

REPUBLIC OF LEBANON

COUNCIL FOR DEVELOPMENT & RECONSTRUCTION

EXISTING OLD LANDFILL FINAL CLOSURE IN TRIPOLI CITY



Volume 2

Technical Specifications

June 2022



DAR AL HANDASAH NAZIH TALEB & PARTNERS SAL
دار الهندسة نزيه طالب وشركاه شمل

Founded 1958

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PREAMBLE TO THE TECHNICAL SPECIFICATIONS

The *Technical Specifications*, hereafter referred to as the *Specifications*, shall be read in conjunction with all other documents pertaining to the project. The *Specifications* are provided to the Contractor to indicate minimum standards for the design and construction of the facilities and are applicable, as appropriate, to any Contract subsequently awarded under this project. The Contractor may utilize materials and workmanship to equivalent or higher standards provided the specifications proposed do not in any way reduce or harm the integral stability, strength, long-life, durability or aesthetic qualities of the facilities to be constructed and operated.

For the avoidance of doubt, nothing contained in the *Specifications* shall limit, in any manner, the obligations of the Contractor under the Conditions of Contract.

The entire works shall be constructed and completed by the Contractor in accordance with a design, prepared and detailed by CDR.

The Contractor is free to propose, without constraint, alternative methods of site engineering and site operation to those described, provided that such methods are deemed to meet:

- the minimum performance standards set out in the *Specifications*;
- the Laws of Lebanon;
- any conditions stipulated in the Conditions of Contract.

Notwithstanding any of the above, the *Client* (which expression shall hereafter include the *Engineer*) will consider the Contractor's proposed methods of site engineering and site operation, subject to such methods being described in sufficient detail, and presented in such a manner, that will enable proper and thorough evaluations to be carried out.

The Contractor may offer materials and work in accordance with such other standards or specifications that provide for quality and workmanship not inferior to the standards quoted herein. Where the Contractor designs elements of the Works not covered by the *Specifications* or proposes alternative specifications to those contained herein, the Contractor shall supply outline specifications for all aspects of the work concerned. Authenticated English translations shall be submitted if the specifications are in another language.

A. Abbreviations

Abbreviations, where used, are as follows:

- AASHTO American Association of State Highways and Transportation Officials;
- ACI American Concrete Institute;
- ASTM American Society for Testing Materials;
- BS British Standards (Institution);
- IEC International Electrical Commission;
- ISO International Standards Organisation;
- SI System Internationale; and
- WPCF Water Pollution Control Federation.

B. General Requirements

The Contractor shall provide, whether specifically mentioned or not in the Specifications and/or on the Drawings, all equipment, materials, apparatus, plant, machinery, tools, fuel, water, shuttering, timbering and tackle of every description, transport, offices, stores, workshop, staff, skilled and unskilled labor necessary for undertaking and completing the Contract.

The Contractor's obligations shall include, but shall not be limited to, the provision of proper and sufficient protective works, temporary fencing, lighting, first aid equipment, accommodation, including clean and sanitary washrooms and toilets for labor and staff, the effecting and maintenance of insurances, the payment of wages, salaries, fees, royalties, duties and other charges arising out of the erection of works, the regular clearance of rubbish, and any necessary reinstatement and cleaning up on completion.

The Contractor shall leave the Works in a satisfactory condition and state of repair, acceptable to CDR, at the Intended Completion Date for the whole of the Works.

All works carried out under the Contracts are subject to a defects liability period of twelve (12) months.

C. Plant and Equipment

Sufficient plant and equipment shall be provided by the Contractor to ensure that the landfill site and associated facilities are constructed and operated as designed, to the satisfaction of the CDR.

Plant and equipment shall be maintained and/or replaced, as necessary, during the course of the Contract in order to ensure the continuous provision of the service under the terms of the Contract.

The use of plant and equipment within the Works shall satisfy the following conditions:

- the Contractor shall demonstrate by means of trials, to the satisfaction of the CDR before the commencement of the work, that any or all plant and equipment proposed for the Works is capable of achieving the Specifications (whether contained herein or as proposed by the Contractor) and the minimum performance standards stipulated in the Contract Documents;
- all plant and equipment provided shall be of proven efficiency and shall be operated and maintained at all times in a manner acceptable to CDR, generally in accordance with the manufacturer's recommendations; and
- no plant and equipment shall be removed from the Site without the written permission of the CDR Representative.

D. Quality Management and Quality Assurance

The Contractor shall be responsible, in accordance with the Conditions of Contract, for implementing a quality assurance system acceptable to CDR. The Contractor's quality assurance system shall encompass the requirements for quality management systems also.

In general the Contractor's proposed quality management and quality assurance systems shall adopt, as appropriate, the principles and guidelines set out in the ISO 9000 series of publications.

The Contractor shall submit, for the approval of the Engineer, an overview of his proposed quality management system and quality assurance system and procedures within seven (7) days of the Start Date. Full details of the quality management and assurance systems to be adopted on the Site shall be submitted to a schedule proposed by the Contractor and agreed with CDR.

E. Manufacturing Standards, Materials and Workmanship

The Works shall be of modern design and meet the latest perceived and obligatory standards in their design, construction, operation and maintenance.

The design, construction, operation and maintenance of the Works shall conform to:

- prevailing national legislation;
- the Specifications and minimum performance standards stipulated in the Drawings and in the Contract Documents generally;

The Works shall be executed in conformance with sound engineering practice and shall comply with any specific Codes of Practice and Standards, or their equivalent, stated in the Specification, or as proposed by the Contractor and acceptable to the Project Manager. In addition, the Works shall conform to the best practice waste management principles, recommendations and mandatory design elements described in the Contract Documents.

The Works shall be designed and maintained to give the utmost reliability in their operation.

The Contractor shall avoid causing a nuisance during, or as a result of, the execution of the Works and shall minimize inconvenience to the public, particularly to residents in the vicinity of the Site or the routes to the Site. The Contractor shall ensure that all the elements of the landfill design and operations contribute to this objective.

F. Standards and Codes of Practice

All construction works, mechanical, electrical and process equipment shall be designed and built to appropriate standards. In the absence, in the Specifications or in the Drawings, of any definite provision on any particular issue or matter, reference shall be made to the latest Codes, as applicable, of AASHTO, ACI, ASTM, BS, IEC, ISO or equivalent internationally recognized standards. The Contractor shall abide by the appropriate Local Standards or, where these do not exist, by the appropriate international standards.

All design standards used by or referenced by the Contractor shall be the latest version available, current at the time of the design submission of the element of construction to which the standard refers.

The Contractor shall supply to the Project Manager within ninety (90) days of the Start Date one (1) new copy of each set of standards that the Contractor proposes to apply to the Works.

G. Units

Metric units shall be used in all design and in the construction of the Works in accordance with the SI "Systeme International". All drawings, sketches, designs and calculations prepared by the Contractor shall be expressed in SI units.

Where other units (e.g. inches, lbs etc.) have been used in describing specifications (for example in ASTM) the equivalent SI units apply.

H. Information Provided

The information given hereunder, and provided elsewhere in the Contract Documents, is given in good faith by CDR. It is incumbent upon the Contractor to satisfy himself regarding all aspects of Site conditions; no claim will be entertained on the plea that the information supplied is erroneous or insufficient.

The Contractor should note that the use of the any site investigation data is entirely at the Contractor's discretion and CDR will not accept any liability arising out of the use of this data.

END OF SECTION

General Requirements

- 1- Description of Works and Site**
- 2- Documents and Drawings**
- 3- Management Procedures**
- 4- Quality Standards and Control**
- 5- Temporary Works and Services**

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1- DESCRIPTION OF WORK AND SITE

1-1 The Works

1-1-1 General Description

This Specification covers the works related to the **“Existing Old Landfill Final Closure in Tripoli City”** project, as shown on the Drawings, Bill of Quantities, and as detailed in the Contract Documents and directed by the Engineer.

The project is located as shown on the project drawings.

