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MATIMBA POWER STATION: ASH DUMP
PROJECT TECHNICAL SPECIFICATIONS

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Knight Piésold CONSULTING

EXECUTIVE SUMMARY

This Construction Project Specification is provided as a guide to the construction works associated with works for Matimba Ash Dump Project. It is intended to aid the Employer, Engineer and Contractor in all aspects related to the project.

Standard procedures will be used for all activities and, in general, they will be those adopted by recognized organizations. These recognized organizations include the South African National Standards (SANS), American Society for Testing and Materials (ASTM and the American Association of State Highway and Transportation Officials (AASHTO),

The Design Report, Bill of Quantities and Drawings issued for construction of the Matimba Ash Dump and Associated works constitute an integrated set of documents defining design intent and construction approach. This specification is intended to be read in conjunction with these documents to provide a complete understanding of the project. This document has been prepared with the intent that project personnel will be sufficiently trained and experienced to be able to implement not only the specific criteria noted herein but to recognize conditions that differ from those described in the design documents and take a proactive role in seeing that the intent of the design documents is met. The information described herein is the minimum required, and it is intended that project personnel will take a proactive role in performing additional work as needed to see that construction is accomplished to meet the intent of the design.

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1.1.1 PROJECT DESCRIPTION

The project comprises the construction of Ash dump, two return water dams, two silt traps, perimeter access road, dirty water canal, clean water canal and dust suppression pipeline. The ash dump has a Class C liner with underdrainage works. The Ash dump will be constructed in 4-year phases to the end of the station's life.

1.1.2 PROJECT LOCATION

The Ash Dump Disposal Facility is approximately 3km south of the Matimba Power Station terrace and to the south-west of the main road from Lephalale (Ellisras) to the Power Station and Grootegeluk coal mine. (Route P1675).

Matimba Power Station is a coal fired power station of which the coal is sourced from the adjacent EXXARO mine. The process of burning coal results in producing ash as a by-product which needs to be disposed of on a designated waste disposal facility. The power station was commissioned from 1987 to 1991 and must operate for 60 years up to 2055.

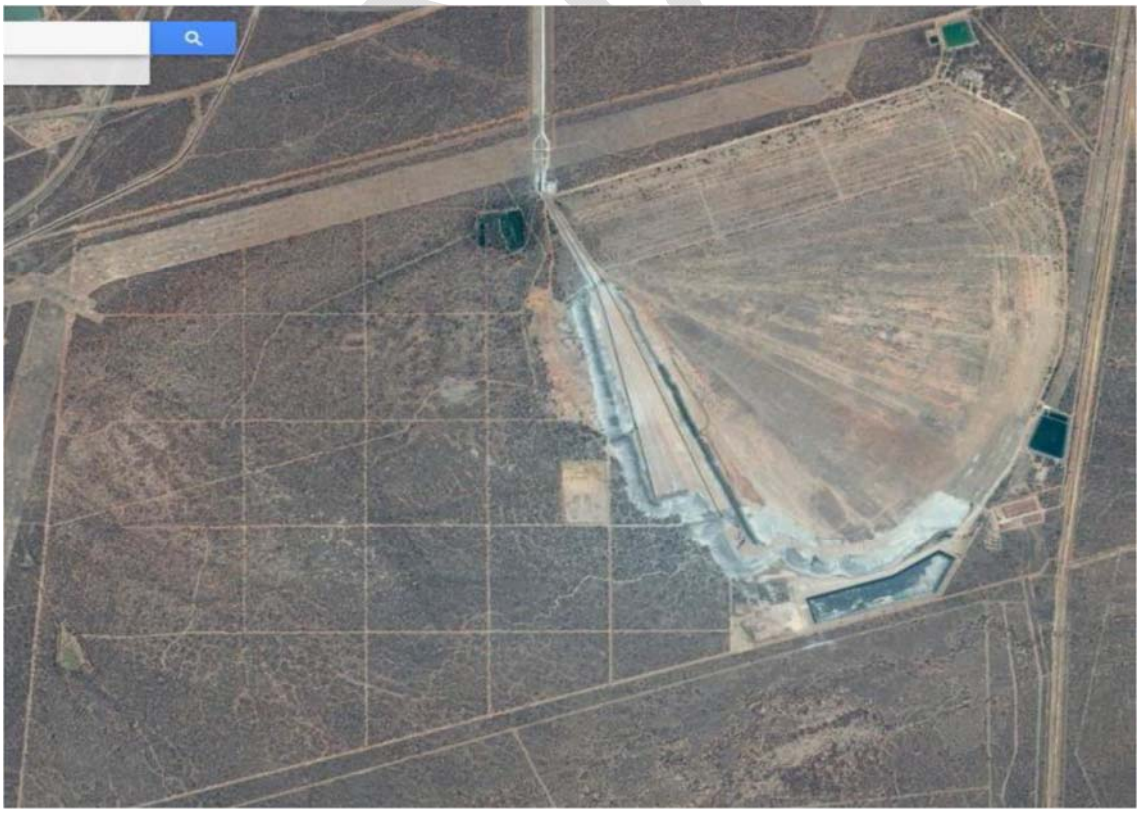

Figure 1.1 Google Earth Image of the Matimba Ash Dump Project

1.1.3 SCOPE OF WORK

The Contractor shall provide all equipment, materials, consumables, and services required to complete. the Ash Dump and associated Construction work as specified herein. The scope of the Ash Dump Construction works includes, but is not limited to, the following:

- Construction Storm Water Management
- Clearing and Grubbing and Surface Preparation, including compaction of all scope of work areas.
- Construct the Ash Dump.
- Construct penstock and pipeline under the ash dump
- Furnish and Install a Class C Single Liner System and All Associated Terrace Preparations, Liner under Drainage and overlying gravel drainage layer for an Area of 4 Years of Co-Disposal of ash as defined on drawings.
- Construct Raw Water Dams and Pumping Station
- Furnish and Install a Class C Single Liner System with underdrainage for the Raw Water Dams.
- Clean Water Drains for 4 years of Co-disposal and all common areas, including all drainage works
- Construct Silt Traps
- Dirty Water Drains for 4 years of Co-disposal and all common areas.
- Ash Dump Dust Suppression System -Discharge pipeline to termination point on drawings
- Terracing and road layer works associated with the Perimeter and Associated Roads for the First 4 years
- Provide Seeding and/or other stabilization methods of scope of work areas as shown on the drawings. If no information provided on the drawings, seeding is the default requirement. Also, any disturbed areas past scope of work areas needs to be restored to their original conditions.
- Provide Perimeter Fencing per drawings. Provide additional fencing requirements for laydown yard or other Contractor security needs (not shown on drawings).
- Contractor Laydown yards must have a stormwater and erosion control plan submitted by the Contractor and approved by the Engineer for implementation and maintenance by the Contractor. Laydown yards must be stabilized with grass or rock or other acceptable methods as approved by the Engineer.
- Prepare areas as designated on the drawings as topsoil storage areas. All topsoil stripped from project area is to be stored here until future use.
- Prepare areas for bulk material storage areas. Contractor can submit preferred location for Engineer's approval based on work program. Proposed, pre-approved areas for bulk material storage provided on drawings.
- Prepare and Maintain Temporary Construction Phase Access Roads
- Perform all testing of works

- Thrust blocks for underground piping.
- Various piping per drawings.

1.2 PROGAMME FOR CONSTRUCTION AND DATES FOR COMPLETION

The Contractor shall provide a program of Works (related to issue of order) with his tender based on a 18-month completion date taking into account any lead time that he requires. The Programme shall allow for inclement weather and air, road & rail deliveries, as delays resulting from these will not be accepted. The Completion Date is a critical date in the progress of the overall operation of the Power Station.

Within two weeks of the award of the Order, the Contractor shall submit to the Engineer, for his approval, a detailed program, preferably “Microsoft Project” together with a complete precedence network. The network shall show the order and procedure in which the Contractor proposes to carry out the work, taking due account of the agreed final completion date/s. Also, the required plant, labour and material shall be incorporated into the programme.

The Contractor shall submit weekly written reports in an approved form together with an updated version of the programme (hard & electronic copy if requested) relating progress achieved to the agreed target program. The Contractor shall give reasons for any variance that has occurred or may occur between the program and actual progress and if behind schedule, he shall state his proposed action to return back to target. Should the Contractor fall behind schedule with the work, the Contractor shall provide whatever additional plant, labour and materials that are required to rectify the position. No extra payment to the Contractor will be made in such cases unless such extra payment is due in terms of any specific provision in the Order.

1.3 CODES AND STANDARDS

The standard specification for this project is SANS 1200 (1986) ‘Standardised Specification for Civil Engineering Construction’ as are applicable in their entirety and SANS 10409:2005. This document contains variations and additions to the standard specifications and therefore takes precedence where applicable.

Variations and Additions contained in this document pertain to the following specifications:

PSA: GENERAL

PSAB: ENGINEER'S OFFICE

PSC: SITE CLEARANCE

PSD: EARTHWORKS

PSDB: EARTHWORKS (PIPE TRENCHES)

PSDK: GABIONS AND PITCHING

PSDE: SMALL EARTH DAMS: SANS 1200DE

PSG: CONCRETE (STRUCTURAL)

PSLB: BEDDING (PIPES)

PSLE: STORMWATER DRAINAGE

PSME: SUBBASE

PSMF: BASE

The standard specifications are written in terms of three parties, namely:

i. The Employer

ii. The Engineer

iii. The Contractor

The Employer has appointed the Engineer to ensure that the Contractor is adhering to technical and quality issues (quality assurance).

Particular standards relating to items not covered in SANS 1200 (1986) 'Standardised Specification for Civil Engineering Construction' are outlined in the following specifications:

1. PARTICULAR SPECIFICATION PAA: GEOMEMBRANE SHEETING
2. PARTICULAR SPECIFICATION PAB: NON-WOVEN PROTECTION GEOTEXTILES
3. PARTICULAR SPECIFICATION PAC: HIGH DENSITY POLYETHYLENE (HDPE) GEOMEMBRANE LINER
4. PARTICULAR SPECIFICATION PAD: GEOSYNTHETIC CLAY LINER (GCL)

2.0 EMPLOYER'S DOCUMENTS

2.1 GENERAL

The Contractor shall be given free of charge 3 (three) paper prints of all Drawings. If for any reason the Contractor requires additional prints, the cost of these prints will be charged to him. At the completion of the Works the Contractor shall return one complete set of drawings marked-up to show all as-constructed “As-built” details and levels and positions.

The Engineer may, if he considers it necessary, instruct the Contractor to prepare working drawings showing his proposed method of construction. All Contractor's drawings, whether ordered by the Engineer or not shall be made at the Contractor's expense and one paper print of each shall be supplied to the Engineer for approval. The approval of the Engineer must be obtained before any Works involving them is commenced.

The approval by the Engineer of the Contractor's working drawings does not relieve the Contractor of any responsibility for the accuracy of dimensions or details, and for agreement and conformity with the Specifications and Drawings attached to the Contract. At the completion of the Works the Contractor shall supply to the Employer free of charge electronic copies of his drawings in dxf or dwg format.

At the completion of the Works the Engineer’s representative must develop one set of complete “as-built” plans of all constructed works including levels and final positions. One hard and an electronic copy will be submitted to the Employer. Data for the as-built drawings will be provided by the Contractor.

It is requested that the Employer and Engineer review the proposed method of construction (if any) and review the design considerations as proposed on the construction drawings. Any deviations that are presented by the Contractor or the Engineer must include options and measures with its implications.

2.2 DRAWINGS

The drawings listed under Appendix B shall form part of the Employer's Documents.

2.3 BILL OF QUANTITIES

The Bill of Quantities is provided and contains descriptions and/or measurements of all items of work required to carry out the Ash Dump construction project and is compiled from information provided in drawings. It is provided to assist in the administration and financial control of the Ash dump and associated works construction project. Payment rates shall be as provided in the project bill of quantities and any amendments to the quantities or rates provided shall be as directed and agreed to by the Employer.

3.0 MATERIALS

3.1 MATERIAL QUALITY

Samples of materials to be used upon the Works shall, when required, be submitted at the Contractor's expense to the Engineer for approval before use, and any material brought on to the Works which, in the opinion of the Engineer, does not meet the standard of the sample so submitted or is considered by him in any way unsuitable for its designed purpose, shall be removed immediately once instructions to that effect have been given.

3.2 QUALITY ASSURANCE

Workmanship shall comply with the best and most modern practice and shall be open for inspection by the representatives of the Employer (Eskom Holdings). The Contractor shall comply with the intent of SABS ISO 9002 or shall be working towards compliance in accordance with formal plans and programs.

Quality control plans will:

- List the sequence of events of manufacture / fabrication, including inspections and tests.
- Identify the applicable procedure, drawing or specification for the performance of each event.
- Identify the acceptable standard for each event.
- Identify those events for which records are required by the Manufacturer, Contractor and Employer. and provide the identification of the records.
- Provide for the notation of non-conformance and concession data.
- Provide for acceptance signatures by the Manufacturer, Contractor and Employer for each event.

4.0 PSA: CONTRACTOR'S PLANT AND TOOLS

The Contractor's Plant and tools shall be of modern design and construction, suitable for the duties required of them. They shall be in sound working condition and shall be sufficiently ample in capacity or number to enable the Works to be carried out efficiently and expeditiously.

If during the course of the Contract, the Engineer or the Engineer's Representative considers that any item or items of constructional plant are in any way inefficient or inadequate to complete the Works within the Contract period, or do not meet the required safety standards, the Engineer shall have the right to call on the Contractor to either:

i. Put the constructional plant in order, or

ii. Remove such constructional Plant and replace it with other efficient and /or safe Plant, or, and

iii. Provide additional similar Plant or plant of greater capacity.

The Employer shall have the right to stop all or part of the Works where constructional Plant not complying with required safety standards is being used until such time as the Plant has been made safe or replaced with approved Plant.

No additional payment will be made to the Contractor for expenses incurred in complying with any or all of the above".

In addition, he shall have available on the Site or readily available adequate standby Plant to ensure that operations designed to be executed continuously are not unduly disrupted because of breakdown of any Plant provided for such operations.

4.1 PSA: CONSTRUCTION

4.1.1 SURVEY AND SETTING OUT (IF APPLICABLE)

i. Prior to any construction taking place the Employer Surveyor will supply Contractor with a Lidar Survey of the total area where the construction will take place and supply the relevant benchmark information to be used for the setting out of the works. This DTM will form the basis for all original ground levels to be used for all cut and fill volume controls. The Contractor may carry his own checks with regard to the DTM and the benchmarks and report any discrepancies to the Engineer. Once agreement has been reached the DTM and relevant benchmark information must be signed off as accepted by the Contractor.

ii. Should the Contractor require additional benchmarks for the setting out of his works this must be discussed with the Engineer and the Employer Surveyor. The Contractor must construct such benchmarks to industry standards which will be surveyed by the Employer surveyor and the relevant spatial data handed over to the Contractor for agreement and signoff.

iii. The Contractor's Surveyor will be responsible for the setting out of all works from the benchmarks supplied by the Employer Surveyor.

iv. All earthwork volumes will be checked and approved by the Employer Surveyor before payments are made.

v. The Engineer will carry out random checks to ensure works are set out correctly

vi. The following survey tasks will be required from the Contractor mine surveyor for agreement with the Engineer.

a. Ground levels must be recorded at 5m or 10m intervals on the centre line, upstream and downstream toe positions of all structures, embankments and fills after site clearance and again after:

- removal of unsuitable material
- completion of excavations

The grids and lines for each survey operation must be co-incident in plan.

i. Ground levels must be recorded at 10m intervals on the centre line left and right bank positions of all trenches, canals and drains after site clearance and prior to excavation and again on completion of the excavation to the required depths and grades.

ii. Ground levels must be recorded on a 15m grid over borrow areas immediately after site clearance. After removal of unsuitable materials and/or topsoil and/or fill material as required, a re-survey will be required on the ground and records levels as described above. The grids and lines before and after soil removal must be co-incident in plan. Where borrow areas are within the dam basin, the borrow areas must be re-surveyed on the same co-incident grid to form part of the as-built records.

iii. Upon completion of the works an as-built survey and with marked-up drawings are required showing as-constructed details and levels and positions of all embankments and structures. The survey must be in electronic format in an ASCII text file (-Y, -X, Z).

The Employer must inform the Engineer on the completion of impoundment walls and trenches to design elevations and cross-sections. Thereafter, a check may be carried out by the Engineer's Representative to verify these elevations and cross-sections.

4.1.2 WATCHING, BARRICADING, LIGHTING AND TRAFFIC CROSSINGS

The Contractor must programme his Works in such a way that the area is secure at all times. The Employer reserves the right to suspend Works if, in his opinion, this requirement is not being complied with and, further, to make secure the area and recover any costs involved in labour and materials from monies due to the Contractor.

The Contractor shall make provision for any temporary Works as may be required for the purpose of ensuring the safety of adjoining Works and property and for the protection of all persons or animals. He shall be responsible for all damage, injuries and accidents that may occur through his omission of any necessary provision in this respect.

The Contractor shall make full provision for all watching and lighting necessary for the protection of all persons, animals, vehicles, etc., from injury by reason of the Works. He shall provide ample warning signs; guard rails, etc., around open trenches, stacks of material, excavated materials, debris or the like, and shall provide walkways over trenches wherever required for the convenience of the public.

The Contractor shall provide and maintain all necessary temporary protection of finished and/or existing Works liable to be damaged during the progress of the Works by properly covering up, isolating, etc.,

as required. The Contractor shall be responsible for any damage which may occur and shall make good at his own expense.

Every excavation which is accessible to the public, including the Employer's personnel, or which is adjacent to public roads or thoroughfares, or whereby the safety of persons may be endangered shall be:

i. In accordance with SHE Rules for Contractors

ii. Provided with red warning lights, or other boundary indicators, which are clearly visible at night, or when visibility is poor.

The Employer reserves the right to stop any Works in progress which he deems to be unsafe and to expedite all necessary and appropriate action. All costs in this regard will be to the Contractor's account.

The Contractor shall so arrange his Works that flow of the Employer's vehicular and pedestrian traffic can be maintained at all times. In this respect, it may be necessary that culverts and pipes be constructed in sections.

All work must be arranged so that onsite operations and pedestrian traffic can be maintained at all times.

4.1.3 PROTECTION OF OVERHEAD AND UNDERGROUND SERVICES

Further to the provisions of this sub-clause, the Contractor shall arrange with the Engineer or the Employer to point out any underground or overhead services which may be affected by construction activities prior commencing with the Works. Where necessary the Contractor shall excavate trenches by hand under direction of the Engineer or Employer to establish the exact location of services.

The Contractor shall be solely responsible throughout the contract period for the safety and protection of services. Repair of known services damaged by the Contractor shall be to his account.

Any deviation of services affected by construction, whether carried out by the Contractor or other authority will be paid for by the Employer.

4.1.4 POLLUTION

The Contractor shall provide adequate containers with lids for the disposal of refuse. Containers shall be provided at the Site for employees and if applicable at the Site office. The Contractor shall ensure that his employees do not pollute any Works areas with refuse.

All domestic and general waste generated by the Contractor during the execution of the Works shall be neatly maintained, in accordance with the requirements of the EMP and SHE Rules. All waste shall be disposed of on a regular basis in the same way as the Mine disposes of its waste. The Contractor is to familiarise himself with the preferred disposal Site and associated procedures for all his waste disposal requirements during construction.

In general, no on-Site disposal of domestic and general waste will be permitted.

Inert construction waste shall be collected and dumped by the Contractor at locations approved by the Engineer and/or Employer. The dumps shall be covered by soil.

4.1.5 SAFETY

The Contractor shall comply with the Occupational Health and Safety Act (Act 85 of 1993) and its Regulations. In particular the Construction Regulations, 2003 (Government Gazette No 5207) shall be adhered to at all times. The Contractor shall have no grounds for a claim against the Employer for extension of time and/or additional costs if the construction of the works or any part thereof is suspended by the Engineer in terms of the Conditions of Contract for breach of the requirements of the above legislation.

All Contractor's Equipment, constructional plant, Temporary Works and Materials used by the Contractor and the Works carried out by the Contractor's personnel are subject to the safety regulations of the Employer (SHE Rules) and thereby also subject to the inspection and acceptance by their officials at all times.

The Contractor shall prominently display a copy of this Act.

4.1.5.1 HEALTH AND SAFETY PLAN.

The health and safety plan required by the Act and supporting Regulations shall include, but not be limited to, the following:

- Occupational health and safety policy
- Administrative requirements
- Risk identification and assessment including maintenance of all registers
- Training
- Incident and accident reporting
- Incident and accident investigation
- First aid
- Occupational heath and safety representatives
- Occupational heath and safety committees
- Permits
- Certificates of competence and compliance Permits
- Audits and inspections

4.1.5.2 HEALTH AND SAFETY FILE.

Every Contractor shall ensure that a health and safety file, which shall include all documentation required in terms of the provisions of the Act and the relevant Regulations, is kept on site and made available to the client, agent or inspectors on request.

A Principal Contractor shall hand over a consolidated health and safety file to the client upon completion of the construction work and shall, in addition to the documentation referred to in the regulations, include a record of all drawings, designs, materials used and other similar information concerning the completed works.

A Principal Contractor shall ensure that in addition to the documentation required in the health and safety file as determined in the regulations, a comprehensive and updated list of all sub- contractors on site accountable to the principal contractor, the agreements between the parties and the type of work being done are included and available.

4.1.5.3 SAFETY OFFICER.

The Contractor shall in accordance with the act and supporting regulations upon having considered the size of the project, the degree of dangers likely to be encountered or the accumulation of hazards or risks on the site, appoint a full-time or part-time construction safety officer with the necessary competencies and resources to assist him in the control of all safety related aspects on the site.

4.1.5.4 HEALTH AND SAFETY TRAINING.

The Contractor shall provide employees with the necessary information and training or supervision that is necessary to enable them to perform their work safely and without risk to health, and shall ensure that every employee becomes familiar with work-related hazards and risks and the measures that must be taken to eliminate, control and minimize those hazards and risks.

4.1.5.5 PERSONAL PROTECTIVE CLOTHING AND EQUIPMENT (PPE).

All employees employed on the construction site and visitors shall wear clothing and equipment as prescribed in the site hazard analysis

The Contractor shall identify tasks requiring protective clothing and equipment and issue the necessary to employees on site.

Employees shall maintain all PPE in a safe, clean condition.

Personnel not wearing PPE where PPE is prescribed will be disciplined in accordance with the company's disciplinary code of conduct.

4.1.6 METHOD OF CONSTRUCTION

Acceptance of the Works does not signify acceptance of methods of construction and does not in any way relieve the Contractor of any of his responsibilities for the Works, and it shall not be used as a basis for claiming compensation where the proposed methods of construction do not comply with the requirements of construction.

The Engineer reserves the right to instruct the Contractor to supply, for approval prior to the start of the activity, a detailed method statement for any construction activity.

4.1.7 SITE INSTRUCTION BOOK

A communication and site instruction book/diary must be made available onsite to record all requests and decisions made.

5.0 PSC: SITE CLEARANCE: SANS 1200C

5.1 PSC: DISPOSAL OF MATERIAL

All material from the clear and grub exercise is to be placed in a neat stockpile(s), as directed by the Engineer. The disposal area shall be within a one-way distance of 2 000 m of the area from which it was excavated.

Vegetation and wood from the clearing operations shall be disposed of either by stockpiling as firewood at designated locations, or by stockpiling and burning within the basin area if authorized in writing by the Engineer. Any ash and large stumps or other unburned pieces shall be buried within the basin in a manner so as to ensure that debris cannot interfere with the operation of dam outlets or drainage systems or detract from the appearance of the area.

Any burning shall take place within a cleared area, under strict supervision, after obtaining all necessary burning permits and the Engineer's approval, so as to ensure that no fires can spread to the surrounding areas.

Adequate fire fighting equipment shall be available during and for sufficient time after all burning operations to eliminate all fire hazards. The Contractor shall be liable for any damage which occurs due to fires running out of control.

Where applicable, fencing wire shall be neatly wound into rolls or coils and all such wire, together with all fence posts, gates and other material from structures shall be stacked at designated Sites within the contract area or as directed by the Engineer.

5.2 PSC: CONSERVATION OF TOPSOIL

Where overburden or material resulting from clearance of the Site is acceptable for use as topsoil, it shall be stockpiled adjacent to the Site from which it is stripped for later use on embankment slopes and elsewhere where topsoil is specified or required. Topsoil not required for the Works shall be stockpiled in a designated topsoil stockpile for later use by others.

6.0 PSD EARTHWORKS: SANS 1200D

6.1 PSD: EXCAVATION OF TRENCHES, CANALS AND FOUNDATION BASES

The Contractor shall excavate whatever materials are encountered to the depths, cross-sections and grades shown on the drawings. Excavated material not required or unsuitable for backfill and / or for embankment construction shall be transported to and disposed of at a suitable Site away from the Site of Works as directed by the Engineer. The disposal area shall be within a one-way distance of 2 000 m of the area from which it was excavated.

The unit of measurement for all excavation (other than for the purposes of borrowing to fill) shall be the cubic metre of in-situ material excavated (measured Nett). It should be noted that when excavations are cut through embankments for the placing of drains, pipes, pipe encasements, puddle flanges etc., the payment for these excavations shall be based on Nett dimensions with the measurable depth of excavation limited to that of the maximum vertical dimension of the drain, pipe or encasement structure at each particular cross-section. Similarly, the measurable width shall be the design width of each particular cross-section. All costs associated with the excavation greater than these dimensions i.e. battering back (but excluding backfilling with concrete or soil in over break as stipulated), shall not be considered for payment.

Working space for formworks insertion and removal inclusive of additional excavation and backfill compacted to specification will only be paid for where instructed in writing by the Engineer. The measurement shall be the square metre of shuttered face.

The rates tendered must allow for the operation as described and haulage to within a one-way distance of 2 000 m of the Site. The disposal area is to be left as described in **Clause 5.2.2.3**.

The bases of all excavations are to be inspected and approved by the Engineer before backfilling commences or blinding is cast as the case may be. (Refer **Clause 5.2.2.1**).

