2 885 856,849	1440,966
B11	EC	206,783	-79 928,502	+2 885 857,143	1440,953
B12	END	228,046	-79 949,649	+2 885 854,641	1440,900

CHANNEL C					
POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
C01	START	0,000	-79 901,516	+2 886 029,349	1441,720
C02	BC	50,586	-79 922,878	+2 885 983,495	1441,567
C03	EC	54,623	-79 924,073	+2 885 979,651	1441,555
C04	BC	126,134	-79 935,948	+2 885 909,133	1441,339
C05	EC	130,403	-79 936,053	+2 885 904,880	1441,326
C06	END	178,697	-79 930,379	+2 885 856,921	1441,060

CHANNEL D					
POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
D01	START	0,000	-79 949,649	+2 885 854,641	1440,900
D02	BC	3,720	-79 949,207	+2 885 850,947	1440,888
D03	EC	5,459	-79 949,101	+2 885 849,213	1440,884
D04	BC	46,243	-79 948,972	+2 885 808,429	1440,782
D05	EC	49,620	-79 949,340	+2 885 805,079	1440,774
D06	BC	169,671	-79 975,774	+2 885 687,974	1440,473
D07	EC	179,611	-79 980,903	+2 885 679,671	1440,449
D08	BC	208,180	-80 003,007	+2 885 661,572	1440,377
D09	EC	219,458	-80 008,372	+2 885 651,953	1440,349
D10	BC	232,930	-80 010,157	+2 885 638,600	1440,315
D11	EC	258,017	-80 028,511	+2 885 625,998	1440,252
D12	BC	334,382	-80 102,785	+2 885 643,744	1440,061
D13	EC	344,853	-80 112,978	+2 885 642,572	1440,035
D14	END	366,254	-80 132,121	+2 885 633,005	1439,848

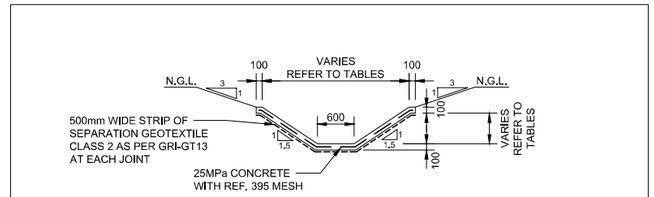
CHANNEL E1					
POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
E101	START	0,000	-80 018,747	+2 885 935,704	1441,700
E102	BC	105,604	-80 004,238	+2 886 040,307	1441,015
E103	EC	106,766	-80 004,034	+2 886 041,451	1441,007
E104	END	165,300	-79 991,527	+2 886 098,633	1440,628

CHANNEL E2					
POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
E201	START	0,000	-79 988,660	+2 886 111,743	1440,541
E202	END	2,000	-79 988,233	+2 886 113,697	1440,528

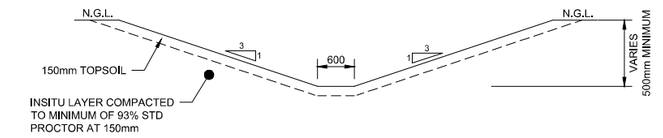
CHANNEL E3					
POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
E301	START	0,000	-79 988,233	+2 886 113,697	1440,528
E302	END	189,280	-79 947,791	+2 886 298,606	1439,300

CHANNEL E4					
POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
E401	START	0,000	-79 947,791	+2 886 298,606	1439,300
E402	END	30,000	-79 951,229	+2 886 328,421	1438,000

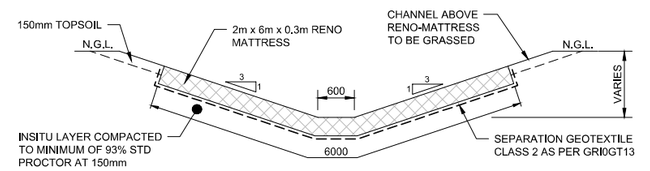
DETAILS OF INFRASTRUCTURE				
CHANNEL NAME	CHANNEL TYPE	CHANNEL GRADIENT (m/m)	CHANNEL HEIGHT/ DEPTH (m)	CHANNEL TOP WIDTH (m)
A	CONCRETE LINED TRAPEZOIDAL	-0.0025	0.3	1.50
B	CONCRETE LINED TRAPEZOIDAL	-0.0025	0.3	1.50
C	CONCRETE LINED TRAPEZOIDAL	-0.0025	0.3	1.50
D	CONCRETE LINED TRAPEZOIDAL	-0.0025	0.5	2.10
E1	CONCRETE LINED TRAPEZOIDAL	-0.0065	0.45	1.95
E2	EARTH, GABION LINED TRAPEZOIDAL	-0.0065	0.7	4.80
E3	EARTH, GRASSED TRAPEZOIDAL	-0.0065	0.5	3.60
E4	EARTH, GABION LINED TRAPEZOIDAL	-0.0433	0.7	4.80



TYPICAL CROSS SECTION
SCALE 1 : 50



TYPICAL CROSS SECTION
FOR CHANNEL E3
GRASS LINED
SCALE 1 : 50



TYPICAL CROSS SECTION
FOR CHANNEL E2 & E4
RENO MATTRESS LINING
SCALE 1 : 50

CULVERTS						
CULVERT NAME	TYPE	No. OF OPENINGS	DIMENSIONS/ OPENING	LENGTH (m)	DEPTH, INVERT TO NGL (m)	INFRASTRUCTURE CROSSED
CULVERT A	BOX	1	0.6 m WIDE x 0.45 m DEEP	15 x 1.22 m = 18.3 m	0.9	ROAD
CULVERT B1	BOX	1	0.45 m WIDE x 0.3 m DEEP	3 x 1.22 m = 3.66 m	0.8	RAIL
CULVERT B2	BOX	3	0.45 m WIDE x 0.3 m DEEP	13 x 1.22 m = 16.2 m	0.65	RAIL & ROAD
CULVERT D	PIPE (100D)	1	0.75 m ND	9 x 2.44 m = 21.96 m	2.55	ROAD
CULVERT E	BOX	3	0.45 m WIDE x 0.3 m DEEP	11 x 1.22 m = 13.42 m	0.62	ROAD

NOTE:
1. ALL THE CONCRETE CHANNELS WILL BE 100mm THICK 25MPa CONCRETE WITH MESH REF 395 IN THE CENTRE. PANELS ARE TO BE CAST IN MAX 3m LONG LENGTHS WITH 10mm THICK SOFTBOARD JOINTS AND A 500mm WIDE STRIP OF SEPARATION GEOTEXTILE, CLASS 2, AS PER GRI-GT13 BELOW EVERY JOINT.
2. THE SOFTBOARD WILL BE SEALED WITH 10mm THICK POLY-SULPHIDE SEALANT. THE TOP OF THE SEALANT WILL BE 5mm BELOW THE CONCRETE SURFACE

REV	NATURE OF REVISION	DATE	SIGNED
A	FOR DISCUSSION	08-04-2022	T. BAIER

DESIGNED	T. BAIER
CHECKED	G. ROBERTSON
DRAWN	B. NEWTON
CHECKED	T. BAIER

DESIGN APPROVED:
JG AFRIKA (Pty) Ltd
J.C. NORRIS
NAME
SIGNATURE
-
DATE

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CLIENT
NAME
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CLIENT
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Email: uneysa.tajard@lafargeholcim.com

PROJECT
LAFARGE LICHTENBURG WULA SPECIALIST STUDIES AND PCD DESIGN

DRAWING TITLE
LAFARGE TSWANA QUARRY STORMWATER CHANNELS
GENERAL LAYOUT & DETAILS

ISSUED FOR DISCUSSION

SHEET 1 of 1	SCALE AS SHOWN	SIZE A1

CLIENT DRAWING No.
-

JG AFRIKA (Pty) Ltd. DRAWING No
5707-JGA-P-LTQ-CI-1001

REVISION
A

Newton® 04-05-2022

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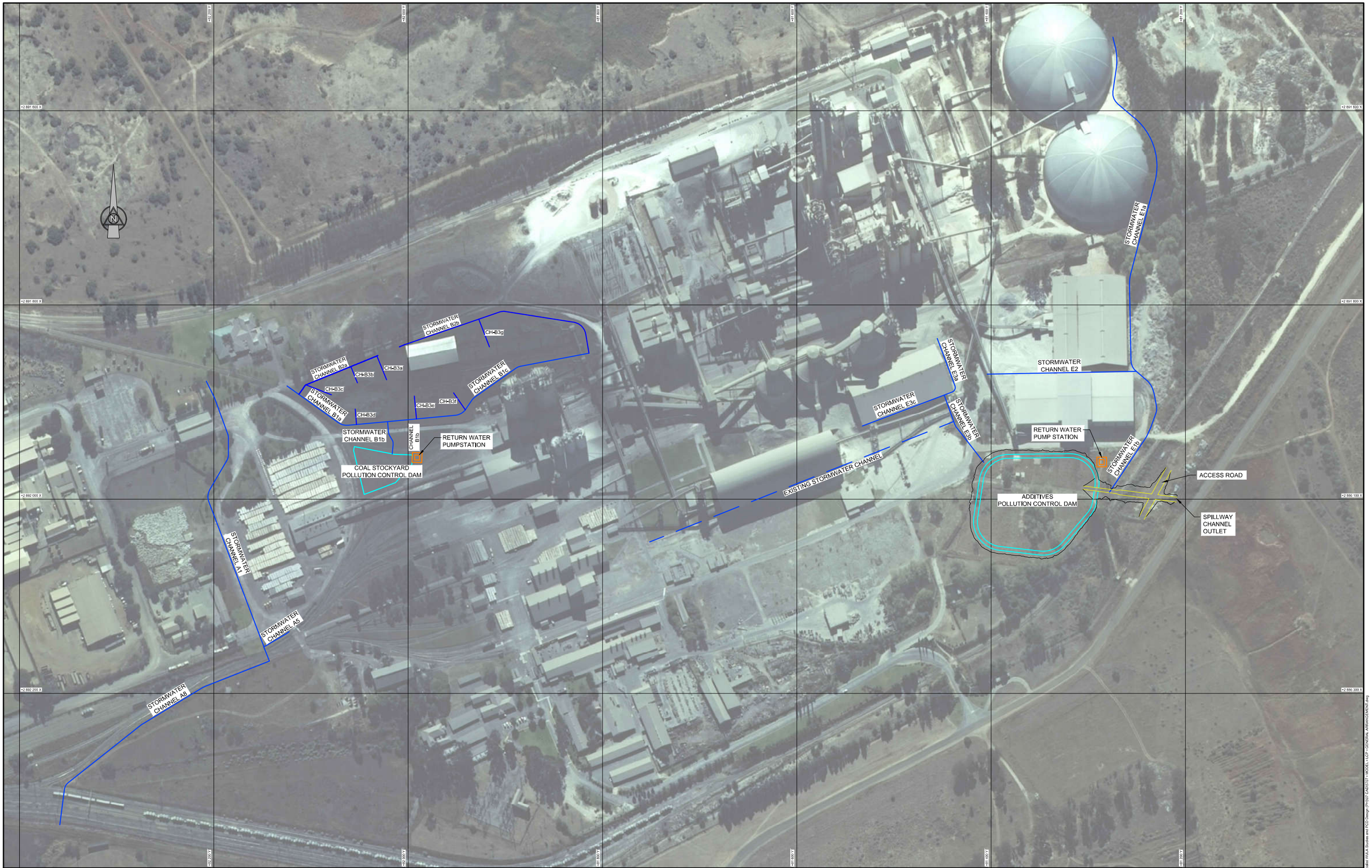

REV	NATURE OF REVISION	DATE	SIGNED
A	FOR DISCUSSION	08-04-2022	G.R.

DESIGNED	G. ROBERTSON
CHECKED	J.C. NORRIS
DRAWN	B. NEWTON
CHECKED	G. ROBERTSON

DESIGN APPROVED:
JG AFRIKA (Pty) Ltd
NAME J.C. NORRIS
SIGNATURE -
DATE

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PROJECT
LAFARGE CEMENT PLANT

DRAWING TITLE
STORMWATER MANAGEMENT AND POLLUTION CONTROL DAMS
GENERAL ARRANGEMENT

ISSUED FOR DISCUSSION

SHEET	SCALE	SIZE
1 of 1	1 : 1750	A1

CLIENT DRAWING No.: -

JG AFRIKA (Pty) Ltd. DRAWING No: 5707-JGA-P-LCP-GA-0001

REVISION: A

Newton® 04-05-2022

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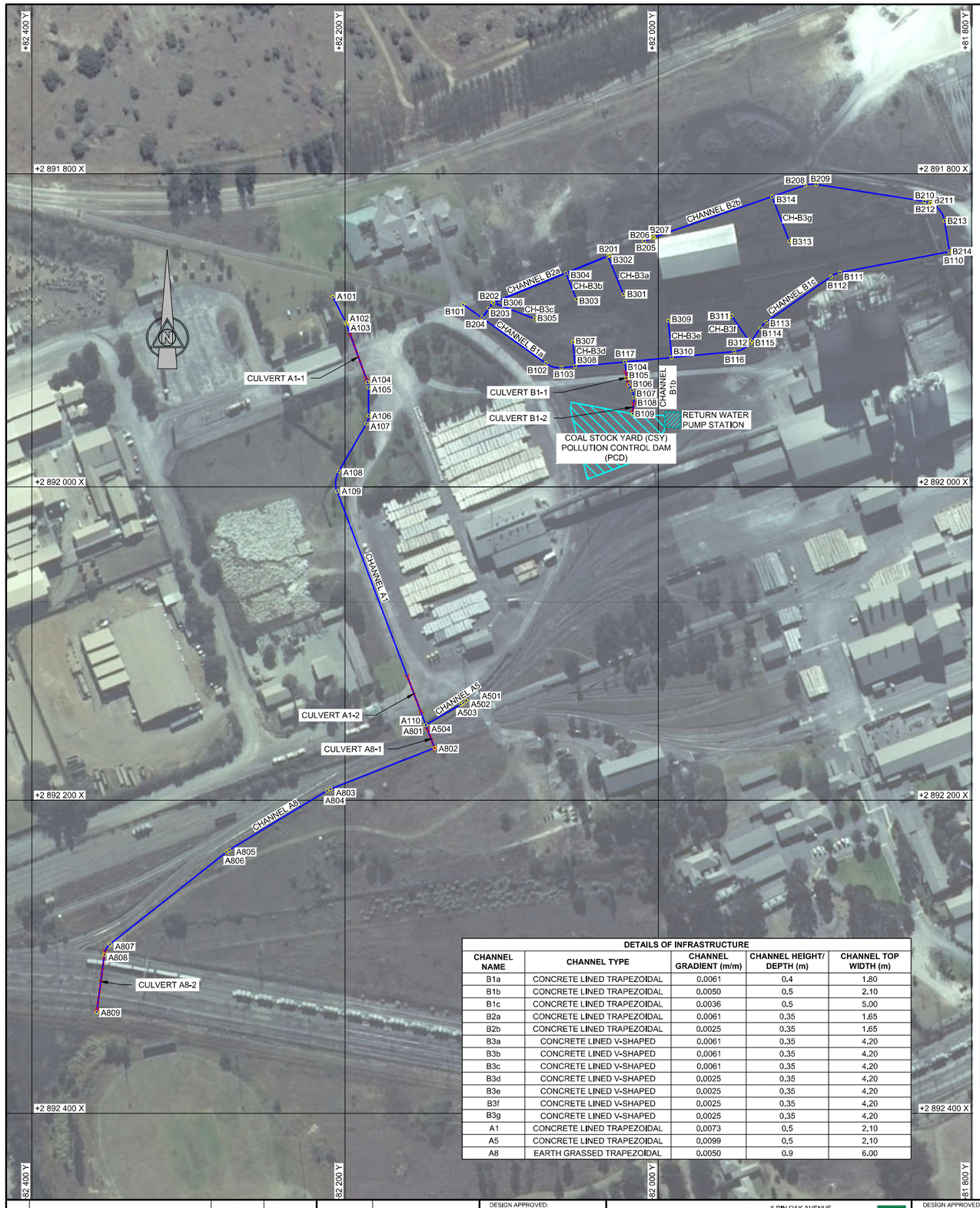