1-1-2 The Works:

This project is related to the works to be carried out for the **“Existing Old Landfill Final Closure in Tripoli City.”**

Tripoli dumpsite started to receive waste in 1980 and in the year 2000 it was converted into a semi controlled dump with the integration of a gas collection system and containment wall. The dump used to receive an average of 500t/day from Tripoli, Al Mina and Beddaoui Municipalities, otherwise known as the Union of Municipalities of Al Fayhaa, in addition to solid waste coming from Qalamoun Municipality and displaced camps via UNRWA. It was estimated that 1.1 million m³ of solid waste are currently in place at the dumpsite, spread over an area of 70,000m².

Despite various failures that occurred since 2012 in the peripheral wall, this dumpsite remained operational till February 12, 2019 in extreme hard conditions where the vertical height of the dumpsite increased till reaching more than 40m (+0 at Main Sea Level).

Given its current status and that it can barely accommodate any new volumes of incoming wastes, the Tripoli dumpsite needs to be upgraded for final closure.

The works include Earthworks (including landfill reshaping), Structural Works (related to gabion walls), Sealing works (final capping, top soil cover), Leachate management works, Biogas management works and minor Infrastructure works.

Leachate and Biogas works shall include the drilling of boreholes and wells, as well as the conveyance networks, and the required treatment. For Biogas the flow of the proposed biogas system network shall discharge into the existing flare that is to be reassembled and rehabilitated. Three gas wells were previously executed within emergency measures. Their location is shown on drawings. These wells are to be connected to the proposed works. As for Leachate, the flow of the leachate proposed network shall discharge into the new treatment plant in other project (New Tripoli Landfill Extension) through a proper connection.

Structural works will consist of additional Gabion Walls placed in front of the existing earth reinforced walls, hence ensuring structural stability without interventions on the existing walls. A layer of rocks and a capping with cyclopean concrete layer above it, will constitute a proper foundation for the additional Gabion Walls.

Sealing works will include (from the top):

- Top soil cultivation layer
- Water Drainage Geocomposite layer
- Geomembrane
- Gas Drainage Geocomposite layer
- Final leveling soil layer (above solid waste)

1-1-3 Concurrent Work

Other work not forming part of the Contract will be carried out by the Employer or other contractors or public bodies during the execution of the works.

Allow for the coordination of this work to enable the installation to progress without disruption to the completion of the works. Allow for the provision of all necessary temporary facilities as required and afford all reasonable access and assistance to enable the completion of these works in a timely manner.

1-1-4 Restraints

The maintenance of the existing utilities and access during the whole period of construction (i.e. electrical supplies water supply sewage disposal and telecommunications) imposes serious restraints upon the programming of the works. The Contractor is to consider carefully and incorporate all the restraints into his program of works and allow for same in his contract price.

1-1-5 Phasing Of Work

The phasing of the work will be developed by the Employer and Contractor upon consideration of the Contractor's proposals for the program of works and construction activities. The Contractor has to prepare his program in accordance with section 3-1 of these documents.

The Contractor shall prepare his program to ensure that proper outlets will be provided to adjacent networks as soon as practicable and especially before wet seasons.

1-1-6 Sectional Completion

The Works are to be completed and will be taken over by the Employer, in accordance with the relevant Clause of the Conditions of Contract, after agreement of the construction program.

1-1-7 Restrictions on Methods of Working

The Contractor is to ascertain from the appropriate authorities any restrictions on the methods of working, incorporate into works and include in the Contract price.

1-1-8 Sequence of Construction

The limited workspace and numerous utilities in the Project Area require a thorough and well-studied construction sequence. The Contractor shall prepare a construction sequence in conformity with his construction program. Such a sequence / program has to include procedures regarding maintenance of service during construction as well as utility diversion to ensure such service.

1-1-9 Restrictions on Times of Working

The Contractor is to ascertain from the various authorities the local restrictions during the completion of the works. The Contractor is to assume for the purposes of the tender that normal working hours shall be from dawn to dusk.

1-2 The Site

1-2-1 General

The Site is described on drawings; the Contractor shall make all necessary arrangements, including payment, if need be, regarding any land outside the Site that may be needed as work areas. The Employer will not acknowledge any liability in respect of such land. The Contractor shall also be responsible for ensuring that all roads and temporary facilities needed are sufficient to divert traffic adequately.

1-2-2 Contractors Site Compound

The Contractor shall locate and select sites outside the right-of-way for use of his plant, equipment, site offices, residences, Temporary Works or any other uses which are essential during the execution of the Contract. The Contractor shall take the necessary measures for using these sites and shall be responsible for all expenses that may become due in return for such use. Prior to using any land owned by public or private owner outside the Site, the Contractor shall obtain the approval of the concerned Authorities and the Project Manager/Engineer.

1-2-3 Existing Utilities and Obstacles

Utilities shall include, but not be limited to, existing water lines, gas lines, sewer lines, wire lines, service connections, water and gas meters and valve boxes, light poles and masts, pylons, cableways, signals, and all utility appurtenances within the limits of the proposed construction.

The Contractor shall:

- Take into account that the diversion works will be carried out to the requirements and approval of the Utility Owners and/or under their supervision, and that where required by the Utility Owners specialist diversion works be carried out by accredited specialist Contractors
- Verify and identify by excavating trial pits and other measures including, detection means existing utilities. Map these utilities and prepare detailed and accurate existing utilities drawings identifying after coordinating with the respective authorities the utilities that are in service and those that are dead or abandoned. Submit to the Project Manager/Engineer and to the Utility Owners existing utilities Drawings that are accurate and detailed giving location of utilities in plan and section with all pertinent data of the respective utility
- Work out and develop in coordination with the Utility Owners and the Project Manager/Engineer approved utilities diversion schemes as will be required, and also to enable execution of the Contract Works and maintain continued utilities services in the Area, and to the users

- Execute and provide superintendence for the execution of the utility diversions whether they are carried out by the Contractor directly or by other parties employed by him
-
- Provide accurate as Built Drawings of all permanent utility diversions that are executed under the Contract
- Include activities for such works in the Program of Work
- Be responsible for safeguarding and protecting from damage, all utilities and appurtenances encountered during the Works and be responsible for the costs of making good any damage thereto, arising out of his own negligence.

Existing Obstacles shall include, but not be limited to existing, buildings, bridges and the like, walls, fences, gates, wells, septic tanks, manholes, pits, pipes, culverts, roadways, sidewalks, signs and rubbish dumps, whether or not shown on the Drawings. The Contractor shall, at the commencement of the Contract, examine the Site and identify/verify all obstacles within the right-of-way above or below ground, and shall record all such information on suitable Site Drawings which shall be submitted to the Engineer within the agreed program but prior to commencement of that part of the work.

1-2-4 Utility Diversions

The necessary utility diversions, either temporary or permanent, shall be carried out by the Contractor. Alternatively, the Employer may make arrangements for such works to be executed by other parties, normally the Utility Owners. The Contractor shall take into account that the diversion works will be carried out to the requirements and approval of the Utility Owners and/or under their supervision.

2- DOCUMENTS AND DRAWINGS

2-1 Documents Generally

The Documents are arranged in four volumes namely:

Volume One	Bid Conditions and Procedures
	Conditions of Contract
Volume Two	Technical Specifications
Volume Three	Bill of Quantities
Volume Four	Drawings

2-2 Drawings

2-2-1 Contract Drawings

Contract Drawings are detailed on the list of Drawings, Volume 4 Drawings.

2-2-2 Dimensions and Details

Drawings are not to be scaled. Take all sizes from the dimensions shown on the Drawings or, where appropriate, as measured on site. Use detailed drawings in preference to layout drawings.

2-3 Drawings Etc. Provided by the Contractor

2-3-1 General

The Engineer will supplement the Contract Drawings with further drawings issued in accordance with the relevant sub-clause of the Conditions of Contract as he deems necessary. The Contractor shall prepare all other drawings required for Temporary Works and for fabrication and coordination of trades and prepare all shop drawings and other drawings and documents required under the Contract, in addition to drawings for work to be designed by the Contractor.

2-3-2 Design

The Contractor shall provide and maintain a design office and design personnel to provide the coordination, control and development of the detailed construction design of the works. The Contractor is required to develop, where necessary, the Engineer design intent by providing the detailed drawings to enable the construction of the works.