Where applicable, the standard specification for preparation of rock surfaces shall apply to hard, non-erodible rock surfaces. “Slush” grouting with 1:3 cement / sand grout may be required on hard, highly fractured rock and shall be measured per square metre of specified thickness under the relevant billed item where instructed by the Engineer.

Soft, erodible rock surfaces shall be prepared by removal of all loose particles and moistened immediately before being covered with fill material, or grout as instructed by the Engineer.

NB: Excavations for pipe plinths and anchor blocks shall be so carried out and so trimmed to the outline of the concrete Works shown on the drawings that the excavated surfaces will act as forms for the concrete Works. No shuttering will be considered or paid for below ground level.

6.2 EXCAVATION OF UNSUITABLE MATERIAL BELOW COMPACTED WALLS

Unsuitable material (sludge) must be removed to such depths, widths and lengths as the Engineer may determine once the dams or ponds have been dewatered. The material removed must be transported

to and disposed of at a suitable site in accordance with the EMP guidelines or as directed by Employer away from the Site of Works or stockpiled for re-use as directed by the Engineer.

The unit of measurement for unsuitable material removal shall be the cubic metre of in-situ material removal (measured Nett). The rates must allow for the operation as described and haulage to within 2 000 m of the Site. The disposal area is to be left as described in **Clause 5.2.2.3**.

6.3 PREPARATION OF APPROVED NATURAL SOIL BENEATH COMPACTED BASIN OR SLOPES

Prior to commencement of construction of compacted embankments, the approved natural soil beneath the base areas shall be prepared by ripping or other means to a depth of 300mm, water added if necessary, mixed and then compacted to the approval of the Engineer by not less than eight passes of an approved six metric tonne roller (method) or to 95% Standard Proctor dry density as directed by the Engineer.

It is imperative that this layer is compacted to such a degree to ensure that the indicated densities and moisture contents or such lesser densities and corresponding moisture contents as may be specified by the Engineer can be achieved on subsequent layers.

The unit of measurement for ripping, watering, rotivating and compacting the approved founding layer is the design square metre.

6.4 CONSTRUCTION OF FINAL BASIN AND SLOPE LAYERS

The final basin and slopes must be constructed or shaped by obtaining selected soil from excavations, approved borrow pits or stockpiles or commercial sources and prepared the same into a homogeneous mix in a manner and location approved by the Engineer and then forming it to the dimensions and elevations given on the drawings.

Material forming the final basin and slopes shall be compacted in layers as detailed in **Clause 5.2.3.1** and of regular appearance with all cross-sections having the minimum sizes detailed on drawings and having side slopes not steeper than specified. The sides of the embankments must be compacted to hard durable faces. Any spoil resulting from this operation is to be removed and disposed of at no extra cost.

The unit of measurement for embankment construction shall be the design cubic metre of placed material after compaction, trimming and forming to the specified dimensions. The Contractor will not be paid for embankments constructed in excess of the dimensions specified. The Engineer will decide on acceptance or rejection of embankments which are oversized.

The Contractor is to allow in his rate for re-shaping the slopes and compacting the slopes to the correct size final shape and size.

Material suitable for basin and slopes shaping construction should fit within the bounds defining G7 or G9 material as a minimum. The material must be verified from onsite investigations against these criteria before use.

Test of suitable material must form a smooth curve within the bounds of the grading envelope. The Contractor shall carry out sufficient test to satisfy himself about the consistency of material placed in the embankments. Check test will be carried out by the Engineer and the results made available to the contractor. Material not conforming to the specifications should be blended to achieve requirements, or, failing this, the material must be spoiled. Any material containing organic material is unsuitable and must be stockpiled for later use as topsoil cover on the ash dump final surface.

6.5 BORROW PITS (IF APPLICABLE)

6.5.1 GENERAL

Borrow pit areas shall be kept to a minimum. Opening of borrow pit areas shall be limited to the areas required to provide material for construction. Areas not authorized by the Engineer and surplus to requirements will not be considered for payment.

The Contractor shall be responsible for ensuring that materials obtained from borrow pits conform to the material requirements specified by the Engineer. These criteria include in brief terms, the material particle size distribution ((i.e. grading envelope) minimum density and moisture content requirements.

To this end the Contractor will be required to excavate a reasonable number of trial pits at his own cost to prove suitability of each borrow area location.

The Contractor, unless otherwise directed, shall obtain the required material by borrowing in these areas to such widths, lengths and depths as the Engineer may direct, no payment for removal of borrow material to fill will be made. (Payment will only be made for the formation of basin and slopes or as selected fill where applicable.

Furthermore, in all instances (unless otherwise waived by the Engineer), the Contractor will be required to bring to the optimum moisture content range, material in the borrow pits designated for construction use. Such material must have a uniform moisture content before leaving the borrow area(s).

No polluted water is to be used in any moisture conditioning requirement for materials used in the Works.

Payment for the opening of borrow areas not allocated by the Engineer, will not be considered.

Borrow from borrow pits will normally be limited to material which can be loosened by the use of mechanical rippers having a minimum fly wheel power of 130 kW and operating weight of 23 000 kg (e.g. a Caterpillar D7, Komatsu D85) in good condition and driven by a competent operator.

All borrow areas are to be left in a safe and neat state as directed by the Engineer at no extra cost.

Should stripping of unsuitable material overlying suitable material in a borrow pit be required, it shall be to such depths as determined by the Engineer. These unsuitable materials shall be disposed of at a suitable Site near the borrow area or as directed by the Engineer. The disposal area shall be within a one-way distance of 2 000 m of the area from which it was removed.

The unit of measurement for unsuitable material removed shall be the volume of in-situ material removed measured in cubic metres. The rates tendered must allow for the operation as described, including haulage to within 2 000 m of the borrow area, and, stockpiling or spreading and sloping as required by the Engineer. The disposal area is to be left as described in **Clause 5.2.2.3.**

6.5.2 BORROW PITS – RESTRICTIONS

Fill material for all compacted basin and slopes must be free of all surface vegetation and approved by the Engineer. This material will generally be obtained from the following sources:

- borrow pit(s) within the confines of the Employers property,
- suitable spoil from trenches and excavations,
- borrow areas outside of the Employers boundaries and
- from commercial sources.

Under no circumstances must fill for compacted basin and slopes be obtained from the following areas:

- 2.0 m either side of the area of the toe drains,
- 2.0 m either side of the centre line of the drainage outlet trenches and
- 2.0 m downstream of the any pond or dams
- Within a distance of 30 m from the inside toe of the inner perimeter wall.

Should these restrictions not be adhered to, the Contractor shall, at his own expense, restore the original ground level in the affected areas by compacting selected material to the specifications provided by the Engineer.

Borrow pit areas shall be neatly and safely finished off and unused material shall be levelled off and compacted within the pits. Final sides of borrow pits shall not be steeper than 1 vertical in 3 horizontals. The costs of these Works are deemed to be included in the rates for excavation of unsuitable to waste and / or placing fill from borrow.

6.6 COMPACTION TO A SPECIFIED DENSITY

6.6.1 GENERAL

The standards of compaction required are shown on the drawings and densities obtained must be not less than the minimum specified Proctor density. The Proctor density described herein is the Standard Proctor – unless otherwise stated.

All compacted fill material is to be placed in horizontal layers and compacted in loose layers, with a depth not greater than 200mm, to a density not less than the minimum specified density. It should be further noted that a uniform moisture content (as per specification) is to be achieved throughout the loose layer prior to compaction. (Refer to materials preparation in **Clause 5.2.3.1**).

All compaction must be carried out in a direction parallel to the centre line of the earthworks, working on a predetermined pattern that must ensure that the whole area of the layer receives uniform compaction.

The moisture content must, unless otherwise specified, be in the range between two per cent (2%) below and two per cent (2%) above Standard Proctor Density optimum moisture content, (or any other range specified on the drawings or by the Engineer from time to time) whichever is applicable. Compacted layers with non-uniform moisture contents or moisture contents outside the specified range

are deemed to have failed regardless of the densities achieved. The required moisture content must be distributed uniformly throughout each layer of material.

Suitable compaction equipment must be utilized to ensure efficiency of operations.

Layer thicknesses are to be maintained to specification at all times. Preparation of each newly laid layer prior to placement of each additional layer should specifically involve:

- Scarification of the approved layer (newly laid compacted layer).
- Watering of the approved in-situ layer prior to bringing in the next loose layer.

6.6.2 COMPACTION CONTROL

The Contractor shall provide an adequate Site laboratory, equipment, facilities and experienced and competent personnel for carrying out the required compaction tests. Should the Engineer at any time consider any of the above to be inadequate for this purpose, he shall instruct the Contractor to cease further Works on compaction or other laboratory related Works until such time as the Contractor has remedied the deficiency.

The onus shall be on the Contractor to ensure the following:

i. That the state of the material when placed is such that the compaction as specified in **the** drawings will be obtained.

ii. That material selected for use in compacted embankments shall be approved by the Engineer on the basis of the maximum dry density (Proctor or Mod AASHTO, whichever is applicable) being equal to or greater than a minimum density to be specified by the Engineer as well as being at the required moisture content, and, on the basis of the particle size distribution of the material falling within a specified envelope (refer **Clause 5.2.3.1**).

Hence with the object of controlling the selection and compaction of all materials used in the various layers of fill, grading analyses, Standard Proctor density tests must be performed whichever is applicable and corresponding moisture content evaluations on each type of material which are to be used, including mixed or blended materials.

No polluted water is to be used in any moisture conditioning requirement for materials in the Works.

In addition to the tests required for his own control the Contractor shall allow for at least two density checks per 1000 square metre block of material compacted per layer, or, in the case of narrow widths (as determined by the Engineer) at least 2 tests per 100m of narrow strip. The recognised method of determining the density is the sand replacement test. However, the Radio Isotope or other approved method may be used (if approved by the Engineer) for density and moisture checks, provided suitable agreement is obtained between this method and the sand replacement method and provided the necessary calibration and specified tests to these instruments are undertaken at intervals to be specified by the Engineer.

If an alternative method of density determination is accepted, the sand replacement method shall be used as a control check on a frequency determined by the Engineer on site. The moisture content of the sample shall be determined by oven drying as specified for the Standard Proctor compaction methods.

To account for material variability, approved density tests are to be accepted based on the following:

i. Basin compacted to 95% Standard Proctor Density: If any one of the two density tests per 1000m² block (or narrow strip) is below 95% then the entire block will be re-ripped, re-watered and re-compacted.

ii. The compaction control tests must be carried out as laid down in “Standard Methods of Road Construction Materials, TMH 1” published by the National Institute of Transport and Road Research of the CSIR. Standard Proctor density tests shall be carried out in accordance with procedures set out in ASTM D 698.

iii. Field density and moisture content tests are to be carried out within 6 hours after the completion of each section of the layer, unless otherwise agreed by the Engineer.

The Engineer reserves the right to order additional in-situ density tests at any location on any strip.

When the compaction of any section of any layer, for which a density and moisture content is specified, is completed, test results must be made available to the Engineer.

No subsequent layer is to be placed until such time as the previous layer has been approved by the Engineer in writing.

Accurate records of all compaction control tests must be maintained throughout the construction process, i.e. test data, chainage and layer elevation.

These records must be available on Site for inspection by the Engineer at all times.

Where tests reveal that the density or moisture content of any layer, at any depth, is not to specification, the layer must be re-ripped, re-compact and re-water. If the specified density cannot be obtained by further compaction of the material such material must be removed and replaced by material capable of yielding the specified density.

6.6.3 TESTING ADJACENT TO ADJOINING STRUCTURES (IF APPLICABLE)

Where compacted material abuts up against adjoining structures, at least two density tests shall be taken per layer of contact material adjacent to the structure.

Such testing may be increased to confirm the density of the material in close proximity to such structures to ensure water tightness of the join. The Engineer reserves the right to order additional testing or independent confirmatory testing as the situation warrants.

6.7 STRIPPING AND STOCKPILING OF TOPSOIL

Topsoil from excavations and borrow pits must be stripped to such depths and extent as indicated on the drawings or as directed by the Engineer and stockpiled for later re-use in rehabilitating the embankment side slopes or as otherwise required by the Engineer in accordance with the ESIA/EMP requirements.

6.8 SAFETY PRECAUTIONS IN EXCAVATIONS AND CONTRACTOR’S LIABILITY

6.8.1 SAFETY PRECAUTION

It is the Contractor's responsibility to ensure safety of all excavations and must ensure that all reasonable measures are considered to ensure that shoring or by side sloping of the ground takes place. The Engineer reserves the right to instruct the Contractor to strut banks and sides of excavations, etc and / or side slope of such banks and sides of excavations etc. over any surface where the excavations are dangerous and / or to conform with any safety precaution in terms of relevant regulations.

Such instructions must be considered final and binding.

All strutting must be of sufficient strength to ensure the safety of all persons in the excavations and must be suitably arranged to permit the construction of whatever is necessary, and the Engineer's decision as to this shall be binding upon the works. The works must be immediately rectified if any strut is deemed by the Engineer to be unsafe or of such character as will impede or impair the construction of the Works. No under-cutting of excavations will be allowed.

6.8.2 CONTRACTOR'S LIABILITY

The Contractor shall be responsible for making good, or having made good, at his own expense any slips, falls, caving in of ground, damage to walls, structures or Works caused by reason of his acts or Works, or by causes within his control and shall indemnify the Engineer against any claims made in respect of loss of life, or injury or damage to persons, animals or things, caused by reason of his Works or through causes in his control. The Contractor's rates will be held to cover all such liabilities and the Engineer shall have the right, if they shall have suffered loss by reason of the above, to deduct the value of such loss from any monies due or that may become due to the Contractor.

6.9 DE-WATERING

Suitable pumps, pumping equipment, well points must be operated and maintained and all other water devices necessary to properly de-water and maintain free from water all excavations and all groundwater until completion of the Works.

No work shall be executed in water without the written permission of the Engineer.

The whole of the Works must be thoroughly drained and clear of water as long as may be required.

Channels or sumps excavated outside the works for dewatering purposes, must be refilled and made good to a standard equivalent to the original conditions (and as directed by the Engineer) when they are no longer required.

The Engineer may order additional permanent works to be constructed to deal with springs or seepage liable to endanger the Works after completion of the Works.

6.10 SPOIL DISPOSAL

Dumping areas (which may include used borrow pits) shall be allocated for the disposal of all surplus material from clear Site operations, excavations, removal of unsuitable material, and for topsoil stripped from the Site etc. Such areas shall be within a one-way distance of 2 000 m of the Sites of excavation. These areas shall be maintained in a neat condition and when completed, levelled off by grading to

within 150 mm from level or a given surface as directed. The rates tendered must allow for all such levelling and trimming and for haulage within a one-way distance of 2 000 m from the Sites of removal. Dumping area shall be approved by the Engineer.

6.11 SURFACES

6.11.1 BACKFILLING

Backfilling to foundations and trenches must be carried out by replacing selected excavated material in loose 150mm or 200mm layers or as specified on the drawings, each layer being thoroughly compacted, rammed and / or consolidated before the succeeding layer is placed or such other ways as may be directed by the Engineer. In areas where specified compaction densities and moisture contents are required for backfill, then the identical testing and approval procedures as outlined in Clause PSD 6 will be enforced.

Heavy compaction equipment may not approach so close as to cause damage or permanent displacement of structures.

Any defects caused due to subsidence of the backfilling, must be repaired at the ground surface, by filling by banking to a height of about 100mm above the level of the adjacent ground surface to allow for any settlements and before completion of the Works.

Care must be taken to ensure that any structures being buried are not damaged by the compaction effort. Repairs for and damage arising from this shall be for the Contractor's account, and items for repair or replacement shall be indicated and accepted by the Engineer at his sole discretion.

6.11.2 OVER EXCAVATION

Backfilling to over-excavation below the required levels or depths necessary to obtain a suitable bottom is to be carried out to the instructions and satisfaction of the Engineer and entirely at the Contractor's expense as follows:

i. **Material not for structural Support** - Where the material excavated is not required for structural support, the over-excavation must be filled with selected material, free from stones in 150mm or 200mm layers or as specified on the drawings and compacted to a density not less than that of the surrounding undisturbed material at the designated moisture content.

ii. **Material for Structural Support -** Where the material excavated was required for structural support, the over-excavation shall be backfilled with 15 MPa/19mm concrete (or concrete of other strength and or aggregate sizing to be specified by the Engineer) including all necessary work etc to prevent its inclusion with the structural concrete.

6.11.3 SURFACES TO RECEIVE CONCRETE

Before any concrete is cast all foundation, surfaces must be clean and generally prepared to receive it to the satisfaction of the Engineer. The same applies to placing of all other materials in excavations.

In no case must concrete or other materials be placed in any excavation until the approval of the Engineer has been obtained.

6.11.4 SURFACES TO RECEIVE LINER

The Geomembrane Installer will be required to thoroughly check the finished earthworks surface ahead of installing the Geomembrane and to remove particles remaining that could damage the Geomembrane. No protruding sharp objects will be allowed. Checking and picking of the final layer will be the responsibility of the Contractor.

The surface must be inspected in the presence of the Engineer before the sheets are installed. If the Engineer is satisfied with the finished earthworks, he will sign the Substrate Clearance certificate to allow the Geomembrane Installer to commence installation of the plastic Geomembrane. Any subsequent repairs required to finished earthworks shall be the responsibility of the Contractor.

The surface may require rolling just prior to laying of the geomembrane due typically to erosion tunnels caused by rainstorms and damage due to picking. This rolling is to be done by the Contractor.

6.11.5 SURFACE TO RECEIVE UNDERDRAINS

The ground surface on which the horizontal section of the under drains are to be constructed including drain outlet trench bases are to be prepared to the cross-section, grades and elevations shown on the drawings. Prior to the placing of geofabric and permeable material the blanket section is to be trimmed, wetted if required and nominally compacted to the satisfaction of the Engineer. The rate for the preparation of the base area of the blanket section and trench bases shall be the design square metre prepared.

6.12 MEASUREMENTS AND EXCAVATION CLASSIFICATION

6.12.1 GENERAL

All excavation quantities throughout, in all classes of material, will be measured nett. Such excavation quantities do not include for cut to fill operations from borrow areas where material removed will be measured in placed and or compacted fill.

Excavations shall be measured per cubic metre, divided into the following classes:

i. **Material Class "A" -** This classification shall include all kinds of ground encountered except those defined in Class "B" hereinafter and shall include made-up ground, pavings, rubbish, gravel, sand, silt, hard ouklip and calcareous material, clay, soft rock, ground interspersed with small boulders of rock not exceeding 0.5 m3 (one half of a cubic metre), dumped waste rock, material in compacted embankments and all other materials which can, in the opinion of the Engineer, be excavated by hand or by machine without drilling and blasting, or without the use of power breaking tools such as an hydraulic hammer,

ii. **Material Class "B" -** In the case of canal, trench and small excavation, this classification shall mean granite, quartz, dolomite etc, or rock of similar hardness which in the opinion of the Engineer or his representative, can only be removed by drilling and blasting. Solid boulders in excess of 0.5 m^3 (one half of a cubic metre) will be classified in this category. This classification shall apply whether or not blasting is authorised.

In the case of bulk excavation this classification shall mean granite, quartz, dolomite etc or rock of similar hardness found in its original position which cannot be loosened by a bulldozer having a minimum fly wheel power of 130 kW and operating weight of 23 000 kg (e.g. a Caterpillar D7, Komatsu D85 or equivalent in good condition, fitted with an approved single tine ripper and driven by a competent operator). This classification shall apply whether or not blasting is authorised.

One rate has been allowed in the Schedule of Rates for Class "B" material to cover all types and depths of excavation work. Spoiling of Class "B" material shall be as for Class "A" material. The excavation rate for Class "B" shall therefore include any extra required for spoiling the rock.

Note: If the Contractor considers that any material to be excavated is classified as Class "B" above, he shall submit a written request to the Engineer or his representative for his ruling. Failing such a request, the excavations shall be deemed to be in Class "A". The decision of the Engineer as to the classification of the material shall be final and binding.

6.12.2 OVER BREAK

The backfill to an over-break zone will either be a specified class of concrete or selected and compacted earth filling. In the case of compacted earth filling, this will be done in 150mm loose layers compacted at OMC to the specified density.

For the purpose of these Works, concrete backfill will be 15MPa/19mm and earth backfill will be selected and approved material compacted to 95% Proctor density at OMC. The type of filling to be used will be determined by the Engineer. All backfilling will be to the Engineer's approval.

The same shall apply to sloping surfaces. All over-break zones must be kept to a minimum.

6.13 UNAUTHORISED EXCAVATION

An unauthorised excavation must be avoided where possible unless authorised by the Engineer.

6.14 HAULAGE

The Contractor shall at his own cost construct and maintain temporary haul roads as required along the routes designated by the Engineer.

If the Contractor chooses, for reasons of his own, to transport material by a different route, the measurement of distance for transport will be along the routes designated by the Engineer.

In the case of borrow pits, the Contractor shall be restricted to the routes designated by the Engineer.

Free haulage of material excavated from a borrow pit, excavation etc or cutting shall be limited to a distance of two kilometres (2 000 m) measured from the edge of the borrow pit or cutting along the designated route. Haulage from designated sources or to designated stockpiles shall also be included as free haul.

Overhaul is that portion of the total haulage beyond the freehaul limit and is measured separately. For the purposes of this Contract, the freehaul distance has been set at a one-way distance of two kilometres (2 000 m).

The unit of measurement for overhaul in the case of compacted fill or placed material shall be the cubic metre. kilometre being the product of distance measured in kilometres to the nearest tenth of a kilometre and the cubic metres of compacted or placed (whichever is applicable) material transported. However, in the case of cut to spoil, or stockpile the unit of measurement for overhaul shall be the cubic metre. kilometre being the product of the distance measured in kilometres to the nearest tenth of a kilometre and the cubic metre of undisturbed in-situ material prior to being transported.

7.0 PSDB-PIPE TRENCHES: SANS 1200DB

7.1 GENERAL

The floor of the pipe trenches if any must be compacted to 95% Proctor density at optimum moisture content or any other specified density and moisture content that the Engineer may authorise, to a minimum depth of 150mm.

7.1.1 TRENCH BOTTOM

Unsuitable material shall only be excavated once the Engineer has given a written instruction to this effect. Backfilling material for over excavation shall comply with the requirements of SANS 1200 LB and shall be compacted to 95 % modified AASHTO.

7.1.2 BACKFILLING

Pipe joints shall be left open for 300 mm to either side until the pipeline has successfully been tested and approved by the Engineer.

7.1.3 DISPOSAL OF SOFT EXCAVATION MATERIAL

Disposal of surplus material shall take place at agreed sites within the freehaul distance from the source of such excavation.

8.0 GABIONS AND STONE PITCHING (IF ANY)

8.1 MATERIAL

8.1.1 GEOTEXTILE

Filter fabric for groundwater drains shall be a non-woven continuous filament, needle punched, spun-bounded polyester geotextile having the following physical characteristics:

- Mass per unit surface 150 g/m² (min)
- Porosity under 0,5 kPa 93%
- Porosity under 200 kPa 82%
- Normal permeability under 2 kPa 3×10^{-3} m/s
- Normal permeability under 200 kPa 7×10^{-4} m/s
- Normal through flow under constant head of 400mm 270 ℓ /m²/s

Alternatively - for woven filter fabrics the following characteristics shall apply:

- Mass per unit area 270 g/m²
- Water percolation 160 ℓ/m²/s
- Composition polypropylene tape and polyethylene monofill.

The material shall be placed as directed and shall not be exposed to direct sunlight for prolonged period."

9.0 SMALL EARTHWORKS DAMS: SANS 1200DE

9.1 DEFINITIONS

i. **Defects:** Any aspect of materials and workmanship forming part of the Works that, in the opinion of the Engineer, is due to the failure of the Contractor to comply with his obligations in terms of the agreement.

ii. **Defects Liability Period: one year (1 year) at the completion date of the Works.**

9.2 CLASS OF EXCAVATIONS

The classes of material for excavation shall be as defined in Project Specification **Clause 6.12.1**. The Contractor shall excavate whatever materials are encountered to the depths, cross-sections and grades shown on the drawings. Excavated material not required or unsuitable for backfill and / or for embankment construction shall be transported to and disposed of at a suitable Site away from the Site of Works as directed by the Engineer. The disposal area shall be within a one-way distance of 2 000 m of the area from which it was excavated. The unit of measurement for all excavation shall be the cubic metre of in-situ material excavated (measured nett). It should be noted that when excavations are cut through embankments for the placing of drains, pipes, pipe encasements, puddle flanges etc., the payment for these excavations shall be based on nett dimensions with the measurable depth of excavation limited to that of the maximum vertical dimension of the drain, pipe or encasement structure at each particular cross-section. Similarly, the measurable width shall be the design width of each particular cross-section. All costs associated with excavations greater than these dimensions (i.e. including backfilling with concrete or soil as required) shall not be considered for payment.

The rates tendered must allow for the operation as described and haulage to within a one-way distance of 2 000 m of the Site (Refer **Clause SANS 5.2.8.1**). The disposal area is to be left as described in **Clause SANS 5.2.2.5.**

9.3 HDPE FLEXIBLE DRAINAGE PIPES

Flexible HDPE drainage pipes may be used in the sub-surface seepage collector drains. The pipes must have a smooth internal bore. ‘Drainex’ or similar equivalent may be used but must be approved by the Engineer. Drainex is obtainable as “unslotted” and “slotted”. The slotted piping is to be used as seepage collector piping within the sub-surface drains, and the unslotted to carry the seepage out of the impoundment and to safely discharge it into the solution trenches or other collection points.

All pipes are to be laid to the required grades and elevations as detailed on the drawings, or as directed by the Engineer.

The unit of measurement for slotted and unslotted piping shall be the linear metre of piping in place. The linear meter rate must include for all push-fit couplings and rubber ring seals that are required to all couplings. Typically, white push-fit couplings, complete with rubber “O” rings, must be used to connect all unslotted Drainex piping, in order that the seals can be easily seen in place. Yellow push-fit

couplings, without “O” rings, must be used to connect all slotted Drainex piping. The linear meter rate must also include for all cutting to size of both types of piping. Specials in the form of uPVC bends, tees, laterals and crosses will be measured separately and paid for on a unit basis.