CULVERTS

CULVERT NAME	TYPE	No. OF OPENINGS	DIMENSIONS/ OPENING	LENGTH (m)	DEPTH, INVERT TO NGL (m)	INFRASTRUCTURE CROSSED
CULVERT A1-1	BOX	1	0.45 m WIDE x 0.3 m DEEP	24 x 1.22 m = 29.28 m	0.7	ROAD
CULVERT A1-2	BOX	1	0.6 m WIDE x 0.6 m DEEP	19 x 1.22 m = 23.18 m	1.1	ROAD
CULVERT A8-1	BOX	3	0.45 m WIDE x 0.6 m DEEP	10 x 1.22 m = 12.2 m	0.74	RAIL
CULVERT A8-2	BOX	3	0.45 m WIDE x 0.90 m DEEP	31 x 1.22 m = 37.8 m	1.05	RAIL
CULVERT B1-1	BOX	2	0.45 m WIDE x 0.45 m DEEP	6 x 1.22 m = 7.32 m	0.83	RAIL
CULVERT B1-2	BOX	2	0.45 m WIDE x 0.45 m DEEP	5 x 1.22 m = 6.10 m	0.65	RAIL

SETTING OUT POINTS FOR STORMWATER CHANNELS

WGS 84 - Lo 27

CHANNEL B1a

POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
B101	START	0.000	+82 124.609	+2 891 883.485	1489.709
B102	BC	64.791	+82 071.851	+2 891 921.094	1489.315
B103	EC	75.452	+82 061.774	+2 891 923.817	1489.250
B104	END	116.164	+82 021.233	+2 891 920.098	1489.003

CHANNEL B1b

POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
B104	START	0.000	+82 021.233	+2 891 920.098	1489.003
B105	BC	10.493	+82 020.274	+2 891 930.547	1488.950
B106	EC	14.926	+82 018.920	+2 891 934.730	1488.927
B107	BC	18.960	+82 016.864	+2 891 938.200	1488.907
B108	EC	25.281	+82 015.515	+2 891 944.268	1488.875
B109	END	34.351	+82 016.396	+2 891 953.295	1488.83

CHANNEL B1c

POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
B110	START	0.000	+81 813.997	+2 891 849.657	1489.826
B111	BC	71.248	+81 883.968	+2 891 863.090	1489.567
B112	EC	77.615	+81 889.783	+2 891 865.562	1489.544
B113	BC	128.063	+81 931.014	+2 891 894.632	1489.36
B114	EC	133.579	+81 934.843	+2 891 898.559	1489.34
B115	BC	143.621	+81 940.421	+2 891 906.909	1489.303
B116	EC	156.936	+81 951.483	+2 891 913.511	1489.255
B117	END	226.996	+82 021.233	+2 891 920.098	1489

CHANNEL A1

POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
A101	START	0.000	+82 207.787	+2 891 878.448	1489.000
A102	BC	18.442	+82 199.567	+2 891 894.956	1488.865
A103	EC	19.578	+82 199.119	+2 891 896.000	1488.857
A104	BC	59.046	+82 185.647	+2 891 933.098	1488.568
A105	EC	62.516	+82 185.046	+2 891 936.497	1488.543
A106	BC	80.584	+82 185.021	+2 891 954.565	1488.410
A107	EC	85.877	+82 186.383	+2 891 959.617	1488.372
A108	BC	120.897	+82 204.024	+2 891 989.869	1488.116
A109	EC	134.256	+82 205.090	+2 892 002.746	1488.018
A110	END	293.878	+82 148.463	+2 892 151.986	1486.850

CHANNEL A5

POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
A501	START	0.000	+82 122.605	+2 892 136.478	1487.150
A502	BC	2.609	+82 124.711	+2 892 138.018	1487.124
A503	EC	4.150	+82 125.999	+2 892 138.862	1487.109
A504	END	30.247	+82 148.532	+2 892 152.027	1486.850

CHANNEL A8

POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
A801	START	0.000	+82 148.532	+2 892 152.027	1486.850
A802	BC	22.689	+82 140.224	+2 892 173.140	1486.735
A803	BC	93.655	+82 206.235	+2 892 199.193	1486.374
A804	EC	96.194	+82 208.507	+2 892 200.320	1486.361
A805	BC	168.238	+82 270.107	+2 892 237.679	1485.995
A806	EC	170.125	+82 271.655	+2 892 238.756	1485.986
A807	BC	256.319	+82 339.163	+2 892 292.348	1485.548
A808	EC	264.017	+82 342.861	+2 892 298.883	1485.508
A809	END	299.714	+82 347.488	+2 892 334.280	1485.327

CHANNEL B2a

POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
B201	START	0.000	+82 031.248	+2 891 852.109	1490.181
B202	BC	75.965	+82 101.614	+2 891 880.734	1489.718
B203	EC	84.429	+82 108.168	+2 891 885.910	1489.666
B204	END	91.998	+82 112.567	+2 891 892.069	1489.620

CHANNEL B2b

POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
B205	START	0.000	+82 009.012	+2 891 843.065	1490.333
B206	BC	5.962	+82 003.490	+2 891 840.819	1490.318
B207	EC	6.783	+82 002.721	+2 891 840.530	1490.316
B208	BC	108.601	+81 906.447	+2 891 807.390	1490.061
B209	EC	115.911	+81 899.237	+2 891 806.755	1490.043
B210	BC	185.928	+81 830.068	+2 891 817.618	1489.868
B211	EC	189.686	+81 826.467	+2 891 818.658	1489.858
B212	BC	190.092	+81 826.094	+2 891 818.818	1489.857
B213	EC	205.100	+81 817.223	+2 891 830.149	1489.820
B214	END	224.872	+81 813.997	+2 891 849.656	1489.770

CHANNEL B3a

POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
B301	START	0.000	+82 022.230	+2 891 876.933	1490.336
B302	END	28.391	+82 032.174	+2 891 852.486	1490.175

CHANNEL B3b

POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
B303	START	0.000	+82 052.254	+2 891 880.088	1490.308
B304	END	18.000	+82 059.036	+2 891 863.414	1490.198

CHANNEL B3c

POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
B305	START	0.000	+82 079.059	+2 891 892.474	1489.866
B306	END	28.208	+82 105.351	+2 891 882.255	1489.694

CHANNEL B3d

POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
B307	START	0.000	+82 054.532	+2 891 907.266	1489.695
B308	END	15.821	+82 053.074	+2 891 923.019	1489.598

CHANNEL B3e

POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
B309	START	0.000	+81 993.646	+2 891 893.829	1489.834
B310	END	23.559	+81 991.475	+2 891 917.288	1489.775

CHANNEL B3f

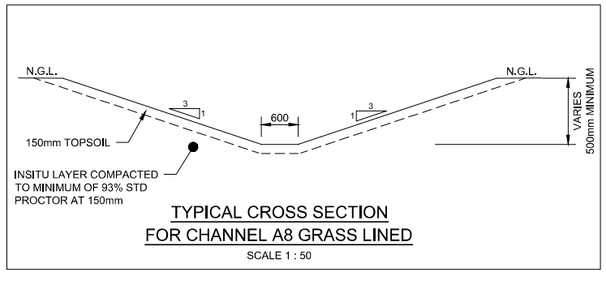
POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
B311	START	0.000	+81 953.244	+2 891 890.585	1490.009
B312	END	21.147	+81 941.198	+2 891 907.965	1489.956

CHANNEL B3g

POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
B313	START	0.000	+81 916.396	+2 891 843.106	1490.193
B314	END	30.552	+81 927.351	+2 891 814.586	1490.116

DETAILS OF INFRASTRUCTURE

CHANNEL NAME	CHANNEL TYPE	CHANNEL GRADIENT (m/m)	CHANNEL HEIGHT/ DEPTH (m)	CHANNEL TOP WIDTH (m)
B1a	CONCRETE LINED TRAPEZOIDAL	0.0061	0.4	1.80
B1b	CONCRETE LINED TRAPEZOIDAL	0.0050	0.5	2.10
B1c	CONCRETE LINED TRAPEZOIDAL	0.0036	0.5	5.00
B2a	CONCRETE LINED TRAPEZOIDAL	0.0061	0.35	1.65
B2b	CONCRETE LINED TRAPEZOIDAL	0.0025	0.35	1.65
B3a	CONCRETE LINED V-SHAPED	0.0061	0.35	4.20
B3b	CONCRETE LINED V-SHAPED	0.0061	0.35	4.20
B3c	CONCRETE LINED V-SHAPED	0.0061	0.35	4.20
B3d	CONCRETE LINED V-SHAPED	0.0025	0.35	4.20
B3e	CONCRETE LINED V-SHAPED	0.0025	0.35	4.20
B3f	CONCRETE LINED V-SHAPED	0.0025	0.35	4.20
B3g	CONCRETE LINED V-SHAPED	0.0025	0.35	4.20
A1	CONCRETE LINED TRAPEZOIDAL	0.0073	0.5	2.10
A5	CONCRETE LINED TRAPEZOIDAL	0.0099	0.5	2.10
A8	EARTH GRASSED TRAPEZOIDAL	0.0050	0.9	6.00

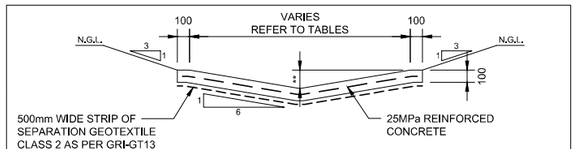


TYPICAL CROSS SECTION
FOR CHANNEL A8 GRASS LINED

SCALE 1 : 50

NOTE:

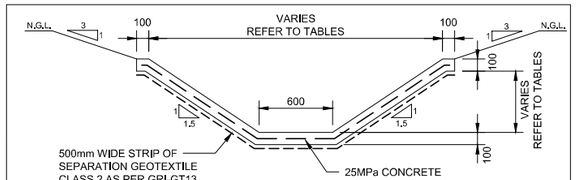
1. ALL THE CONCRETE CHANNELS WILL BE 100mm THICK 25MPa CONCRETE WITH MESH REF 395 IN THE CENTRE. PANELS ARE TO BE CAST IN MAX 3m LONG LENGTHS WITH 10mm THICK SOFTBOARD JOINTS AND A 500mm WIDE STRIP OF SEPARATION GEOTEXTILE, CLASS 2, AS PER GRI-GT13 BELOW EVERY JOINT.
2. THE SOFTBOARD WILL BE SEALED WITH 10mm THICK POLY-SULPHIDE SEALANT. THE TOP OF THE SEALANT WILL BE 5mm BELOW THE CONCRETE SURFACE



TYPICAL CROSS SECTION
FOR CHANNELS B3a - B3g

** DEPTH VARIES
REFER TO TABLES

SCALE 1 : 25



TYPICAL CROSS SECTION
FOR CHANNELS B1a-B1c & A1 & A5

SCALE 1 : 25

REV	NATURE OF REVISION	DATE	SIGNED
A	FOR DISCUSSION	08-04-2022	T.B.

DESIGNED	T. BAIER
CHECKED	G. ROBERTSON
DRAWN	B. NEWTON
CHECKED	T. BAIER

DESIGN APPROVED:
JG AFRIKA (Pty) Ltd
J.C. NORRIS
NAME
SIGNATURE
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DATE

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Email: uneysa.tajjaro@lafargeholcim.com