2-3-3 Design and Shop Drawings

The Contractor shall prepare and submit for approval, design and shop drawings, specifications, calculations, manufacturers' data etc. as required by the Specification or instructed by the Engineer in good time to meet the program (including an allowance of 30 days for Engineer's approval and extra time for resubmission in the case of rejection) and, in any case, a minimum of 45 days before the work is to be commenced or order placed, as appropriate. Drawings shall be carefully checked before submission to ensure that no conflict exists with other parts of the work.

2-3-4 Supporting Data

Supporting Data such as manufacturers' standard details, performance standards etc. are to be in English, or accompanied by a translation, and are to be properly referenced to the Drawings and Specifications and to be presented in accordance with Procedures Note 2: Submittals for Product Data (included at the end of this Section).

2-3-5 Procedure for Submission and Approval

1. Submit two copies of drawings and other documents for approval to the Engineer.
2. Within 30 days of receipt at the Engineer's design office, the Engineer will return one copy of the drawings stamped as:
 - (a) approved, or
 - (b) approved subject to amendments shown on the returned copy or in an accompanying letter, or
 - (c) rejected, with recommendations for resubmission.

3. In the case of approval, work may be commenced or orders placed.
4. In the case of approval with qualifications, work may be commenced or orders placed, at the Contractor's risk, providing the qualifications are implemented. Submit revised drawings for approval.
5. In case of rejection, resubmit until approval is obtained.
6. Provide four copies, and reproducible copy if required, of all approved material in accordance with the Conditions of Contract.

2-3-6 "As-Built" Drawings

The Contractor shall neatly and professionally prepare as-built drawings for all work completed, on reproducible copies of the drawings and on electronic diskette in a program stipulated by the Engineer for all the trades Architectural, Structural, Mechanical, Electrical, Environmental, Landscape and other utilities and such other "As Built" drawings as are called for by the Specification and submit to the Engineer for approval, and shall provide additional drawings of those parts of the permanent work designed by the Contractor in accordance with the relevant sub clause of the Conditions of the Contract to clearly show details for such as electrical signal line and wiring connections, piping and instrumentation diagram, and other applicable drawings and sketches prepared for the work as required (being drawings which the Contractor or any subcontractor has to prepare for the purpose of the Works) and shall transmit the As- Built drawings to the Engineer on a continuous basis before completion of construction but in all cases prior to issuance of the certificate of completion of the Works.

The Contractor shall maintain on site one complete set of the Contract which shall be available to the Engineer at all times and upon which the Contractor shall record on a continuous basis all changes and field adjustments. On a continuous basis shall mean as the work is progressively accomplished in relation to each Drawing. As Built drawing progress prints shall be submitted to the Engineer for review and approval as each Contract drawing reached the 50 percent, 75 percent, and 100 percent completions stage.

As Built Drawings shall be considered as part of Contractor's work effort. Failure to submit as- built drawings will be the cause for delay of the Engineer's issuance of the Certificate of Completion.

2-3-7 Instruction and Maintenance Manuals

Where required under the Conditions of Contract and where required by the Specification, the Contractor shall provide four copies of instructions and maintenance manuals for equipment and installations. Manuals are to be in English and are to be properly bound in good quality hard covers and shall be submitted in accordance with Procedure Note 3: Instruction and Maintenance Manuals (included at the end of this section).

2-3-8 Completion

The works shall not be considered as complete for the purposes of the taking over under the relevant Clause the Contract until the "as built" drawings and instruction and maintenance manuals have been provided.

2-4 Bill Of Quantities

2-4-1 Measurement Procedures Generally

All Works shall be measured net and in accordance with of the General Conditions of Contract. All units of measurement shall be in the Metric System, unless specified otherwise.

2-4-2 Field Measurements

Field Measurements of quantities for monthly certificates and for final payment shall be made by the Contractor in the presence of the Engineer. Original copies of the field measurement notes, signed by the Contractor, will be retained by the Engineer.

If the Contractor fails to measure any Pay Items, the Engineer may, at his discretion, estimate quantities of such items for the monthly Payment Certificate or recommend that no payment be made for the Items not measured and quantities not computed until it is measured.

2-4-3 Manufactured Items

Whenever standard manufactured items are specified, such as fence wire, plates, rolled shapes, pipe conduit, etc. and these items are identified by gauge, unit weight, section dimensions, etc., such identifications shall be deemed to be Nominal weights or dimensions. Unless controlled by tolerances in cited specifications, manufacturing established by the industries involved may be accepted by the Engineer at the recommendation of the Concerned Authorities

2-4-4 Gage Designations

The term "gage" when referring to the size steel plate shall mean U.S. Standard Gage, except when referring to galvanized sheets used in the manufacture of corrugated metal pipe, metal plate pipe culverts and arches and metal cribbing, when "gage" shall be as specified in AASHTO M36 or AASHTO M167, and when referring to wire when "gage" shall be as specified in AASHTO M32.

2-4-5 Fittings and Accessories

When items are shown on the Drawings or specified as requiring miscellaneous fittings and accessories for which no separate measurement is provided, the Pay Item will be deemed to include for all such fittings and accessories.

2-4-6 Weight Measurements

All materials which are to be measured or proportioned by weight shall be on accurate and approved scales by competent and qualified personnel, at locations designated or approved by the Engineer.

Trucks used to haul material being paid for by weight shall be weighed empty each day at such times as the Engineer directs and each truck shall bear a plainly visible and legible identification mark.

2-4-7 Linear and Area Measurements

All items which are to be measured by linear meter, such as pipe culverts, guardrail, underdrains, etc., shall be measured parallel to the base or foundation upon which such structures are placed, unless otherwise shown on the Drawings.

Unless otherwise specified longitudinal measurements for area computations shall be made horizontally and no deductions shall be made for fixtures with an area less than one sq.m. Transverse measurements for area computations shall be the neat dimensions shown on the Drawings or as ordered by the Engineer.

2-4-8 Volume Measurements in Vehicles

Materials to be measured by volume in the hauling vehicle shall be hauled in approved type vehicles and measured therein at the point of delivery. Vehicles for this purpose may be of any size or type approved by the Engineer provided that the body is of such shape that the actual contents may be readily and accurately determined. All vehicles shall be loaded to their level capacity and the Engineer may require loads to be leveled when the vehicles arrive at the point of delivery.

When requested by the Contractor and if approved by the Engineer material specified to be measured by the cu.m. may be weighed and such weights will be converted to cu.m. for payment purposes. Factors for conversion from weight measurement to volume measurement will be determined by mutual agreement between the Engineer and the Contractor if no agreement is obtained the factors will be determined by the Engineer and shall be accepted by the Contractor.

2-4-9 Earthwork Volume Measurements

The average end area method shall be used in computing quantities of earthworks except where the error exceeds plus or minus 5% when compared with the results obtained using the prism formula, in which case the Engineer direct the use of the prism formula. The Contractor shall request such direction before he submits his quantities for approval.

The quantities of excavation paid for under the Contract unit prices shall be limited to the lines shown on the Drawings and on approved cross sections. Excavation beyond lines shown on approved cross sections shall not be paid for unless approved by the Engineer. Excavation in excess of approved cross sections will be measured for payment only in the case of unstable or unsuitable materials ordered by the Engineer to be removed.

The Engineer will adjust the angle of slopes for cuts and fills as the Works proceed and make determinations of the appropriate slope angles following his evaluation of soil conditions in case there is a change in the type of the soil. The actual slopes of the cuts as constructed shall be measured and recorded by the Contractor. The Engineer will check these records and, if satisfactory, will approve the measurements as a basis for payment.

Within 60 days of the date of field survey, the Contractor shall submit to the Engineer for his approval plots of due original and final earthwork cross sections together with the area and volumetric earthwork computations. The Contractor's cross sections shall be on transparent

cross section sheets for print reproductions. All sheets shall have a title block and be of the size designated by the Engineer. On final approval of the Contractor's cross sections, the Contractor shall submit the original transparencies and 3 prints of each such transparency.

In case of any variations from the approved Drawings, the Contractor shall submit the original and 2 copies of the plotted cross sections and profiles and the notes and computations of his survey. The Contractor shall take cross sections at maximum 25m intervals along the centerline and at other locations if directed by the Engineer. Upon mutual agreement between the Engineer and the Contractor, the Contractor may submit cross sections intermediate to these locations. The Engineer will indicate, on one copy, his approval of the proposed lines of the Work or his revisions thereto and return such copy to the Contractor. The Contractor shall resubmit for approval any cross sections the Engineer may have revised.