The Contractor is to note the positions of the slots in relation to the underlying bedding in the collector drain trenches. To this end the Contractor is to carefully position the “top” of every slotted drainpipe (indicated by a yellow stripe) to ensure that the piping is installed according to manufacture specification. Furthermore, the Contractor is to clearly mark, down the full length of each unslotted pipe, as soon as such piping arrives on Site, two bright coloured paint marks that are not easily removed to prevent unslotted piping being inadvertently placed in the collector drain.

Once the drain piping has been laid, the Engineer or Engineer’s Representative is to inspect the laid piping, with the Contractor’s appointed foreman, to ensure that it meets with design requirements and to ensure that no slotted/unslotted piping is in the wrong location. No piping, inclusive of specials, is to be covered over until the inspection has been carried out and approval given. To this end the Contractor is to timeously inform the Engineer of the required inspection (at least twenty-four (24) hours notice is required).

Furthermore, all installed and covered drain piping will be subject to water and drainpipe “pig” clearance tests, the costs of which are to be included in the unit rate for supply and installation of the piping. All piping will be tested for approval purposes. The tests are to be conducted jointly by the Engineer and the Contractor.

The method and equipment required is to be timeously and jointly agreed between the Engineer and the Contractor, the Contractor will be responsible for initialising such requirements. Piping that fails the tests will be removed and replaced. All costs in this regard will be to the Contractor’s account

9.4 GEOFABRIC LINING TO DRAINS

Where shown on the drawings or directed by the Engineer subsurface pipe drainage systems must be lined with approved geofabric.

The type of geofabric to be used must be as indicated on the drawings or an approved equivalent. The Engineer reserves the right to approve the make and grade of any alternative type of geofabric considered.

The geofabric shall be stored under cover and out of direct sunlight at all times. Manufacturer’s wrappings must not be removed until just prior to use. Any geofabric exposed for more than 10 (ten) days cannot be used and must be removed from the Works if already incorporated therein.

Joining of the geofabric is to be undertaken with an approved nylon yarn as shown on the drawings or by double lines of stitching along a 150mm lap width made by means of a “sac-up” type of portable machine obtainable from “Industrial Sewing Machines” or any approved similar machine, using Lubes M20 nylon thread obtainable from “Natal Thread Co” or an approved equivalent. Prior to backfilling/covering, the placed geofabric and stitching are to be approved by the Engineer.

The surface upon which the fabric is laid must be even and free of protruding or sharp-edged stones. Any damage caused to the fabric during installation or during placing of the permeable material may render it unsuitable for use. Should the damage be sufficiently localised, the Engineer may direct that the fabric be patched. Patching shall only be carried out after the Engineer’s permission has been given.

Where pipes come out of the geofabric-wrapped drain (i.e. pipes required for carrying water away from subsurface drains, but not forming a part thereof), the fabric must be tied around the pipes with suitable nylon or other approved yarn in a manner which is satisfactory to the Engineer.

9.5 FILTER AND DRAIN MATERIAL CLASSIFICATION

Filter and drain material utilised onsite must be approved by the Engineer. Each drainage layer is classed as a structural entity. Stringent quality control checks on the cleanliness of the material, grading of the material, material thickness, and dimensional correctness, will be applied to ensure the integrity of each drainage layer.

The following quality control measures must be applied to all permeable materials.

Generally, one grading analysis is to be carried for every 50 m^3 of material brought to Site. However, if materials are observed to be variable, then the Engineer reserves the right to insist that one grading analysis per truck load be undertaken. The grading analyses are to be submitted to the Engineer for approval which must be obtained prior to placement of the permeable material.

The preparation of filter media stockpile bases must be positioned and approved by the Engineer prior to bringing filter material on to site. It is imperative that sufficient quantities are available as the Works proceeds.

It should be noted that independent ad hoc sampling and testing will also be instituted to access the validity of such materials.

Any material which fails to meet with the specification will be rejected and must be removed from Site.

Stockpiles are to be formed on approved areas rendered free of vegetation and loose contaminant matter. Furthermore, to ensure an acceptable level of quality assurance and to minimise contamination, the number of stockpiles used and their location is to be approved by the Engineer.

Permeable material as used in the filter drains must comply with the following:

9.5.1 CRUSHED AGREGATE

The stone shall be in accordance with SABS 1083 - 1994, with the grading requirements as follows:

19 mm graded crushed stone filter

Sieve size (mm)	Percentage passing (%)
26.5	100
19.0	85 – 100
13.2	0 – 30
9.5	0 – 5
Dust	0

Hardness: When tested in accordance with test method No. B1 of SMTRCM the aggregate crushing value shall not exceed 21%.

Flakiness: The maximum flakiness index when testing in accordance with the test method NO. B3 of SMTRCM, shall be 25%.

Above criteria must be confirmed through onsite testing.

9.6 UNDER DRAINS

9.6.1 GENERAL

Under drains shall be constructed as shown on the drawings or as directed by the Engineer.

Excavation for the under drains shall be to the specified tolerances. Where applicable, the geofabric specified in **Clause 9.7** of this Specification shall be carefully and neatly laid on the ground and shall be wrapped around the filter material and pipe.

Piping forming the seepage collector system shall be laid to straight grades and shall be to the routes, levels and grades indicated on the drawings, or as agreed with the Engineer on Site.

At all junctions within the under-drainage system or at any other section where required by the Engineer, no permeable material shall be placed until the junction and the laid piping has been inspected and approved by the Engineer. The Contractor shall undertake the necessary rodding and/or water testing as required by the Engineer. All such costs shall be included in the price for laying the pipes.

The course materials shall be placed as shown on the drawings. The finished thickness of each layer of course material shall nowhere vary below the specified thickness.

Care should be exercised when placing the course materials so as not to damage the sub-surface drainage pipes or the geofabric.

The Engineer shall carry out tests from time to time to ensure that course materials to be used conform to the minimum requirements as set out in **Clause 9.5.1 of this specification**.

Any material placed as course material not conforming to the minimum requirements as set out in **Clause 9.5.1** above shall, at the discretion of the Engineer, be removed and replaced with suitable material at the Contractor's expense.

9.7 GEOTEXTILE

Filter fabric for groundwater drains shall be a non-woven continuous filament, needle punched, spun-bounded polyester geotextile having the following physical characteristics:

- Mass per unit surface — 150 g/m² (min)
- Porosity under 0,5 kPa — 93%
- Porosity under 200 kPa — 82%
- Normal permeability under 2 kPa — 3×10^{-3} m/s
- Normal permeability under 200 kPa — 7×10^{-4} m/s
- Normal through flow under constant head of 400mm — 270 ℓ /m²/s

Alternatively - for woven filter fabrics the following characteristics shall apply:

- Mass per unit area 270 g/m²
- Water percolation 160 ℓ/m²/s
- Composition polypropylene tape and polyethylene monofil.

The material shall be placed as directed and shall not be exposed to direct sunlight for prolonged period."

10.0 PSG-CONCRETE: SANS 1200GE

10.1 GENERAL

This specification sets out additions and changes to Standard Specification SANS 1200G.

10.2 DEFINITIONS

The following are defined as

i. PFA – Pulverised Fuel Ash

ii. OPC – Ordinary Portland Cement.

10.3 MATERIALS

10.3.1 APPROVAL OF MATERIAL

Aggregates must be supplied from approved sources which may not be changed without approval of the Engineer.

Testing of water, if required, shall be in accordance with BS 3148: 1980.

10.3.2 CEMENT

Cement used shall be CEM 1 – 42.5 (formerly OPC). Blends of OPC with 30% PFA may be used.

PFA shall comply with the relevant requirements of SANS 50450 -1 & 2:2011.

Cement sacks must be closely stacked not exceeding 12 sacks in height, off the floor and not touching the walls of the storage facility. All cement shall be stored to ensure that cement is used in the order in which it is received.

Cement shall not be kept in storage for longer than three months without the Engineer's permission.

10.3.3 AGGREGATES

“Plums” shall not be used without the specific written permission of the Engineer for each location of use.

10.4 STAFF, PLANT AND FORMWORK

10.4.1 GENERAL

The Contractor shall provide a responsible person(s), approved by the Engineer, with an adequate knowledge of concrete technology in as far as mixing, placing and curing of concrete is concerned. This supervisor shall be on Site at all times during concrete construction.

10.4.2 FORMWORK

20mm x 20mm rebates or fillets are to be provided at all corners of concrete work unless otherwise stated on the Drawings.

The Contractor shall advise the Engineer when he intends to strip any formwork.

10.4.3 CONCRETE STRENGTH

Strength concrete shall be used in the Works. The grade of concrete and position on the works shall be as shown on the drawings, and as described in the Schedule of Quantities or as directed by the Engineer from time to time.

The minimum cementious content and minimum cement/water ratio shall be:

i. 300kg/m3 and 1.5 for unreinforced concrete;

ii. 340kg/m3 and 1.7 for reinforced concrete;

iii. 400kg/m3 and 2.0 for pre-stressed concrete and for concrete of strength greater than or equal to Grade 40MPa.

Grout mix design will consist 1-part cement to 4 parts fine aggregate.

The maximum aggregate size shall be 19 mm unless otherwise shown on the drawings or authorised by the Engineer.

Not less than two weeks before the start of any concrete work on the Site, mix design proportions must be submitted to the Engineer, for his information and approval. This statement shall provide the following information:

A method statement outlining the method to be adopted for adjusting the amount of water added, to compensate for variation in moisture content of the aggregate, and for each class of concrete:

i. Mix proportions and types

ii. Slump

iii. Target strength.

The statement must be accompanied by evidence in the form of either a statement from an approved laboratory of the results of trial mixes, or an authoritative report previous use and experience, establishing that concrete made with the materials in the proportions proposed will have the properties specified

10.4.4 READY MIX CONCRETE

Test results obtained by a ready-mix production facility as part of its quality control system will not be acceptable for evaluation. All concrete must be sampled at the point of placing and test cubes made in accordance with the relevant methods.

10.4.5 INSPECTIONS AND APPROVAL

No concrete may be poured without the prior approval of the Engineer. No approval will be given unless there is sufficient time to complete the Works in normal daylight hours, unless special arrangements

have been made with the Engineer concerning working after normal hours and adequate lighting arrangements are in place before the start of the pour. Possible falls in temperature must be considered in planning this Works.

Concrete may not be placed before the Engineer's approval has been given in writing and a minimum written notice of 24 hours prior to pouring is required for each part of the structure. All concrete works must be checked prior to it being inspected by the Engineer.

10.4.6 CONSTRUCTION JOINTS

The position and angle of all construction joints selected for each structure are to be submitted to and approved by the Engineer.

All kickers are to be cast monolithically with the base element. All joints are to be scrabbled to remove laitance to expose stone aggregate.

10.4.7 CURING

Curing compounds may not be used except with the prior written approval of the Engineer. Should the Contractor wish to use a curing compound he shall submit full details to the Engineer at least 21 days before the first concrete is to be poured. Curing compounds, if approved, must be resin based and contain a fugitive dye, and must be applied immediately after formwork removal.

The method of curing and protection shall be to the Engineer's approval.

10.4.8 CONCRETE SURFACES

Unless otherwise noted all exposed unformed surfaces are to have a wood-float finish.

10.4.9 WATERTIGHT CONCRETE

All concrete structures in this contract are to be watertight.

10.4.10 RECORDS

The Contractor shall also keep a record of the mix proportions (including the water content) and slump test results for each pour and any other records considered necessary by the Engineer. Such records shall clearly indicate any changes made to the mix proportions or changes in slump during the pour. Records shall be available for inspection by the Engineer at all times

10.5 TOLERANCES

All exposed concrete Works must be to degree of accuracy II. Buried concrete will be accepted to degree of accuracy III.

The top surface of the spillway sill must have a relative level accuracy of –5 mm to + 5mm.

The permissible deviation of any bolt in a related group of bolts relative to any other bolt in the group shall be ± 2,0mm.

The permissible deviation of any bolt from its designated location in plan shall be ± 4mm.

The permissible deviation of the top of any bolt from its designated location in elevation shall be ± 10mm.

The permissible deviation of other cast-in items from their designated locations must be ± 10mm, save that where the designated location is a concrete face and the item is to be cast flush with the face it shall be cast within 2mm of the face.

10.6 TESTING

Six concrete test cubes shall be taken from each individual concreting operation, 3 for testing at seven (7) days and 3 for the prescribed twenty-eight (28) day tests. All cubes shall be clearly marked. The Contractor shall keep a cube identification logbook recording:

i. The class and source of concrete

ii. The member being cast and date of casting

iii. The cube identification markings

iv. The cube compressive test results

Copies of cube compressive test results and plant calibration records shall be submitted to the Engineer within twenty (24) hours of receipt and / or testing by the Contractor.

Should seven (7) day strengths be obtained at any stage, which indicate in the opinion of the Engineer, that the specified twenty-eight (28) day characteristic strength will not be achieved, the Engineer may stop concreting operations, or order adjustments to the mix, until the twenty-eight (28) day strengths of such concrete are available, without compensation for losses and delays.

The Contractor shall be responsible for transporting and curing of cubes in accordance with the requirements of SABS (SANS) 863: 1994, to the satisfaction of the Engineer.

Where more than three valid test results for a particular grade of concrete become available the average strength of all the available results for the grade shall not be less than the required average strength given below. If the average strength is less than that given below the mix design shall be adjusted to ensure compliance with the required average strength.

Table 10.1Required Average Strength (Refer to Clause 14.3.3 of SANS 0100-2)

No. OF SETS (OF THREE TEST CUBES)	REQUIRED AVERAGE STRENGTH
4	Specified strength + 3.0 MPa
5	Specified strength + 4.5 MPa
6	Specified strength + 5.0 MPa
10	Specified strength + 6.0 MPa
20	Specified strength + 7.0 MPa
30 or more	Specified strength + 8.0 MPa

11.0 PSLB- BEDDING (PIPES)

Unless otherwise instructed by the Engineer, all pipes shall be laid and bedded as detailed on the drawings.

Selected granular and selected fill materials obtained from trench excavations may be used as bedding materials if proof can be provided to the Engineer that the soil falls within the requirements of Materials, Compaction, and Testing requirements as shown on the drawings.

Prior to placing bedding material, all soil clods shall be broken or discarded by means of sieving/screening so that no single soil clod used in the pipe bedding shall have a nominal size in excess of 10 mm.

11.1 SELECTION

11.1.1 SUITABLE MATERIAL AVAILABLE FROM TRENCH EXCAVATION.

Prior to placing bedding materials, the Contractor will sieve/screen the bedding materials such that all soil clods shall be broken down or discarded so that no single soil clod used in the pipe bedding shall have a nominal size in excess of 10 mm.

11.1.2 SOILCRETE.

Where so specified or as instructed by the Engineer, soilcrete will be used for pipe bedding and/or as a backfill material above pipe bedding.

Soilcrete shall consist of an approved soil or gravel mixed with 5% cement of the type CEM II 32,5N or stronger, and only sufficient water to give it a consistency that will permit the soilcrete to be so placed, with the use of vibrators, as to properly fill all voids between the pipes and sides of excavations.

The aggregate used for soilcrete shall preferably be a sandy material but may contain larger particles up to 38 mm and its plasticity index shall not exceed 10. Harmful percentages of silt or clay shall be avoided, and the aggregate shall be obtained from an approved source.

The soilcrete shall be mixed on Site by means of suitable concrete mixers. The water and cement contents shall be carefully controlled during mixing. Tile material shall be placed and then thoroughly compacted by means of concrete vibrators so as to fill all voids as described above.

11.1.3 CONSTRUCTION

11.1.3.1 GENERAL.

11.1.3.1.1 Details of Bedding.

No sharp-edged stones shall be allowed to come into contact with the pipe, pipe couplings and fittings.

11.1.3.2 TOLERANCES

11.1.3.2.1 MOISTURE CONTENT AND DENSITY.

Unless specified to the contrary, the permissible deviation from OMC shall comply with a degree of accuracy II.

11.1.4 TESTING

11.1.4.1 DENSITY.

The nuclear gauge equipment and the sand replacement method are the approved method to be used to determine the degree of compaction (density) attained. In the event that the Nuclear Density Gauge is the method used, the sand replacement method will be used periodically as a check against the NDG calibration.

11.1.4.1.1 Equipment Calibration, Maintenance, and Operation

The calibration, maintenance, and operating procedures for all Nuclear density gauge must be submitted to the Engineer prior to use on site, with all calibration certificates submitted to the Engineer for approval.

Manufacturers' specifications for instrument calibration and maintenance will be followed. A record of calibration and maintenance activities will be maintained in field notebooks

Each piece of equipment used in activities affecting data quality shall be calibrated at a frequency specified by the manufacturer.

Each piece of equipment used in activities affecting data quality shall be maintained. Following maintenance, instruments will be calibrated according to the manufacturer's specifications to ensure proper completion of the works.

11.1.5 VOLUME OF BEDDING MATERIALS.

The volume of bedding materials shall be computed from the trench widths determined in accordance with the details shown on the drawings, or in the absence of such details, in the case of conventional excavations in accordance with Clause 5.2 of SANS 1200 DB.

The volume of bedding material shall be measured net, i.e. the volume of the pipe is to be deducted, in accordance with the details shown on Drawing LB-4 of SANS 1200 LB.

12.0 PSLE-STORMWATER DRAINAGE

12.1 MATERIALS

12.1.1 CULVERT UNITS AND PIPES. A) PRECAST CONCRETE PIPES.

Prior to commencing manufacture, drawings of all concrete sections, fittings, reinforcing steel and joint details shall be provided for Engineer's review and acceptance. Manufacturing shall not begin until the Engineer has accepted the drawings.

Concrete pipe shall not be delivered to the site of the work until concrete control cylinders representing the pipe have attained a compressive strength of at least 80 percent of the specified minimum 28-day strength.

a) Joints. All joints shall be silt-tight and leak resistant

b) uPVC Pipes. uPVC pipes shall comply with the applicable requirements of SASS 791.

12.2 CONSTRUCTION

12.2.1 BEDDING AND LAYING

12.2.1.1 GENERAL.

Pipe grades between designated invert elevations shall be uniform to provide unrestricted flow and to eliminate low spots that would retain water.

Pipe shall be laid starting at the lowest elevation, with the groove ends facing upstream. Flared end sections shall have groove end on outlet end section and tongue end on inlet end section. Longitudinal seams shall be placed at the side of the trench.

When pipe laying is stopped for the day, the open end of the pipe shall be closed with an end board or plug closely fitting the end of the pipe to prevent the entry of earth. The end board or plug shall have several small holes near the centre to permit entry of water and prevent floatation.

12.2.2 TOLERANCES

12.2.2.1 INVERT LEVELS.

The permissible deviation of the level of the invert from the designated level shall be ± 12.15 mm

(measured on the main flow culvert at the inlet to the manhole or catchpit, as relevant).

13.0 PSME-SUBBASE

13.1 MATERIALS

13.1.1 GENERAL

Layer work material shall be obtained only from approved borrow areas or such other sources of supply as may be specified or approved for use from time to time. Only soil, gravel, aggregate or other approved material shall be used for the construction of layer works.

13.1.2 PHYSICAL PROPERTIES.

13.1.2.1 SUBBASE MATERIAL.

The maximum dimension of coarse aggregate shall not exceed the lesser quantity of two-thirds of the thickness of the compacted layer or 50 mm.

Grading of the above-mentioned materials shall comply with requirements as indicated on SANS 1200 M Table 8 and density requirements will be as indicated on drawings. In addition, Nuclear testing shall be performed as per SANS 1200 M.

13.1.2.2 SUBBASE LAYER

Subbase layer material shall, unless otherwise authorised, conform to the requirements given in **Table 13.1** when finally placed.

Table 13.1 Requirements for Subbase

Criteria	Subbase – G6
Parent Material	Natural gravel or natural gravel and boulders which may require crushing, or crushed rock.
Additional Fines	May contain approved natural fines not obtained from parent rock.
Strength	CBR =25 at 95% of Mod. AASHTO max. Swell at 100% of Mod. AASHTO max. density shall not exceed 0.5%.
Durability	Mudrock only to be used if directed by the Engineer.
Atterberg Limits	LL shall not exceed 30 PI shall not exceed 12. LS shall not exceed 5%.
Grading	The maximum size of crushed material shall be 2/3 of the layer thickness.

Criteria	Subbase – G6
Compaction	The minimum dry density of the compacted layer shall be 95% of modified AASHTO density.

14.0 PSMF-BASE

14.1 PHYSICAL AND CHEMICAL PROPERTIES.

14.1.1 NATURAL GRAVEL (UNSTABILIZED).

The maximum dimension of the gravel shall not exceed the lesser quantity of two-thirds of the thickness of the compacted layer or 53 mm.

Grading of the above-mentioned materials shall comply with requirements as indicated on SANS 1200 M Table 8 and density requirements will be as indicated on drawings. In addition, Nuclear testing shall be performed as per SANS 1200 M.

14.1.2 GRADED CRUSHED STONE.

The maximum dimension of the crushed stone shall not exceed the lesser quantity of two-thirds of the thickness of the compacted layer or 53 mm.

14.1.3 TOLERANCES

14.1.3.1 DIMENSIONS, LEVELS, ETC.

The dimensions and levels shall be as shown on the drawings

14.1.3.2 THICKNESS.

The average thickness of the base in any length of road, determined from measurements taken before and after construction of the base or from test holes, shall be at least the specified thickness, and in no place shall the actual thickness of the base be more than 10 mm less than the specified thickness.

14.1.3.3 BASE LAYER

Base layer material shall, unless otherwise authorised, conform to the requirements given in **Table 14.1** when finally placed.

Table 14.1 Requirements for Base

Criteria	Base - G5
Parent Material	Natural gravel or natural gravel and boulders which may require crushing, or crushed rock.
Additional Fines	May contain approved natural fines not obtained from parent rock.
Strength	CBR at 95% of Mod. AASHTO max. density shall be at least 45%. Swell at 100% of Mod. AASHTO max. density shall not exceed 0.5%.
Durability	Mudrock only to be used if directed by the Engineer.
Atterberg Limits	LL shall not exceed 30. PI shall not exceed 10, except that if less than 30% of the sample passes the 2.00 mm sieve, the PI shall not exceed 12. LS shall not exceed 5%.
Grading	The maximum size of crushed material shall be 53 mm before compaction. The maximum size of uncrushed material shall be 63 mm. The percentage (by mass) passing the 2.00 mm sieve shall be not less than 20% and not more than 70%. Grading modulus shall be not less than 1.5 and not more than 2.5.
Compaction	The minimum dry density of the compacted layer shall be 95% of modified AASHTO density.

15.0 GRAVEL WEARING COURSE

The gravel wearing course material shall, unless otherwise authorised, conform to the requirements given in **Table 15.1** when finally placed.

Table 15.1 Requirements for Gravel Wearing Course

PARAMETER	LIMIT	
	TYPE 1	TYPE 2
Maximum size, mm	37.5	37.5
Oversize Index (I_o) (maximum), %	<5	0
Shrinkage product (Sp)	100 – 365 (maximum of 240 preferable)	100 – 240
Grading coefficient (Gc)	16 – 34	16 – 34
CBR at ≥ 95% modified AASHTO Compaction (soaked value) (minimum), %	≥ 15	≥ 15
I_o = Oversize index (per cent retained on 37.5 mm sieve Sp = Linear shrinkage x (per cent passing 26.5 mm – per cent 2.0 mm) x per cent passing 4.75 mm/100 Gc = (Per cent passing 26.5 mm – per cent passing 2.0 mm) x per cent passing 4.75 mm/100		

Note: All parameters in **Table 15.1** are defined in TRH 20.

16.0 FENCING

16.1 GENERAL

The fencing material shall, unless otherwise authorised, conform to the requirements given in drawings or otherwise approved by the Engineer.

16.2 REQUIREMENTS FOR FENCING:

1) **Straining Posts:**

   3175x100dimaeter x 3mm Mild Steel Tubing with steel Cap and 230x230x3mm Base Plate, Fully Galvanized (SANS 121/ISO 1461)

2) **Straining Posts (Corner Posts)**

   3425x100dimaeter x 3mm Mild Steel Tubing with steel Cap and 230x230x3mm Base Plate, Fully Galvanized (SANS 121/ISO 1461)

3) **Stays:**

   3900x60 dimaterx3mm Mild Steel Tubing with Cap and 230x230x3mm Base Plate, Fully Galvanized (SANS 121/ISO 1461)

4) **Standards:**

   3175x60dimaeter x 3mm Mild Steel Tubing with steel Cap and 230x230x3mm Base Plate, Fully Galvanized (SANS 121/ISO 1461)

5) **Droppers:** Fully Galvanized

6) **Cross Brace Support:**

   2400x60dimaeter x 3mm Mild Steel Tubing with steel Cap and 230x230x3mm Base Plate, Fully Galvanized (SANS 121/ISO 1461). Ends Pressed Flat To +-8mm

7) **Vehicle Gate:**

   42 Diameter x 2mm Mild Steel Tubing Frame with 21.4mm diameter x 2mm Mild Steel Tube Bracing Complete with Hinges, Washers, Bolts and Locking Device. Fully Galvanized (SANS 121/ISO 1461) After Fabrication.

8) **Barbed Wire:**

   3.2 x 2.5mm Oval High Tensile Grade Single Strand (SANS 675) Fully Galvanized.

9) **Smooth Wire:**

   3mm Diameter High Tensile Grade Single Strand (SANS 675) Fully Galvanized.

10) **Smooth Wire:**

    4mm Diameter High Tensile Grade Single Strand (SANS 675) Fully Galvanized. Lower Wire To be Fixed to Concrete Using Hilt 6mm diameter eyes and Anchors.

11) Tying Wire:

2.5mm diameter Mild Steel (SANS 675). Fully Galvanized for Tying to Standards.

1.6mm diameter Mild Steel (SANS 675). Fully Galvanized for Tying mesh to smooth wires.