PROJECT
LAFARGE CEMENT PLANT

DRAWING TITLE
STORMWATER MANAGEMENT
STORMWATER DRAINAGE
GENERAL LAYOUT & DETAILS

ISSUED FOR DISCUSSION

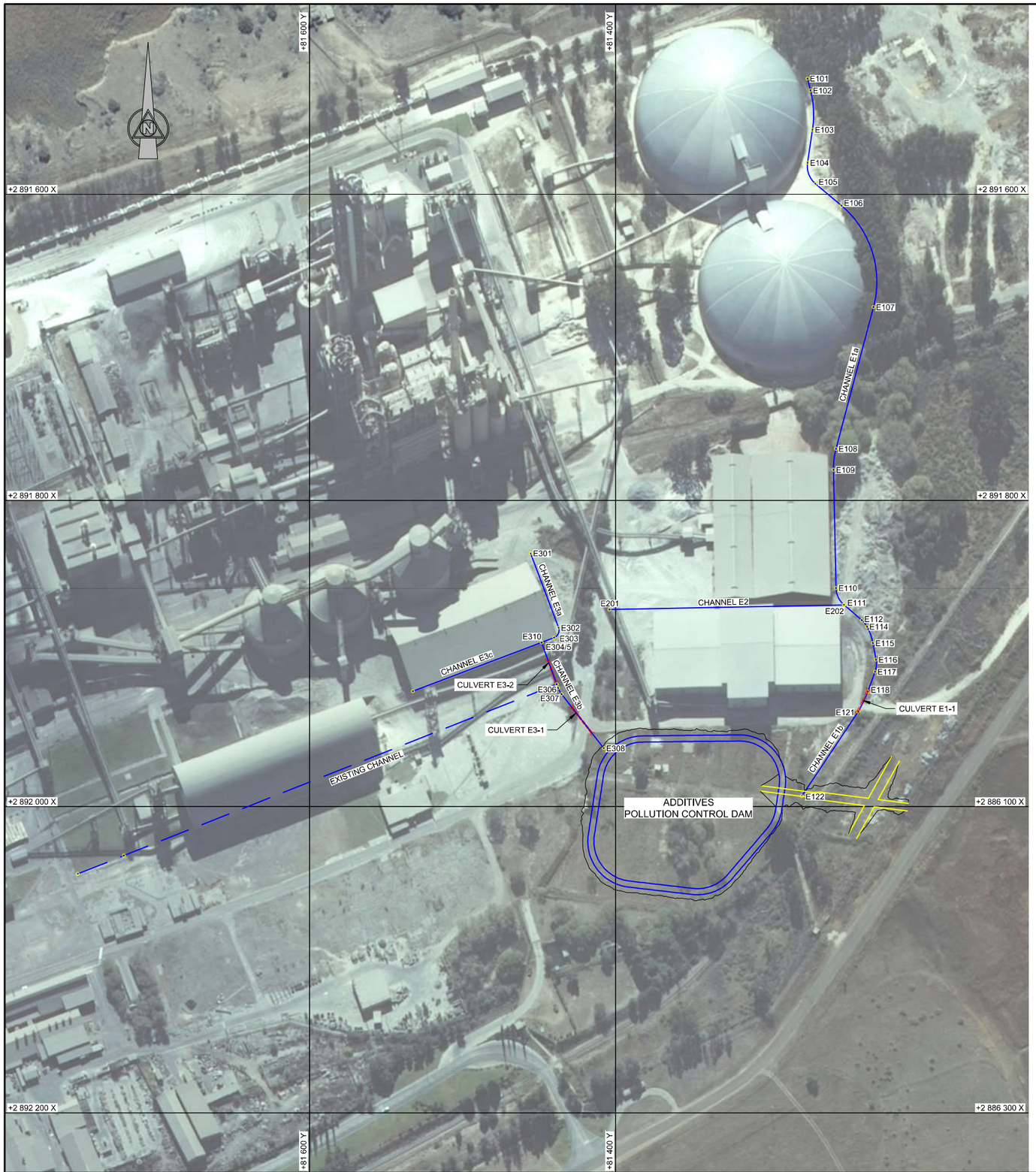
SHEET 1 of 2	SCALE AS SHOWN	SIZE A1

CLIENT DRAWING No.
-

JG AFRIKA (Pty) Ltd. DRAWING No
5707-JGA-P-LCP-CI-1001

REVISION
A

NewtonB 04.05.2022

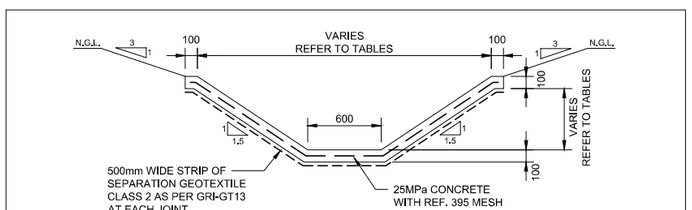


DETAILS OF INFRASTRUCTURE				
CHANNEL NAME	CHANNEL TYPE	CHANNEL GRADIENT (m/m)	CHANNEL HEIGHT/ DEPTH (m)	CHANNEL TOP WIDTH (m)
E1a	CONCRETE LINED TRAPEZOIDAL	0.0056	0.3	1.50
E1b	CONCRETE LINED TRAPEZOIDAL	0.0025	0.6	2.40
E2	CONCRETE LINED TRAPEZOIDAL	0.0050	0.4	1.80
E3a	CONCRETE LINED TRAPEZOIDAL	0.0489	0.3	1.50
E3a	CONCRETE LINED TRAPEZOIDAL	0.0050	0.3	1.50
E3b	CONCRETE LINED TRAPEZOIDAL	0.0050	0.4	1.80
E3c	CONCRETE LINED TRAPEZOIDAL	0.0050	0.4	1.80

NOTE:
1. ALL THE CONCRETE CHANNELS WILL BE 100mm THICK 25MPa CONCRETE WITH MESH REF 395 IN THE CENTRE. PANELS ARE TO BE CAST IN MAX 3m LONG LENGTHS WITH 10mm THICK SOFTBOARD JOINTS AND A 500mm WIDE STRIP OF SEPARATION GEOTEXTILE, CLASS 2, AS PER GRI-GT13 BELOW EVERY JOINT.
2. THE SOFTBOARD WILL BE SEALED WITH 10mm THICK POLY-SULPHIDE SEALANT. THE TOP OF THE SEALANT WILL BE 5mm BELOW THE CONCRETE SURFACE

SETTING OUT POINTS FOR STORMWATER CHANNELS					
WGS 84 - Lo 27					
CHANNEL E1					
POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
E101	START	0.000	+81 274.653	+2 891 524.392	1489.000
E102	BC	8.043	+81 272.670	+2 891 532.186	1488.955
E103	EC	33.883	+81 271.377	+2 891 557.824	1488.812
E104	BC	55.696	+81 274.601	+2 891 579.398	1488.691
E105	EC	70.977	+81 269.435	+2 891 593.084	1488.606
E106	BC	93.172	+81 252.465	+2 891 607.389	1488.482
E107	EC	166.544	+81 231.521	+2 891 673.699	1488.075
E108	BC	262.232	+81 255.977	+2 891 766.208	1487.543
E109	EC	276.180	+81 257.628	+2 891 780.012	1487.485
E110	BC	353.419	+81 256.044	+2 891 857.235	1487.291
E111	EC	365.658	+81 250.995	+2 891 867.995	1487.260
E112	BC	381.336	+81 239.144	+2 891 878.260	1487.221
E113	EC	386.498	+81 235.895	+2 891 882.238	1487.208
E114	BC	386.702	+81 235.795	+2 891 882.416	1487.208
E115	EC	398.217	+81 231.882	+2 891 893.191	1487.179
E116	BC	409.199	+81 229.874	+2 891 903.988	1487.151
E117	EC	417.190	+81 230.525	+2 891 911.858	1487.131
E118	-	-	-	-	-
E119	-	-	-	-	-
E120	BC	440.650	+81 239.155	+2 891 933.656	1487.072
E121	EC	445.479	+81 241.502	+2 891 937.871	1487.060
E122	BC	511.916	+81 278.390	+2 891 993.126	1486.894
E123	EC	517.644	+81 282.392	+2 891 997.175	1486.880
E124	END	526.231	+81 289.478	+2 892 002.026	1486.858
CHANNEL E2					
POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
E201	START	0.000	+81 404.053	+2 891 871.223	1488.557
E202	END	153.446	+81 250.635	+2 891 868.308	1487.789
CHANNEL E3a					
POINT	DESCRIPTION	CHAINAGE (m)	Y	X	Z
E301	START	0.000	+81 455.528	+2 891 834.520	1490.4
E302	BC	51.961	+81 437.270	+2 891 883.168	1489.174
E303	EC	59.786	+81 440.167	+2 891 889.596	1489.134
E304	END	68.598	+81 448.399	+2 891 892.740	1489.09
CHANNEL E3b					
E305	START	0.000	+81 448.399	+2 891 892.740	1489.09
E306	BC	31.610	+81 437.611	+2 891 922.452	1488.93
E307	EC	36.333	+81 435.332	+2 891 926.566	1488.906
E308	END	81.157	+81 407.738	+2 891 961.890	1488.68
CHANNEL E3c					
E309	START	0.000	+81 532.573	+2 891 924.678	1489.541
E310	END	90.028	+81 448.400	+2 891 892.740	1489.09

CULVERTS						
CULVERT NAME	TYPE	No. OF OPENINGS	DIMENSIONS/ OPENING	LENGTH (m)	DEPTH, INVERT TO NGL (m)	INFRASTRUCTURE CROSSED
CULVERT E1-1	BOX	1	0,9 m WIDE x 0,6 m DEEP	10 x 1,22 m = 12,2 m	1,4	ROAD
CULVERT E3-1	BOX	3	0.45 m WIDE x 0.3 m DEEP	13 x 1.22 m = 15,86 m	0.6	ROAD
CULVERT E3-2	BOX	3	0.6 m WIDE x 0.45 m DEEP	11 x 1.22 m = 13.42 m	1.0	ROAD



TYPICAL CROSS SECTION
FOR CHANNELS B1a-B1c & A1 & A5
SCALE 1 : 25

REV	NATURE OF REVISION	DATE	SIGNED
A	FOR DISCUSSION	08-04-2022	T.B.

DESIGNED	T. BAIER
CHECKED	G. ROBERTSON
DRAWN	B. NEWTON
CHECKED	T. BAIER

DESIGN APPROVED:
JG AFRIKA (Pty) Ltd
NAME J.C. NORRIS
SIGNATURE
DATE -

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DESIGN APPROVED:
CLIENT
NAME
SIGNATURE
DATE

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Email: uneysa.tajjard@lafargeholcim.com

PROJECT
LAFARGE CEMENT PLANT

DRAWING TITLE
STORMWATER MANAGEMENT
STORMWATER DRAINAGE
GENERAL LAYOUT & DETAILS

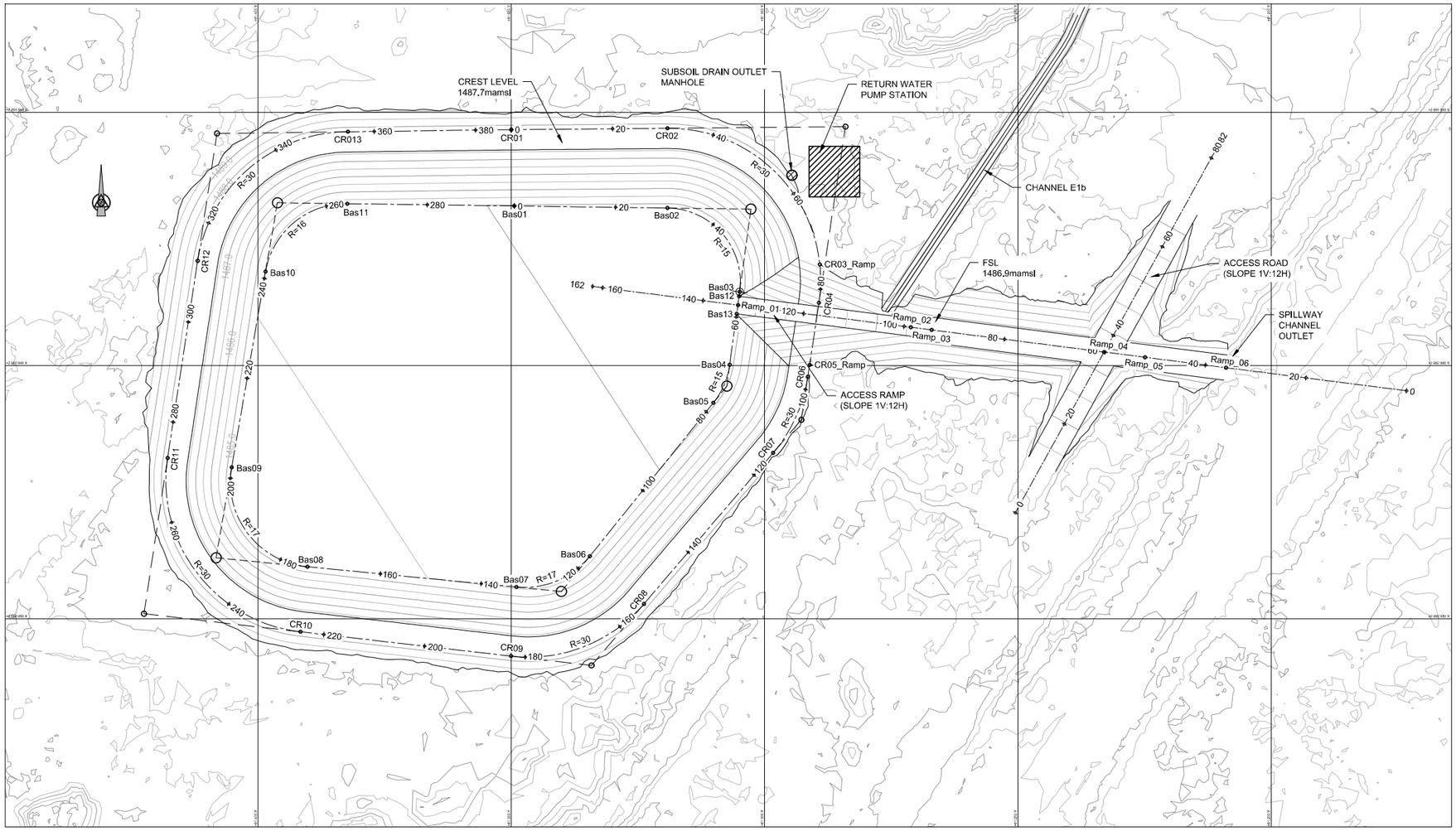
ISSUED FOR DISCUSSION

SHEET 2 of 2 | SCALE 1 : 1500 / AS SHOWN | SIZE A1

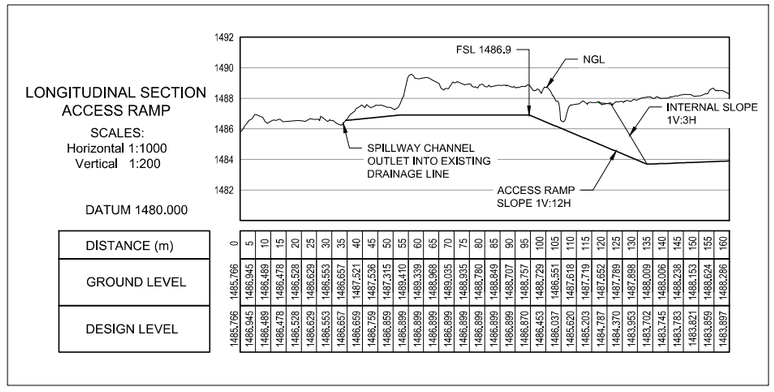
CLIENT DRAWING No. -

JG AFRIKA (Pty) Ltd. DRAWING No 5707-JGA-P-LCP-CI-1002 | REVISION A

Newton® 04-05-2022



ADDITIVES PCD SETTING OUT POINTS				
WGS84 Lo 27				
CHAINAGE (m)	POINT	Y	X	Z
CREST SETTING OUT POINTS				
0,000	CR01	+81 293,806	+2 891 978,641	1487,710
30,828	CR02_rad_30	+81 319,204	+2 891 953,163	1487,710
75,114	CR03_ramp	+81 289,099	+2 891 980,062	1487,710
82,700	CR04-rad_30	+81 289,271	+2 891 987,626	1487,710
95,100	CR05_ramp	+81 291,117	+2 891 999,888	1487,710
97,463	CR06-rad_30	+81 291,468	+2 892 002,224	1487,710
114,191	CR07_rad_30	+81 298,324	+2 892 017,246	1487,710
153,416	CR08_rad_30	+81 323,803	+2 892 047,070	1487,710
182,782	CR09_rad_30	+81 350,056	+2 892 057,386	1487,710
224,637	CR10_rad_30	+81 391,634	+2 892 052,582	1487,710
272,838	CR11_rad_30	+81 417,849	+2 892 018,269	1487,710
312,208	CR12_rad_30	+81 411,929	+2 891 979,347	1487,710
354,413	CR13_rad_30	+81 382,660	+2 891 953,861	1487,710
ACCESS RAMP SETTING OUT POINTS				
CHAINAGE (m)	POINT	Y	X	Z
133,032	Ramp_01	+81 305,233	+2 891 988,080	1483,700
98,648	Ramp_02	+81 271,128	+2 891 992,451	1486,566
94,648	Ramp_03	+81 267,161	+2 891 992,960	1486,900
60,185	Ramp_04	+81 232,978	+2 891 997,346	1486,900
52,000	Ramp_05	+81 224,859	+2 891 998,383	1486,900
35,921	Ramp_06	+81 208,910	+2 892 000,427	1486,600
BASIN SETTING OUT POINTS				
CHAINAGE (m)	POINT	Y	X	Z
0,000	Bas01	+81 349,433	+2 891 968,500	1483,960
30,251	Bas02_rad_14.592	+81 319,185	+2 891 968,907	1483,720
54,950	Bas03_rad_14.592	+81 304,923	+2 891 985,466	1483,700
55,832	Bas12_ramp	+81 305,042	+2 891 986,340	1483,700
59,332	Bas13_ramp	+81 305,514	+2 891 989,808	1483,700
69,470	Bas04_rad_15.290	+81 306,882	+2 891 999,854	1483,770
77,771	Bas05_rad_15.290	+81 310,126	+2 892 007,384	1483,800
116,655	Bas06_rad_16.550	+81 334,522	+2 892 037,662	1484,210
133,035	Bas07_rad_16.550	+81 349,015	+2 892 043,750	1484,410
174,477	Bas08_rad_16.825	+81 390,262	+2 892 039,731	1484,690
202,154	Bas09_rad_16.825	+81 405,209	+2 892 020,116	1484,710
241,400	Bas10_rad_16.142	+81 398,517	+2 891 981,445	1484,440
264,207	Bas11_rad_16.142	+81 382,394	+2 891 968,057	1484,230