The Contractor may, as an alternate method of earthwork computation, request approval to use an electronic computer. Such request shall include details of the computer hardware, the earthwork software programs, the input and output, and a complete summary of the methods and procedures to be used. The Contractor may use an electronic computer for computations, only if approved, and continuance of such approval is contingent upon satisfactory results being achieved. If results are not as represented or are otherwise deemed unsatisfactory, the Contractor shall recompute the earthwork quantities by the cross-section method.

2-4-10 Ordering Materials

The quantities stated in the Bills of Quantities are not to be used for ordering materials.

2-4-11 Shop Drawings

- A. Submit newly prepared information, drawn to accurate scale. Do not reproduce Contract Documents or copy standard printed information as the basis of Shop Drawings.
 - 1. Include the following information on Shop Drawings:
 - i. Dimensions
 - ii. Identifications of products and materials included
 - iii. Compliance with specified standards
 - iv. Notation of co-ordination requirements
 - v. Notation of dimensions established by the field measurement.
 - 2. Submit Coordination drawings where required for integration of different construction elements. Show construction sequences and relationship of separate components where necessary to avoid conflicts in utilization of the space available.
 - 3. Highlight, encircle or otherwise indicate deviations from the Contract Documents on the Shop Drawings.
 - 4. Do not permit Shop Drawings copies without an appropriate final stamp or other marking indicating the action taken by the Engineer to be used in connection with construction.
 - 5. Initial Submittal: Submit copy and one reproducible Engineers review, the reproducible print will be returned.
 - 6. Final Submittal: submit 4 copies and one reproducible copy.

2-5 Procedure Note 1

2-5-1 Submittals For Shop Drawings

2-5-1-1 Shop Drawings

- A. Submit newly prepared information, drawn to accurate scale. Do not reproduce Contract Documents or copy standard printed information as the basis of Shop Drawings.
 - 1. Include the following information on Shop Drawings:
 - i. Dimensions
 - ii. Identifications of products and materials included
 - iii. Compliance with specified standards
 - iv. Notation of coordination requirements
 - v. Notation of dimensions established by the field measurement.
 - 2. Submit Coordination drawings where required for integration of different construction elements. Show construction sequences and relationship of separate components where necessary to avoid conflicts in utilization of the space available.
 - 3. Highlight, encircle or otherwise indicate deviations from the Contract Documents on the Shop Drawings.
 - 4. Do not permit Shop Drawings copies without an appropriate final stamp or other marking indicating the action taken by the Engineer to be used in connection with construction.
 - 5. Initial Submittal: Submit copy and one reproducible Engineer's review, the reproducible print will be returned.
 - 6. Final Submittal submit 4 copies and one reproducible copy.

2-6 Procedure Note 2

2-6-1 Submittals For Product Data 2-6-1-1 Product Data

- A. Collect Product Data into a single submittal for each element of construction or system. Mark each copy to show which choices and options are applicable to the Project.
 - 1. Where Product Data have been printed to include information on several similar products, some of which are not required for use on the Project, or are not included in this submittal, mark copies to clearly indicate which information is applicable.
 - 2. Where Product Data must be specially prepared for required products, materials or systems, because standard printed data are not suitable for use, submit as Shop Drawings not Product Data.
 - 3. Include the following information in Product Data:
 - i. Manufacturer's printed recommendations
 - ii. Compliance with recognized trade association standards
 - iii. Compliance with recognized testing agency standards

- iv. Application of testing agency labels and seals
- v. Notation of dimensions verified by field measurement
- vi. Notation of co - ordination requirements.
- 4. Do not submit Product Data until compliance with requirements of the Contract Documents has been confirmed.
- 5. Submittals: Submit 2 copies of each required Product Data submittal; submit 2 additional copies where copies are required for maintenance manuals. The Engineer will retain one copy, and will return the other marked with the action taken and corrections or modifications required. Unless the Engineer observes non-compliance with provisions of the Contract Documents, the submittal may serve as the final submittal.
- 6. Distribution: Furnish copies of final Product Data submittal to manufacturers, suppliers, fabricators, installers, governing authorities and others as required for performance of the construction activities. Show distribution on transmittal forms
 - i. Do not proceed with installation of materials, products and systems until a copy of Product Data applicable to the installers, governing authorities and others as required for performance of the construction activities. Show distribution on transmittal forms.
 - ii. Do not permit use of unmarked copies of Product Data in Connection with construction.

2-7 Procedure Note 3

2-7-1 Instruction And Maintenance Manuals 2-7-

1-1 Summary

- A. This Procedure Note specifies administrative and procedural requirements for instruction and maintenance manuals including the following:
 - 1. Preparation and submittal of instruction of operating and maintenance manuals for building operation systems or equipment.
 - 2. Preparation and submittal of instruction manuals covering the care, preservation and maintenance of architectural products and finishes.
 - 3. Instruction of the Employer's operating personnel in operation and maintenance of building systems and equipment.
- B. Special operating and maintenance data requirements for specific pieces of equipment or building operating systems are included in the appropriate Sections of Divisions - 2 through 16.

2-7-1-2 Quality Assurance

- A. Maintenance Manual Preparation: In Preparation of Maintenance Manuals, use personnel thoroughly trained and experienced in operation and maintenance of the equipment or system involved.
 - 1. Where written instructions are required, use personnel skilled in technical writing to the extent necessary for communication of essential data.
 - 2. Where Drawings or diagrams are required, use draftsmen capable of preparing Drawings clearly in an understandable format.

- B. Instruction for the Owner's Personnel: For instruction of the Employer's operating
- C. and maintenance personnel, use experienced instructors thoroughly trained and experienced in the operation and maintenance of the building equipment or system involved.

2-7-1-3 Submittals

- A. Submittals Schedule: Comply with the following schedule for submittal of operating and maintenance manuals.
 - 1. Before Substantial Completion, when each installation that requires submittal of operating and maintenance manuals is nominally complete, submit two draft copies of each manual to the Engineer for review. Include a complete index or table contents of each manual. The Engineer will return one copy of the draft with comments within thirty days of receipt.
 - 2. Submit one copy of data in final form at least thirty days before final of receipt of the Engineer's comments. inspection. This copy will be returned within thirty days after final inspection, with comments.
 - 3. After final inspection make corrections or modifications to comply with the Engineer's comments. Submit the specified number of copies of each approved manual to the Engineer within fifteen days of receipt of the Engineer's comments.
- B. Form of Submittal: Prepare operating and maintenance manuals in the form of an instructional manual for use by the Employer's operating personnel. Organize into suitable sets of manageable size. Where possible, assemble instructions for similar equipment's into a single binder.
 - 1. Binder's: for each manual, provide heavy - duty, commercial quality, durable, 3 - ring vinyl covered loose-leaf binder, in thickness necessary to accommodate contents, sized to receive 8- 1/2" by 11" paper. Provide a clear plastic sleeve on the spine, to hold labels describing the contents. Provide pockets in the covers to receive folded sheets.
 - i. Where two or more binders are necessary to accommodate data, correlate data in each binder into related groupings in accordance with the Project Manual table of contents. Cross- reference other binders where necessary to provide essential information for proper operation or maintenance of the piece of equipment or system.
 - ii. Identify each binder on the front and spine, with the typed or printed title "OPERATION AND MAINTENANCE MANUAL" Project title or name, and subject matter covered. Indicate the volume number for multiple volume sets of manuals.
 - 1. Dividers: Provide heavy paper dividers with celluloid covered tabs for each separate Section. Mark each tab to indicate contents. Provide a typed description of the product and major parts of equipment included in the Section on each divider.
 - 2. Protective Plastic Jackets: Provide protective transparent plastic jackets designed to enclose diagnostic software for computerized electronic equipment.
 - 3. Text Material: Where written material is required as part of the manual use the manufacturer's standard printed material, or if it is not available, specially, prepared data, neatly typewritten, on 8-1/2 " by 11", 20 pound white bond paper.
 - 4. Drawings: Where drawings or diagrams are required as part of the manual, provide reinforced punched binder tabs on the drawings and bind in with the text.