12) Straining Wire:

4mm diameter Mild Steel (SANS 675). Fully Galvanized. (4 Strands Doubled and Twisted to take Strain).

13) Bolts for Stays:

12mm diameter Mild Steel, Including Nuts and washers, Fully Galvanized.

14) Maximum Spacing of:

Straining Posts	36m c/c
Standards	12m c/c

15) All wires to be erected on the roadside of the fence unless otherwise instructed.
16) Minimum concrete strength of footings 20MPa at 28 days.

17) Welded Mesh:

50mmx50mmx2.5mm diameter welded mesh 2.3m wide.

18) Steel Peg:

12mm diameter Mild Steel Fully Galvanized.

19) Posts to be dipped in bitumen Solution before being concreted in (Lower 800mm)

17.0 GEOMEMBRANE: PAA

17.1 SCOPE

This Particular Specification covers the supply, installation and testing of geomembrane sheeting.

17.2 GENERAL

For the geomembrane specification and installation, refer to quality control assurance manual, ref: 301-00204/15

17.2.1 NON-WOVEN PROTECTION GEOTEXTILE: PAB

17.2.1.1 SCOPE

This Particular Specification covers the supply, installation and testing of geotextile sheeting.

17.2.1.2 PRODUCTS

For the geotextile specification material shall be as manufactured by the approved manufacturer with the following physical specifications or as approved by the Engineer:

Table 17.1 Geotextile Properties

Mechanical Properties			**Bidim A6**	
Thickness	Under 2 kPa	mm	3.1	SANS 9863-1:13 / ISO 9863-1:05
Tensile Strength (200mm wide strip)	Weaker Direction	Typical kN/m	26.0	*SANS 1525:13 / ISO 10319:08
		MARV kN/m	22.2	
	Elongation	50-70%		
Static Puncture Strength	CBR	Typical kN	4.8	*SANS 12236:13 / ISO 12236:06
		MARV kN	4.3	
Puncture Resistance	Diameter of hole (max)	mm	13	SANS 13433:13 / ISO 13433:06
Trapezoidal Tear Strength	Weaker Direction	Typical N	800	ASTM D4533
		MARV N	650	
Grab Strength	Weaker Direction	Typical N	1550	ASTM D4632
		MARV N	1410	
	Elongation	50-80%		

UV Stability	70% strength retained after 1000		ASTM D4355	
Hydraulic Properties				
Normal Throughflow	@ 50mm head	ℓ/s/m^2	70	SANS 11058:13 / ISO 11058:10
In-plane Throughflow	Flow Rate (per m width)	ℓ/hr	55	ISO 12958:10
Permeability	@ 50mm head	m/s x10^{-3}	4.3	SANS 11058:13 / ISO 11058:10
Pore Size	O95 W	µm	130	SANS 12956:13 / ISO 12956:10
Roll Dimensions				
Width	Standard	m	2.65 & 5.3	
Length	Standard	m	75	

17.2.2 HIGH DENSITY POLYETHYLENE (HDPE) GEOMEMBRANE LINER: PAC

17.2.2.1 SCOPE OF SUPPLY

Scope of supply shall include furnishing and installation of high-density polyethylene (HDPE) geomembrane liner, and associated quality control/quality assurance inspection and testing.

All work shall be done in strict accordance with the project drawings, these specifications and membrane lining fabricator's approved shop drawings.

Geomembrane panels will be supplied sufficient to cover all areas, including appurtenances, as required in the project, and shown on the drawings. The fabricator/installer of the liner shall allow for shrinkage and wrinkling of the field panels.

17.2.2.2 CODES AND STANDARDS

Work performed under these specifications shall be done in accordance with the codes and standards indicated in these specifications. Unless otherwise specified, the applicable governing edition and addenda to be used for all references to codes or standards specified herein shall be interpreted to be the jurisdictionally approved edition and addenda. If a code or standard is not jurisdictionally mandated, then the current edition and addenda in effect at the date of this document shall apply. These references shall govern the work.

Liner Installation work in accordance with **SANS 1526, SANS 10409**

17.2.2.3 MATERIALS

The following materials shall be used:

Component	Material
Geomembrane Liner	High density polyethylene (HDPE)

17.2.2.4 PRODUCTS

The lining material shall be as manufactured by the approved lining manufacturer with the following physical specifications:

Flat Die Extruded Single or Double Textured HDPE Technical Data

Textured Geoliner is produced from HDPE resin conforming to the requirements of the GRI-GM13 specification.

Properties	Units	Test Method	Test Frequency	Min Average Values			
Thickness. Minimum Avg.(a)	mm	ASTM D 5994	Per roll	1	1.5	2.00	2.5
Asperity Height Minimum Avg.	mm	ASTM D 7466	Every 2 rolls	≥0.65	≥0.65	≥0.65	0.65
Formulated Density	g/cc	ASTM D 792 ASTM D 1505	90 000kg/ approx. every 60 rolls	≥0.94	≥0.94	≥0.94	≥0.94
Tensile Properties - Minimum Avg. (b)							
• Yield Strength	kN/m	ASTM D 6693	9 000kg/ approx. every 6 rolls	15	22	29	37
• Yield Elongation	%	Type IV		12	12	12	12
• Break Strength	kN/m	Dogbone		10	16	21	26
• Break Elongation	%			300	300	300	300
Tear Resistance. Minimum Avg.	N	ASTM D 1004	20 000kg/ approx. every 12 rolls	125	187	249	311
Puncture Resistance. Minimum Avg.	N	ASTM D 4833	20 000kg/ approx. every 12 rolls	267	400	534	667
Dimensional Stability	%	ASTM D 1204	every 40 rolls	±2	±2	±2	±2
Rapid tensile test (300mm/min)	visual	ASTM D 6693	90 000kg/ approx. every 60 rolls	No Separation Visible			
Carbon Black Content	%	ASTM D 4218	9 000kg/ approx. every 6 rolls	2 - 3	2 - 3	2 - 3	2 - 3
Carbon Black Dispersion	Category	ASTM D 5596	20 000kg/ approx. every 12 rolls	cat.1 / cat.2	cat.1 / cat.2	cat.1 / cat.2	cat.1 / cat.2
Oxidative Induction Time (OIT)							
Standard OIT	minutes	ASTM D 3895	90 000kg/ approx. every 60 rolls	>100	>100	>100	>100
— and —							
High Pressure OIT	minutes	ASTM D 5885		>400	>400	>400	>400
Stress Crack Resistance (SP - NCTL)	Hours	ASTM D 5397 Appendix	180 000kg/ approx. every 120 rolls	500	500	500	500
Oven Aging at 85°C (c)		ASTM D 5721					
Standard OIT (min. avg.) retained after 90 days	%	ASTM D 3895	Per Formulation	55	55	55	55
— or —							
High Pressure OIT (min. avg.) retained after 90 days	%	ASTM D 5885		80	80	80	80
UV Resistance - % retained after 1600 hrs.		ASTM D 7238	Per Formulation				
High Pressure OIT (min. avg.)	%	ASTM D 5885		50	50	50	50

a) Thickness: Nominal -5%. Lowest individual for 8 out of 10 values = -10%
Lowest individual for any of the 10 values = -15%
b) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.

a. Yield elongation is calculated using a gage length of 33 mm
b. Break elongation is calculated using a gage length of 50 mm

c) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

17.2.2.5 TEST REQUIREMENTS

The following testing shall be conducted in accordance with the specified source. This testing is to be considered part of the defined scope of work, and all associated costs are the responsibility of the Contractor unless specifically identified as Employer-conducted. Tests identified as an option are to be priced separately. If identified as Employer-conducted, costs for the initial test will be the responsibility of the Employer. However, the Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Table 17.2 HDPE Test Requirements

Tests	In Accordance With	Conducted By
Specific gravity	ASTM 01505/792 Method B	Contractor
Carbon black content	ASTM 01603	Contractor
Melt index	ASTM 01238	Contractor
Carbon black dispersion	ASTM 05596	Contractor
Thickness - smooth	ASTM 05199	Contractor
Thickness - textured	ASTM 05994	Contractor
Tensile strength	ASTM 0638, Type IV	Contractor
Tear resistance	ASTM 01004	Contractor
Low temperature impact	ASTM 0746	Contractor
Stress crack resistance	ASTM 05397	Contractor
Puncture resistance	ASTM 04833	Contractor
Dimensional stability	ASTM 01204	Contractor
Continuous vacuum box extrusion welded seams	ASTM 04545/4437/5641	Contractor
Bond shear strength for seams and seam peel adhesion	ASTM 06392	Contractor
Air pressurized testing on all double fusion welded seams	ASTM 05820	Contractor
Ultrasonic testing on extrusion welded seams that do not permit vacuum box testing (short slopes, corners or details)	ASTM 07006	Contractor
Spark testing on extrusion welded seams that do not permit vacuum box testing (short slopes, corners or details)	ASTM 06365	Contractor

Tests	In Accordance With	Conducted By
Oven aging at 85° C	ASTM 05721	Contractor
Test method for rubber property effect of liquids	ASTM 0471	Contractor
Oxidation Induction Time- Standard	ASTM 03895	Contractor

17.2.3 GEOSYNTHETIC CLAY LINER (GCL)

17.2.3.1 SCOPE

This Particular Specification covers the supply, installation and testing of clay liner sheeting.

17.2.3.2 PRODUCTS

The lining material shall be as manufactured by the approved manufacturer with the following physical specifications:

Table 17.3 GCL Properties

Material Property	Test Method	Test Frequency m^2 (ft^2)	Bentomat® ST	Bentomat® DN
Bentonite Swell Index[1]	ASTM D 5890	1 per 50 tonnes	24 ml/2 g min	24 ml/2g min
Bentonite Fluid Loss[1]	ASTM D 5891	1 per 50 tonnes	18 ml max	18 ml max
Bentonite Mass/Area[2]	ASTM D 5993	4,000 (40,000)	3.6 kg/m^2 min (0.75 lb/ft^2)	3.6 kg/m^2 min (0.75 lb/ft^2)
GCL Grab Strength[3]	ASTM D 6768	20,000 (200,000)	53 N/cm MARV (30 lbs/in MARV)	88 N/cm (MARV) (50 lbs/in MARV)
GCL Peel Strength[3]	ASTM D 6496	4,000 (40,000)	6.1 N/cm min (3.5 lbs/in)	6.1 N/cm min (3.5 lbs/in)
GCL Index Flux[4]	ASTM D 5887	Weekly	1x10^{-8} m^3/m^2/sec max	1x10^{-8} m^3/m^2/sec max
GCL Hydraulic Conductivity[4]	ASTM D 5887	Weekly	5 x 10^{-9} cm/sec	5 x 10^{-9} cm/sec max
GCL Hydrated Internal Shear Strength[5]	ASTM D 5321 ASTM D 6243	Periodic	500 psf (24 kPa) Typ 2 0 0 psf	500 psf (24 kPa) Typ 2 0 0 psf

18.0 TESTING

Standard testing forms developed by the Engineers Representative or the Contractor shall be used for the tests described in this section. When reference is made to an external test procedure, e.g., ASTM, the relevant test procedure documentation is considered to be an integral part of this manual. If these external test procedures reference or require other additional external procedures, they also are considered to be an integral part of this document.

The tests required are divided into two categories:

- Control tests
- Record tests

Control tests are used to determine that materials comply with the Earthwork, Concrete, Roads, Gabions & Pitching and Riprap Specifications prior to placement and to determine other parameters such as optimum moisture content and maximum dry density so that the requirements of the Specifications are achieved. The frequency of control tests can be reduced when material characteristics are relatively constant and consistent.

Record tests are performed, usually after placement of the materials, to determine that the in-place materials meet the requirements as set forth in the Specifications and/or are in accordance

with the Design intent. Tests are performed by the methods indicated and at the frequencies shown in the Specifications. The tests will be performed at least the minimum number of times indicated. The Engineer may increase the number of tests required.

18.1 EARTHWORK

Testing of all fill materials shall be completed in accordance with the procedures and at the frequencies detailed in Specifications.

If the layer thickness for fill exceeds the test equipment working depth, compaction through the layer must be verified at the commencement of fill placement. This is done by excavating a pit. Thereafter, the compaction profile is established by testing the top of the layer. Periodic testing using pits may then be used to confirm continued acceptable compaction throughout the layer. Acceptance of riprap shall be based on the visual observation of the placed riprap by the Engineers Representative. If the Engineers Representative deems it necessary, field measurements to determine the particle size distribution of the riprap shall be undertaken and other test work undertaken to determine its suitability and compliance with the requirements of the Specifications.

18.2 PIPEWORK

The following tests are required prior to burial:

- Visual inspection of all non-welded joints connected by bolts.
- Visual inspection of all welds.

The following tests are required after backfill placement and compaction around the culverts.

- Visual inspection and testing, as required, of all culvert backfill. Periodically, the backfilled culvert shall be exposed when specified by the Engineers Representative to allow inspection of the completed backfill.
- Sections of the pipe shall be tested for leaks as indicated in the Specifications.

All inspections and test results are to be recorded on the Work Activity Inspection Form.

18.3 CONCRETE

Inspections required are shown in the Specifications. Any testing deemed necessary will be performed at the discretion of the Engineer. All concrete shall be accepted by the Engineers Representative on the Work Activity Inspection Form.

18.4 FIELD DENSITY TESTS

18.4.1 SAND REPLACEMENT TEST

In general, the in-place density and unit weight of soil and rock are determined using the appropriate ASTM test method:

- ASTM D 5030:
  - Minimum test pit volume
  - Maximum particle size
- ASTM D 1556 or D 2167
  - Minimum test pit volume
  - Minimum particle size

The material being tested must be sufficiently cohesive to maintain stable sides during testing. It must not deform or slough while digging the hole or pouring the sand. In general, these test methods are limited to materials in an unsaturated condition and are not recommended for soft, friable, or seeping materials.

18.4.2 FAILED TESTS

The Engineers Representative will individually consider each record test which fails to meet the requirements of the Specifications and recommend an appropriate course of action. This may involve resampling, reworking, and retesting or some combination of these. In every case, all documentation associated with the original test and the recommended remedial work will be clearly cross referenced so that the entire sequence of activities can be completely reconstructed.

18.5 EQUIPMENT CALIBRATION, MAINTENANCE, AND OPERATION

Manufacturers' specifications for instrument calibration and maintenance will be followed. A record of calibration and maintenance activities will be maintained in field notebooks. The calibration, maintenance, and operating procedures for all instruments, equipment, and

sampling tools are based on or are the actual manufacturer's instructions, specifications, and criteria for calibration, maintenance, and operation. Each piece of equipment used in activities affecting data quality shall be calibrated at a frequency specified by the manufacturer.

Each piece of equipment used in activities affecting data quality shall be maintained. Following maintenance, instruments will be calibrated according to the manufacturer's specifications to ensure proper completion of the maintenance procedure.

19.0 INSPECTION

19.1 FOUNDATION PREPARATION

The basin area of dam must be stripped, cleared, scarified, and compacted to form a Foundation. In general, the Foundation must be of material having density and strength parameters sufficient for the support of the proposed construction. In indicated Foundation areas, any unsuitable material must be removed until suitable material is reached unless approved otherwise by the Engineer, any porous zones must be noted for later treatment with impervious material, and the location of any springs, seeps, and zones of shallow groundwater must be noted for remedial design. The Engineers Representative must accept, on the Work Activity Inspection Form, prepared Foundation prior to the placement of overlying material.

Inspections required:

- Check for correct and complete stripping of topsoil, organic material, and unsuitable materials.
- Check for preparation and compaction of Foundation surface.
- Check for location of porous zones.
- Check for location of encased pipes.
- Check for location of underdrains
- Check for compliance with the intent of the Design.

19.2 FILL MATERIAL ON DAM

Fill Material on Specified Zones of the dam is to be used to backfill the wall areas as indicated on the Drawings or specified by the Engineer. The materials are to be placed, worked and compacted as required as per Specification. All fill shall be accepted by the Engineers Representative on the Work Activity Inspection Form.

Inspection required:

- Check for compliance with Specifications regarding moisture, spreading, layer thickness, surface finish, and compaction.
- Check for compliance with the lines and grades shown on the Drawings.
- Check for compliance with the intent of the Design.
- Check for the presence of organic material.
- Check for control on maximum particle size and maximum fines content.

19.3 CONCRETE

All concrete shall be accepted by the Engineers Representative on the Work Activity Inspection Form. The Engineers Representative will perform three inspections:

- One prior to placement of concrete
- One during placement of the concrete
- Final inspection following curing

Inspections required:

- Check for compliance with the relevant Specifications regarding materials and methods.
- Check for compliance with the Drawings for line, grade, and method.
- Check for reinforcing size, spacing, and alignment.
- Check for form dimensions.
- Check for casting surface cleanliness.
- Check for vibration.
- Check for surface finish.
- Check for curing.

19.4 MEASUREMENTS & PAYMENTS

19.4.1 FORMWORK

Fillets up to 20 mm * 20 mm will be deemed to be included in the rates for formwork.

Narrow formwork shall only apply to items less than 300 mm wide.

Wood and steel float finishes will only be paid to the items listed in the schedule of quantities. All other floating or striking off shall be deemed to be covered in the formwork and concrete placing rates.

19.4.2 REINFORCEMENT

The rate submitted for each type of bar, mild or high yield, shall apply for all sizes of bar.

19.4.3 JOINTS

Joints will only be paid for the items listed in the schedule of quantities. All other joints shall be deemed to be covered in the concrete placing rates.

20.0 REPORTS

20.1 DAILY REPORTS

The Engineers Representative will prepare a daily report summarizing work inspected, tests performed, and other relevant items. The daily report will indicate any failed inspections or tests, the actions taken to rectify these, and reports received or given about unacceptable or substandard procedures or materials.

20.2 MONTHLY PROGRESS REPORT

The Engineers Representative will prepare a monthly progress report. This report will:

- Summarize construction activities
- Summarize construction methods
- Summarize all CQA/QC activities
- Summarize all inspection and testing results
- Indicate problems encountered and resolutions
- Indicate potential difficulties
- Provide photographs

The Engineers Representative may include such other items as Drawings, figures, and tables as are necessary to clearly present the work performed and planned.

20.3 AS-BUILT REQUIREMENTS

A record of all changes to Drawings due to unforeseen design omissions shall be recorded on a standard As-built Record Sheet and updated timeously. This sheet will include item/s changed, date, brief description, a sketch that is clear and descriptive with dates and originator referenced to the item and information on correspondence between the Main Contractor and the Engineer or Owner. Changes that take place and need to be updated on Drawings for As-built Drawings shall be forwarded to the Engineer as soon as practicable. They should also be reported in the daily and monthly progress reports.

20.4 CONSTRUCTION REPORT

Upon completion of the work, the Engineer will prepare a comprehensive Construction Report.

This report will include:

- A summary of construction methods and materials
- A summary of any problems encountered and the solutions to them

- Results of inspections
- Results of all tests
- A record of Construction Drawings
- Photographs

The Construction Report will be submitted to the Owner.

20.5 TEST METHODS AND TESTING FREQUENCIES

Test Methods – Earthwork

Type of Test Method

(ASTM)

Atterberg Limits D 4318

Particle Size Distribution D 422 a

Laboratory Compaction D 1557

Nuclear Method Field Density D 2922 b

Sand Cone Field Density D 1556

Notes:

C = Control Tests

R = Record Tests

21.0 DATA PACKAGE

During the execution of the works, the Contractor shall complete a data package which shall include, but not be limited to or encompass only, the activities identified on the quality control plan but also all certificates called in for the specification. The package shall be handed to the Engineer for review and acceptance at the end of the project

The data package shall typically include the following:

- Index of contents
- Completed and signed quality plan
- Issued permits
- Method statements
- Identification of material
- Material test certificates
- Dimensional checks
- Inspection and test reports
- Re-work / repair details
- Variation orders
- Non-conformance reports and concessions granted
- Snag list
- Request for taking over certificates
- As-built drawings

22.0 CERTIFICATION

This report was prepared and reviewed by the undersigned.

Prepared: 

Ephraim Nkobani, Pr Tech Eng.
Senior Civil Technologist

Reviewed: 

Jannie Viljoen, Pr.Eng.
Senior Civil Engineer

Approval that this document adheres to Knight Piésold Quality Systems:

APPENDIX A

QCP Manual

(Pages 1 to 38)

Prepared for
Eskom Holdings Limited

Prepared by
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2128

Project Number
301-00825/1

MATIMBA POWER STATION: ASH DUMP
PROJECT QCP MANUAL

Rev	Description	Date
0	Issued in Final	April 1, 2020

Knight Piésold CONSULTING

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1.0 GENERAL NOTE

This Construction Quality Assurance/Quality Control (CQA/QC) Manual is provided as a guide to field and laboratory personnel conducting field inspection and testing associated with construction of Matimba Power Station Ash Dump and associated works for Matimba Project. It is intended to aid field personnel in all aspects of inspection, data collection, reporting, and control onsite. CQA/QC procedures for inspecting and reporting are necessary to ensure that all work is performed to professional standards, in accordance with recognized procedures, and that specific requirements for regulatory submissions are met and that the intent of the design is met.

Standard procedures will be used for all activities and, in general, they will be those adopted by recognized organizations. These recognized organizations include the South African National Standards (SANS), American Society for Testing and Materials (ASTM and the American Association of State Highway and Transportation Officials (AASHTO),

The Design Report, Technical Specifications, and Drawings issued for construction of the Matimba Power Station Ash Dump constitute an integrated set of documents defining design intent and construction approach. This manual is intended to be read in conjunction with these documents to provide a complete understanding of the project. This manual has been prepared with the intent that site personnel will be sufficiently trained and experienced to be able to implement not only the specific criteria noted herein but to recognize conditions that differ from those described in the design documents and take a proactive role in seeing that the intent of the design documents is met. The testing described herein is the minimum required, and it is intended that site personnel will take a proactive role in performing additional testing as needed to see that construction is accomplished to meet the intent of the design.

2.0 ORGANIZATION AND RESPONSIBILITIES

For the purposes of the CQA/QC Manual, the definitions given in the Contract and the following definitions shall apply.

The **Owner** is defined as Eskom Holdings or any of its authorized representatives. “Engineer” is defined as appointed Consultant or any of its authorized representatives.

“Contractor” is defined as the party that has executed a contract agreement with Eskom Holdings. for completing the Work of the project as described in the tender and as required by Specifications and any Modifications and as detailed on the Drawings.

“Sub-Contractor” is defined as the party that has executed a contract with the Contractor for completing any other specialized work that the Contractor deems specialized. Specifications and any Modifications and as detailed on the Drawings and the installation of Geotechnical Instrumentation.

“Drawings” are defined as the construction drawings at Revision 0 or above that have been issued for the Matimba Power Station Ash Dump Construction.

“Modifications” are defined as changes made to any Specifications or the Drawings that are approved by the Engineer and Eskom Holdings. in writing, after the Specifications and Drawings have been issued for construction. These also refer to changes to design elements in the field to account for unforeseen conditions.

“Work” is defined as the entire completed construction as shown on the Drawings and as described in the Specifications and Project Contract.

“Manufacturers” is defined as the party(ies) which manufacture(s) material that will be required to complete construction of the project as detailed in Drawings and Specification. This may be more than one company.

“Site” is defined as the Matimba Power Station Ash Dump working area owned by Eskom Holdings. and where the Works are to be completed as described in the Specifications and detailed on the Drawings.

“Plant” is defined as all equipment, materials, supplies, temporary accommodations, temporary offices, or other things brought onto the Site by the Main Contractor and Sub-contractors to carry out the Work, but this shall not include any equipment, materials, supplies, or other things incorporated into the permanent portions of the Work.

“**Construction Quality Assurance**” is defined as the responsibility of technical direction of the Work to ensure conformity of the Work to the designed intent. Construction Quality Assurance (CQA) is the responsibility of the Contractor and must be carried out to meet the requirements of the CQA/QC plan or as specified by the Engineer and Eskom.

“**Engineers Representative**” is defined as a Person who is independent from the Contractor and is responsible for observing, signing off inspections, completed work and keeping record of quality assurance documents from the Contractor during the construction period. This person can be site personnel representing the Engineer or the Owner. Activities to be assured include earthwork including roadwork, pipework and concrete construction but are not limited to the mentioned list.

"**Quality Control"** is defined as the testing and inspection necessary to ensure that the Work is constructed in compliance with the Specifications of the project. Quality Control observation and/or testing for the project are the responsibility of the Contractor. This will include all components of the project that need to be tested or observed. Quality Control testing must be carried out to meet the requirements of the CQA/QC plan or as specified by Eskom and the Engineer.

"Installer" is defined as the party that has executed a contract agreement with the Contractor for the installation of works described in the Project Specifications and as detailed on the Drawings. The Installer shall at all times be responsible for CQA/QC on its portion of work. This shall not exclude the Contractor from taking overall responsibility of the quality control and assurance of the works as indicated above. The Engineer and/or Eskom shall have access to the records of the Installer to check if records are kept and updated regularly. The Engineer will still be required to sign off at different stages as work is carried out. Should the Installer cover or bury any item without the Engineer's written instruction to continue, the Installer shall open or expose the area for the Engineer to perform his duties as detailed in the project Specifications. Under no circumstances will any Installer be excused from maintaining project Specifications and the Contractor shall make sure that the Installer is notified of such requirements in writing. Failure to do so will be taken as breach of contract.

"Units." In general, the Specifications and the Drawings refer to metric units for sieve sizes, pipe diameters, geotextile thickness, weights, etc.

3.0 STANDARD PROCEDURES

Each inspection and as-built documentation item are referenced as it is in the Specifications. The Specifications and Drawings are intended to transmit the design intent to the construction professionals, inspectors, and technicians in the field. The inspection and as-built items defined herein are minimum requirements.

3.1 SAMPLING

3.1.1 SAMPLE IDENTIFICATION

The following information is to be recorded when taking samples:

- Project number
- Project name
- Material type
- Sample number
- Sample location
- Sample elevation or depth
- Sampler name
- Name of person obtaining sample
- Date

At the time the sample is taken, the sampler records all relevant information in a field book or the project records.