DISTANCE (m)	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160
GROUND LEVEL	1485,766	1486,945	1486,489	1486,478	1486,528	1486,629	1486,553	1486,657	1487,521	1487,536	1487,315	1489,410	1489,339	1488,968	1489,035	1488,935	1488,789	1488,949	1488,707	1488,757	1488,729	1486,551	1487,618	1487,719	1487,652	1487,789	1487,898	1488,009	1488,006	1488,238	1488,153	1488,624	1488,286
DESIGN LEVEL	1485,766	1486,945	1486,489	1486,478	1486,528	1486,629	1486,553	1486,657	1486,659	1486,759	1486,859	1486,899	1486,899	1486,899	1486,899	1486,899	1486,899	1486,899	1486,899	1486,870	1486,453	1486,037	1485,620	1485,203	1484,787	1484,370	1483,953	1483,702	1483,745	1483,783	1483,821	1483,859	1483,897

REV	NATURE OF REVISION	DATE	SIGNED
A	FOR DISCUSSION	08-04-2022	G.R.

DESIGNED	G. ROBERTSON
CHECKED	J.C. NORRIS
DRAWN	B. NEWTON
CHECKED	G. ROBERTSON

DESIGN APPROVED:
JG AFRIKA (Pty) Ltd
J.C. NORRIS
NAME
SIGNATURE
-
DATE

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DESIGN APPROVED:
CLIENT
NAME
SIGNATURE
DATE

CLIENT
LAFARGE
Lafarge Industries South Africa (PTY) LTD Lichtenburg
1 Manana Road, Industrial Site, 2740
Tel: +27 21 633 3011
Email: uneysa.tajjard@lafargeholcim.com

PROJECT
LAFARGE CEMENT PLANT

DRAWING TITLE
ADDITIVES POLLUTION CONTROL DAM
LAYOUT PLAN & SECTIONS

ISSUED FOR DISCUSSION

SHEET 1 of 1	SCALE 1 : 500 / AS SHOWN	SIZE A1

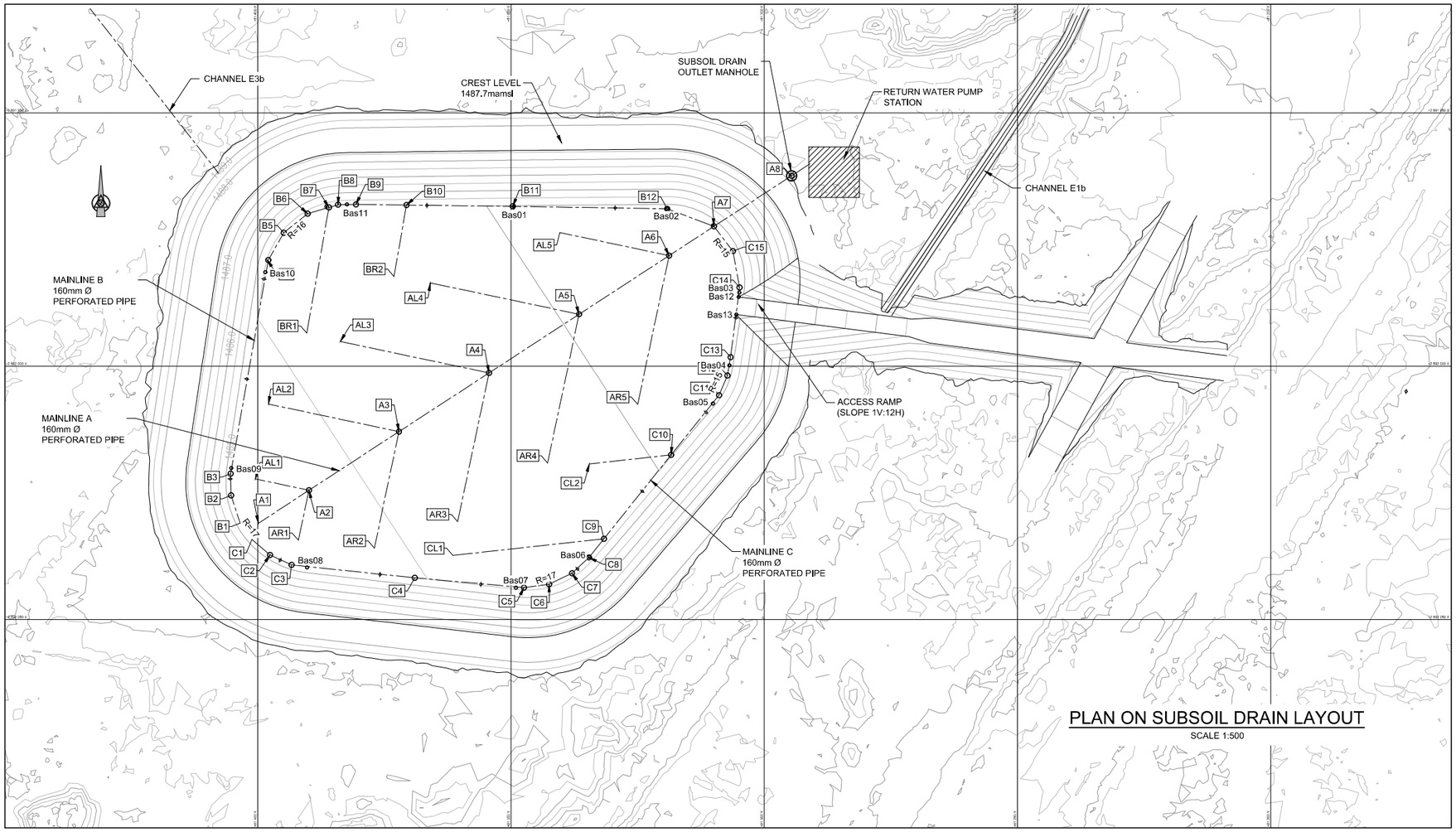
CLIENT DRAWING No.
-

JG AFRIKA (Pty) Ltd. DRAWING No
5707-JGA-P-LCP-CI-2001

REVISION
A

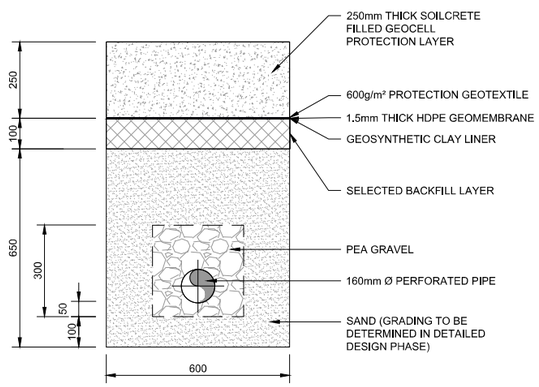
NewtonB 22.04.2022

W:\Projects\JGA\5707 - Lafarge Lichtenburg Expansion\WULA Studies and PCD Design (Phase)\ CAD\5707 - MODEL - LCP - ADDITIVES PCD.dwg



PLAN ON SUBSOIL DRAIN LAYOUT

SCALE 1:500



TYPICAL DAM LINER & SUBSOIL DRAIN

SCALE 1:10

ADDITIVE PCD SUBSOIL DRAIN SETTING OUT POINTS

WGS84 Lo 27

CHAINAGE (m)	POINT	Y	X	PIPE INVERT LEVEL (mamsl)
0	A1	+81 399.874	+2 892 031.009	1483.869
11.927	A2	+81 389.881	+2 892 024.499	1483.750
33.14	A3	+81 372.106	+2 892 012.919	1483.538
54.353	A4	+81 354.332	+2 892 001.340	1483.326
75.566	A5	+81 336.558	+2 891 989.761	1483.114
96.78	A6	+81 318.784	+2 891 978.182	1482.902
107.364	A7	+81 309.915	+2 891 972.405	1482.796
125.643	A8	+81 294.599	+2 891 962.427	1482.613

CHAINAGE (m)	POINT	Y	X	PIPE INVERT LEVEL (mamsl)
0	B1	+81 403.484	+2 892 030.973	1483.899
5.738	B2	+81 405.245	+2 892 025.512	1483.856
10.019	B3	+81 405.353	+2 892 021.233	1483.823
52.85	B4	+81 397.917	+2 891 979.052	1483.500
59.041	B5	+81 394.860	+2 891 973.669	1483.454
65.068	B6	+81 390.145	+2 891 969.913	1483.408
69.463	B7	+81 385.932	+2 891 968.666	1483.375
71.329	B8	+81 384.142	+2 891 968.136	1483.361
74.873	B9	+81 380.598	+2 891 968.080	1483.334
84.854	B10	+81 370.618	+2 891 968.200	1483.259
105.827	B11	+81 349.647	+2 891 968.451	1483.101
136.309	B12	+81 319.169	+2 891 968.943	1482.871
146.189	A7	+81 309.915	+2 891 972.405	1482.796

CHAINAGE (m)	POINT	Y	X	PIPE INVERT LEVEL (mamsl)
0	C1	+81 401.127	+2 892 034.212	1483.899
4.686	C2	+81 397.582	+2 892 037.276	1483.864
9.378	C3	+81 393.319	+2 892 039.238	1483.828
33.843	C4	+81 368.987	+2 892 041.780	1483.644
55.484	C5	+81 347.433	+2 892 043.723	1483.481
60.468	C6	+81 342.494	+2 892 043.060	1483.443
65.51	C7	+81 337.949	+2 892 040.877	1483.405
70.078	C8	+81 334.606	+2 892 037.763	1483.371
74.805	C9	+81 331.651	+2 892 034.074	1483.335
96.018	C10	+81 318.387	+2 892 017.519	1483.175
111.135	C11	+81 308.934	+2 892 005.722	1483.061
115.344	C12	+81 307.277	+2 892 001.853	1483.030
119.019	C13	+81 306.653	+2 891 998.231	1483.002
132.896	C14	+81 304.878	+2 891 984.468	1482.897
140.178	C15	+81 306.191	+2 891 977.305	1482.842
146.333	A7	+81 309.915	+2 891 972.405	1482.796

CHAINAGE (m)	POINT	Y	X	PIPE INVERT LEVEL (mamsl)
0	AL1	+81 400.458	+2 892 022.266	-0,850
10.81	A2	+81 389.881	+2 892 024.499	1483.750
0	AL2	+81 397.852	+2 892 007.486	-0,850
26.313	A3	+81 372.106	+2 892 012.919	1483.538
0	AL3	+81 383.685	+2 891 995.145	-0,850
30	A4	+81 354.332	+2 892 001.340	1483.326
0	AL4	+81 365.911	+2 891 983.566	-0,850
30	A5	+81 336.558	+2 891 989.761	1483.114
0	AL5	+81 340.351	+2 891 973.630	-0,850
22.043	A6	+81 318.784	+2 891 978.182	1482.902

CHAINAGE (m)	POINT	Y	X	PIPE INVERT LEVEL (mamsl)
0	AR1	+81 391.960	+2 892 034.353	-0,850
10.072	A2	+81 389.881	+2 892 024.499	1483.750
0	AR2	+81 376.962	+2 892 035.925	-0,850
23.513	A3	+81 372.106	+2 892 012.919	1483.538
0	AR3	+81 360.527	+2 892 030.694	-0,850
30	A4	+81 354.332	+2 892 001.340	1483.326
0	AR4	+81 342.753	+2 892 019.115	-0,850
30	A5	+81 336.558	+2 891 989.761	1483.114
0	AR5	+81 324.979	+2 892 007.536	-0,850
30	A6	+81 318.784	+2 891 978.182	1482.902

CHAINAGE (m)	POINT	Y	X	PIPE INVERT LEVEL (mamsl)
0	BR1	+81 390.308	+2 891 993.492	-0,850
25.209	B7	+81 385.932	+2 891 968.666	1483.375
0	BR2	+81 373.101	+2 891 982.282	-0,850
14.3	B10	+81 370.618	+2 891 968.200	1483.259

CHAINAGE (m)	POINT	Y	X	PIPE INVERT LEVEL (mamsl)
0	CL1	+81 361.470	+2 892 037.365	-0,850
30	C9	+81 331.651	+2 892 034.074	1483.335
0	CL2	+81 334.526	+2 892 019.301	-0,850
16.238	C10	+81 318.387	+2 892 017.519	1483.175

REV	NATURE OF REVISION	DATE	SIGNED
A	FOR DISCUSSION	08-04-2022	G.R.