- i. Where oversize drawings are necessary, fold the drawings to the same size as the text pages and as a foldout.
- ii. If drawings are too large to be used practically as a fold out, place the drawing, neatly folded, in the front or rear pocket of the binder. Insert a typewritten page indicating the drawing title, description of contents and drawing location at the appropriate location in the manual.

2-7-1-4 Manual Content

- A. In each manual include information specified in the individual Specification Section, and the following information for each major component of building equipment and its controls.
 1. General system or equipment description
 2. Design factors and assumptions
 3. Copies of applicable Shop Drawings and Product data
 4. System or equipment identification, including:
 - i. Name of manufacturer
 - ii. Model number
 - iii. Serial number of each component
 5. Operating instructions
 6. Emergency instructions
 7. Wiring diagrams
 8. Inspection and test procedures
 9. Maintenance procedures and schedules
 10. Precautions against improper use and maintenance
 11. Copies of warranties
 12. Repair instructions including spare parts listing
 13. Sources of required maintenance materials and related services
 14. Manual Index.
- B. Organize each manual into separate Sections for each piece of related equipment. As a minimum each manual shall contain a title page, a table of contents, copies of product Data, supplemented by drawings and written text, and copies of each warranty, bond and service Contract issued.
 1. Title Page: Provide a title page in a transparent plastic envelope as the first sheet of each manual. Provide the following information.
 - i. Subject matter covered by the manual
 - ii. Name and address of the Project
 - iii. Date of submittal
 - iv. Name, address, and telephone number of the Employer
 - v. Name and address of the Employer
 - vi. Cross reference to related systems in other operating and maintenance manuals.
 2. Table of Contents: After the Title Page, include a typewritten table of contents for each volume, arranged systematically according to the Project Manual format. Include a list of each product included, identified by the product name or other appropriate identifying symbol and indexed to the content of the volume.
 - i. Where more than one volume is required to accommodate data for a particular system, provide a comprehensive table of contents for all volumes in each volume of the set.

3. General Information: Provide a general information Section immediately following the Table of Contents, listing each product included in the manual, identified by product name. Under each product, list the name, address, and the maintenance contractor. Clearly delineate the extent of responsibility of each of these entities. In addition, list a local source for replacement parts and equipment.
4. Product Data: Where manufacturer's standard printed data is included in the
5. manuals, include only sheets that are pertinent to the part or product installed. Mark each sheet to identify each part or product included in the installation. Where more than one item in a tabular format is included, identify each item, using appropriate references from the Contract Documents. Identify data that is applicable to the installation and delete references to information that is not applicable.
6. Written Text: Where manufacturer's standard printed data is not available, and information is necessary for proper operation and maintenance of equipment or systems, or it is necessary to provide additional information to supplement data included in the manual, prepare written text to provide necessary information. Organize the text in a consistent format under separate headings for different procedures. Where necessary, provide a logical sequence of instruction for each operating or maintenance procedure.
7. Drawings Provide specially prepared drawings where necessary to supplement manufacturer's printed data to illustrate the relationship of component parts of equipment or systems, or to
8. Provide Control or flow diagrams. Co - ordinate these drawings with information contained in Project record Drawings to assure correct illustration of the completed installation.
9. Do not use original Project Record Documents as part of the Operating and Maintenance Manuals.
10. Warranties, Bonds and Service Contracts: Provide a copy of each warranty, bond or service contract in the appropriate manual for the information of the Owner's operating personnel. Provide written data outlining procedures to be followed in the event product failure. List circumstances and conditions that would affect validity of the warranty or bond.

2-7-1-5 Material And Finishes Maintenance Manual

- A. Submit four copies of each manual, in final form on material and finishes to the Engineer for distribution. Provide one section for architectural products, including applied materials and finishes, and a second for products designed for moisture protection and products exposed to the weather.
 1. Refer to individual Specification Sections for additional requirements on care and maintenance of materials and finishes.
- B. Architectural Products: Provide manufacturer's data and instructions on care maintenance of architectural products
 1. Manufacturer's Data: Provide complete information on architectural products, including the following as applicable
 - i. Manufacturer's catalogue number
 - ii. Size
 - iii. Material composition
 - iv. Color

- v. Texture
 - vi. Reordering information for specially manufactured products.
- 2. Care and Maintenance Instructions: Provide information on care and maintenance, including manufacturer's recommendation for types of cleaning agents to be used and methods of cleaning. Provide information regarding cleaning agents and methods that could prove detrimental to the product. Include manufacturer's recommended schedule for cleaning and maintenance.
- C. Moisture
 - Protection and Weather
 - Exposed Products: Provide complete manufacturer's data with instructions on inspection, maintenance and repair of products exposed to the weather or designed for moisture protection purposes.
 - 1. Manufacturer's Data: Provide manufacturer's data giving detailed information, including the following, as applicable:
 - i. Applicable standards
 - ii. Chemical composition
 - iii. Installation details
 - iv. Inspection procedures
 - v. Maintenance information
 - vi. Repair procedures
- D. Schedule: Provide complete information in the materials and finished manual on products as directed by the Engineer.

2-7-1-6 Equipment And Systems Maintenance Manual

- A. Submit four copies of each completed manual on equipment and systems, in final form, to the Engineer for distribution. Provide separate manuals for each unit of equipment, each operating system, and each electric and electronic systems.
 - 1. Refer to Specification Sections for additional requirements on operating and maintenance of the various pieces of equipment and operating systems
- B. Equipment and Systems: Provide the following information for each piece of equipment, each building operating system, and each electric or electronic system.
 - 1. Description: Provide a complete description of each unit and related component parts, including the following
 - i. Equipment or system function
 - ii. Operating characteristics
 - iii. Limiting conditions
 - iv. Performance curves
 - v. Engineering data and tests
 - vi. Complete nomenclature and number of replacement parts.
 - 2. Manufacturer's Information: For each manufacturer of a component part or piece of equipment provide the following:
 - i. Printed operating and maintenance instructions
 - ii. Assembly drawings and diagrams required for maintenance
 - iii. List of items recommended to be stocked as spare parts.
 - 3. Maintenance Procedures: Provide information detailing essential maintenance procedures, including the following:
 - i. Routine operations
 - ii. Trouble - shooting guide
 - iii. Disassembly, repair and reassembly
 - iv. Alignment, adjusting and checking

4. Operating Procedures: Provide information on equipment and system operating procedures, including the following:
 - i. Start - up procedures
 - ii. Equipment or system break - in
 - iii. Routine and normal operating instructions
 - iv. regulation and control procedures
 - iv. Instructions on stopping
 - v. Shut - Down and emergency instructions
 - vi. Summer and winter operating instructions
 - vii. Required sequences for electric or electronics systems
 - ix. Special operating instructions.
5. Servicing Schedule. Provide a schedule of routine servicing and lubrication
6. requirements, including a list of required lubricants for equipment with moving parts.
7. Controls: Provide a description of the sequence of operation and as - installed control diagrams by the control manufacturer for systems requiring controls.
8. Co-ordination Drawings: Provide each Contractor's co - ordination drawings.
 - i. Provide as
 - installed color
 - coded piping diagrams, where required for identification.
9. Valve Tags: Provide charts of value tag numbers, with the location and function of each valve.
10. Circuit Directories: For electric and electronic systems, provide complete circuit directories of panelboards, including the following:
 - i. Electric service
 - ii. Controls
 - iii. Communication.
- C. Schedule: Provide complete information in the equipment and systems manual on products specified as requested by the Engineer.

2-7-1-7 Instructions Of The Employer's Personnel

- A. Prior to final inspection, instruct the Employer's personnel in operation, adjustment and maintenance of products, equipment and systems. Provide instruction at mutually agreed upon times.
 1. For equipment that requires seasonal operation, provide similar instructions during other seasons.
 2. Use operation and maintenance manuals for each piece of equipment or system as the basis of instruction. Review contents in detail to explain all aspects of operation and maintenance.

3- MANAGEMENT PROCEDURES

3-1 Commencement, Program And Progress

3-1-1 Commencement

After receipt of the Order to Commence the Contractor shall inform the Engineer's Representative at least 7 days in advance, of the proposed date for commencing work on Site.