3.1.2 SAMPLE PROCEDURE

The following general procedure will be used, modified as appropriate for the sample type and purpose:

- Collect samples in accordance with the Earthwork, Concrete and Roads Specifications and any other Specifications that may require samples to be collected.
- Collect an adequate, representative sample.
- Handle the sample as little as possible.
- Transfer or dispatch it properly and promptly.
- Store in correct area and avoid contamination.
- Accept samples only after checking for identification and integrity.
- Retain or dispose of samples as directed by the Owner

3.2 DOCUMENTATION

3.2.1 TEST RECORDS

The Engineers Representative will maintain a record of all tests. Individual test data and results will be recorded on a standard form applicable to the test being performed. The location of all tests will be

recorded and accurately described. A plan indicating the positions of all tests and “Work Activity Inspection Forms” detailing inspection of specific areas will be maintained by the Engineers Representative. The Officer who will perform such assurance will provide Eskom Holdings with copies of all test records or maintain them on file for reference. The Contractor upon performing tests and agreeing with the Engineers Representative and cosigning any document shall make a copy of the document signed and forward it to the Engineers Representative for record keeping.

3.3 APPROVAL OF WORK BY MAIN CONTRACTOR

In certain circumstances, it is necessary that the Engineer approve in writing the quality and/or condition of a part of the Work before subsequent Work can take place.

The following general procedures will be used:

- The Contractor shall notify the Engineers Representative in writing of the area, type, and extent of inspection or testing required.
- The Engineers Representative will perform all necessary inspections and witness tests so that the least delay is caused to the Work.
- The Engineers Representative will sign off with the Contractor the test results in the Work Activity Inspection Form. The written approval will contain a clear description and plan of the Work approved. If the Work is rejected, the reasons for so doing will be clearly set out.

3.4 MATERIAL PRE-APPROVAL

All “equivalent” materials must be approved by the Engineer in writing and requests for use of equivalent materials will be submitted to the Engineer with relevant information. The Engineer will review each request in view of the requirements of the relevant Specifications and the intentions of the design.

As soon as reasonably possible, the Engineer will inform the Contractor in writing of the acceptance or rejection of the proposed equivalent material. In the case of rejections, the reasons will be clearly stated.

4.0 INSPECTION

4.1 EARTHWORK

4.1.1 FOUNDATION PREPARATION

The basin area of storm water dam, associated site access road and haul roads must be stripped, cleared, scarified, and compacted to form a Foundation. In general, the Foundation must be of material having density and strength parameters sufficient for the support of the proposed construction. In indicated Foundation areas, any unsuitable material must be removed until suitable material is reached unless approved otherwise by the Engineer, any porous zones must be noted for later treatment with impervious material, and the location of any springs, seeps, and zones of shallow groundwater must be noted for remedial design. The Engineers Representative must accept, on the Work Activity Inspection Form, prepared Foundation prior to the placement of overlying material.

Inspections required:

- Check for correct and complete stripping of topsoil, organic material, and unsuitable materials.
- Check for preparation and compaction of Foundation surface.
- Check for location of porous zones.
- Check for location of encased pipes.
- Check for location of underdrains (if needed).
- Check for compliance with the intent of the Design.

4.1.2 STABILIZATION ROCK FILL

Stabilization Rock Fill is to be used to backfill on indicated Foundation areas to strengthen the surface to be backfilled. Low areas that need to be filled to provide a reasonably level surface for the intended construction shall be filled as indicated on the Drawings or specified by the Engineer. The Engineers Representative must accept, on the Work Activity Inspection Form, prepared Foundation prior to the placement of overlying material.

Inspection required:

- Check for compliance with Specifications regarding size of Rock Fill, hardness, spreading, layer thickness, surface finish, and compaction.
- Check for compliance with the lines and grades shown on the Drawings.
- Check for compliance with the intent of the Design.
- Check for the presence of organic material.
- Check for control on maximum particle size and maximum fines content.

4.1.3 FILL MATERIAL DAM WALLS

Fill Material on Specified Zones is to be used as backfill as indicated on the Drawings or specified by the Engineer. The materials are to be placed, worked and compacted if required as per Specification. All fill shall be accepted by the Engineers Representative on the Work Activity Inspection Form.

Inspection required:

- Check for compliance with Specifications regarding moisture, spreading, layer thickness, surface finish, and compaction.
- Check for compliance with the lines and grades shown on the Drawings.
- Check for compliance with the intent of the Design.
- Check for the presence of organic material.
- Check for control on maximum particle size and maximum fines content.
- Check for regular, consistent mixing of particles to eliminate segregation of coarse particles and formation of seepage paths.

4.1.4 EROSION PROTECTION ON OUTER SLOPES OF DAM WALL

Stockpiled topsoil is to be used for the erosion protection of constructed embankments on the earthfill dam of the dam, as approved by Engineer. All Erosion Protection shall be accepted by the Engineers Representative on the Work Activity Inspection Form.

Inspections required:

- Check for compliance with Specifications regarding particle size distribution, spreading, layer thickness and surface finish.
- Check for uniform distribution of haul truck traffic over the entire fill.
- Check for control on maximum particle size.
- Check for compliance with the intent of the Design.

4.1.5 STEEL DRAINAGE PIPELINE

The Drainage Pipeline shall be checked for defects prior to being placed. The pipes shall be assembled and tested for leaks by the Contractor. The testing shall be witnessed and accepted by the Engineers Representative. If there are leaks the pipe will be made good or replaced if necessary.

Inspection required:

- Check for compliance with relevant Specifications regarding pipes, and connections
- Check for damage to pipes
- Check to be sure that all valves work before they are installed, and coating is not damaged.
- Check for compliance with the configuration shown on the Drawings.

- Check for compliance with the intent of the Design.

4.1.6 PIPES

All pipes shall be accepted by the Engineers Representative on the Work Activity Inspection Form. Inspections required:

- Prior to delivery, check material certifications for compliance with the relevant Specifications.
- On delivery, check that the material delivered is that matching the material certifications.
- Check for damage to pipe materials prior to installation.
- After installation, check for damage and conformance with Relevant Specifications and Drawings.
- Check for compliance of installation with manufacturer's recommendations.
- Check for flushing prior to acceptance testing.
- Check for compliance with the intent of the Design.

4.1.7 DENTAL CONCRETE AND GROUT

All Dental Concrete and Grout shall be accepted by the Engineers Representative on the Work Activity Inspection Form.

Dental Concrete shall be used to fill joints, cavities, depressions, and overhangs. Prior to placement, the surfaces of the joint, cavity, depression, or overhang will be thoroughly cleaned using suitable methods identified in Specifications or by the Engineer.

Inspection required:

- Check for compliance with Specifications regarding aggregate size, workability, layer thickness, surface finish, and compaction.
- Check for compliance with the lines and grades shown on the Drawings.
- Check for compliance with the intent of the Design.
- Check for control on characteristic strength of concrete.
- Check for regular, consistent mixing of concrete to eliminate segregation of coarse particles and formation of weak spots.

4.1.8 CONCRETE

All concrete shall be accepted by the Engineers Representative on the Work Activity Inspection Form.

The Engineers Representative will perform three inspections:

- One prior to placement of concrete
- One during placement of the concrete
- Final inspection following curing

Inspections required:

- Check for compliance with the relevant Specifications regarding materials and methods.
- Check for compliance with the Drawings for line, grade, and method.
- Check for reinforcing size, spacing, and alignment.
- Check for form dimensions.
- Check for casting surface cleanliness.
- Check for vibration.
- Check for surface finish.
- Check for curing.

4.2 GEOTEXTILE

4.2.1 RAW MATERIAL

Quality control testing shall be carried out by the Geotextile Manufacturer to demonstrate that the product meets the Specifications. Prior to installing any geotextile materials, the geotextile supplier, through the Main Contractor, shall provide the Engineers Representative via the Engineer with the following information:

- The origin (name and production plant), identification (brand name, number), production date, and batch (or rail car number) of the resin
- A copy of the quality control certificates issued by the geotextile manufacturer with results of the density, penetration load, tensile strength, permeability and thickness & compressibility tests
- A copy of the quality control test results issued by the geomembrane manufacturer verifying the quality of the resin used to manufacture the geomembrane

4.2.2 DELIVERY

4.2.2.1 GEOTEXTILE DELIVERY

Upon arrival of geotextile materials at the site, the Engineers Representative shall immediately receive via the Contractor a copy of the bill of lading of all geotextile materials and accessories delivered. All materials received on the site shall be immediately logged on the Log of Geosynthetics Received. Upon unloading of the geotextile, the Engineers Representative shall verify that the materials delivered:

- Meet the Geotextile Specifications
- Match those which are listed on the bill of lading

Any discrepancies shall be brought to the immediate attention of the Engineer. The materials shall be inspected for any visible damage or defects, which shall be noted in the log. Materials damaged during unloading shall be noted as such.

4.2.2.2 GEOTEXTILE STORAGE

Geotextile materials shall be stored at a site near the Workplace that is free of hazard. Materials should be stored on a smooth surface free of sharp objects and in an area that will remain in a relatively dry condition at all times. The Engineers Representative shall note any material damaged while in storage.

4.2.2.3 GEOTEXTILE ACCEPTANCE

The Engineers Representative shall neither accept nor allow the installation of any materials that do not meet the requirements of the Geosynthetics Specifications. Materials that are not acceptable shall be clearly marked as such by the Engineers Representative. The Contractor shall be notified by the Engineers Representative via the Engineer as soon as possible as to the deficiencies of materials which do not meet the Geotextile Specifications. Materials that do not meet the requirements of the Specifications shall be removed from the site.

4.2.3 SUBGRADE

4.2.3.1 SUBGRADE INSPECTION

The Engineers Representative shall inspect and accept on the Work Activity Inspection Form the subgrade prior to submittal of an area to the Contractor via the Engineer for his acceptance. The subgrade is the upper surface of the Prepared Subbase.

Inspections required:

- Check for proper compaction.
- Check for proper moisture content.
- Check for correct material type.
- Check for required surface smoothness.
- Check for fill free of debris and sharp objects.

4.2.3.2 SUBGRADE ACCEPTANCE

The Engineers Representative shall obtain from the Main and Gabion Contractor via the Engineer written acceptance for the subgrade prior to the installation of geotextile material. The acceptance of the subgrade shall be recorded on the Work Activity Inspection Form. If any damage has occurred since acceptance, the Engineers Representative shall obtain reacceptance of any area that has been damaged and repaired prior to installation of geotextile materials. The Contractor is responsible for maintaining the condition of the accepted area(s) until it is accepted by others for later stages of Work.

4.2.4 GEOTEXTILE DEPLOYMENT

4.2.4.1 GEOTEXTILE FIELD PANEL DEPLOYMENT

Deployment of geotextile shall be in a systematic and planned fashion.

Inspections required:

- Check for correct direction of deployment.
- Check for correct amount of overlap.

- Check for the amount of geotextile deployed.
- Check for prevention of water from entering between panels.
- Check for temporary anchorage.
- Check for open holes.

The Engineers Representative shall re-inspect any subgrade that may have been damaged after deployment has taken place to ensure that the subgrade still meets the Specifications. This may include removal of deployed panels. Re-inspection will be recorded on the Work Activity Inspection Form. In addition, written acceptance of the damaged and repaired area shall be provided following the guidelines set forth in 4.2.3.2, Subgrade Acceptance.

4.2.4.2 GEOTEXTILE FIELD PANEL DEPLOYMENT SCHEDULE

Deployment of geomembrane materials shall take place within an acceptable period as agreed by both the Contractor, Installer and the Engineers Representative via the Engineer. The speed of deployment shall consider the deterioration of subgrade, materials to be placed on top of the geotextile and the geotextile with time.

4.2.4.3 GEOTEXTILE FIELD PANEL DEPLOYMENT PROGRESS REPORTS

The Contractor shall record on a daily basis the location, date, and roll number of each panel deployed. Daily progress reports shall be submitted to the Engineer. The Engineer shall check these daily reports against his own records to ensure completeness.

4.2.4.4 GEOTEXTILE OVERLAP

The geotextile field panel layout shall be inspected for proper overlap prior to covering. Field joints shall be overlapped as per Drawings or Specifications.

4.2.4.5 GEOTEXTILE DEPLOYMENT WEATHER CONDITIONS

Deployment shall not take place during inclement weather. The Engineers Representative shall have the final authority to determine if weather conditions warrant halting or not starting deployment operations. These conditions include, but are not limited to, the following:

- Precipitation of any kind including condensing fogs
- Areas of ponded water
- Periods of excessive wind

4.3 HIGH DENSITY POLYETHYLENE (HDPE) GEOMEMBRANE LINER

4.3.1 SCOPE OF SUPPLY

Scope of supply shall include furnishing and installation of high-density polyethylene (HDPE) geomembrane liner, and associated quality control/quality assurance inspection and testing.

4.3.2 CODES AND STANDARDS

Work performed under these specifications shall be done in accordance with the codes and standards indicated in these specifications. Unless otherwise specified, the applicable governing edition and addenda to be used for all references to codes or standards specified herein shall be interpreted to be the jurisdictionally approved edition and addenda. If a code or standard is not jurisdictionally mandated, then the current edition and addenda in effect at the date of this document shall apply. These references shall govern the work.

Liner Installation work in accordance with **SANS 1526, SANS 10409**

4.3.3 MATERIALS

The following materials shall be used:

Component	Material
Geomembrane Liner	High density polyethylene (HDPE)

Flat Die Extruded Single or Double Textured HDPE Technical Data

Textured Geoliner is produced from HDPE resin conforming to the requirements of the GRI-GM13 specification.

Properties	Units	Test Method	Test Frequency	Min Average Values			
Thickness. Minimum Avg.(a)	mm	ASTM D 5994	Per roll	1	1.5	2.00	2.5
Asperity Height Minimum Avg.	mm	ASTM D 7466	Every 2 rolls	≥0.65	≥0.65	≥0.65	0.65
Formulated Density	g/cc	ASTM D 792 ASTM D 1505	90 000kg/ approx. every 60 rolls	≥0.94	≥0.94	≥0.94	≥0.94
Tensile Properties - Minimum Avg. (b)							
• Yield Strength	kN/m	ASTM D 6693	9 000kg/ approx. every 6 rolls	15	22	29	37
• Yield Elongation	%	Type IV		12	12	12	12
• Break Strength	kN/m	Dogbone		10	16	21	26
• Break Elongation	%			300	300	300	300
Tear Resistance. Minimum Avg.	N	ASTM D 1004	20 000kg/ approx. every 12 rolls	125	187	249	311
Puncture Resistance. Minimum Avg.	N	ASTM D 4833	20 000kg/ approx. every 12 rolls	267	400	534	667
Dimensional Stability	%	ASTM D 1204	every 40 rolls	±2	±2	±2	±2
Rapid tensile test (300mm/min)	visual	ASTM D 6693	90 000kg/ approx. every 60 rolls	No Separation Visible			
Carbon Black Content	%	ASTM D 4218	9 000kg/ approx. every 6 rolls	2 - 3	2 - 3	2 - 3	2 - 3
Carbon Black Dispersion	Category	ASTM D 5596	20 000kg/ approx. every 12 rolls	cat.1 / cat.2	cat.1 / cat.2	cat.1 / cat.2	cat.1 / cat.2
Oxidative Induction Time (OIT)							
Standard OIT	minutes	ASTM D 3895	90 000kg/ approx. every 60 rolls	>100	>100	>100	>100
— and —							
High Pressure OIT	minutes	ASTM D 5885		>400	>400	>400	>400
Stress Crack Resistance (SP - NCTL)	Hours	ASTM D 5397 Appendix	180 000kg/ approx. every 120 rolls	500	500	500	500
Oven Aging at 85°C (c)		ASTM D 5721					
Standard OIT (min. avg.) retained after 90 days	%	ASTM D 3895	Per Formulation	55	55	55	55
— or —							
High Pressure OIT (min. avg.) retained after 90 days	%	ASTM D 5885		80	80	80	80
UV Resistance - % retained after 1600 hrs.		ASTM D 7238	Per Formulation				
High Pressure OIT (min. avg.)	%	ASTM D 5885		50	50	50	50

a) Thickness: Nominal -5%. Lowest individual for 8 out of 10 values = -10%
Lowest individual for any of the 10 values = -15%
b) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.

a. Yield elongation is calculated using a gage length of 33 mm
b. Break elongation is calculated using a gage length of 50 mm

4.3.4 TEST REQUIREMENTS

The following testing shall be conducted in accordance with the specified source. This testing is to be considered part of the defined scope of work, and all associated costs are the responsibility of the Contractor unless specifically identified as Employer-conducted. Tests identified as an option are to be

priced separately. If identified as Employer-conducted, costs for the initial test will be the responsibility of the Employer. However, the Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Tests	**In Accordance With**	**Conducted By**
Specific gravity	ASTM 01505/792 Method B	Contractor
Carbon black content	ASTM 01603	Contractor
Melt index	ASTM 01238	Contractor
Carbon black dispersion	ASTM 05596	Contractor
Thickness - smooth	ASTM 05199	Contractor
Thickness - textured	ASTM 05994	Contractor
Tensile strength	ASTM 0638, Type IV	Contractor
Tear resistance	ASTM 01004	Contractor
Low temperature impact	ASTM 0746	Contractor
Stress crack resistance	ASTM 05397	Contractor
Puncture resistance	ASTM 04833	Contractor
Dimensional stability	ASTM 01204	Contractor
Continuous vacuum box extrusion welded seams	ASTM 04545/4437/5641	Contractor
Bond shear strength for seams and seam peel adhesion	ASTM 06392	Contractor
Air pressurized testing on all double fusion welded seams	ASTM 05820	Contractor
Ultrasonic testing on extrusion welded seams that do not permit vacuum box testing (short slopes, corners or details)	ASTM 07006	Contractor
Spark testing on extrusion welded seams that do not permit vacuum box testing (short slopes, corners or details)	ASTM 06365	Contractor

Tests	In Accordance With	Conducted By
Oven aging at 85° C	ASTM 05721	Contractor
Test method for rubber property effect of liquids	ASTM 0471	Contractor
Oxidation Induction Time- Standard	ASTM 03895	Contractor

4.3.5 PRODUCTS

4.3.5.1 GENERAL

This section covers the material requirements for both smooth and textured HDPE geomembrane material. The geomembrane shall be installed to the limits indicated on the drawings in accordance with the manufacturer's recommendations and these specifications.

The geomembrane manufacturer and Contractor shall have sufficient experience in satisfactory production and installation of geomembrane similar to the type specified. The Contractor shall be the geomembrane manufacturer, or an installer acceptable to the manufacturer.

4.3.5.2 QUALITY CONTROL.

Quality control (QC) shall be performed by the Contractor in accordance with these specifications. Quality control testing requirements and frequency shall be in accordance with **Section 4.3.8**.

Field Quality Control. All quality control field and laboratory testing will be performed by an independent testing laboratory secured by the Contractor and acceptable to the Employer.

4.3.5.3 DRAWINGS AND DATA

The Contractor shall submit drawings, manufacturer specifications, and data for the geomembrane and all accessories to the Engineer in for approval. The installation drawings shall indicate the extent, size, and details of the proposed panel layout, panel numbers, seam locations, seam numbers, seam details, penetration details, geomembrane terminations, and all special details. The Contractor shall also submit proposals for method and sequence of installation to minimize heat expansion sheet undulations and cold contraction sheet tensions. Data shall include current test reports verifying conformance to the material specifications. The Contractor shall furnish "as-built" drawings that record all panel and seam numbers as well as the locations and dimensions of compensation strips, if any.

All changes in submitted installation drawings and procedures must be accepted by the Engineer. Requests for field changes to the approved installation drawings, procedures, and schedule shall be submitted in writing to the Engineer for review and comment. No changes shall be allowed prior to written acceptance by the Engineer. Changes shall be documented on original drawings submitted by Contractor

4.3.5.4 WARRANTIES

The following material and installation warranties shall be furnished in writing to the QC personnel, by the manufacturer and Contractor, respectively.

4.3.5.4.1 Material Warranty.

The geomembrane material shall be warranted on a prorated basis against manufacturing defects and material degradation for the period as stipulated by the manufacturer from the date of official acceptance by the Engineer. Material, which fails within 1 year of acceptance, shall be replaced and installed at no cost to Employer.

4.3.5.4.2 Installation Warranty.

The geomembrane installation shall be warranted against defects for the period as stipulated by the manufacturer from the date of official acceptance by the Engineer. Repairs required during the warranty period, caused by defects due to improper installation, shall be made at no cost to Employer.

4.3.5.5 MATERIALS

The sheet shall be extruded to produce a uniform sheet free of defects such as holes, tears, punctures, blisters, or other manufacturing defects that may affect its durability. Minimum manufactured sheet width shall be 6 m.

Physical property requirements for the HDPE geomembrane shall apply to the extrusion material used for joining sheets.

Melting behavior, melt appearance, and forming behavior shall be continuously observed during production of the geomembrane sheets. The data, labeled with the respective batch and sheet roll numbers, shall be assembled as product quality control documentation and be made available in the event of the material failing during installation or while in service. If a batch does not show favorable behavior in all three respects, it shall be excluded from production regardless of previous acceptance. Important extrusion data (processing parameters) including, but not limited to, melt temperature and production rate shall be monitored and made available. The results shall be submitted upon request.

One sample 21 by 30 centimeters or larger will be excised from the finished roll across the full sheet width. One sample from each roll will be stored with appropriate labeling, and one sample will be tested by the sheet manufacturer for each 4,645 square meters of geomembrane manufactured. This testing will include tensile strength, thickness, and density tests. Test results will meet or exceed the specified minimum requirements.

The values will be documented for each individual sample, stored with the respective sheet report and production report, and submitted upon request. The completed labeled sheet roll will not be placed in storage if any of its test values deviate from the limits. It is the manufacturer's express obligation to exclude any sheet not complying with these quality standards.

A sheet report covering the entire sheet roll shall be prepared for each roll, on which any visible faults must be accurately entered.

A stress cracking durability of range of tolerance equal to or greater than 1,000 hours shall be documented in testing. Test results shall be submitted to the Engineer upon request.

The sheet roll shall not be released for installation unless acceptable results of the production control tests are obtained. If unacceptable results are obtained, the test shall be repeated on another sample from the sheet roll in question. If these results confirm a substandard tensile cracking durability, the material shall be rejected.

4.3.6 EXECUTION

4.3.6.1 SUBGRADE PREPARATION

Geomembrane liner materials shall not be placed until the required subgrade preparation has been completed and the Contractor certifies in writing that the surface on which the geomembrane is installed is acceptable. The Engineer and Contractor, prior to placing any geomembrane, will perform a walk-through inspection.

It will be the responsibility of the Contractor to keep the previously prepared receiving surface in the accepted condition until the geomembrane installation is complete.

Subgrade prepared for geomembrane installation will be smooth and free of debris, roots, and angular or sharp rocks or other objects that might be detrimental to the performance of the geomembrane.

Maximum particle size of objects shall typically not exceed 3 mm. If the in-situ soil is unsuitable, a sand or fine gravel blinding layer of thickness at least 2.5 times the largest dimension of the largest particle in the in-situ soil, or 50 mm (whichever is the thicker), or a suitable geotextile with properties sufficient to meet the above requirements, shall be placed over the entire area to be covered. The subgrade will be protected from erosion. Any areas of the subgrade that are soft, weak; maintain inadequate moisture conditioning; contain ruts, stones, sharp breaks, or holes; or are otherwise unacceptable will be removed or repaired prior to releasing the subgrade for liner installation.

4.3.6.2 DELIVERY AND STORAGE

Upon arrival at the site, the geomembrane rolls shall be unloaded and placed on a smooth surface free of rocks, mud, debris, or any other protrusions which may damage the material. Materials shall not be stored directly on the ground. The Contractor shall provide adequate equipment and personnel at the time of each delivery in order to ensure that the geomembrane is not damaged. Personnel shall handle the geomembrane with care.

Any geomembrane rolls delivered to the site prior to the Contractor's mobilization shall be kept covered and dry. The Contractor shall examine all rolls for defects and damage and shall report observed damage to the Engineer immediately.

The geomembrane rolls shall be stored onsite at a location that shall be selected to minimize onsite handling. Geomembrane rolls shall not be stacked in a manner that could cause damage to underlying rolls. Geomembrane shall not be stacked higher than two rolls. During storage, the rolls shall be protected from vandalism, passage of vehicle, and theft.

The CQA personnel will obtain a sample of the delivered material. The rate of sampling will be one sample per 9,290 square meters of material. The sample will be 1 meter in length across the entire roll width. The sample shall be tested for conformance at the request of the Engineer. Testing shall include thickness, specific gravity, carbon black dispersion, carbon black content, tensile properties (yield, break, and elongation), tear resistance, and puncture resistance.

4.3.6.3 GEOMEMBRANE INSTALLATION

The geomembrane will be installed in accordance with the manufacturer's recommendations, to the limits indicated on the drawings, and as specified herein.

The geomembrane shall be installed by crews experienced in the installation of HDPE sheet, the type and thickness specified. The onsite installation supervisor shall have supervised in the field or installed at least the square meters of the HDPE liner required in **Section 4.3.8**. All seamers shall have at least the required experience of HDPE geomembrane seaming.

Extreme care shall be taken during installation of the geomembrane to be certain no damage is done to any part of the material. Dragging of the geomembrane on the subgrade shall be avoided. Smoking and use of glass containers by installation personnel shall be prohibited. Installation personnel shall be equipped with boots that will not cause damage to the liner. All handling and installation procedures used by the Contractor shall not damage the liner. If damage occurs, the QC personnel shall require changes in equipment and procedures. No vehicular traffic shall be allowed on the HDPE liner without a minimum of 300 mm of soil cover between the vehicle and the membrane. Exceptions shall be as agreed by the QC personnel. All motor driven equipment using fuel shall have spark arrestors. No gasoline driven generators or cans of gas or solvent shall be placed directly on the HDPE material. Under no circumstances shall the HDPE liner be used as a work area to prepare patches or to store tools and supplies. If needed, a tarpaulin of approved material shall be spread out as a work area.