DESIGNED	G. ROBERTSON
CHECKED	J.C. NORRIS
DRAWN	B. NEWTON
CHECKED	G. ROBERTSON

DESIGN APPROVED:
JG AFRIKA (Pty) Ltd
J.C. NORRIS
NAME
SIGNATURE
-
DATE

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DESIGN APPROVED:
CLIENT
NAME
SIGNATURE
DATE

CLIENT
LAFARGE
Lafarge Industries South Africa (PTY) LTD Lichtenburg
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Email: uneysa.taljard@lafargeholcim.com

PROJECT
LAFARGE CEMENT PLANT

DRAWING TITLE
ADDITIVES POLLUTION CONTROL DAM
SUB-SOIL DRAINS
LAYOUT & SETTING OUT DETAILS

ISSUED FOR DISCUSSION

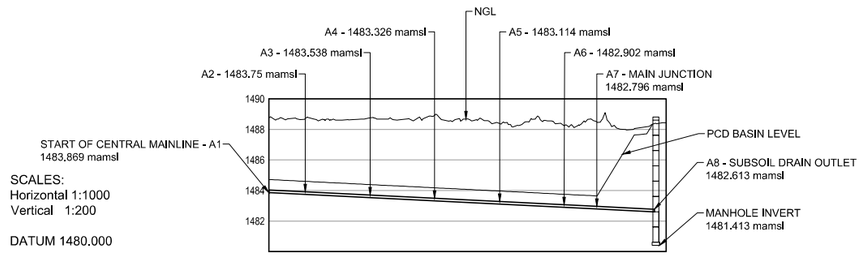
SHEET	SCALE	SIZE
1 of 1	1 : 500	A1

CLIENT DRAWING No.
-

JG AFRIKA (Pty) Ltd. DRAWING No
5707-JGA-P-LCP-CI-2002

REVISION
A

Newton® 22.04.2022

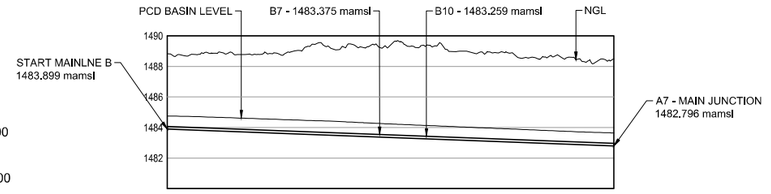


SCALES:
Horizontal 1:1000
Vertical 1:200

DATUM 1480.000

DISTANCE (m)		10	20	30	40	50	60	70	80	90	100	110	120	130
GROUND LEVEL	1488.758	1488.553	1488.601	1488.674	1488.716	1488.623	1488.511	1488.633	1488.170	1488.365	1488.128	1489.074	1488.066	1488.433
PCD DESIGN LEVELS	1484.719	1484.619	1484.519	1484.419	1484.319	1484.219	1484.119	1484.019	1483.919	1483.819	1483.719	1484.497	1487.637	
SUBSOIL DRAIN INVERT LEVELS		1483.769	1483.669	1483.569	1483.469	1483.369	1483.269	1483.169	1483.069	1482.970	1482.870	1482.770	1482.670	

LONGITUDINAL SECTION
SUBSOIL - CENTRE MAIN
FROM 0.000 TO 130.024

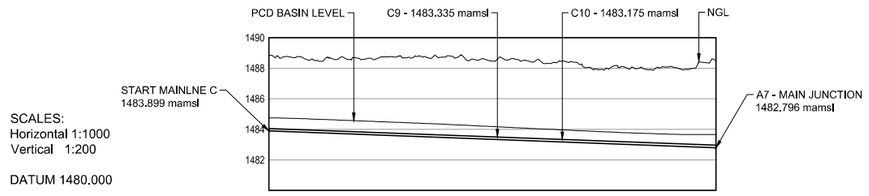


SCALES:
Horizontal 1:1000
Vertical 1:200

DATUM 1480.000

DISTANCE (m)		0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	146
GROUND LEVEL	1488.820	1488.769	1488.869	1488.772	1488.920	1489.557	1489.474	1489.210	1489.339	1489.406	1488.894	1488.923	1488.566	1488.472	1488.243	1488.465	
PCD DESIGN LEVELS	1484.749	1484.712	1484.644	1484.575	1484.507	1484.439	1484.355	1484.257	1484.172	1484.089	1484.006	1483.922	1483.840	1483.757	1483.662	1483.650	
SUBSOIL DRAIN INVERT LEVELS	1483.899	1483.824	1483.748	1483.673	1483.597	1483.522	1483.446	1483.371	1483.295	1483.220	1483.144	1483.069	1482.994	1482.918	1482.843	1482.796	

LONGITUDINAL SECTION
SUBSOIL - LEFT MAIN
FROM 0.000 TO 146.189



SCALES:
Horizontal 1:1000
Vertical 1:200

DATUM 1480.000

DISTANCE (m)		0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	146
GROUND LEVEL	1488.847	1488.755	1488.673	1488.565	1488.753	1488.757	1488.772	1488.622	1488.627	1488.295	1488.384	1487.922	1487.969	1488.073	1488.129	1488.485	
PCD DESIGN LEVELS	1484.749	1484.705	1484.627	1484.549	1484.471	1484.392	1484.309	1484.210	1484.115	1484.020	1483.925	1483.830	1483.753	1483.688	1483.650	1483.650	
SUBSOIL DRAIN INVERT LEVELS	1483.899	1483.824	1483.748	1483.673	1483.597	1483.522	1483.447	1483.371	1483.296	1483.221	1483.145	1483.070	1482.994	1482.919	1482.844	1482.796	

LONGITUDINAL SECTION
SUBSOIL - RIGHT MAIN
FROM 0.000 TO 146.333

REV	NATURE OF REVISION	DATE	SIGNED
A	FOR DISCUSSION	08-04-2022	G.R.

DESIGNED	G. ROBERTSON
CHECKED	J.C. NORRIS
DRAWN	B. NEWTON
CHECKED	G. ROBERTSON

DESIGN APPROVED:
JG AFRIKA (Pty) Ltd
J.C. NORRIS
NAME
SIGNATURE
-
DATE

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E-MAIL pietermaritzburg@jgafrika.com

DESIGN APPROVED:
CLIENT
NAME
SIGNATURE
DATE

CLIENT
LAFARGE
Lafarge Industries South Africa (PTY) LTD Lichtenburg
1 Manana Road, Industrial Site, 2740
Tel: +27 21 633 3011
Email: uneysa.taljard@lafargeholcim.com

PROJECT
LAFARGE CEMENT PLANT

DRAWING TITLE
ADDITIVES POLLUTION CONTROL DAM
SUB-SOIL DRAINS
LONGITUDINAL SECTIONS

ISSUED FOR DISCUSSION

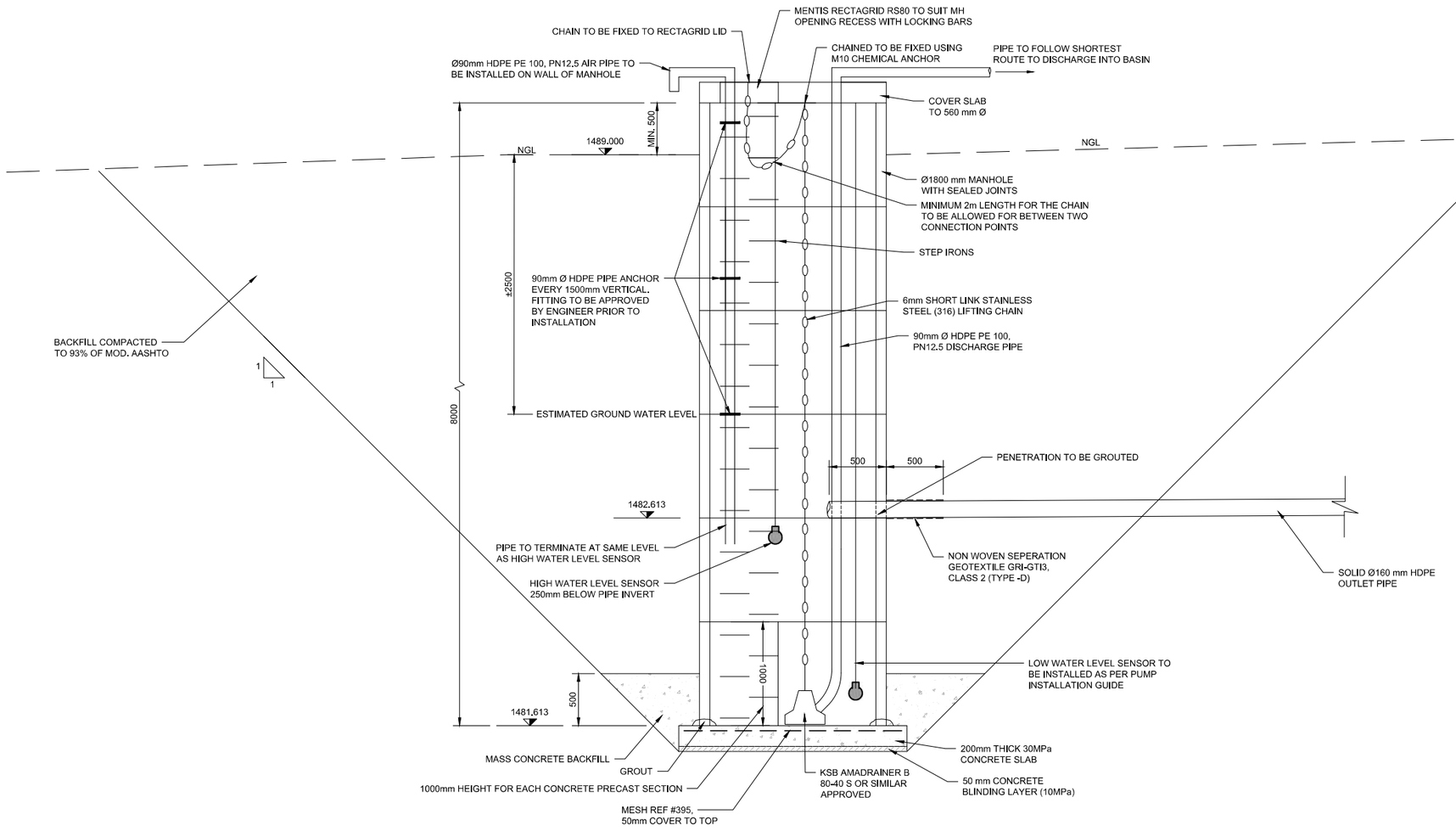
SHEET 1 of 1 | SCALE AS SHOWN | SIZE A1

CLIENT DRAWING No.
-

JG AFRIKA (Pty) Ltd. DRAWING No
5707-JGA-P-LCP-CI-2003

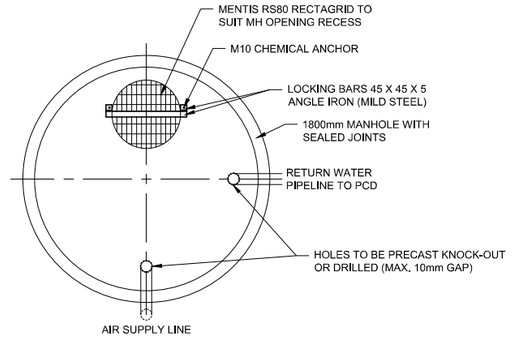
REVISION A

Newton® 22-04-2022



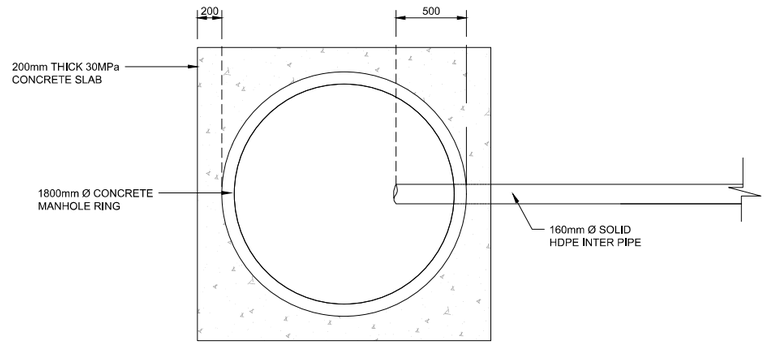
ADDITIVES PCD MANHOLE DETAIL

SCALE 1:25



TYPICAL MANHOLE COVER DETAIL

SCALE 1:25



TYPICAL MANHOLE PLAN VIEW

SCALE 1:25

REV	NATURE OF REVISION	DATE	SIGNED
A	FOR DISCUSSION	08-04-2022	G.R.

DESIGNED	G. ROBERTSON
CHECKED	J.C. NORRIS
DRAWN	B. NEWTON
CHECKED	G. ROBERTSON

DESIGN APPROVED:
JG AFRIKA (Pty) Ltd
NAME: J.C. NORRIS
SIGNATURE:
DATE: -

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DESIGN APPROVED:
CLIENT
NAME
SIGNATURE
DATE

CLIENT
LAFARGE
Lafarge Industries South Africa (PTY) LTD Lichtenburg
1 Manana Road, Industrial Site, 2740
Tel: +27 21 633 3011
Email: uneysa.taljard@lafargeholcim.com