3-1-2 Co-Ordination

The Contractor shall co-ordinate the construction activities included therein to assure efficient and orderly installation of each Part of the works. Coordinate construction operations included under differing sections of the Specifications that are depended upon each other for proper installation connection and operation.

- a. Where installation of one part of the work is dependent on the installation of the components either before or after its own installation schedule construction activities in the sequence required to obtain the best results.
- b. Where availability of space is limited restricted by access or security co-ordinate
- c. installation of the different components to assure maximum accessibility at desired times for required maintenance service and repair.
- d. Make adequate provisions to accommodate items scheduled for later installation.

3-1-3 Program

The Contractor shall provide for the Engineer's review in accordance with Conditions of Contract a computer-based program in critical path network (CPN) form, showing at least the following information:

- a. Contract milestones (Engineer's Notice to commence, Commencement Date, date for completion of Sections of the Works, date for completion of the whole of the Works etc.)
- b. Duration Of each construction activity in working days
- c. Earliest/latest start and completion dates for each construction activity
- d. Free float time for each activity
- e. Total float time for each activity
- f. Cost of each activity as per contract rates
- g. Duration and earliest/latest dates for procurement of materials and plant
- h. Duration and earliest/latest dates for activities to be performed by subcontractors
- i. Number of working days per week and list of holidays
- j. Number of working shifts per day for each construction activity
- k. Activities for temporary works to be supplied and constructed and the dates for supply construction and removal
- l. Dates for supply by the engineer of drawings and other information in accordance with the conditions of contract relevant Clauses
- m. Dates for submission by the Contractor of shop drawings samples and the like and
- n. dates for approval by the Project Manager/Engineer in accordance with the relevant sub-clauses of the Conditions of Contract

- o. Dates and times for work to be performed by other Contractors or for materials and Plant to be supplied by the Employer
- p. Duration and earliest/latest dates for testing and commissioning plant and engineering installations
- q. Bar chart showing earliest dates and total float of activities

3-1-4 Guidance

The Contractor shall abide by the following:

- a. The Engineer will guide the Contractor in the determination of the level of detail to be included in the CPN
- b. Construction activities will not be scheduled to exceed twenty-five (25) working days without the approval of the Engineer
- c. One day will be the smallest time unit used

3-1-5 Hardware

The computer hardware shall be IBM compatible

3-1-6 Computer Software

Project management software shall be of the professional high-end type (e.g. "Open Plan" "Primavera" or of similar capabilities) and it shall be to the approval of the Engineer. Contractor is to identify and submit details in his tender of his proposed software program.

3-1-7 Resource Schedules

The computer program used for preparing the program shall also be used for preparation of resource schedules to be submitted to the Engineer with the program. The resource schedules shall show at least the following information:

- a. quantity of materials to be used for each activity
- b. numbers and classes of workmen to be employed on the Site for each activity
- c. numbers and classes of equipment to be used for each activity
- d. histogram for workmen by class and overall classes
- e. histogram for equipment by class and overall classes.

3-1-8 Cash Flow Estimate

The computer program used for preparing the program shall also be used to prepare the cash flow estimate to be submitted by the Contractor in accordance with the relevant sub-clause of the Conditions of Contract.

3-1-9 Monitoring

The Contractor shall monitor progress of the works and the supply of resources and cash flow compared with the program schedules and estimate, update the program with actual progress data monthly and shall revise the program schedules and estimate as required by Conditions of

Contract relevant Clause. Copies of revised programs etc. and notices of actual and forecast delays and shortfalls shall be regularly given to the Engineer.

3-1-10 Computer Program

The Contractor shall provide the Engineer with a copy on the computer diskette of the Target updated and new Target programs, schedules and estimates.

3-1-11 Materials Procurement Schedules

The Contractor shall submit within 98 days after the date of the Letter of Acceptance a comprehensive Materials Procurement Schedule, tied with the Program of Works to include submission approval order and delivery stages status. The Contractor shall update this schedule monthly. Copy of revised schedule shall be regularly gives to the Engineer.

3-2 Records And Measurements

3-2-1 Labor Record

The Contractor shall provide each week a record showing the number and description of workmen employed each day on the Works including those employed by subcontractors.

3-2-2 Materials And Plant Record

The Contractor shall provide each week a record showing the quantity and description of all materials and plant delivered to the Site complete with copies of delivery notes.

3-2-3 Equipment Record

The Contractor shall provide each week a record showing the number, type and capacity of all Contractors Equipment, excluding hand tools daily employed on the Works.

3-2-4 Daily Work Record

The Contractor shall provide each day a record showing activities performed and locations in which work has been carried out and any other matter requested by the Engineer's Representative.

3-2-5 Monthly Report

The Contractor shall provide monthly reports which summarize the daily and weekly reports and deliver to the Engineer's Representative not later than one week following the end of each month.

3-2-6 Wages Books And Time Sheets

The Contractor shall keep accurate and proper wage books and time sheets showing wages paid to and time worked by workmen and, when required, produce such wage books and time sheets for inspection by the Engineer's Representative.

3-2-7 Climatic Conditions

The Contractor shall measure and keep an accurate daily record of and submit to the Engineer's Representative at the end of each week.

Air temperatures: maximum and minimum Humidity

Rainfall: total in mm and hours

3-2-8 Special Records

In the event of delays for which an extension of time for completion is sought under the relevant Clause of the Conditions of the Contract or in the event of any claim for costs, the Contractor shall keep such special records of the circumstances as the Engineer's Representative may require, and submit copies regularly for his inspection.

3-2-9 Photographs

The Contractor shall provide progress photographs taken from approved stations but not less than 36 (thirty six) at monthly intervals and submit the negative and 3 prints not less than 16 cm x 20 cm of each negative.

3-3 Site Administration

3-3-1 Engineer's Site Meetings

The Engineer's Representative will hold site meetings once a month or more frequently if he deems necessary for the efficient management of the Works and he will distribute minutes. Attend all such meetings and secure the attendance of subcontractors and others if requested by the Engineer's Representative.

3-3-2 Contractor's Site Meetings

The Contractor shall hold such meetings as are necessary for co-ordination of subcontractors and review of progress.

3-3-3 Co-Ordination Of Subcontractors Etc.

The Contractor shall co-ordinate the work of all trades and subcontractors so as to avoid delay and disruption or abortive work. The Contractor shall provide all drawings, dimensions and other information required for the proper execution of subcontract works and of associated builder's work and accept responsibility for the accuracy and fitness of subcontract works.

3-3-4 Quality Control

The Contractor shall prepare and submit for approval by the Engineer a proposal for the Quality Control Management of the project. This proposal shall incorporate the requirements set out in B S 5750 or its equivalent and shall be incorporated into the Procedure Manual and will form an integral part of the Contractors management of the project. The proposal shall include, but not be restricted to:

- The provision and maintenance of a quality control program throughout the project,
- Inspection and testing of products, both on and off site, by independent professional inspection and testing companies,
- Provision of inspection and testing equipment,
- Verification of affidavits and certificates that selected materials meet the specified standards,
- The maintenance of quality control documentation in accordance with the various procedures identified in these documents.

3-3-5 Procedures Manual

The Contractor shall prepare and agree with the Engineer a Procedure Manual for the administration of the Project.

3-4 Completion

3-4-1 Notice Of Completion

The Contractor shall give the Engineer's Representative a period of at least four weeks' notice from the anticipated date of substantial completion of the whole or any part of the Works.

3-4-2 Making Good Defects

The Contractor shall make arrangements with the Employer and give reasonable of the dates for access to the various parts of the Works for the purpose of making good defects and shall inform the Engineer's Representative of the dates and when remedial works to the various parts of the Works are completed.

4- QUALITY STANDARDS AND CONTROL 4-1

Generally

4-1-1 Good Practice

Where and to the extent that materials products and workmanship are not fully specified they are to be of a standard appropriate to the Works and suitable for the purposes stated in or reasonably to be inferred from the Contract Documents, and in accordance with good building practice including the relevant provisions of current standards regulations etc.