The Contractor Quality Control personnel shall perform visual inspection of geomembrane materials upon arrival at site for possible transport damage. Geomembrane materials showing damage will be isolated, clearly labeled as damaged, and returned to the manufacturer as determined by the QC personnel. The geomembrane surface will be inspected as it is unpacked or unrolled. If damage or faults not previously observed are discovered, they will be clearly marked, and the respective sheet roll will be set aside. Damaged areas will be repaired in a manner acceptable to the QC personnel, or the entire roll shall be returned to the manufacturer as determined by the CQA personnel. All scuffed surfaces resulting from abuse of any kind caused by the Contractor in performance of the work shall be repaired at no additional cost to the Employer.

Installation work shall not begin until all required drawings and data have been submitted and the Engineer and Contractor have certified the acceptability of the subgrade in writing. The geomembrane shall be installed over the prepared subgrade to the limits indicated on the drawings. Geomembrane panels shall be arranged to minimize field seaming. All geomembrane panels over 2.3 square meters in area shall be designated with a panel number. The Contractor shall be responsible for assigning the number and shall locate the number near the middle of panels less than 15.25 meters in length and at both ends of panels over 15.25 meters in length. These numbers shall be noted on "as-built" drawings and daily progress reports and shall correspond to the drawings initially submitted by the Contractor. Any panel under 2.3 square meters shall be considered a patch and shall not require a panel number; these however will be identified (location and approximate size) on the "as-built" drawings.

Only geomembrane panels scheduled for each day's field seaming shall be spread each day. Panels shall be seamed on the same day they are spread and shall be held in position by sandbags placed at the edges of the sheets until field seaming is complete. Sandbags shall be sufficiently close-knit to preclude fine material from exiting the bag. Metal or wire ties shall not be used.

All rips, tears, punctures, or other injuries to the geomembrane shall be repaired the same day they occur in accordance with procedures as specified herein. At the CQA personnel's discretion, excessive patching shall result in removal and replacement of entire geomembrane sheet at Contractor's expense.

Cleanup within the work area shall be an ongoing responsibility of the Contractor. Care shall be taken to ensure that no trash, tools, and other unwanted materials are dragged across or trapped beneath the geomembrane. Care shall be taken to ensure that all scraps of geomembrane material and other installation related debris are removed from the work area.

Installation. The geomembrane shall be installed on the prepared subgrade to the limits indicated on the drawings. The geomembrane panels shall be arranged in a manner to minimize the number and length of field seaming. The geomembrane panels shall be installed such that field seams run longitudinally down the embankment slope. The installation shall allow for thermal expansion and contraction of the geomembrane. Adequate compensation for liner thermal effects and sheet stability shall be allowed for by the Contractor. Compensations strips shall be installed as required and shall be clearly noted on the "as-built" drawing.

Prior to liner installation, the Contractor shall provide the QC personnel with a table listing the required additional compensation material necessary versus sheet temperature. The minimum design operating liner temperature for this table shall be -34.4' C. This table shall include the necessary compensation for sheet stability. No liner shall be installed until the table has been submitted to the QC personnel. The Contractor shall install at each pipe penetration, roadway edge, or concrete cover enough compensation to eliminate stress at the liner anchorage due to temperature and sheet stability contraction.

The Contractor shall provide temporary wind anchorage during geomembrane installation. All faulty areas shall be repaired. The geomembrane panels shall be installed by experienced workmen and handled carefully. All rips, tears, punctures, or other injuries to the geomembrane shall be repaired the same day to the satisfaction of the QC personnel and in accordance with procedures specified herein.

Liner attachments to structures and penetrations shall be performed by the Contractor in accordance with the drawings.

4.3.6.4 SEAMING.

Field seams shall be made by fusion or extrusion welding methods. Extrusion welding shall only be used in areas where fusion welding equipment cannot operate.

The Contractor shall use only welding apparatus on which proper control of extrudate or wedge temperature, apparatus pressure, welding speed, width of weld, and sheet preheating temperature can be maintained. Certification that the welding apparatus meets these requirements shall be presented before any field seams are made. Welding apparatus or employees shall not damage the geomembrane.

No horizontal seams shall be placed in areas of potential stress concentrations, such as the toe of slopes. The location of horizontal seams shall be discussed with the QC personnel.

A seam numbering system compatible with a panel numbering system shall be established prior to commencing geomembrane installation and submitted to the QC personnel. This information shall be included on the "as-built" drawings and the daily progress reports.

A test weld of length in accordance with **Section 4.3.3**, a determination of sheet surface temperature, and visual inspection of the seam surface and cross section shall be performed satisfactorily before any seam welding is begun each day and before startup of any welding equipment after it has been shut down for any time period exceeding 30 minutes. Trial seams shall be made under the same conditions as actual seams. The CQA personnel may require a trial seam be made at any time during seaming production to verify equipment, operator performance, and seam integrity.

Three 25 mm wide specimens shall be cut from the trial seam, each having the seam centrally located. Using a field tensiometer, the specimens shall be tested in peel and shear, respectively. If either of the'

samples fail in the seam, the operation shall be repeated until the deficiencies are corrected and two successful trial welds are achieved. After positive evaluation of the test weld, the seaming shall begin.

Before welding, the seam areas will be cleaned of wall dust, dirt, and other foreign materials. Welding shall not be performed unless the sheet is dry, and the sheet temperature is within the temperatures specified in **Section 4.3.8**. Welding may be required in cold temperatures. Cold temperature welding procedures shall be provided to the CQA personnel for review prior to start of welding. In no case shall seaming continue if the peel and shear tests fail to meet the specified requirements. Panel layout and other preparatory work may be completed with the aid of artificial light (light plants). A visual inspection of the seaming surface and cross section will be performed before any seam welding or equipment startup has begun.

The Contractor may propose seaming procedures for adverse weather conditions, which will be evaluated by the QC personnel prior to use. Work at night shall take place only with acceptable lighting and the Engineer's approval. All personnel onsite shall be required to carry suitable flashlights during no-day light.

Extrusion field seams shall be made only in areas where fusion seaming is not practical. The sheet surface for extrusion welding shall be roughened by an acceptable means before extrudate is placed. Excessive grinding resulting in grooving of the liner or reducing liner thickness greater than 10 percent shall not be permitted. Grinding shall be performed perpendicular to the seam.

Extrusion seams shall be made by overlapping adjacent sheets a minimum of 80 mm and extruding a ribbon of hot fusion-joining resin no less than 20 mm in width between the overlapped sheets or over the seams between the overlapped sheets.

Fusion field seams shall be made by overlapping adjacent sheets a minimum of 80 mm and forming a double welded seam separated by an air space approximately 10 mm in width. Welded seams shall be produced by a double hot shoe welder capable of maintaining a recordable temperature determined by onsite conditions.

Penetrations through the geomembrane for pipe, patches, concrete structures, other structures, etc. will be field welded, using an extrusion weld joint gun. The seaming procedure shall consist of cleaning and roughening the surface and softening the geomembrane material by application of heated air. Directly following the application of heat, a hot strip of the same HDPE from which the sheet is made will be extruded over the seam to produce the fusion-welded seam.

Repairs of small holes less than 50 mm in the geomembrane surface shall be made with an extrusion joint gun. Geomembrane materials shall be cleaned of all dirt, dust, and other foreign material; all smooth HDPE surfaces roughened, heated to the prescribed temperature, and a hot strip of HDPE resin shall be extruded over the hole to produce a fusion-welded repair.

Larger holes shall be repaired with a HDPE patch and extrusion joint gun. A HDPE patch, meeting the requirements of the HDPE membrane, shall be placed over the hole. The patch shall completely cover the hole, with a minimum clearance between the hole and edge of patch of 80 mm. Membrane and patch material shall be cleaned of all dirt, dust, and other foreign material. All smooth HDPE surfaces shall be roughened, heated to the prescribed temperature, and the patch extrusion welded to the membrane to complete the repair. All patches shall have rounded corners.

4.3.6.5 INSPECTION AND TESTING.

Along with observance of the welding parameters, continuous vacuum box testing shall be performed on all extrusion welded seams and air pressure testing on all double fusion welded seams according to **Section 4.3.4**, as product control. All double fusion seams will be tested at the pressure required in **Section 4.3.3** over the maximum uninterrupted panel seam length for the time required in **Section 4.3.3**. If the pressure drop in the seam is greater than that required, the leak will be located, repaired and the seam retested.

Extrusion welded seams that do not permit vacuum box testing (on short slopes, corners, or details) shall undergo ultrasonic testing similar to the Ultrasonic Shadow Method or Spark testing in accordance with ASTM 06365. The Contractor shall be responsible for submitting the testing method to be used in these instances to the QC personnel.

Weak or unbonded seams shall be repaired with a minimum 155 mm overlay patch and retested. All liner repairs shall be made using patches with rounded corners.

A sample coupon of production seams approximately 915 mm long by 305 mm wide shall be taken in accordance with the specification requirements. The sample coupon shall allow for a total of ten 25.4 mm wide production field seams to be tested. All testing will be performed at the Contractor's onsite quality control laboratory. A portion of each sample coupon 305 by 305 mm shall be labeled and submitted to the CQA personnel for archiving purposes.

Five samples shall be tested for bonded shear strength and five samples shall be tested for seam peel adhesion in accordance with **ASTM 04437**.

The samples obtained from double fusion and extrusion welded seams shall exhibit at least the minimum percent of sheet tensile yield strength in shear required in **Section 4.3.3**. The samples obtained from double fusion and extrusion weld seams shall exhibit at least the minimum percent of sheet yield strength in peel required in **Section 4.3.3**.

All five of the specimens tested in shear and four out of five of the specimens tested in peel shall fail in film tear bond (FTB), that is, the break should occur in the parent geomembrane. The failure mechanism of the seam shall be ductile in nature, with no indication of crystallization.

Test results shall be submitted as soon as possible to the QC personnel and signed by the Contractor's

4.3.6.6 QUALITY CONTROL MANAGER.

If the sample proves defective, by either destructive or nondestructive testing, additional testing shall be performed to determine the extent of the defect. A test section a minimum of 3 meter on both sides of the failed seam shall be retested. If these tests pass, the weld between these areas shall be cap stripped. If failure occurs, the testing shall be continued until the extent of the defect is established. All defects shall be repaired to the satisfaction of the QC personnel.

Destructive weld test sample reports shall be delivered to the QC personnel within 48 hours of obtaining the sample from the production seam. The geomembrane shall not be covered until acceptable destructive and nondestructive testing has been completed.

It is the Contractor's obligation to forward to the Engineer all weld seam reports, labeled with the weld seam number in accordance with the installation drawings.

Faulty spots shall be repaired by one of the two methods previously specified, patching or filling, and the repaired sections subjected to thorough visual inspection and vacuum box testing.

4.3.6.7 LINER DEGRADATION MONITORING (APPLIES TO DAM LINERS).

To monitor durability and compliance with warranty requirements, test samples shall be installed at several locations within the dam. Each test sample shall include factory seams, field seams, patches, and other representative operations performed during liner installation. Each test sample shall be 1.5 meters wide by 3.0 meters long with Hach seam running the long dimension. Each test sample shall be placed over the permanent liner on 50 mrn of fill material.

The number of test samples installed within the dam shall be in accordance with the specifications or as directed by the Engineer. The location of test samples shall be acceptable to the Engineer.

4.3.7 DOCUMENTATION

4.3.7.1 SHEET INSTALLATION.

The Contractor shall perform a visual inspection on each liner sheet for puncture, tears, rips, or other injuries. Daily installation progress reports shall be prepared including the following information:

- Names and job description of personnel. Date.
- Weather conditions, including range of wind speed and temperature, cloud cover, and precipitation.
- Project location
- . Panels installed.
- Panels seamed, including panel and seam number.
- Liner repair (puncture, tears, rips, or other injuries and method of repair). Field observations.
- Roll number.

Copies shall be provided to the QC personnel on a daily basis.

4.3.7.2 LINER SEAMING.

Quality control records shall be prepared by the Contractor detailing the initial weld qualification of equipment and welding crews. Daily seam quality control reports shall be maintained on all field seaming including, but not limited to, the following information:

- Date.
- Project location.
- Weld location, seam number, and panel number (including liner repair situations). Sheet temperature.
- Weld crew identification. Weld machine identification.
- Weld samples, if taken (including test weld documentation). General observations.

4.3.8 FIELD QUALITY CONTROL

This article describes the activities necessary to monitor the construction of the geomembrane. Specific tests mentioned in this section shall be performed by the Contractor's QC personnel as part of the construction quality control for the project. Additional confirmation tests may be performed by the CQA personnel.

4.3.8.1 PRECONSTRUCTION.

Preconstruction activities for the liners include observation of the raw materials, manufacturing operations, fabrication operations, and final product quality; observations related to transportation, handling, and storage of the synthetic liner; monitoring of the subgrade (base) preparation; and evaluation of the personnel and equipment to be used to install the liners. These activities are discussed in the following articles.

4.3.8.2 QUALITY CONTROL OF MANUFACTURER.

The Contractor must provide documentation confirming that the raw materials comply with the manufacturer's product properties and performance requirements. The manufacturer must have a manufacturing quality control program that the CQA personnel will review. If there are areas where the QC personnel feel that the manufacturer's quality control program is weak, they may request that the manufacturer conduct additional tests.

The liner will be tested by the manufacturer after it is manufactured into rolls and these documented test results reviewed by CQA personnel for compliance with the test methods and properties included in the specifications.

The synthetic liner manufacturer shall retain a sample of the finished liner from each raw material batch (identified by lot number) for future reference. Appropriate documentation (e.g., product specifications, lot number) will be included with each sample. Documentation will be available to the QC personnel.

No factory seam of the synthetic liners will be allowed. The QC personnel shall observe the synthetic liner material for the presence of factory seams.

4.3.8.3 TRANSPORTATION AND STORAGE.

CQA personnel will confirm that the synthetic liner has been protected with appropriate covering material. The roll of finished liner material must be marked to show the following minimum information:

- Name of manufacturer. Product type.
- Product thickness. Manufacturing batch code. Date of manufacture.
- Physical dimensions (length and width).

The liner material will be observed to confirm that it is not damaged by the following: Punctures from handling, nails, splinters, etc.

Tears from operation of equipment or inadequate packaging. Exposure to temperature extremes resulting in unusable material.

Blocking resulting from the bonding together of adjacent membrane layers due to excessive heat and pressure.

Crumpling or tearing from inadequate packaging support.

When damage to a roll cover has occurred, examination of the underlying material will be conducted. If damage is found, CQA personnel will examine the entire shipment tor damage.

The CQA personnel will review delivery tickets and quality control documentation to confirm that the liner rolls received onsite meet the project specifications. Samples of the product may be "fingerprinted" and compared with the fingerprint of the product originally contracted for. If these fingerprints are different, the material will be rejected.

The CQA personnel will confirm that the synthetic liner material is stored in a secure area with provisions for protection from adverse weather to avoid damage caused by heavy winds, precipitation, temperature extremes, vandals, and any other causes.

4.3.8.4 CONSTRUCTION.

The observations and tests necessary to detect defects during construction are discussed in the following articles.

4.3.8.4.1 Synthetic liner placement.

Identifying labels from each roll will be taken and saved for future reference. Further, the position of each roll of material will be noted on a final installation drawing. This document can be used for future reference. Monitoring activities that are necessary and that will be documented during liner placement include the following:

Written acceptance by the Contractor that subgrade is in a condition suitable for liner deployment.

Observations regarding the liner placement plan.

Observations of the weather conditions (i.e., temperature, humidity, precipitation, and wind) and that they are appropriate for liner placement and seaming.

Observations and measurements of the anchor trench so that it is as specified in the construction drawings; that trench corners are rounded to limit stressing the membrane; and that backfilling of the trench is performed as soon as possible and compacted with care so as not to damage the liner.

Observations and tests to confirm that all designed liner connections are appropriately installed.

Measurements to confirm that the required overlaps of adjacent synthetic liner sheets were achieved, that proper temporary anchorage was used, that specified temporary and final seaming materials techniques were used, and that the synthetic liner was placed in a relaxed (non-stressed) state. As each synthetic membrane panel is placed, it shall be inspected for tears, punctures, and thin spots.

To accomplish this, the panels will be traversed by CQA personnel in such a way that the entire surface is observed.

If the weather becomes unacceptable for installation of the liner, the QC personnel will stop the synthetic liner installation until conditions again become favorable, thus minimizing the potential for unacceptable installation.

4.3.8.4.2 Liner seaming.

The following will be documented by the Contractor during field seaming operations:

- Observations that the membrane seaming areas are free from dirt, dust, and moisture. Observations that the seaming materials and equipment are as specified.

- Observations that the seaming placement plan was followed.
- Observation that a firm foundation, free from sharp rocks, debris or other deleterious material supports the liner.
- Observation of weather conditions.
- Measurement of temperatures, pressures, and speed of seaming, when applicable, and that they are as specified (e.g., gauges and dials will be read, and readings recorded).
- Measurement of the curing time between seaming and seam testing.
- Observation of the liner to detect damage caused by equipment or personnel during the seaming process.
- Observation of the startup testing of welding equipment including peel and shear testing of sample welds.
- Observation of field seam installation so that a homogeneous bond was formed. Observation of nondestructive tests on 100 percent of the field seams. Failed seams will be recorded as to location and seaming crew and equipment. The data will be reviewed for possible patterns. Repairs will be made in accordance with approved techniques and retested to confirm their integrity.
- Observation of destructive seam testing at frequency required in the specifications of as directed by the Engineer. If different seaming techniques are used, additional tests in accordance with seaming type will be added. Additional test locations and shorter testing frequency may be necessary at the QC personnel's discretion. Test locations and testing frequency will be based on suspicion of contamination by dirt or moisture, change in seaming materials, increase in ambient temperature, increase in failed nondestructive tests, and other causes that could result in unacceptable seams.
- Confirmation that destructive seam samples are large enough for the Contractor to test in the laboratory, for an independent laboratory evaluation and for Employer archiving. Seam samples will be a minimum of 305 mm wide by 915 mm long.
- Confirmation that testing is performed in accordance with design specifications with predetermined pass/fail values. Both peel and shear testing should be performed as specified.
- Confirmation that for field seams that fail, the installer did go on either side of the failed seam location (3 meters minimum), take another sample, test it and if it passes, cap strip the seam between the two locations. Acceptable seams must be bounded by two passed-test locations, unless the capped seam extends to the edge of the lining.
- Confirmation that repairs are performed as soon as possible and in accordance with the specifications. Each repair will be nondestructively tested for continuity. Documentation of all repairs including location, type, and method used will be made.

4.4 GEOSYNTHETIC CLAY LINER (GCL)

4.4.1 EQUIPMENT REQUIREMENTS

GCLs are delivered in rolls typically 2,600-2,950 lbs (1180-1340 kg). Roll dimensions and weights will vary with the dimensions of the product ordered. It is necessary to support this weight using an appropriate core pipe. For any installation, the core pipe must not deflect more than 3 inches (75 mm) as measured from end to midpoint when a full GCL roll is lifted.

4.4.2 SHIPPING, UNLOADING & STORAGE

All lot and roll numbers should be recorded and compared to the packing list. Each roll of GCL should also be visually inspected during unloading to determine if any packaging has been damaged. Damage, whether obvious or suspected, should be recorded and the affected rolls marked.

4.4.2.1 UNLOADING

Major damage suspected to have occurred during transit should be reported immediately to the Engineer. The nature of the damage should also be indicated on the bill of lading with the specific lot and roll numbers. Accumulation of some moisture within roll packaging is normal and does not damage the product.

The party directly responsible for unloading the GCL should refer to the manufacturers manual prior to shipment to ascertain the appropriateness of their unloading equipment and procedures. Unloading and on-site handling of the GCL should be supervised.

4.4.2.2 STORAGE

Rolls should be stored at the job site away from high-traffic areas but sufficiently close to the active work area to minimize handling. The designated storage area should be flat, dry and stable. Moisture protection of the GCL is provided by its packaging; however, an additional tarpaulin or plastic sheet is recommended.

Rolls should be stacked in a manner that prevents them from sliding or rolling. This can be accomplished by chocking the bottom layer of rolls. Rolls should be stacked no higher than the height at which they can be safely handled by laborers (typically no higher than four layers of rolls). Rolls should never be stacked on end.

4.4.3 SUBGRADE PREPARATION

Subgrade surfaces consisting of granular soils or gravel may not be acceptable due to their large void fraction and puncture potential. In high-head (greater than one foot or 30 cm) applications, subgrade soils should possess a particle size distribution such that at least 80 percent of the soil is finer than a #60 sieve (0.250 mm) unless a membrane-laminated GCL (Bentomat CL or Bentomat CLT) is used.

When the GCL is placed over an earthen subgrade, the subgrade surface must be prepared in accordance with the project specifications. The Engineer's approval of the subgrade must be obtained prior to installation. The finished surface should be firm and unyielding, without abrupt elevation changes, voids, cracks, ice, or standing water.

The subgrade surface must be smooth and free of vegetation, sharp-edged rocks, stones, sticks, construction debris, and other foreign matter that could contact the GCL. The subgrade should be rolled with a smooth-drum compactor to remove any wheel ruts greater than 1 inch in depth, footprints, or other abrupt grade changes. Furthermore, all protrusions extending more than12 mm from the subgrade

surface shall be removed, crushed, or pushed into the surface with a smooth-drum compactor. The GCL may be installed on a frozen subgrade, but the subgrade soil in the unfrozen state should meet the above requirements.

4.4.4 INSTALLATION

GCL rolls should be taken to the work area of the site in their original packaging. The orientation of the GCL (i.e., which side faces up) may be important if the GCL has two different types of geosynthetics. Check with the Engineer in order to determine if there is a preferred installation orientation for the GCL. If no specific orientation is required, allow the roll to unwind from the bottom rather than pulling from the top. The arrow sticker on the plastic sleeve indicates the direction the GCL will naturally unroll when placed on the ground Prior to deployment, the packaging should be carefully removed without damaging the GCL.

Equipment which could damage the GCL should not be allowed to travel directly on it. Acceptable installation, therefore, may be accomplished such that the GCL is unrolled in front of backwards-moving equipment. If the installation equipment causes rutting of the subgrade, the subgrade must be restored to its originally accepted condition before placement continues.

If sufficient access is available, GCL may be deployed by suspending the roll at the top of the slope with a group of laborers pulling the material off of the roll and down the slope. GCL rolls should not be released on the slope and allowed to unroll freely by gravity.

Care must be taken to minimize the extent to which the GCL is dragged across the subgrade in order to avoid damage to the bottom surface of the GCL. Care must also be taken when adjusting Bentomat CLT panels to avoid damage to the geotextile surface of one panel of GCL by the textured sheet of another panel of GCL. A temporary geosynthetic subgrade covering, commonly known as a slip sheet or rub sheet, may be used to reduce friction damage during placement.

The GCL should be placed so that seams are parallel to the direction of the slope. End-of-panel seams should also be located at least 1m from the toe and crest of slopes steeper than 4H:1V. End-of-roll seams on slopes should be used only if the liner is not expected to be in tension.

All GCL panels should lie flat, with no wrinkles or folds, especially at the exposed edges of the panels. When Bentomat with SuperGroove is repositioned, it should be gripped inside the SuperGroove by folding the edge.

The GCL should not be installed in standing water or during rainy weather. Only as much GCL shall be deployed as can be covered at the end of the working day with soil, geomembrane, or a temporary waterproof tarpaulin. The GCL shall not be left uncovered overnight. If the GCL is hydrated when no confining stress is present, it may be necessary to remove and replace the hydrated material.
The Engineer and the Manufacturer should be consulted for specific guidance if premature hydration occurs. The type of GCL, duration of exposure, degree of hydration, location in the liner system, and expected bearing loads should be considered.
In many instances, a needle punch reinforced GCL may not require removal/replacement if the following are true:

a) The geotextiles have not been separated, torn or otherwise damaged;
b) There is no evidence that the needle punching between the two geotextiles has been compromised;
c) The Bentomat does not leave deep indentations when stepped upon; and
d) Any overlapped seams with bentonite enhancement are intact.

For the convenience of the installer, hash marks are placed on Bentomat every 1.5 m of length.

4.4.5 ANCHORAGE

If required by the project drawings, the end of the GCL roll should be placed in an anchor trench at the top of a slope. The front edge of the trench should be rounded to eliminate any sharp corners that could cause excessive stress on the GCL. Loose soil should be removed or compacted into the floor of the trench.

If a trench is used for anchoring the end of the GCL, soil backfill should be placed in the trench to provide resistance against pullout. The size and shape of the trench, as well as the appropriate backfill procedures, should be in accordance with the project drawings and specifications.

The GCL should be placed in the anchor trench such that it covers the entire trench floor but does not extend up the rear trench wall.

Sufficient anchorage may alternately be obtained by extending the end of the GCL roll back from the crest of the slope and placing cover soil. The length of this “runout” anchor should be prepared in accordance with project drawings and specifications.

4.4.6 SEAMING

GCL seams are constructed by overlapping adjacent panel edges and ends. Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris. Supplemental bentonite is not required for Claymax 200R. Bentomat ST, DN, and SDN with Supergroove have self-seaming capabilities in their longitudinal overlaps and do not require supplemental bentonite. For pond applications, supplemental bentonite must be used in longitudinal seams regardless of the GCL used.

- Longitudinal seams should be overlapped a minimum of 6 inches (150mm) for Bentomat and 12 inches (300mm) for Claymax.
- End-of-panel overlapped seams should be overlapped 24 inches (600mm) for Bentomat and 48 inches (1,200mm) for Claymax.
- End-of-panel overlapped seams are constructed such that they are shingled in the direction of the grade to prevent runoff from entering the overlap zone.
- Bentomat end-of-panel, bentonite-enhanced, overlapped seams are constructed first by overlapping the adjacent panels, exposing the underlying panel, and then applying a continuous bead or fillet of granular sodium bentonite from the edge of the underlying panel. (The minimum application rate at which the bentonite is applied is one-quarter pound per linear foot (0.4 kg/m).

4.4.7 SEALING AROUND PENETRATIONS AND STRUCTURES

Cutting the GCL should be performed using a sharp utility knife. Frequent blade changes are recommended to avoid irregular tearing of the geotextile components of the GCL during the cutting process.