PROJECT
LAFARGE CEMENT PLANT

DRAWING TITLE
ADDITIVES POLLUTION CONTROL DAM
SUB-SOIL DRAINS
MANHOLE DETAILS

ISSUED FOR DISCUSSION

SHEET	SCALE	SIZE
SHEET 1 of 1	1 : 25	A1

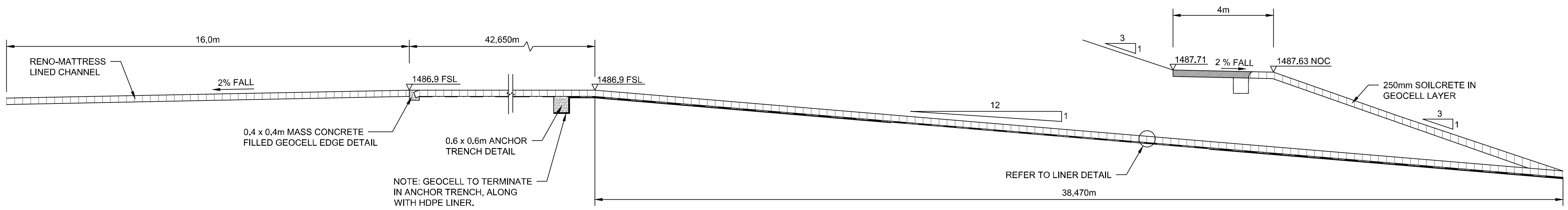
CLIENT DRAWING No.: -

JG AFRIKA (Pty) Ltd. DRAWING No: 5707-JGA-P-LCP-CI-2004

REVISION: A

Newton® 04.05.2022

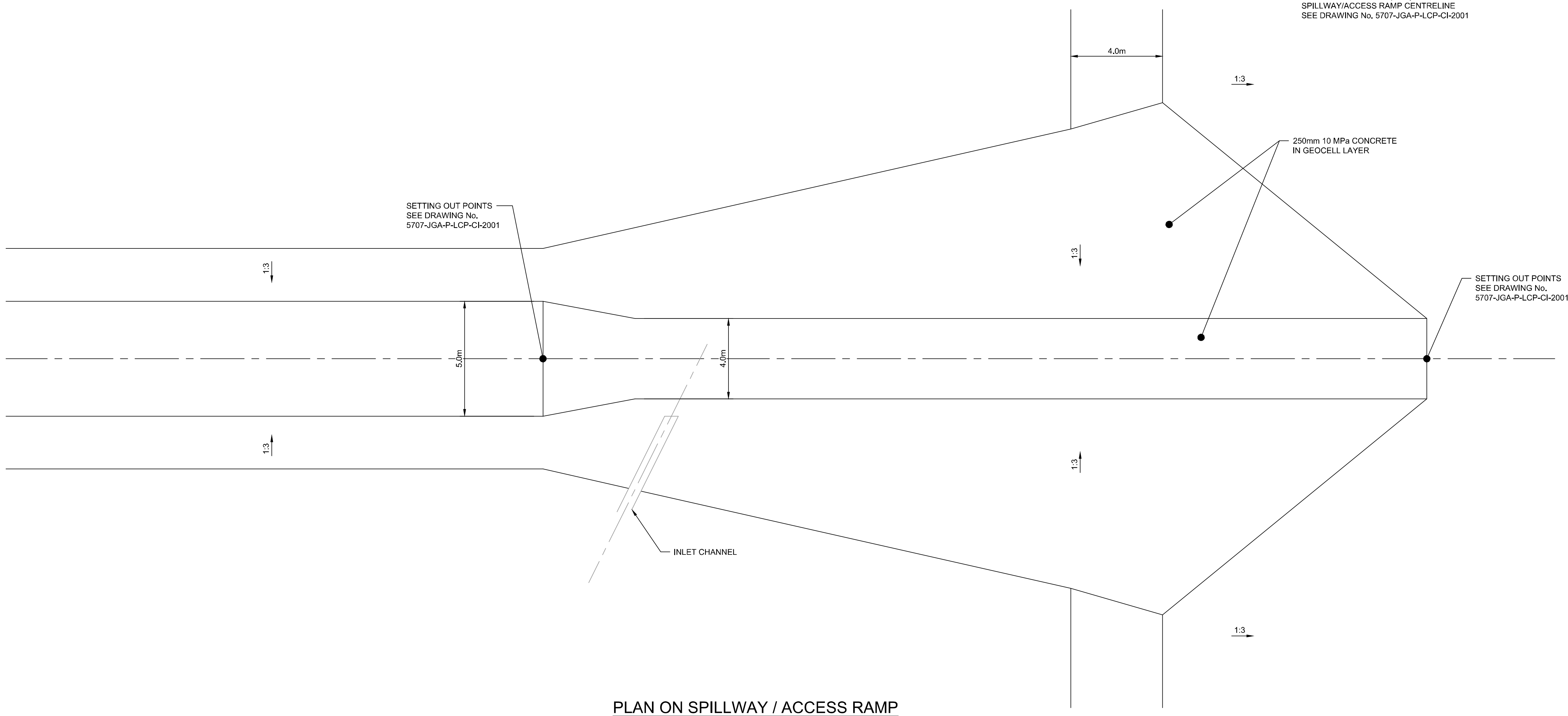
N:\Flynn\JGA\5707 - Lafarge Lichtenburg Specialist Work Studies and PCD Design (Philip)\7 CAD\5707 - MODEL - LCP - ADDITIVES PCD.dwg



TYPICAL SECTION THROUGH SPILLWAY / ACCESS RAMP

SCALE 1:100m

NOTE:
SETTING OUT POINTS (SOP) ALONG
SPILLWAY/ACCESS RAMP CENTRELINE
SEE DRAWING No. 5707-JGA-P-LCP-CI-2001



PLAN ON SPILLWAY / ACCESS RAMP

SCALE 1:100m

REV	NATURE OF REVISION	DATE	SIGNED
A	FOR DISCUSSION	08-04-2022	G.R.

DESIGNED	M. MUVHALI
CHECKED	G. ROBERTSON
DRAWN	B. NEWTON
CHECKED	G. ROBERTSON

DESIGN APPROVED:
JG AFRIKA (Pty) Ltd
J.C. NORRIS
NAME
SIGNATURE
-
DATE

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PROJECT
LAFARGE CEMENT PLANT

DRAWING TITLE
ADDITIVES POLLUTION CONTROL DAM
SPILLWAY / ACCESS RAMP DETAILS

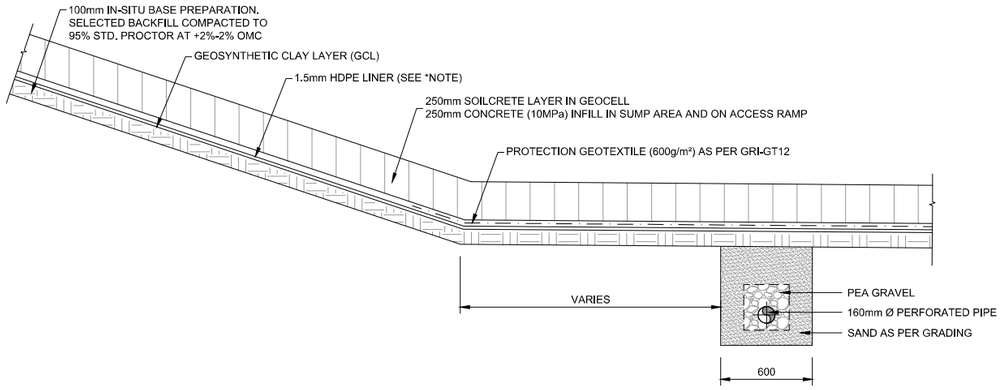
ISSUED FOR DISCUSSION

SHEET 1 of 1 | SCALE AS SHOWN | SIZE A1

CLIENT DRAWING No. -

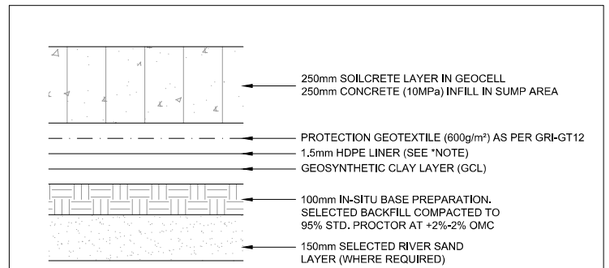
JG AFRIKA (Pty) Ltd. DRAWING No 5707-JGA-P-LCP-CI-2005 | REVISION A

NewtonB 22.04.2022



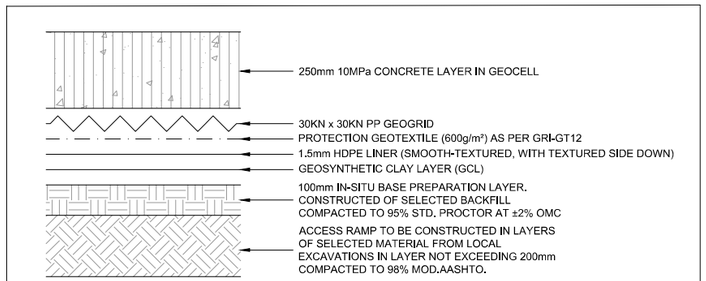
TYPICAL SECTION THROUGH BASIN FLOOR

SCALE 1:20

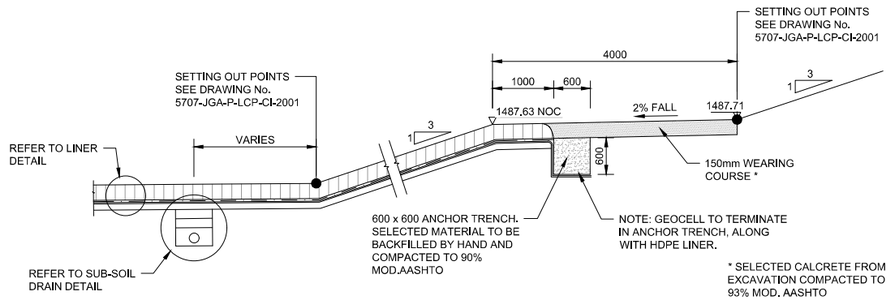


LINER DETAIL CLASS C AS PER GN 636

*NOTE:
1. 1.5mm HDPE LINER IS TO BE SMOOTH-SMOOTH ON BASIN.
2. 1.5mm HDPE LINER IS TO BE SMOOTH-TEXTURED, WITH TEXTURED SIDE PLACED DOWN, ON SIDE SLOPES.



LINER DETAIL FOR ACCESS RAMP



TYPICAL SECTION THROUGH EMBANKMENT CREST

SCALE 1:20

REV	NATURE OF REVISION	DATE	SIGNED
A	FOR DISCUSSION	08-04-2022	G.R.

DESIGNED	G. ROBERTSON
CHECKED	J.C. NORRIS
DRAWN	B. NEWTON
CHECKED	G. ROBERTSON

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PROJECT
LAFARGE CEMENT PLANT

DRAWING TITLE
ADDITIVES POLLUTION CONTROL DAM
TYPICAL SECTIONS & DETAILS

ISSUED FOR DISCUSSION

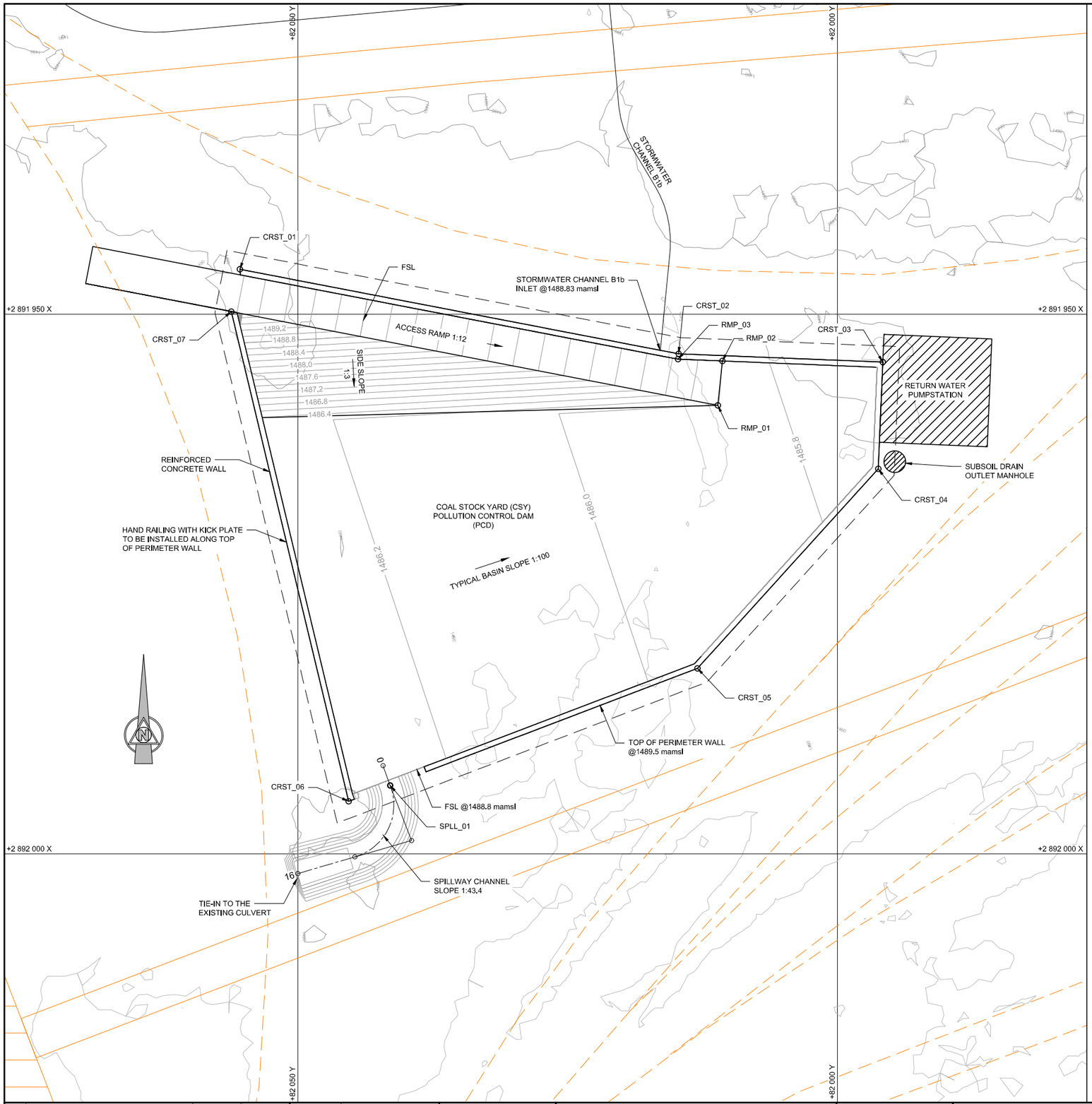
SHEET	SCALE	SIZE
1 of 1	AS SHOWN	A1

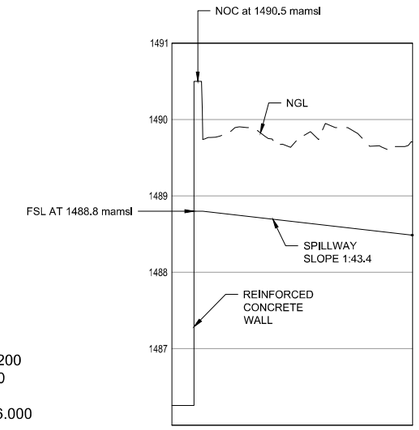
CLIENT DRAWING No.
-

JG AFRIKA (Pty) Ltd. DRAWING No
5707-JGA-P-LCP-CI-2006

REVISION
A

Newton® 22.04.2022





SCALES:
Horizontal 1:200
Vertical 1:40

DATUM 1486.000

DISTANCE (m)	0	2	4	6	8	10	12	14	16
GROUND LEVEL	1486.258	1490.022	1489.871	1489.795	1489.688	1489.926	1489.835	1489.617	1489.703
DESIGN LEVEL		1488.800	1488.755	1488.708	1488.662	1488.616	1488.570	1488.524	1488.485
CUT / FILL		1.222	1.117	1.086	1.026	1.310	1.265	1.093	1.218

LONGITUDINAL SECTION
COAL STOCKYARD SPILLWAY
FROM 0.000 TO 15.759

COAL STOCKYARD PCD SETTING OUT POINTS
WGS84 Lo 27

POINT	Y	X	LEVEL (mamsl)
Crst_01	+82 055.359	+2 891 945.839	1490.500
Crst_02	+82 014.711	+2 891 953.667	1490.500
Crst_03	+81 995.794	+2 891 954.437	1490.500
Crst_04	+81 996.219	+2 891 964.323	1490.500
Crst_05	+82 012.964	+2 891 982.808	1490.500
Spll_01	+82 041.437	+2 891 993.659	1488.800
Crst_06	+82 045.283	+2 891 995.124	1490.500
Crst_07	+82 056.159	+2 891 949.759	1490.500
Rmp_01	+82 011.075	+2 891 958.444	1485.936
Rmp_02	+82 010.657	+2 891 954.337	1486.000
Rmp_03	+82 014.769	+2 891 954.166	1486.357

REV	NATURE OF REVISION	DATE	SIGNED
A	FOR DISCUSSION	13-04-2022	G.R.