4-2 Setting Out And Accuracy

4-2-1 Site Survey

Before commencing Works on site the Contractor shall carry out a topographical survey of the Site in conjunction with or as instructed by the Engineer's Representative or of such parts or the Site as the Engineer's Representative may direct to record the Site limits, dimensions, ground levels obstructions and other features and to establish base lines and points for future setting out and to record the basis for remeasurement of excavation and earthwork, where applicable.

4-2-2 General Setting Out

Shall be performed using methods and measuring instruments described in BS 5606, Section 5 and within the permissible deviations described in Table 4 in relation to the instruments being used.

Details of methods and equipment to be used in setting out the Works shall be submitted to the Engineer's Representative.

The Contractor shall inform the Engineer's Representative when setting out is complete and before Commencing construction and shall provide instruments and assistance for checking the setting out if required by the Engineer's Representative.

4-2-3 Setting Out Utility Works

Shall be as shown on the Drawings or as instructed on Site. Staking shall be revised if, in the opinion of the Engineer's Representative, modification of line or grade is advisable.

4-2-4 Setting Out Civil Work

Shall be as shown on Drawings or as instructed on site.

4-2-5 Record Drawings

The Contractor shall record details of all grid lines, existing ground levels, setting-out stations, bench marks and profiles on the site setting-out drawing; retain on the Site throughout the duration of the Contract and hand to the Engineer's Representative on completion.

4-2-6 All Dimensions And Levels

Both on the Drawings and the Site, shall be checked particularly the correlation between components and the work in place. Materials and components shall not be ordered or work carried out until any discrepancies have been resolved with the Engineer.

4-2-7 Appearance And Fit

The Works shall be constructed to higher levels of accuracy than those specified where necessary to achieve a satisfactory appearance and to ensure that materials, elements and components of the building fit together as designed. Wherever the accuracy, fit or appearance of the work is likely to be critical or difficult to achieve, the Contractor shall obtain the Engineer's approval of proposals or of the partially finished work as early as possible

4-2-8 Non-Compliance

Work which fails to meet the specified levels of accuracy must not be rectified without approval. Submit proposals for such rectification or removal and replacement and meet all costs arising, including effects on other work.

4-3 Materials

4-3-1 Products

Are to be new unless otherwise specified and are to be handled stored and fixed with care to ensure they are not damaged when incorporated in the work. Selection of products shall be in accordance with Procedure Note 4: Product Selection (included at the End of this Section).

4-3-2 Product List Schedule

The Contractor shall, before placing any purchase order for any materials intended for incorporation in the Works, submit for approval a product list schedule giving a complete description of all such materials, names of the firms from whom he proposes to purchase them and copies of all test reports verifying conformity with the provisions of the Specifications. Materials shall not be ordered without the approval of the Engineer. When directed by the Engineer or otherwise specified, the Contractor shall submit suitable samples for approval.

4-3-3 Standards

For products and materials specified to a national standard, such as BS or ASTM, certificates of compliance are to be obtained from manufacturers when requested by the Engineer or the Engineer's Representative.

4-3-4 Single Sources

Where a choice of manufacturer or source or supply is allowed for any particular product or material, the whole quantity required to complete the work must be of the same type, manufacture and source. Written evidence of sources of supply are to be provided when

requested by the Engineer or the Engineer's Representative and sources are not to be changed without approval.

4-3-5 Checking Compliance Of Products And Materials

The Contractor shall check all delivery tickets, labels, identification marks and where appropriate, the goods themselves to ensure that all products comply with the Specification. Where different types of any product are specified, he shall ensure that the correct type is being used in each location. In particular, the following shall be checked:

- Sources types, qualities, finishes and colors are correct, and match any approved samples
- Accessories and fixings which should be supplied with the goods have been supplied
- Sizes and dimensions are correct
- Goods are clean, undamaged and in good condition, with intact protective coverings and unbroken seals
- Materials which have a limited shelf life are not out of date.

4-3-6 Storage Of Materials

Materials shall be stored as to assure the preservation of their quality and suitability for the Works. Stored materials, approved before storage, may again be inspected prior to their use in the Works. Stored materials shall be located so as to facilitate their prompt inspection.

Materials shall not be stored in the ROW, unless otherwise permitted by the Engineer. Stockpiling of aggregate material within the ROW shall also be confined to such authorized areas.

Where materials are stockpiled on Government or private property, such sites shall be abandoned immediately upon utilization of all stockpiled materials and the natural surface shall be restored as far as practicable to the original condition by the Contractor and to the satisfaction of the Engineer.

4-3-7 Protection Of Products And Materials

The Contractor shall:

- Prevent over-stressing and any other type of physical damage.
- Keep clean and free from contamination and staining.
- Keep dry and in a suitably low humidity atmosphere to prevent premature setting moisture movement and similar defects. Where appropriate allow free air movement around and between stored components.
- Prevent excessively high or low temperatures and rapid changes of temperature in the material.
- Protect adequately from rain, frost, sun and other elements as appropriate.
- Keep different types and grades of materials separately and adequately identified.
- So far as possible, keep materials in their original wrappings, packings or containers, with unbroken seals, until immediately before they are used.

4-3-8 Materials Supplied By Employer

The Contractor shall be responsible for all materials furnished by the Employer and shall make good any shortages or deficiencies, from any cause whatsoever, or any damage which may occur, after delivery of such materials.

4-3-9 Local Material Sources

When material sources are not designated on the Drawings or in other documents, the Contractor shall be responsible for locating and providing suitable materials from approved sources.

Any information provided in the tender documents about sources of local materials is considered as a guideline only and does not relieve the Contractor of his responsibility in respect of investigation and supply of suitable materials as specified.

Materials, regardless of their source, shall not be incorporated in the Works until approved by the Engineer.

4-4 Contractor's Plant And Equipment

4-4-1 Plant And Equipment

Used on the Works shall be of sufficient size and in such mechanical condition as to meet the requirements of the Specification and shall be available for use when required by the Engineer. The Engineer may order removal and replacement of unsatisfactory plant or equipment.

4-4-2 Plant And Equipment Of A Particular Size or Type

Wherever Plant and Equipment of a Particular Size or type is specified, the Contractor may request permission to use an alternative type in place of that specified. In such cases, the Contractor shall furnish evidence to the Project Manager/Engineer, before approval is given, that the production of the plant or equipment proposed is at least equal to that of the specified type.

4-4-3 Contractor's Schedule Of Plant And Equipment

The Contractor shall submit together with his Tender, a detailed schedule of the numbers and types of plant and equipment which he proposes to utilize on Site to carry out the Works. The schedule shall contain full details for each item, including type, manufacturer, model, identification number, year of manufacture, number of years in use, and, for all new and previously used items, the manufacturer's brochures, catalogs and specifications.

4-4-4 Provision And Use Of Plant And Equipment

The Contractor shall furnish all plant and equipment listed in his Schedule and necessary for construction of each phase of the Works. Such plant and equipment shall be delivered to the Site, inspected, and approved by the Engineer prior to commencement of the particular phase of the Works for which it is intended. Any plant or equipment, or part thereof, which becomes

excessively worn or defective shall be promptly repaired or replaced, as required by the Engineer.

4-4-5 Removal From Site

The Contractor shall not remove from the Site any approved plant or equipment without the permission of the Engineer.

4-5 Workmanship

4-5-1 Work

Work is to be carried out by or under the close supervision of experienced tradesmen skilled in the particular type of work.

4-5-2 Manufacturer's Recommendations

Products shall be handled, stored, prepared and used in accordance with manufacturer recommendations. The Contractor shall inform the Engineer's Representative if these conflict with any other specified requirement and submit copies of manufacturer's recommendations to the Engineer's Representative when requested.

4-5-3 Suitability Of Previous Work And Conditions

Before starting each new type or section of work the Contractor shall ensure that:

- Previous related work is appropriately complete, in accordance with the project documents, to a suitable standard and in a suitable condition to receive the new work.

4-5-4 Defects In Existing Work

The Contractor shall report to the Engineer Representative if any existing work is defective and obtain his instructions before proceeding with new work which may cover up the defective work or which may be adversely affected by the defective work.