The GCL should be sealed around penetrations and structures embedded in the subgrade in accordance with the drawings or as directed by the Engineer. Granular bentonite or a bentonite mastic shall be used liberally (approx. 2 lbs. /ln ft. or 3 kg/m) to seal the GCL to these structures.

When the GCL is placed over a horizontal pipe penetration, a “notch” should be excavated into the subgrade around the penetration. The notch should then be backfilled with granular bentonite. A secondary collar of GCL should be placed around the penetration. It is helpful to first trace an outline of the penetration on the GCL and then cut a “star” pattern in the collar to enhance the collar’s fit to the penetration. Granular bentonite should be applied between the primary GCL layer and the secondary GCL collar.

Vertical penetrations are prepared by notching into the subgrade. The penetration can be completed with two separate pieces of GCL. Alternatively, a secondary collar can be placed.

When the GCL is terminated at a structure or wall that is embedded into the subgrade on the floor of the containment area, the subgrade should be notched as indicated on the drawings or directed by the Engineer.
The notch is filled with granular bentonite, and the GCL should be placed over the notch and up against the structure. Connection to the structure can be accomplished by placement of soil or stone backfill in this area.

5.0 TESTING

Standard testing forms developed by the Engineers Representative or the Contractor shall be used for the tests described in this section. When reference is made to an external test procedure, e.g., ASTM, the relevant test procedure documentation is considered to be an integral part of this manual. If these external test procedures reference or require other additional external procedures, they also are considered to be an integral part of this document.

The tests required are divided into two categories:

- Control tests
- Record tests

Control tests are used to determine that materials comply with the Earthwork, Concrete, Roads, Gabions & Pitching and Riprap Specifications prior to placement and to determine other parameters such as optimum moisture content and maximum dry density so that the requirements of the Specifications are achieved. The frequency of control tests can be reduced when material characteristics are relatively constant and consistent. Record tests are performed, usually after placement of the materials, to determine that the in-place materials meet the requirements as set forth in the Specifications and/or are in accordance

with the Design intent. Tests are performed by the methods indicated and at the frequencies shown in the Specifications. The tests will be performed at least the minimum number of times indicated. The Engineer may increase the number of tests required.

5.1 EARTHWORK

Testing of all fill materials shall be completed in accordance with the procedures and at the frequencies detailed in Specifications.

If the layer thickness for fill exceeds the test equipment working depth, compaction through the layer must be verified at the commencement of fill placement. This is done by excavating a pit. Thereafter, the compaction profile is established by testing the top of the layer. Periodic testing using pits may then be used to confirm continued acceptable compaction throughout the layer. Acceptance of riprap shall be based on the visual observation of the placed riprap by the Engineers Representative. If the Engineers Representative deems it necessary, field measurements to determine the particle size distribution of the riprap shall be undertaken and other test work undertaken to determine its suitability and compliance with the requirements of the Specifications.

5.2 PIPEWORK

The following tests are required prior to burial:

- Visual inspection of all non-welded joints connected by bolts.
- Visual inspection of all welds.

The following tests are required after backfill placement and compaction around the culverts.

- Visual inspection and testing, as required, of all culvert backfill. Periodically, the backfilled culvert shall be exposed when specified by the Engineers Representative to allow inspection of the completed backfill.
- Sections of the pipe shall be tested for leaks as indicated in the Specifications.

All inspections and test results are to be recorded on the Work Activity Inspection Form.

5.3 CONCRETE

Inspections required are shown in the Specifications. Any testing deemed necessary will be performed at the discretion of the Engineer. All concrete shall be accepted by the Engineers Representative on the Work Activity Inspection Form.

5.4 FIELD DENSITY TESTS

5.4.2 SAND REPLACEMENT TEST

In general, the in-place density and unit weight of soil and rock are determined using the appropriate ASTM test method:

- ASTM D 5030:
  - Minimum test pit volume
  - Maximum particle size
- ASTM D 1556 or D 2167
  - Minimum test pit volume
  - Minimum particle size

The material being tested must be sufficiently cohesive to maintain stable sides during testing. It must not deform or slough while digging the hole or pouring the sand. In general, these test methods are limited to materials in an unsaturated condition and are not recommended for soft, friable, or seeping materials.

5.5 FAILED TESTS

The Engineers Representative will individually consider each record test which fails to meet the requirements of the Specifications and recommend an appropriate course of action. This may involve resampling, reworking, and retesting or some combination of these. In every case, all documentation associated with the original test and the recommended remedial work will be clearly cross referenced so that the entire sequence of activities can be completely reconstructed.

5.6 EQUIPMENT CALIBRATION, MAINTENANCE, AND OPERATION

Manufacturers' specifications for instrument calibration and maintenance will be followed. A record of calibration and maintenance activities will be maintained in field notebooks. The calibration, maintenance, and operating procedures for all instruments, equipment, and

sampling tools are based on or are the actual manufacturer's instructions, specifications, and criteria for calibration, maintenance, and operation. Each piece of equipment used in activities affecting data quality shall be calibrated at a frequency specified by the manufacturer.

Each piece of equipment used in activities affecting data quality shall be maintained. Following maintenance, instruments will be calibrated according to the manufacturer's specifications to ensure proper completion of the maintenance procedure.

6.0 REPORTS

6.1 DAILY REPORTS

The Engineers Representative will prepare a daily report summarizing work inspected, tests performed, and other relevant items. The daily report will indicate any failed inspections or tests, the actions taken to rectify these, and reports received or given about unacceptable or substandard procedures or materials.

6.2 MONTHLY PROGRESS REPORT

The Engineers Representative will prepare a monthly progress report. This report will:

- Summarize construction activities
- Summarize construction methods
- Summarize all CQA/QC activities
- Summarize all inspection and testing results
- Indicate problems encountered and resolutions
- Indicate potential difficulties
- Provide photographs

The Engineers Representative may include such other items as Drawings, figures, and tables as are necessary to clearly present the work performed and planned.

6.1 AS-BUILT REQUIREMENTS

A record of all changes to Drawings due to unforeseen design omissions shall be recorded on a standard As-built Record Sheet and updated timeously. This sheet will include item/s changed, date, brief description, a sketch that is clear and descriptive with dates and originator referenced to the item and information on correspondence between the Main Contractor and the Engineer or Owner. Changes that take place and need to be updated on Drawings for As-built Drawings shall be forwarded to the Engineer as soon as practicable. They should also be reported in the daily and monthly progress reports.

6.4 CONSTRUCTION REPORT

Upon completion of the work, the Engineer will prepare a comprehensive Construction Report.

This report will include:

- A summary of construction methods and materials
- A summary of any problems encountered and the solutions to them

- Results of inspections
- Results of all tests
- A record of Construction Drawings
- Photographs

The Construction Report will be submitted to the Owner.

6.5 TEST METHODS AND TESTING FREQUENCIES

Test Methods – Earthwork

Type of Test Method

(ASTM)

Atterberg Limits D 4318

Particle Size Distribution D 422 a

Laboratory Compaction D 1557

Nuclear Method Field Density D 2922 b

Sand Cone Field Density D 1556

Notes:

C = Control Tests

R = Record Tests

All test frequencies are listed in the relevant Specifications.

Approval that this document adheres to Knight Piésold Quality Systems:

APPENDIX B

Drawing List

LIST OF DRAWINGS
PHASE 0 – PHASE 8

CONSULTANT DRAWING NO	DESCRIPTION	CLIENT DRAWING NO	REV
	GENERAL		
301–00825/01–100	LIST OF DRAWINGS	0.58/61412–SHEET 1	1
301–00825/01–101	EXISTING ASH DUMP – GENERAL ARRANGEMENT	0.58/61412–SHEET 2	1
301–00825/01–102	TOPSOIL MANAGEMENT – GENERAL ARRANGEMENT	0.58/61412–SHEET 3	1
301–00825/01–103	BASIN EXCAVATION – GENERAL ARRANGEMENT	0.58/61412–SHEET 4	1
301–00825/01–104	UNDERDRAINAGE LINER SYSTEM – GENERAL ARRANGEMENT	0.58/61412–SHEET 5	1
301–00825/01–105	ROADS AND STORMWATER MANAGEMENT – GENERAL ARRANGEMENT	0.58/61412–SHEET 6	1
301–00825/01–106	REHABILITATED ASH DUMP EXTENSION – GENERAL ARRANGEMENT	0.58/61412–SHEET 7	1
301–00825/01–107	REHABILITATED ASH DUMP EXTENSION – SECTIONS	0.58/61412–SHEET 8	1
301–00825/01–108	FENCING DETAILS – GENERAL ARRANGEMENT	0.58/61412–SHEET 9	1
301–00825/01–109	ASH DUMP EXTENSION – GENERAL ARRANGEMENT	0.58/61412–SHEET 10	0
	PHASE 0		
301–00825/01–110	PHASE 0 (ENABLING WORKS) : ASH DUMP EXTENSION – GENERAL ARRANGEMENT	0.58/61413–SHEET 1	1
301–00825/01–111	PHASE 0 (ENABLING WORKS) : TOPSOIL MANAGEMENT – LAYOUT PLAN AND DETAILS	0.58/61413–SHEET 2	1
301–00825/01–112	PHASE 0 (ENABLING WORKS) : ASH DUMP EXTENSION – FRONT STACK CREST SETTING OUT POINTS	0.58/61413–SHEET 3	1
301–00825/01–113	PHASE 0 (ENABLING WORKS) : ACCESS RAMP – LAYOUT PLAN AND SECTIONS	0.58/61413–SHEET 4	1
301–00825/01–114	PHASE 0 (ENABLING WORKS) : MCP1 AND SCPE1 POSITIONS – LAYOUT PLAN AND SECTIONS	0.58/61413–SHEET 5	1
301–00825/01–115	PHASE 0 (ENABLING WORKS) : MCP1 POSITION – LONGITUDINAL SECTION	0.58/61413–SHEET 6	1
301–00825/01–116	PHASE 0 (ENABLING WORKS) : SCPE1 POSITION – LONGITUDINAL SECTION	0.58/61413–SHEET 7	1
301–00825/01–117	PHASE 0 (ENABLING WORKS) : MCP2 TO MCP8 AND SCPE2 TO SCPE8 POSITIONS – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61413–SHEET 8	1
301–00825/01–118	PHASE 0 (ENABLING WORKS) : EXTENDABLE CONVEYOR AND MCP8 POSITION – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61413–SHEET 9	1
301–00825/01–119	PHASE 0 (ENABLING WORKS) : SCPE8 POSITION – LONGITUDINAL SECTION	0.58/61413–SHEET 10	1
301–00825/01–120	PHASE 0 (ENABLING WORKS) : REHABILITATED ASH DUMP EXTENSION – LAYOUT PLAN	0.58/61413–SHEET 11	1
301–00825/01–121	PHASE 0 (ENABLING WORKS) : REHABILITATED SLOPES DRAINAGE – SECTIONS AND DETAILS	0.58/61413–SHEET 12	1
301–00825/01–122	PHASE 0 (ENABLING WORKS) : REHABILITATED SLOPES DRAINAGE – REINFORCEMENT DETAILS	0.58/61413–SHEET 13	0
	PHASE 1		
301–00825/01–140	PHASE 1 (4 YEARS LINED AREA) : ASH DUMP EXTENSION – GENERAL ARRANGEMENT	0.58/61414–SHEET 1	1
301–00825/01–141	PHASE 1 (4 YEARS LINED AREA) : TOPSOIL MANAGEMENT – LAYOUT PLAN AND DETAILS	0.58/61414–SHEET 2	1
301–00825/01–142	PHASE 1 (4 YEARS LINED AREA) : BASIN EXCAVATION– LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61414–SHEET 3	1
301–00825/01–143	PHASE 1 (4 YEARS LINED AREA) : UNDERDRAINAGE LINER SYSTEM – LAYOUT PLAN	0.58/61414–SHEET 4	1
301–00825/01–144	PHASE 1 (4 YEARS LINED AREA) : UNDERDRAINAGE LINER SYSTEM – SECTIONS AND DETAILS	0.58/61414–SHEET 5	1
301–00825/01–145	PHASE 1 (4 YEARS LINED AREA) : PERMANENT SOUTH RWD ROAD – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61414–SHEET 6	1
301–00825/01–146	PHASE 1 (4 YEARS LINED AREA) : SOUTH RETURN WATER DAM – LAYOUT PLAN, SECTIONS AND DETAILS	0.58/61414–SHEET 7	1
301–00825/01–147	PHASE 1 (4 YEARS LINED AREA) : SOUTH RWD SILT TRAP – LAYOUT PLAN AND SECTIONS	0.58/61414–SHEET 8	1
301–00825/01–148	PHASE 1 (4 YEARS LINED AREA) : SOUTH RWD SILT TRAP – SECTIONS AND DETAILS	0.58/61414–SHEET 9	1
301–00825/01–149	PHASE 1 (4 YEARS LINED AREA) : SOUTH RWD SPILLWAY – LAYOUT PLAN, SECTIONS AND DETAILS	0.58/61414–SHEET 10	1
301–00825/01–150	PHASE 1 (4 YEARS LINED AREA) : SOUTH RWD PUMP SUMP – LAYOUT PLAN, SECTIONS AND DETAILS	0.58/61414–SHEET 11	1
301–00825/01–151	PHASE 1 (4 YEARS LINED AREA) : PERMANENT SOUTH PERIMETER ROAD CH. 0 – CH. 1400 – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61414–SHEET 12	1
301–00825/01–152	PHASE 1 (4 YEARS LINED AREA) : PERMANENT SOUTH DIRTY WATER CHANNEL CH. 0 – CH. 1400 – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61414–SHEET 13	1
301–00825/01–153	PHASE 1 (4 YEARS LINED AREA) : SPILLWAYS – LAYOUT PLAN, SECTIONS AND DETAILS	0.58/61414–SHEET 14	1
301–00825/01–154	PHASE 1 (4 YEARS LINED AREA) : TEMPORARY DIRTY WATER CHANNEL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61414–SHEET 15	1
301–00825/01–155	PHASE 1 (4 YEARS LINED AREA) : TEMPORARY CLEAN WATER CHANNEL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61414–SHEET 16	1
301–00825/01–156	PHASE 1 (4 YEARS LINED AREA) : STORMWATER MANAGEMENT – SECTIONS AND DETAILS	0.58/61414–SHEET 17	1
301–00825/01–157	PHASE 1 (4 YEARS LINED AREA) : CLEAN WATER DECANT PIPELINE CH. 0 – CH. 1133.27 – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61414–SHEET 18	1
301–00825/01–158	PHASE 1 (4 YEARS LINED AREA) : CLEAN WATER DECANT PIPELINE – SECTIONS AND DETAILS SHEET 1 OF 2	0.58/61414–SHEET 19	1
301–00825/01–159	PHASE 1 (4 YEARS LINED AREA) : CLEAN WATER DECANT PIPELINE – SECTIONS AND DETAILS SHEET 2 OF 2	0.58/61414–SHEET 20	1
301–00825/01–160	PHASE 1 (4 YEARS LINED AREA) : ASH DUMP EXTENSION – FRONT STACK CREST SETTING OUT POINTS	0.58/61414–SHEET 21	1
301–00825/01–161	PHASE 1 (4 YEARS LINED AREA) : MCP9 TO MCP23 AND SCP1 TO SCP9 POSITIONS – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61414–SHEET 22	1
301–00825/01–162	PHASE 1 (4 YEARS LINED AREA) : MCP9 AND MCP23 POSITIONS – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61414–SHEET 23	1
301–00825/01–163	PHASE 1 (4 YEARS LINED AREA) : SCP1 POSITION – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61414–SHEET 24	1
301–00825/01–164	PHASE 1 (4 YEARS LINED AREA) : SCP9 POSITION – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61414–SHEET 25	1
301–00825/01–165	PHASE 1 (4 YEARS LINED AREA) : REHABILITATED ASH DUMP EXTENSION – LAYOUT PLAN	0.58/61414–SHEET 26	1
301–00825/01–166	PHASE 1 (4 YEARS LINED AREA) : REHABILITATED SLOPES DRAINAGE – SECTIONS AND DETAILS	0.58/61414–SHEET 27	1
301–00825/01–167	PHASE 1 (4 YEARS LINED AREA) : TEMPORARY DIVIDER WALL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61414–SHEET 28	0
301–00825/01–168	PHASE 1 (4 YEARS LINED AREA) : DECANT OUTLET STRUCTURE – REINFORCEMENT DETAILS	0.58/61414–SHEET 29	0
301–00825/01–169	PHASE 1 (4 YEARS LINED AREA) : SOUTH RETURN WATER DAM – REINFORCEMENT DETAILS SHEET 1 OF 3	0.58/61414–SHEET 30	0
301–00825/01–170	PHASE 1 (4 YEARS LINED AREA) : SOUTH RETURN WATER DAM – REINFORCEMENT DETAILS SHEET 2 OF 3	0.58/61414–SHEET 31	0
301–00825/01–171	PHASE 1 (4 YEARS LINED AREA) : SOUTH RETURN WATER DAM – REINFORCEMENT DETAILS SHEET 3 OF 3	0.58/61414–SHEET 32	0
301–00825/01–172	PHASE 1 (4 YEARS LINED AREA) : REHABILITATED SLOPES DRAINAGE – REINFORCEMENT DETAILS	0.58/61414–SHEET 33	0
301–00825/01–173	PHASE 1 (4 YEARS LINED AREA) : CLEAN WATER DECANT INLET – LAYOUT PLAN, SECTIONS AND REINFORCEMENT DETAILS	0.58/61414–SHEET 34	0
	PHASE 2		
301–00825/01–200	PHASE 2 (8 YEARS LINED AREA) : ASH DUMP EXTENSION – GENERAL ARRANGEMENT	0.58/61415–SHEET 1	1
301–00825/01–201	PHASE 2 (8 YEARS LINED AREA) : TOPSOIL MANAGEMENT – LAYOUT PLAN AND DETAILS	0.58/61415–SHEET 2	1
301–00825/01–202	PHASE 2 (8 YEARS LINED AREA) : BASIN EXCAVATION– LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61415–SHEET 3	1
301–00825/01–203	PHASE 2 (8 YEARS LINED AREA) : UNDERDRAINAGE LINER SYSTEM – LAYOUT PLAN	0.58/61415–SHEET 4	1
301–00825/01–204	PHASE 2 (8 YEARS LINED AREA) : UNDERDRAINAGE LINER SYSTEM – SECTIONS AND DETAILS	0.58/61415–SHEET 5	1
301–00825/01–205	PHASE 2 (8 YEARS LINED AREA) : PERMANENT SOUTH PERIMETER ROAD CH. 1400 – CH. 1780 – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61415–SHEET 6	1
301–00825/01–206	PHASE 2 (8 YEARS LINED AREA) : PERMANENT SOUTH DIRTY WATER CHANNEL CH. 1400 – CH. 1800 – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61415–SHEET 7	1
301–00825/01–207	PHASE 2 (8 YEARS LINED AREA) : SPILLWAYS – LAYOUT PLAN, SECTIONS AND DETAILS	0.58/61415–SHEET 8	1
301–00825/01–208	PHASE 2 (8 YEARS LINED AREA) : TEMPORARY DIRTY WATER CHANNEL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61415–SHEET 9	1
301–00825/01–209	PHASE 2 (8 YEARS LINED AREA) : TEMPORARY CLEAN WATER CHANNEL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61415–SHEET 10	1
301–00825/01–210	PHASE 2 (8 YEARS LINED AREA) : STORMWATER MANAGEMENT – SECTIONS AND DETAILS	0.58/61415–SHEET 11	1
301–00825/01–211	PHASE 2 (8 YEARS LINED AREA) : CLEAN WATER DECANT PIPELINE – LAYOUT PLAN AND SECTION	0.58/61415–SHEET 12	1
301–00825/01–212	PHASE 2 (8 YEARS LINED AREA) : ASH DUMP EXTENSION – FRONT STACK CREST SETTING OUT POINTS	0.58/61415–SHEET 13	1
301–00825/01–213	PHASE 2 (8 YEARS LINED AREA) : MCP24 TO MCP42 AND SCP10 TO SCP18 POSITIONS – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61415–SHEET 14	1
301–00825/01–214	PHASE 2 (8 YEARS LINED AREA) : MCP24 AND MCP42 POSITIONS – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61415–SHEET 15	1
301–00825/01–215	PHASE 2 (8 YEARS LINED AREA) : SCP10 POSITION – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61415–SHEET 16	1
301–00825/01–216	PHASE 2 (8 YEARS LINED AREA) : SCP18 POSITION – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61415–SHEET 17	1
301–00825/01–217	PHASE 2 (8 YEARS LINED AREA) : REHABILITATED ASH DUMP EXTENSION – LAYOUT PLAN	0.58/61415–SHEET 18	1
301–00825/01–218	PHASE 2 (8 YEARS LINED AREA) : REHABILITATED SLOPES DRAINAGE – SECTIONS AND DETAILS	0.58/61415–SHEET 19	1
301–00825/01–219	PHASE 2 (8 YEARS LINED AREA) : TEMPORARY DIVIDER WALL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61415–SHEET 20	0
301–00825/01–220	PHASE 2 (8 YEARS LINED AREA) : REHABILITATED SLOPES DRAINAGE – REINFORCEMENT DETAILS	0.58/61415–SHEET 21	0