DESIGNED	G. ROBERTSON
CHECKED	J.C. NORRIS
DRAWN	B. NEWTON
CHECKED	G. ROBERTSON

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PROJECT
LAFARGE CEMENT PLANT

DRAWING TITLE
COAL STOCKYARD POLLUTION CONTROL DAM
LAYOUT PLAN & SECTIONS

ISSUED FOR DISCUSSION

SHEET 1 of 1 | SCALE 1 : 200 / AS SHOWN | SIZE A1

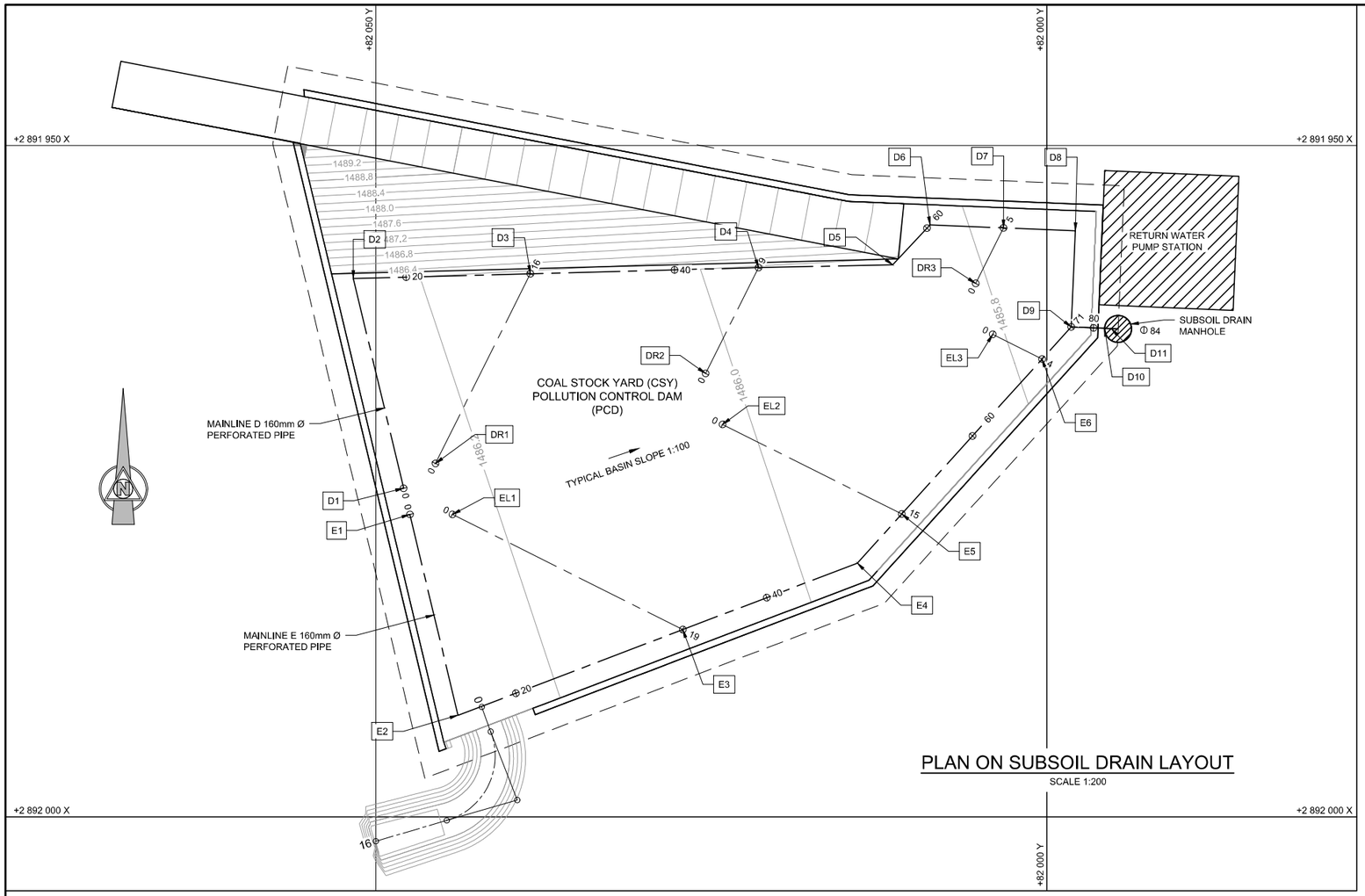
CLIENT DRAWING No.
-

JG AFRIKA (Pty) Ltd. DRAWING No
5707-JGA-P-LCP-CI-3001

REVISION A

Newton® 04.05.2022

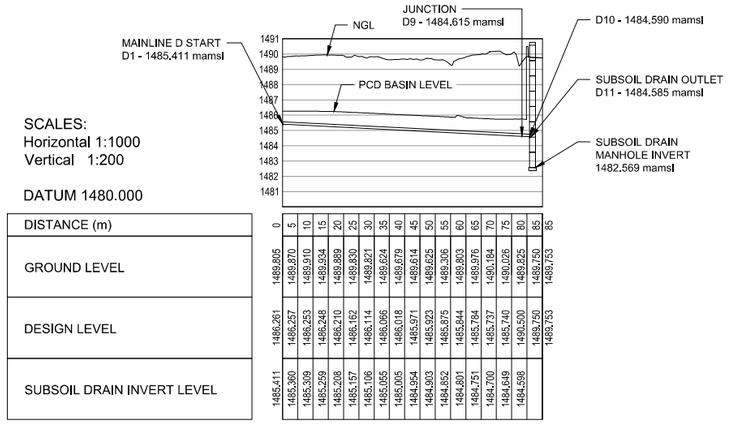
N:\Projects\JGA\5707 - Lafarge Lichtenburg Upgrades\4 WULA Studies and PCD Design (Hydro)\7 CAD\5707 - MODEL - LCP - COAL STOCKYARD PCD.dwg



PLAN ON SUBSOIL DRAIN LAYOUT

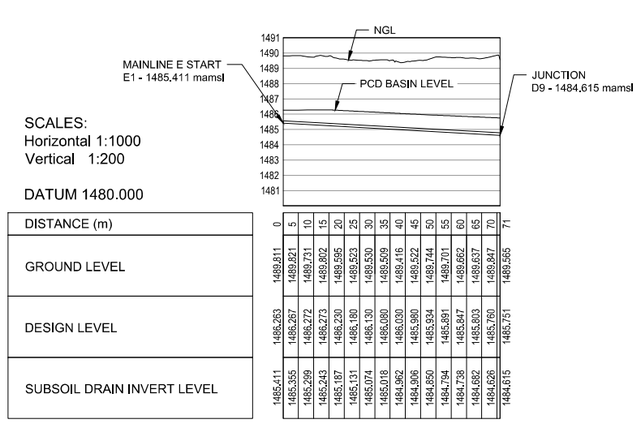
SCALE 1:200

COAL STOCKYARD PCD - SUB-SOIL DRAIN SETTING OUT POINTS				
WGS84 Lo 27				
CHAINAGE (m)	POINT	Y	X	PIPE INVERT LEVEL (mamsl)
0	D1	+82 047.923	+2 891 975.530	1485.411
16.065	D2	+82 051.667	+2 891 959.908	1485.248
29.254	D3	+82 038.483	+2 891 959.553	1485.114
46.26	D4	+82 021.483	+2 891 959.096	1484.941
56.252	D5	+82 011.493	+2 891 958.891	1484.839
60.328	D6	+82 008.709	+2 891 955.913	1484.798
65.81	D7	+82 003.231	+2 891 956.136	1484.742
71.168	D8	+81 997.878	+2 891 956.354	1484.688
78.336	D9	+81 998.186	+2 891 963.516	1484.615
80.826	D10	+81 995.699	+2 891 963.623	1484.590
81.326	D11	+81 995.200	+2 891 963.644	1484.585
CHAINAGE (m)	POINT	Y	X	PIPE INVERT LEVEL (mamsl)
0	E1	+82 047.455	+2 891 977.482	1485.411
15.386	E2	+82 043.869	+2 891 992.445	1485.238
33.307	E3	+82 027.123	+2 891 986.063	1485.037
47.217	E4	+82 014.125	+2 891 981.110	1484.881
52.155	E5	+82 010.810	+2 891 977.451	1484.826
67.729	E6	+82 000.354	+2 891 965.908	1484.651
70.957	D9	+81 998.186	+2 891 963.516	1484.615
CHAINAGE (m)	POINT	Y	X	PIPE INVERT LEVEL (mamsl)
0	DR1	+81 391.960	+2 892 034.353	1485.383
15.801	D3	+82 037.567	+2 891 957.721	1485.087
0	DR2	+81 376.962	+2 892 035.925	1485.171
8.814	D4	+82 020.565	+2 891 957.261	1484.917
0	DR3	+81 360.527	+2 892 030.694	1484.959
4.625	D7	+82 003.231	+2 891 956.136	1484.741
CHAINAGE (m)	POINT	Y	X	PIPE INVERT LEVEL (mamsl)
0	EL1	+81 390.308	+2 891 993.492	1485.383
19.189	E3	+82 027.123	+2 891 986.063	1485.037
0	EL2	+81 373.101	+2 891 982.282	1485.171
14.928	E5	+82 010.810	+2 891 977.451	1484.826
0	EL3	+81 373.101	+2 891 982.282	1484.959
4.116	E6	+82 000.354	+2 891 965.908	1484.651



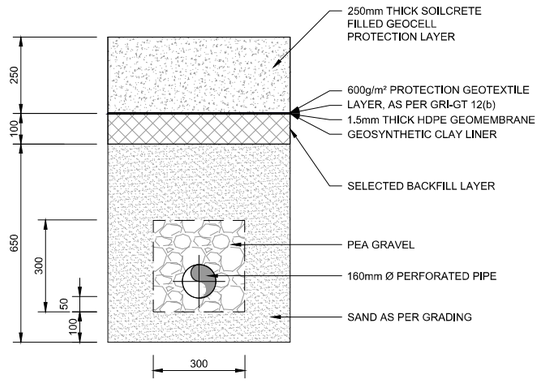
DISTANCE (m)	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
GROUND LEVEL	1489.805	1489.870	1489.910	1489.934	1489.889	1489.830	1489.821	1489.624	1489.679	1489.614	1489.625	1489.306	1489.803	1489.976	1490.184	1490.026	1489.825	1489.750	1489.753
DESIGN LEVEL	1486.261	1486.257	1486.253	1486.248	1486.210	1486.162	1486.114	1486.066	1486.018	1485.971	1485.923	1485.875	1485.844	1485.784	1485.737	1485.740	1490.500	1489.750	1489.753
SUBSOIL DRAIN INVERT LEVEL	1485.411	1485.360	1485.309	1485.259	1485.208	1485.157	1485.106	1485.055	1485.005	1484.954	1484.903	1484.852	1484.801	1484.751	1484.700	1484.649	1484.598		

LONGITUDINAL SECTION
COAL STOCKYARD SUBSOIL DRAIN - LEFT MAIN
FROM 0.000 TO 85.053



DISTANCE (m)	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	71
GROUND LEVEL	1489.811	1489.821	1489.731	1489.802	1489.595	1489.523	1489.530	1489.509	1489.416	1489.522	1489.744	1489.701	1489.662	1489.637	1489.847	1489.565		
DESIGN LEVEL	1486.263	1486.267	1486.272	1486.273	1486.230	1486.180	1486.130	1486.080	1486.030	1485.980	1485.934	1485.891	1485.847	1485.803	1485.760	1485.751		
SUBSOIL DRAIN INVERT LEVEL	1485.411	1485.355	1485.299	1485.243	1485.187	1485.131	1485.074	1485.018	1484.962	1484.906	1484.850	1484.794	1484.738	1484.682	1484.626	1484.815		

LONGITUDINAL SECTION
COAL STOCKYARD SUB-SOIL DRAIN - RIGHT MAIN
FROM 0.000 TO 70.957



TYPICAL DAM LINER & SUBSOIL DRAIN DETAIL

SCALE 1:10

REV	NATURE OF REVISION	DATE	SIGNED
A	FOR DISCUSSION	13-04-2022	G.R.

DESIGNED	G. ROBERTSON
CHECKED	J.C. NORRIS
DRAWN	B. NEWTON
CHECKED	G. ROBERTSON

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J.C. NORRIS
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DESIGN APPROVED:
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Tel: +27 21 633 3011
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PROJECT
LAFARGE CEMENT PLANT

DRAWING TITLE
COAL STOCKYARD POLLUTION CONTROL DAM
SUB-SOIL DRAINS
LAYOUT & SECTIONS

ISSUED FOR DISCUSSION

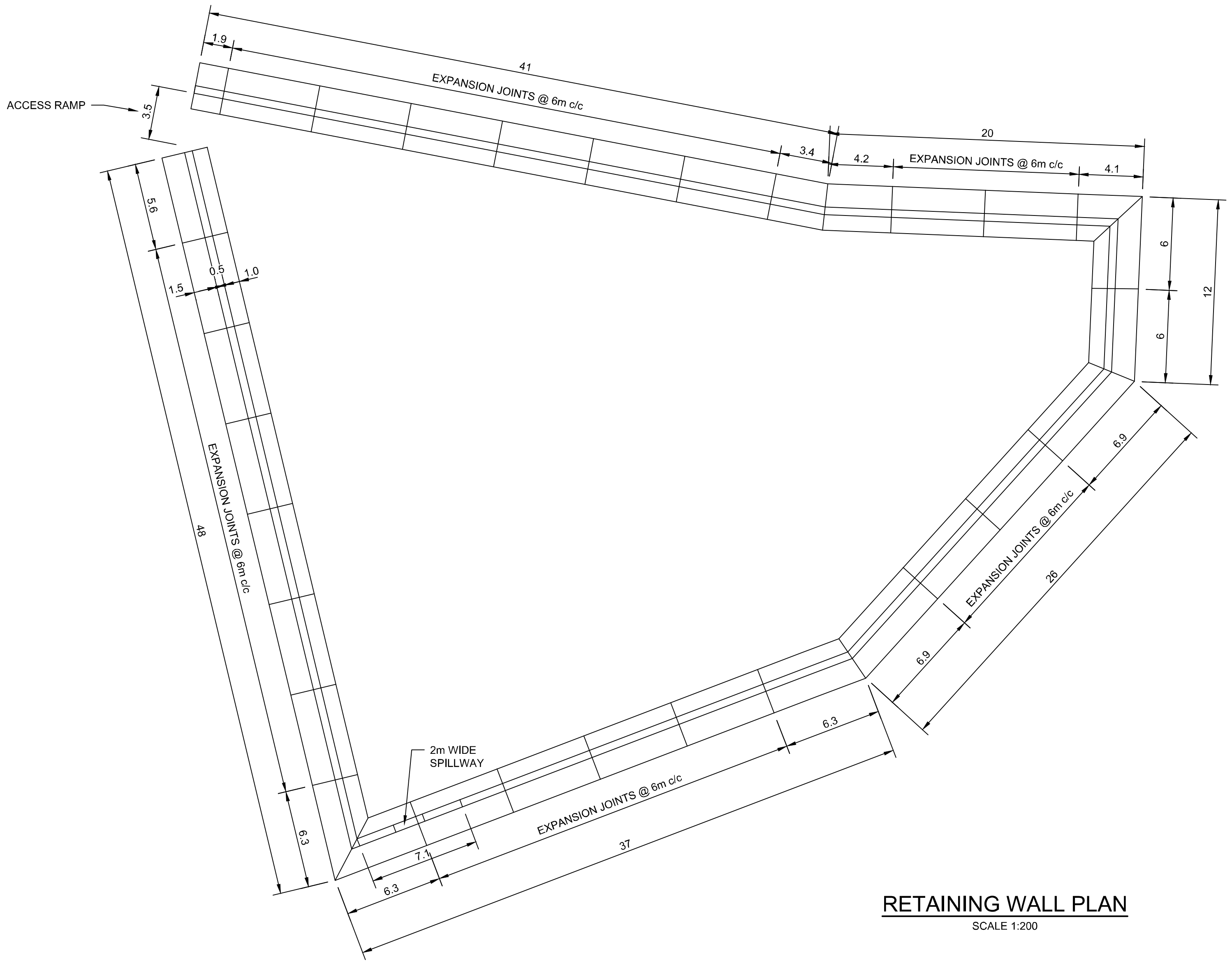
SHEET 1 of 1	SCALE AS SHOWN	SIZE A1

CLIENT DRAWING No.
-

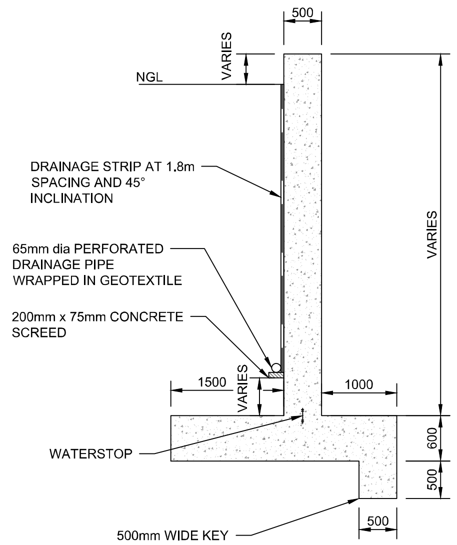
JG AFRIKA (Pty) Ltd. DRAWING No
5707-JGA-P-LCP-CI-3002