CONSULTANT DRAWING NO	DESCRIPTION	CLIENT DRAWING NO	REV
	PHASE 3		
301–00825/01–300	PHASE 3 (12 YEARS LINED AREA) : ASH DUMP EXTENSION – GENERAL ARRANGEMENT	0.58/61416–SHEET 1	1
301–00825/01–301	PHASE 3 (12 YEARS LINED AREA) : TOPSOIL MANAGEMENT – LAYOUT PLAN AND DETAILS	0.58/61416–SHEET 2	1
301–00825/01–302	PHASE 3 (12 YEARS LINED AREA) : BASIN EXCAVATION– LAYOUT PLAN AND SECTIONS	0.58/61416–SHEET 3	1
301–00825/01–303	PHASE 3 (12 YEARS LINED AREA) : UNDERDRAINAGE LINER SYSTEM – LAYOUT PLAN	0.58/61416–SHEET 4	1
301–00825/01–304	PHASE 3 (12 YEARS LINED AREA) : UNDERDRAINAGE LINER SYSTEM – SECTIONS AND DETAILS	0.58/61416–SHEET 5	1
301–00825/01–305	PHASE 3 (12 YEARS LINED AREA) : PERMANENT SOUTH PERIMETER ROAD CH. 1780 – CH. 2120 – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61416–SHEET 6	1
301–00825/01–306	PHASE 3 (12 YEARS LINED AREA) : PERMANENT SOUTH DIRTY WATER CHANNEL CH. 1800 – CH. 2120 – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61416–SHEET 7	1
301–00825/01–307	PHASE 3 (12 YEARS LINED AREA) : SPILLWAYS – LAYOUT PLAN, SECTIONS AND DETAILS	0.58/61416–SHEET 8	1
301–00825/01–308	PHASE 3 (12 YEARS LINED AREA) : TEMPORARY DIRTY WATER CHANNEL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61416–SHEET 9	1
301–00825/01–309	PHASE 3 (12 YEARS LINED AREA) : TEMPORARY CLEAN WATER CHANNEL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61416–SHEET 10	1
301–00825/01–310	PHASE 3 (12 YEARS LINED AREA) : STORMWATER MANAGEMENT – LAYOUT PLAN AND SECTION	0.58/61416–SHEET 11	1
301–00825/01–311	PHASE 3 (12 YEARS LINED AREA) : CLEAN WATER DECANT PIPELINE CH. 1133.27 – CH. 1342.34 – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61416–SHEET 12	1
301–00825/01–312	PHASE 3 (12 YEARS LINED AREA) : CLEAN WATER DECANT PIPELINE – SECTIONS AND DETAILS	0.58/61416–SHEET 13	1
301–00825/01–313	PHASE 3 (12 YEARS LINED AREA) : ASH DUMP EXTENSION – FRONT STACK CREST SETTING OUT POINTS	0.58/61416–SHEET 14	1
301–00825/01–314	PHASE 3 (12 YEARS LINED AREA) : MCP43 TO MCP55 AND SCP19 TO SCP26 POSITIONS – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61416–SHEET 15	1
301–00825/01–315	PHASE 3 (12 YEARS LINED AREA) : MCP43 AND MCP55 POSITIONS – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61416–SHEET 16	1
301–00825/01–316	PHASE 3 (12 YEARS LINED AREA) : SCP19 POSITION – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61416–SHEET 17	1
301–00825/01–317	PHASE 3 (12 YEARS LINED AREA) : SCP26 POSITION – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61416–SHEET 18	1
301–00825/01–318	PHASE 3 (12 YEARS LINED AREA) : REHABILITATED ASH DUMP EXTENSION – LAYOUT PLAN	0.58/61416–SHEET 19	1
301–00825/01–319	PHASE 3 (12 YEARS LINED AREA) : REHABILITATED SLOPES DRAINAGE – SECTIONS AND DETAILS	0.58/61416–SHEET 20	1
301–00825/01–320	PHASE 3 (12 YEARS LINED AREA) : TEMPORARY DIVIDER WALL/ACCESS ROAD – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61416–SHEET 21	0
301–00825/01–321	PHASE 3 (12 YEARS LINED AREA) : CLEAN WATER DECANT INLET – LAYOUT PLAN, SECTIONS AND REINFORCEMENT DETAILS	0.58/61416–SHEET 22	0
301–00825/01–322	PHASE 3 (12 YEARS LINED AREA) : TEMPORARY DIRTY WATER TRENCH – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61416–SHEET 23	0
301–00825/01–323	PHASE 3 (12 YEARS LINED AREA) : REHABILITATED SLOPES DRAINAGE – REINFORCEMENT DETAILS	0.58/61416–SHEET 24	0
	PHASE 4		
301–00825/01–400	PHASE 4 (16 YEARS LINED AREA) : ASH DUMP EXTENSION – GENERAL ARRANGEMENT	0.58/61417–SHEET 1	1
301–00825/01–401	PHASE 4 (16 YEARS LINED AREA) : TOPSOIL MANAGEMENT – LAYOUT PLAN AND DETAILS	0.58/61417–SHEET 2	1
301–00825/01–402	PHASE 4 (16 YEARS LINED AREA) : BASIN EXCAVATION– LAYOUT PLAN AND SECTIONS	0.58/61417–SHEET 3	1
301–00825/01–403	PHASE 4 (16 YEARS LINED AREA) : UNDERDRAINAGE LINER SYSTEM – LAYOUT PLAN	0.58/61417–SHEET 4	1
301–00825/01–404	PHASE 4 (16 YEARS LINED AREA) : UNDERDRAINAGE LINER SYSTEM – SECTIONS AND DETAILS	0.58/61417–SHEET 5	1
301–00825/01–405	PHASE 4 (16 YEARS LINED AREA) : PERMANENT SOUTH PERIMETER ROAD CH. 2120 – CH. 2430 – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61417–SHEET 6	1
301–00825/01–406	PHASE 4 (16 YEARS LINED AREA) : PERMANENT SOUTH DIRTY WATER CHANNEL CH. 2120 – CH. 2430 – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61417–SHEET 7	1
301–00825/01–407	PHASE 4 (16 YEARS LINED AREA) : SPILLWAYS – LAYOUT PLAN, SECTIONS AND DETAILS	0.58/61417–SHEET 8	1
301–00825/01–408	PHASE 4 (16 YEARS LINED AREA) : TEMPORARY DIRTY WATER CHANNEL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61417–SHEET 9	1
301–00825/01–409	PHASE 4 (16 YEARS LINED AREA) : TEMPORARY CLEAN WATER CHANNEL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61417–SHEET 10	1
301–00825/01–410	PHASE 4 (16 YEARS LINED AREA) : STORMWATER MANAGEMENT – SECTIONS AND DETAILS	0.58/61417–SHEET 11	1
301–00825/01–411	PHASE 4 (16 YEARS LINED AREA) : CLEAN WATER DECANT PIPELINE CH. 1342.34 – CH. 1534.06 – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61417–SHEET 12	1
301–00825/01–412	PHASE 4 (16 YEARS LINED AREA) : CLEAN WATER DECANT PIPELINE – SECTIONS AND DETAILS	0.58/61417–SHEET 13	1
301–00825/01–413	PHASE 4 (16 YEARS LINED AREA) : ASH DUMP EXTENSION – FRONT STACK CREST SETTING OUT POINTS	0.58/61417–SHEET 14	1
301–00825/01–414	PHASE 4 (16 YEARS LINED AREA) : MCP56 TO MCP66 AND SCP27 TO SCP33 POSITIONS – LAYOUT PLAN AND SECTIONS	0.58/61417–SHEET 15	1
301–00825/01–415	PHASE 4 (16 YEARS LINED AREA) : MCP56 AND MCP66 POSITIONS – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61417–SHEET 16	1
301–00825/01–416	PHASE 4 (16 YEARS LINED AREA) : SCP27 POSITION – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61417–SHEET 17	1
301–00825/01–417	PHASE 4 (16 YEARS LINED AREA) : SCP33 POSITION – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61417–SHEET 18	1
301–00825/01–418	PHASE 4 (16 YEARS LINED AREA) : REHABILITATED ASH DUMP EXTENSION – LAYOUT PLAN	0.58/61417–SHEET 19	1
301–00825/01–419	PHASE 4 (16 YEARS LINED AREA) : REHABILITATED SLOPES DRAINAGE – SECTIONS AND DETAILS	0.58/61417–SHEET 20	1
301–00825/01–420	PHASE 4 (16 YEARS LINED AREA) : TEMPORARY DIVIDER WALL/ACCESS ROAD – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61417–SHEET 21	0
301–00825/01–421	PHASE 4 (16 YEARS LINED AREA) : CLEAN WATER DECANT INLET – LAYOUT PLAN, SECTIONS AND REINFORCEMENT DETAILS	0.58/61417–SHEET 22	0
301–00825/01–422	PHASE 4 (16 YEARS LINED AREA) : TEMPORARY DIRTY WATER TRENCH – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61417–SHEET 23	0
301–00825/01–423	PHASE 4 (16 YEARS LINED AREA) : REHABILITATED SLOPES DRAINAGE – REINFORCEMENT DETAILS	0.58/61417–SHEET 24	0
	PHASE 5		
301–00825/01–500	PHASE 5 (20 YEARS LINED AREA) : ASH DUMP EXTENSION – GENERAL ARRANGEMENT	0.58/61418–SHEET 1	1
301–00825/01–501	PHASE 5 (20 YEARS LINED AREA) : TOPSOIL MANAGEMENT – LAYOUT PLAN AND DETAILS	0.58/61418–SHEET 2	1
301–00825/01–502	PHASE 5 (20 YEARS LINED AREA) : BASIN EXCAVATION– LAYOUT PLAN AND SECTIONS	0.58/61418–SHEET 3	1
301–00825/01–503	PHASE 5 (20 YEARS LINED AREA) : UNDERDRAINAGE LINER SYSTEM – LAYOUT PLAN	0.58/61418–SHEET 4	1
301–00825/01–504	PHASE 5 (20 YEARS LINED AREA) : UNDERDRAINAGE LINER SYSTEM – SECTIONS AND DETAILS	0.58/61418–SHEET 5	1
301–00825/01–505	PHASE 5 (20 YEARS LINED AREA) : PERMANENT NORTH RWD ROAD – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61418–SHEET 6	1
301–00825/01–506	PHASE 5 (20 YEARS LINED AREA) : NORTH RETURN WATER DAM – LAYOUT PLAN, SECTIONS AND DETAILS	0.58/61418–SHEET 7	1
301–00825/01–507	PHASE 5 (20 YEARS LINED AREA) : NORTH RWD SILT TRAP – LAYOUT PLAN AND SECTIONS	0.58/61418–SHEET 8	1
301–00825/01–508	PHASE 5 (20 YEARS LINED AREA) : NORTH RWD SILT TRAP – SECTIONS AND DETAILS	0.58/61418–SHEET 9	1
301–00825/01–509	PHASE 5 (20 YEARS LINED AREA) : NORTH RWD SPILLWAY – LAYOUT PLAN, SECTIONS AND DETAILS	0.58/61418–SHEET 10	1
301–00825/01–510	PHASE 5 (20 YEARS LINED AREA) : NORTH RWD PUMP SUMP – LAYOUT PLAN, SECTIONS AND DETAILS	0.58/61418–SHEET 11	1
301–00825/01–511	PHASE 5 (20 YEARS LINED AREA) : PERMANENT NORTH PERIMETER ROAD – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61418–SHEET 12	1
301–00825/01–512	PHASE 5 (20 YEARS LINED AREA) : PERMANENT NORTH DIRTY WATER CHANNEL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61418–SHEET 13	1
301–00825/01–513	PHASE 5 (20 YEARS LINED AREA) : PERMANENT SOUTH PERIMETER ROAD CH. 2430 – CH. 2730 – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61418–SHEET 14	1
301–00825/01–514	PHASE 5 (20 YEARS LINED AREA) : PERMANENT SOUTH DIRTY WATER CHANNEL CH. 2430 – CH. 2730 – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61418–SHEET 15	1
301–00825/01–515	PHASE 5 (20 YEARS LINED AREA) : SPILLWAYS – LAYOUT PLAN, SECTIONS AND DETAILS	0.58/61418–SHEET 16	1
301–00825/01–516	PHASE 5 (20 YEARS LINED AREA) : TEMPORARY DIRTY WATER CHANNEL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61418–SHEET 17	1
301–00825/01–517	PHASE 5 (20 YEARS LINED AREA) : TEMPORARY CLEAN WATER CHANNEL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61418–SHEET 18	1
301–00825/01–518	PHASE 5 (20 YEARS LINED AREA) : STORMWATER MANAGEMENT – SECTIONS AND DETAILS	0.58/61418–SHEET 19	1
301–00825/01–519	PHASE 5 (20 YEARS LINED AREA) : CLEAN WATER DECANT PIPELINE CH. 1534.06 – CH. 1714.82 – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61418–SHEET 20	1
301–00825/01–520	PHASE 5 (20 YEARS LINED AREA) : CLEAN WATER DECANT PIPELINE – SECTIONS AND DETAILS	0.58/61418–SHEET 21	1
301–00825/01–521	PHASE 5 (20 YEARS LINED AREA) : ASH DUMP EXTENSION – FRONT STACK CREST SETTING OUT POINTS	0.58/61418–SHEET 22	1
301–00825/01–522	PHASE 5 (20 YEARS LINED AREA) : MCP67 TO MCP71 AND SCP34 TO SCP40 POSITIONS – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61418–SHEET 23	1
301–00825/01–523	PHASE 5 (20 YEARS LINED AREA) : MCP67 AND MCP71 POSITIONS – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61418–SHEET 24	1
301–00825/01–524	PHASE 5 (20 YEARS LINED AREA) : SCP34 POSITION – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61418–SHEET 25	1
301–00825/01–525	PHASE 5 (20 YEARS LINED AREA) : SCP40 POSITION – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61418–SHEET 26	1
301–00825/01–526	PHASE 5 (20 YEARS LINED AREA) : REHABILITATED ASH DUMP EXTENSION – LAYOUT PLAN	0.58/61418–SHEET 27	1
301–00825/01–527	PHASE 5 (20 YEARS LINED AREA) : REHABILITATED SLOPES DRAINAGE – SECTIONS AND DETAILS	0.58/61418–SHEET 28	1
301–00825/01–528	PHASE 5 (20 YEARS LINED AREA) : TEMPORARY DIVIDER WALL/ACCESS ROAD – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61418–SHEET 29	0
301–00825/01–529	PHASE 5 (20 YEARS LINED AREA) : TEMPORARY DIVIDER WALL/ACCESS ROAD TO NORTH RWD – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61418–SHEET 30	0
301–00825/01–530	PHASE 5 (20 YEARS LINED AREA) : CLEAN WATER DECANT INLET – LAYOUT PLAN, SECTIONS AND REINFORCEMENT DETAILS	0.58/61418–SHEET 31	0
301–00825/01–531	PHASE 5 (20 YEARS LINED AREA) : TEMPORARY DIRTY WATER TRENCH – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61418–SHEET 32	0
301–00825/01–532	PHASE 5 (20 YEARS LINED AREA) : NORTH RETURN WATER DAM – REINFORCEMENT DETAILS SHEET 1 OF 3	0.58/61418–SHEET 33	0
301–00825/01–533	PHASE 5 (20 YEARS LINED AREA) : NORTH RETURN WATER DAM – REINFORCEMENT DETAILS SHEET 2 OF 3	0.58/61418–SHEET 34	0
301–00825/01–534	PHASE 5 (20 YEARS LINED AREA) : NORTH RETURN WATER DAM – REINFORCEMENT DETAILS SHEET 3 OF 3	0.58/61418–SHEET 35	0
301–00825/01–535	PHASE 5 (20 YEARS LINED AREA) : REHABILITATED SLOPES DRAINAGE – REINFORCEMENT DETAILS	0.58/61418–SHEET 36	0

CONSULTANT DRAWING NO	DESCRIPTION	CLIENT DRAWING NO	REV
	PHASE 6		
301–00825/01–600	PHASE 6 (24 YEARS LINED AREA) : ASH DUMP EXTENSION – GENERAL ARRANGEMENT	0.58/61419–SHEET 1	1
301–00825/01–601	PHASE 6 (24 YEARS LINED AREA) : TOPSOIL MANAGEMENT – LAYOUT PLAN AND DETAILS	0.58/61419–SHEET 2	1
301–00825/01–602	PHASE 6 (24 YEARS LINED AREA) : BASIN EXCAVATION– LAYOUT PLAN AND SECTIONS	0.58/61419–SHEET 3	1
301–00825/01–603	PHASE 6 (24 YEARS LINED AREA) : UNDERDRAINAGE LINER SYSTEM – LAYOUT PLAN	0.58/61419–SHEET 4	1
301–00825/01–604	PHASE 6 (24 YEARS LINED AREA) : UNDERDRAINAGE LINER SYSTEM – SECTIONS AND DETAILS	0.58/61419–SHEET 5	1
301–00825/01–605	PHASE 6 (24 YEARS LINED AREA) : PERMANENT SOUTH PERIMETER ROAD CH. 2730 – CH. 3080 – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61419–SHEET 6	1
301–00825/01–606	PHASE 6 (24 YEARS LINED AREA) : PERMANENT SOUTH DIRTY WATER CHANNEL CH. 2730 – CH. 3080 – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61419–SHEET 7	1
301–00825/01–607	PHASE 6 (24 YEARS LINED AREA) : SPILLWAYS – LAYOUT PLAN, SECTIONS AND DETAILS	0.58/61419–SHEET 8	1
301–00825/01–608	PHASE 6 (24 YEARS LINED AREA) : TEMPORARY DIRTY WATER CHANNEL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61419–SHEET 9	1
301–00825/01–609	PHASE 6 (24 YEARS LINED AREA) : TEMPORARY CLEAN WATER CHANNEL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61419–SHEET 10	1
301–00825/01–610	PHASE 6 (24 YEARS LINED AREA) : STORMWATER MANAGEMENT – SECTIONS AND DETAILS	0.58/61419–SHEET 11	1
301–00825/01–611	PHASE 6 (24 YEARS LINED AREA) : CLEAN WATER DECANT PIPELINE CH. 1714.82 – CH. 1908.74 – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61419–SHEET 12	1
301–00825/01–612	PHASE 6 (24 YEARS LINED AREA) : CLEAN WATER DECANT PIPELINE – SECTIONS AND DETAILS	0.58/61419–SHEET 13	1
301–00825/01–613	PHASE 6 (24 YEARS LINED AREA) : ASH DUMP EXTENSION – FRONT STACK CREST SETTING OUT POINTS	0.58/61419–SHEET 14	1
301–00825/01–614	PHASE 6 (24 YEARS LINED AREA) : MCP72 TO MCP76 AND SCP41 TO SCP48 POSITIONS – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61419–SHEET 15	1
301–00825/01–615	PHASE 6 (24 YEARS LINED AREA) : MCP72 AND MCP76 POSITIONS – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61419–SHEET 16	1
301–00825/01–616	PHASE 6 (24 YEARS LINED AREA) : SCP41 POSITION – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61419–SHEET 17	1
301–00825/01–617	PHASE 6 (24 YEARS LINED AREA) : SCP48 POSITION – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61419–SHEET 18	1
301–00825/01–618	PHASE 6 (24 YEARS LINED AREA) : REHABILITATED ASH DUMP EXTENSION – LAYOUT PLAN	0.58/61419–SHEET 19	1
301–00825/01–619	PHASE 6 (24 YEARS LINED AREA) : REHABILITATED SLOPES DRAINAGE – SECTIONS AND DETAILS	0.58/61419–SHEET 20	1
301–00825/01–620	PHASE 6 (24 YEARS LINED AREA) : TEMPORARY DIVIDER WALL/ACCESS ROAD – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61419–SHEET 21	0
301–00825/01–621	PHASE 6 (24 YEARS LINED AREA) : CLEAN WATER DECANT INLET – LAYOUT PLAN, SECTIONS AND REINFORCEMENT DETAILS	0.58/61419–SHEET 22	0
301–00825/01–622	PHASE 6 (24 YEARS LINED AREA) : TEMPORARY DIRTY WATER TRENCH – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61419–SHEET 23	0
301–00825/01–623	PHASE 6 (24 YEARS LINED AREA) : REHABILITATED SLOPES DRAINAGE – REINFORCEMENT DETAILS	0.58/61419–SHEET 24	0
	PHASE 7		
301–00825/01–700	PHASE 7 (28 YEARS LINED AREA) : ASH DUMP EXTENSION – GENERAL ARRANGEMENT	0.58/61420–SHEET 1	1
301–00825/01–701	PHASE 7 (28 YEARS LINED AREA) : TOPSOIL MANAGEMENT – LAYOUT PLAN AND DETAILS	0.58/61420–SHEET 2	1
301–00825/01–702	PHASE 7 (28 YEARS LINED AREA) : BASIN EXCAVATION– LAYOUT PLAN AND SECTIONS	0.58/61420–SHEET 3	1
301–00825/01–703	PHASE 7 (28 YEARS LINED AREA) : UNDERDRAINAGE LINER SYSTEM – LAYOUT PLAN	0.58/61420–SHEET 4	1
301–00825/01–704	PHASE 7 (28 YEARS LINED AREA) : UNDERDRAINAGE LINER SYSTEM – SECTIONS AND DETAILS	0.58/61420–SHEET 5	1
301–00825/01–705	PHASE 7 (28 YEARS LINED AREA) : PERMANENT SOUTH PERIMETER ROAD CH. 3080 – CH. 3350 – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61420–SHEET 6	1
301–00825/01–706	PHASE 7 (28 YEARS LINED AREA) : PERMANENT SOUTH DIRTY WATER CHANNEL CH. 3080 – CH. 3350 – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61420–SHEET 7	1
301–00825/01–707	PHASE 7 (28 YEARS LINED AREA) : SPILLWAYS – LAYOUT PLAN, SECTIONS AND DETAILS	0.58/61420–SHEET 8	1
301–00825/01–708	PHASE 7 (28 YEARS LINED AREA) : TEMPORARY DIRTY WATER CHANNEL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61420–SHEET 9	1
301–00825/01–709	PHASE 7 (28 YEARS LINED AREA) : TEMPORARY CLEAN WATER CHANNEL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61420–SHEET 10	1
301–00825/01–710	PHASE 7 (28 YEARS LINED AREA) : STORMWATER MANAGEMENT – SECTIONS AND DETAILS	0.58/61420–SHEET 11	1
301–00825/01–711	PHASE 7 (28 YEARS LINED AREA) : CLEAN WATER DECANT PIPELINE CH. 1908.74 – CH. 2029 – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61420–SHEET 12	1
301–00825/01–712	PHASE 7 (28 YEARS LINED AREA) : CLEAN WATER DECANT PIPELINE – SECTIONS AND DETAILS	0.58/61420–SHEET 13	1
301–00825/01–713	PHASE 7 (28 YEARS LINED AREA) : ASH DUMP EXTENSION – FRONT STACK CREST SETTING OUT POINTS	0.58/61420–SHEET 14	1
301–00825/01–714	PHASE 7 (28 YEARS LINED AREA) : MCP77 TO MCP80 AND SCP49 TO SCP54 POSITIONS – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61420–SHEET 15	1
301–00825/01–715	PHASE 7 (28 YEARS LINED AREA) : MCP77 AND MCP80 POSITIONS – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61420–SHEET 16	1
301–00825/01–716	PHASE 7 (28 YEARS LINED AREA) : SCP49 POSITION – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61420–SHEET 17	1
301–00825/01–717	PHASE 7 (28 YEARS LINED AREA) : SCP54 POSITION – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61420–SHEET 18	1
301–00825/01–718	PHASE 7 (28 YEARS LINED AREA) : REHABILITATED ASH DUMP EXTENSION – LAYOUT PLAN	0.58/61420–SHEET 19	1
301–00825/01–719	PHASE 7 (28 YEARS LINED AREA) : REHABILITATED SLOPES DRAIANGE – SECTIONS AND DETAILS	0.58/61420–SHEET 20	1
301–00825/01–720	PHASE 7 (28 YEARS LINED AREA) : TEMPORARY DIVIDER WALL/ACCESS ROAD – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61420–SHEET 21	0
301–00825/01–721	PHASE 7 (28 YEARS LINED AREA) : CLEAN WATER DECANT INLET – LAYOUT PLAN, SECTIONS AND REINFORCEMENT DETAILS	0.58/61420–SHEET 22	0
301–00825/01–722	PHASE 7 (28 YEARS LINED AREA) : TEMPORARY DIRTY WATER TRENCH – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61420–SHEET 23	0
301–00825/01–723	PHASE 7 (28 YEARS LINED AREA) : REHABILITATED SLOPES DRAINAGE – REINFORCEMENT DETAILS	0.58/61420–SHEET 24	0
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301–00825/01–800	PHASE 8 (32 YEARS LINED AREA) : ASH DUMP EXTENSION – GENERAL ARRANGEMENT	0.58/61421–SHEET 1	1
301–00825/01–801	PHASE 8 (32 YEARS LINED AREA) : TOPSOIL MANAGEMENT – LAYOUT PLAN AND DETAILS	0.58/61421–SHEET 2	1
301–00825/01–802	PHASE 8 (32 YEARS LINED AREA) : BASIN EXCAVATION– LAYOUT PLAN AND SECTIONS	0.58/61421–SHEET 3	1
301–00825/01–803	PHASE 8 (32 YEARS LINED AREA) : UNDERDRAINAGE LINER SYSTEM – LAYOUT PLAN	0.58/61421–SHEET 4	1
301–00825/01–804	PHASE 8 (32 YEARS LINED AREA) : UNDERDRAINAGE LINER SYSTEM – SECTIONS AND DETAILS	0.58/61421–SHEET 5	1
301–00825/01–805	PHASE 8 (32 YEARS LINED AREA) : PERMANENT SOUTH PERIMETER ROAD CH. 3350 – CH. 3693 – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61421–SHEET 6	1
301–00825/01–806	PHASE 8 (32 YEARS LINED AREA) : PERMANENT SOUTH DIRTY WATER CHANNEL CH. 3350 – CH. 3685 – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61421–SHEET 7	1
301–00825/01–807	PHASE 8 (32 YEARS LINED AREA) : SPILLWAYS – LAYOUT PLAN, SECTIONS AND DETAILS	0.58/61421–SHEET 8	1
301–00825/01–808	PHASE 8 (32 YEARS LINED AREA) : PERMANENT NORTH CLEAN WATER CHANNEL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61421–SHEET 9	1
301–00825/01–809	PHASE 8 (32 YEARS LINED AREA) : STORMWATER MANAGEMENT – SECTIONS AND DETAILS	0.58/61421–SHEET 10	1
301–00825/01–810	PHASE 8 (32 YEARS LINED AREA) : CLEAN WATER DECANT PIPELINE CH. 2029 – CH. 2246 – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61421–SHEET 11	1
301–00825/01–811	PHASE 8 (32 YEARS LINED AREA) : CLEAN WATER DECANT PIPELINE – SECTIONS AND DETAILS	0.58/61421–SHEET 12	1
301–00825/01–812	PHASE 8 (32 YEARS LINED AREA) : ASH DUMP EXTENSION – FRONT STACK CREST SETTING OUT POINTS	0.58/61421–SHEET 13	1
301–00825/01–813	PHASE 8 (32 YEARS LINED AREA) : MCP81 TO MCP85 AND SCP55 TO SCP60 POSITIONS – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61421–SHEET 14	1
301–00825/01–814	PHASE 8 (32 YEARS LINED AREA) : MCP81 AND MCP85 POSITIONS – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61421–SHEET 15	1
301–00825/01–815	PHASE 8 (32 YEARS LINED AREA) : SCP55 POSITION – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61421–SHEET 16	1
301–00825/01–816	PHASE 8 (32 YEARS LINED AREA) : SCP60 POSITION – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61421–SHEET 17	1
301–00825/01–817	PHASE 8 (32 YEARS LINED AREA) : REHABILITATED ASH DUMP EXTENSION – LAYOUT PLAN	0.58/61421–SHEET 18	1
301–00825/01–818	PHASE 8 (32 YEARS LINED AREA) : REHABILITATED SLOPES DRAINAGE – SECTIONS AND DETAILS	0.58/61421–SHEET 19	1
301–00825/01–819	PHASE 8 (32 YEARS LINED AREA) : TEMPORARY DIVIDER WALL/ACCESS ROAD – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61421–SHEET 20	0
301–00825/01–820	PHASE 8 (32 YEARS LINED AREA) : TEMPORARY CLEAN WATER CHANNEL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61421–SHEET 21	0
301–00825/01–821	PHASE 8 (32 YEARS LINED AREA) : CLEAN WATER DECANT INLET – LAYOUT PLAN, SECTIONS AND REINFORCEMENT DETAILS	0.58/61421–SHEET 22	0
301–00825/01–822	PHASE 8 (32 YEARS LINED AREA) : TEMPORARY DIRTY WATER TRENCH – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61421–SHEET 23	0
301–00825/01–823	PHASE 8 (32 YEARS LINED AREA) : PERMANENT NORTH PERIMETER ROAD – LAYOUT PLAN AND LONGITUDINAL SECTION	0.58/61421–SHEET 24	0
301–00825/01–824	PHASE 8 (32 YEARS LINED AREA) : PERMANENT NORTH DIRTY WATER CHANNEL – LAYOUT PLAN AND LONGITUDINAL SECTIONS	0.58/61421–SHEET 25	0
301–00825/01–825	PHASE 8 (32 YEARS LINED AREA) : REHABILITATED SLOPES DRAINAGE – REINFORCEMENT DETAILS	0.58/61421–SHEET 26	0
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301–00825/01–900	PHASE 1 (4 YEARS LINED AREA) : DECANT OUTLET STRUCTURE – REINFORCEMENT DETAILS SHEET 1 OF 2	0.58/61422–SHEET 1	1
301–00825/01–902	PHASE 1 (4 YEARS LINED AREA) : NORTH AND SOUTH RETURN WATER DAM – REINFORCEMENT DETAILS SHEET 1 OF 3	0.58/61422–SHEET 3	1
301–00825/01–903	PHASE 1 (4 YEARS LINED AREA) : NORTH AND SOUTH RETURN WATER DAM – REINFORCEMENT DETAILS SHEET 2 OF 3	0.58/61422–SHEET 4	1
301–00825/01–904	PHASE 1 (4 YEARS LINED AREA) : NORTH AND SOUTH RETURN WATER DAM – REINFORCEMENT DETAILS SHEET 3 OF 3	0.58/61422–SHEET 5	1

REV	DATE	REVISION	REV BY	CHKD BY	APP BY	AUTH BY	KKS APP	REFERENCE DRAWINGS

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MATIMBA ASH DUMP
PHASE 0 – PHASE 8
LIST OF DRAWINGS

301–00825/01–100 — REV 1
0.58/61412–SHEET 1 — SHT A0 — REV 1