REVISION
A

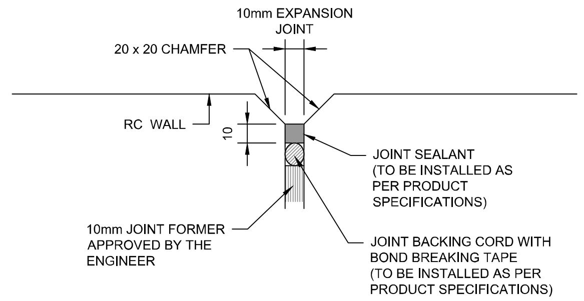
Newton® 22.04.2022



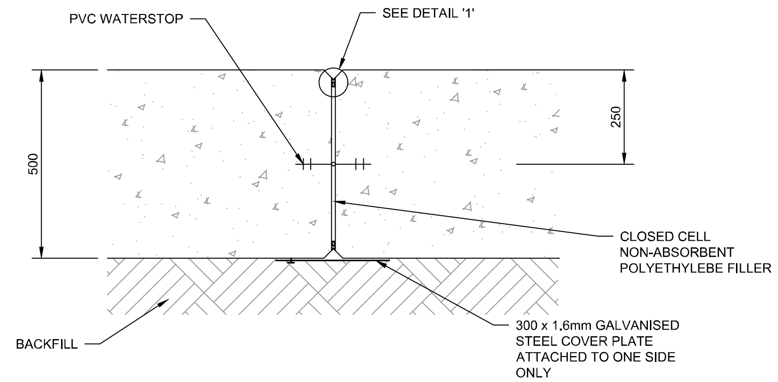
RETAINING WALL PLAN
SCALE 1:200



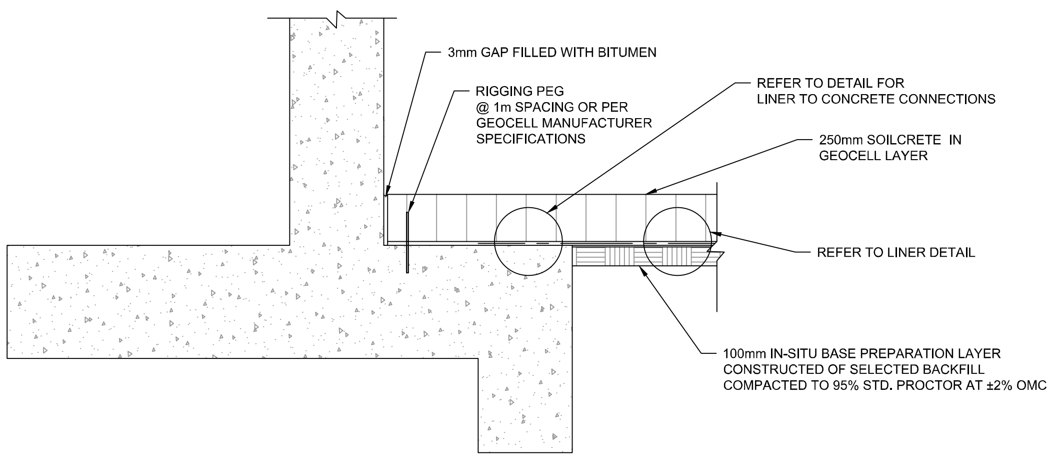
TYPICAL RETAINING WALL DETAIL
SCALE 1:50



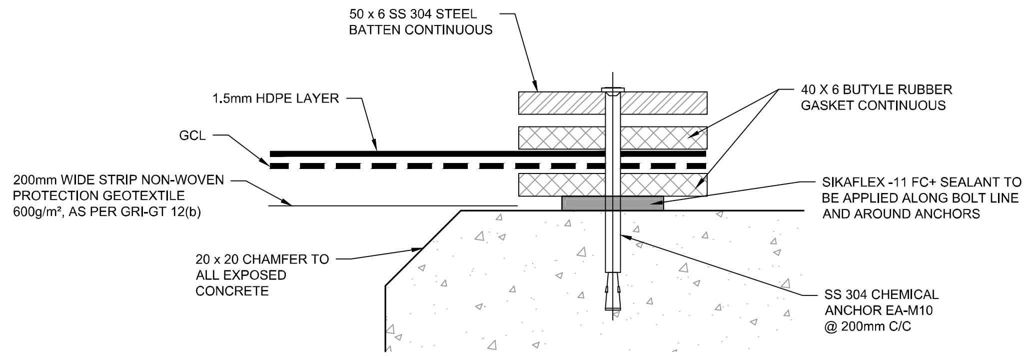
DETAIL '1' SEALING JOINT
SCALE 1:2



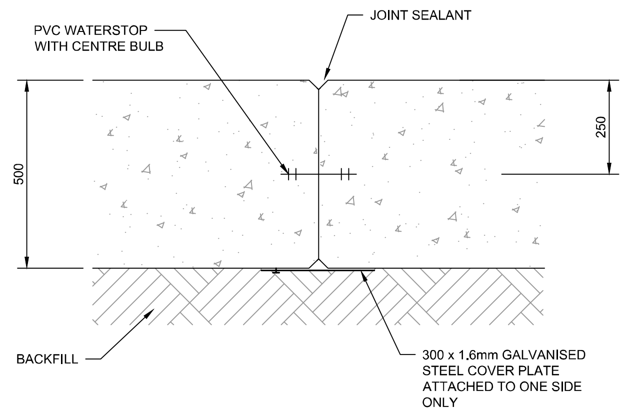
WALL EXPANSION JOINT DETAIL
SCALE 1:10



DETAIL FOR GEOCELL TO CONCRETE CONNECTIONS
SCALE 1:20



DETAIL FOR ALL LINER / CONCRETE CONNECTIONS
SCALE 1:1



WALL CONSTRUCTION JOINT DETAIL
SCALE 1:10

REV	NATURE OF REVISION	DATE	SIGNED
A	FOR DISCUSSION	13-04-2022	G.R.

DESIGNED	M. MUVHALI
CHECKED	G. PEARSON
DRAWN	B. NEWTON
CHECKED	G. ROBERTSON

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JG AFRIKA (Pty) Ltd
J.C. NORRIS
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PROJECT
LAFARGE CEMENT PLANT

DRAWING TITLE
COAL STOCKYARD POLLUTION CONTROL DAM
PERIMETER RETAINING WALL DETAILS

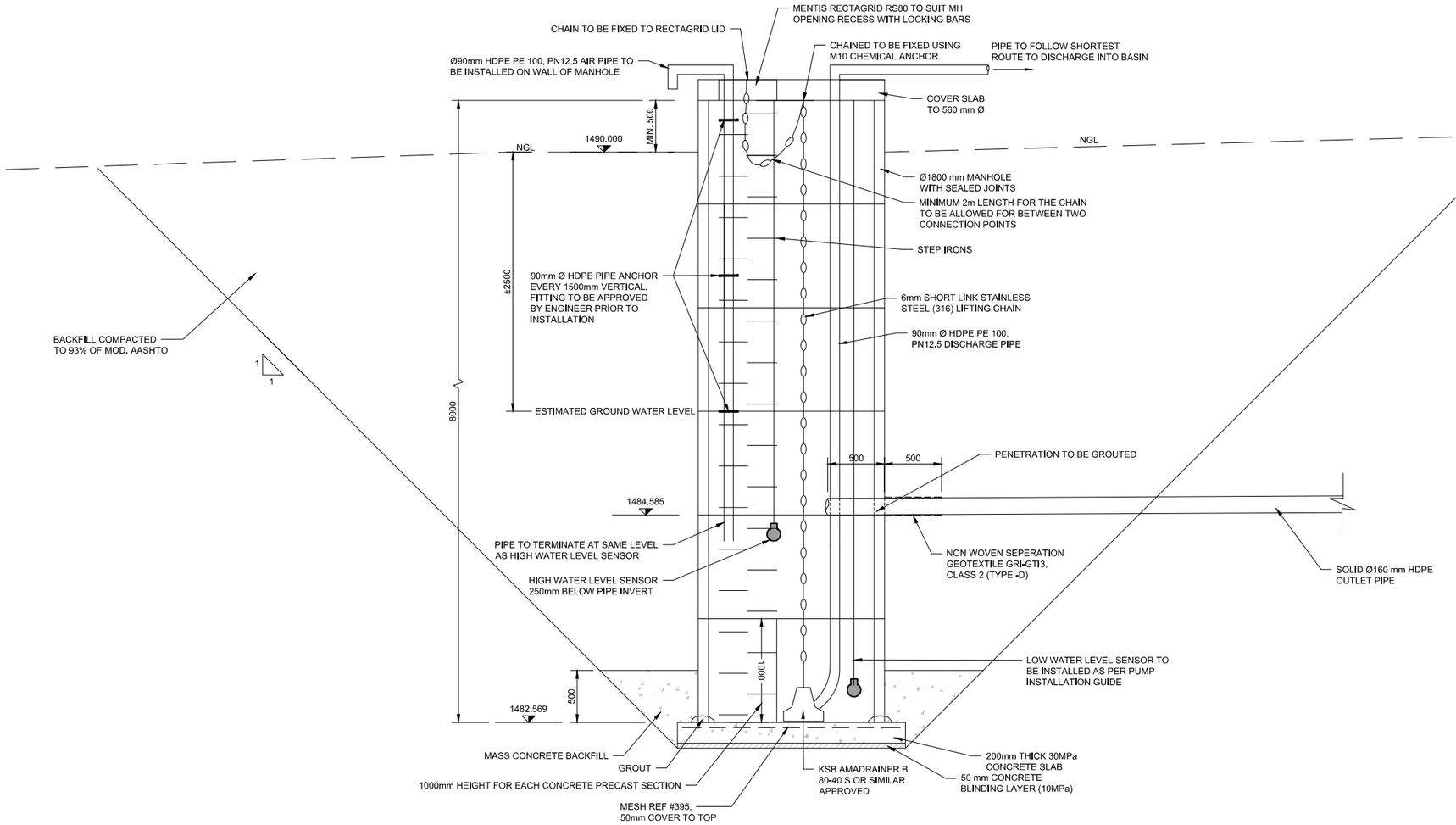
ISSUED FOR DISCUSSION

SHEET 1 of 1 | SCALE AS SHOWN | SIZE A1

CLIENT DRAWING No. -

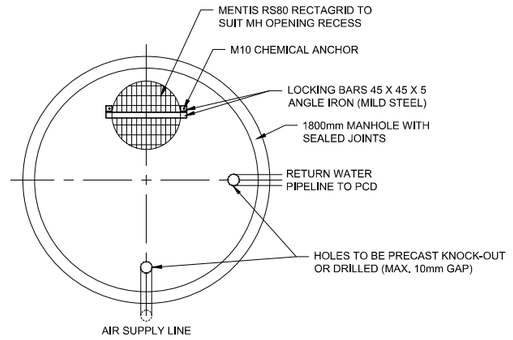
JG AFRIKA (Pty) Ltd. DRAWING No 5707-JGA-P-LCP-CI-3003 | REVISION A

Newton/B 22.04.2022



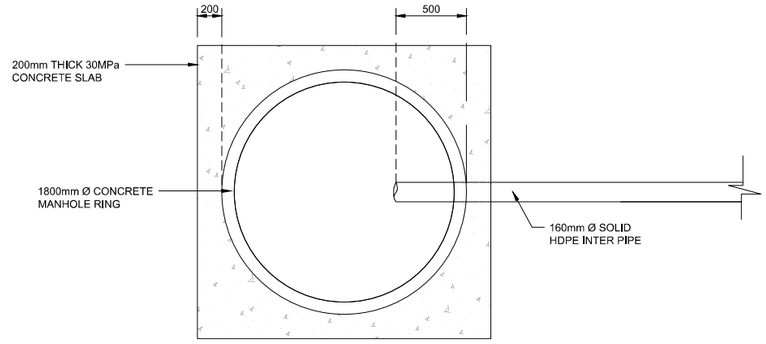
COAL STOCKYARD PCD MANHOLE DETAIL

SCALE 1:25



TYPICAL MANHOLE COVER DETAIL

SCALE 1:25



TYPICAL MANHOLE PLAN VIEW

SCALE 1:25

REV	NATURE OF REVISION	DATE	SIGNED
A	FOR DISCUSSION	13-04-2022	G.R.

DESIGNED	G. ROBERTSON
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CHECKED	G. ROBERTSON

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PROJECT
LAFARGE CEMENT PLANT

DRAWING TITLE
COAL STOCKYARD POLLUTION CONTROL DAM
SUB-SOIL DRAINS
MANHOLE DETAILS

ISSUED FOR DISCUSSION

SHEET	SCALE	SIZE
1 of 1	1 : 25	A1

CLIENT DRAWING No.: -

JG AFRIKA (Pty) Ltd. DRAWING No: 5707-JGA-P-LCP-CI-3004

REVISION: A

Newton® 22.04.2022

W:\Lafarge\JGA\5707 - Lafarge Lichtenburg Specialist WULA Studies and PCD Design (Phase1 CAD)\5707 - MODEL - LCP - COAL STOCKYARD PCD.dwg