4-5-5 Rectification Of Defective Work

If any part of the work is known or is suspected to be not in accordance with the Contract, the Contractor shall submit proposals to the Engineer for opening up, inspecting, testing and rectification and carry out the Engineer's instructions in relation thereto, including, where so instructed, removal and reconstruction.

4-5-6 Warranties

The Contractor shall:

- Comply with specific requirements for warranties for work, products and installations that are required to be warranted in the specifications,

- Ensure that all warranties shall commence on the date of completion and are transferable to the employer upon completion of the defect liability period, if the specific period of warranty exceeds this date.
- Ensure that the following additional requirements are accommodated in the warranties:
 - a) Related damage and losses when correcting warranted work that has failed, replace other work that has been damaged as a result of such failure or that must be removed and replaced to provide access for correction of warranted work.
 - b) Re-instatement of warranty: when work covered a warranty has failed and been corrected by replacement or rebuilding reinstate warranty by written endorsement the reinstalled warranty shall be equal to the original warranty with an equitable adjustment for depreciation.
 - c) Replacement cost: upon determination that the work covered by a warranty has failed, replace or rebuild the work to an acceptable condition complying with the requirements of the Contract Documents. The Contractor shall be responsible for the cost of replacing a rebuilding defective work regardless of whether the Employer has benefited from use of the Work through a portion of its anticipated useful service life.
- Submit written warranties for approval to the Engineer prior to date certified for completion or completion of parts as may be designated.
- At final completion, compile four copies of each required warranty and bind in loose leaf binders in a clear and logical manner.

4-5-7 Warranties Employer Recourse

Written warranties made to the Employer are in addition to implied warranties, and shall not limit the duties, obligations, rights and remedies otherwise available under law, nor shall warranty periods be interpreted as limitations on time in which the Employer can enforce other duties, obligations rights, or remedies.

- Rejection of warranties: The Employer reserves the right to reject warranties to limit selections of products with warranties not in conflict with requirements of the contract documents.

4-6 Samples And Approvals

4-6-1 Samples

Where approval of products or materials is specified, the Contractor shall submit samples or other evidence of suitability. Orders shall not be confirmed or materials used until approval has been obtained. Approved samples are to be retained on the Site for comparison with products and materials used in the Works and removed when no longer required. All materials being used will be subject to inspection, testing, or rejection at any time prior to such incorporation.

Where samples of finished work are specified, the Contractor shall obtain approval of stated characteristics before proceeding with the Works and shall retain approved samples on the Site for comparison with the Works Samples which are not part of the finished works shall be removed when no longer required.

Shall be submitted in accordance with Procedure Note 5: Submittal of Samples (included at the end of this section).

4-6-2 Source Tests

All source samples shall be taken by the Contractor in the presence of the Engineer, using approved sampling procedures. All source approval tests shall be performed under the supervision of the Engineer or, when so specified, by an independent laboratory approved by the Engineer and engaged by the Contractor.

After approval of any source of materials, the Contractor shall produce from such source only to the extent that materials produced are of substantially the same quality as the approved samples.

The Engineer will periodically order retesting of previously approved sources to verify that they continue to conform to the Specifications and may order retesting at the same or at different laboratory from the one performing the original approval tests. If retesting indicates that a previously approved source no longer conforms with the Specifications, the Contractor shall forthwith cease production from such source.

4-6-3 Approvals

Where and to the extent that products materials or work are specified to be approved, or the Engineer instructs or requires that they are to be approved, the same must be supplied and executed to comply with all other requirements and, in respect of the stated or implied characteristics, either to the express approval of the Engineer, or to match a sample expressly approved by the Engineer as a standard for the purpose.

Inspection or any other action by the Engineer must not be taken as approval of materials, products or work unless the Engineer so confirms in writing in express terms referring to:

- Date of inspection
- Part of the work inspected
- Respects or characteristics which are approved
- Extent and purpose of the approval
- Any associated conditions.

Approval, inspection or any other action by the Engineer shall not in any way relieve the Contractor from his responsibility for the suitability and fitness for purpose of materials, products or work.

Where untested and unaccepted materials have been used, without approval of the Engineer, such use shall be at the Contractor's risk.

4-7 Work At Completion

4-7-1 Clearing Etc.

The Contractor shall clear the Works of all rubbish and surplus materials consequent upon the execution of the work. Clearing is to be carried out using methods approved by the Engineer's Representative and is to be completed in accordance with Procedure Note 6 Final Cleaning (included at the end of this section).

4-7-2 Temporary Markings

Coverings and protective wrappings shall be removed unless otherwise instructed by the Engineer's Representative.

4-7-3 Partial Possession By Employer

Where the Works are to be completed in sections, and any such section depends for its adequate functioning on work located elsewhere on the Site, such other work shall be completed in time to permit sectional completion as required.

4-7-4 Project Completion Procedures

The project completion shall be conducted in the manner prescribed in the Procedure Note 7: Project Completion (included at the end of this section).

4-8 Procedure Note 4

4-8-1 Product Selection

4-8-1-1 Product Selection

- A. General Product Requirements: Provide products that comply with the Contract Documents, that are undamaged and, unless otherwise indicated, unused at the time of installation
 - 1. Provide products complete with all accessories, trim, finish, safety guards and other devices and details needed for a complete installation and for the intended use and effect.
 - 2. Standard Products: where available, provide standard products of types that have been produced and used successfully in similar situations on other projects.
- B. Product Selection Procedures: Product selection is governed by the Contract Documents and governing regulations, not by previous Project experience. Procedures governing product selection include the following:
 - 1. Proprietary Specification Requirements: Where only a single product or manufacturer is named, provide the product indicated. No substitutions will be permitted.
 - 2. Semi proprietary Specification Requirements: where two or more products or manufacturers are named, provide one of the products indicated. No substitutions will be permitted.
 - a. Where products or manufacturers are specified by name, accompanied by the term "or equal" or "or approved equal" comply with the Contract Document provisions concerning "substitutions" to obtain approval for use of an unnamed product.
 - 3. Non - Proprietary Specifications: when the Specifications list products or manufacturers that are available and may be incorporated in the Work. but do not restrict the Contractor to use of these products only, the Contractor may propose any available product that complies with Contract requirements. Comply with

Contract Document provisions concerning "substitutions" to obtain approval for use of an unnamed product.

4. Descriptive Specification Requirements: where Specifications describe a product or assembly, listing exact characteristics required, with or without use of a brand or trade name, provide a product or assembly that provides the characteristics and otherwise complies with Contract requirements.
5. Performance Specification Requirements: where Specifications require compliance with performance requirements, provide products that comply with these requirements, and are recommended by the manufacturer for the application indicated. General overall performance of a product is implied where the product is specified for a specific application.
6. Manufacturer's recommendations may be contained in published product literature, or by the manufacturer's certification of performance.
7. Compliance with Standards, Codes and Regulations: where the Specifications only require compliance with an imposed code, standard or regulation, select a product that complies with the standards, codes or regulations specified.
8. Visual Matching: where Specifications require matching an established Sample, the Engineers decision will be final on whether a proposed product matches satisfactorily.
 - a. Where no product available within the specified category matches satisfactorily and also complies with other specified requirements, comply with provisions of the Contract Documents concerning "substitutions" for selection of a matching product in another product category, or for non - compliance with specified requirements.
9. Visual Selection: where specified product requirements include the phrase". as selected from manufacturer's standard colors, patterns, textures " or a similar phrase, select a product and manufacturer that complies with other specified requirements. The Engineer will select the color pattern and texture from the product line selected.

4-9 Procedure Note 5

4-9-1 Submittal Of Samples

4-9-1-1 Samples

Submit samples physically identical with the material or product proposed for use; submit full-size, fully fabricated samples, cured and finished in the manner specified.

1. Mount, display, or package samples in the manner specified to facilitate review of qualities indicated. Prepare samples to match the Engineer's sample where so indicated. Include the following information.
 - a. Generic description of the sample
 - b. Size limitations
 - c. Sample source
 - d. Product name or name of manufacturer
 - e. Compliance with recognized standards
 - f. Compliance with governing regulations
 - g. Availability
 - h. Delivery time.

2. Submit samples for review of kind, color, pattern, and texture, for a final check of these characteristics with other elements, and for a comparison of these characteristics between the final submittal and the actual component as delivered and installed.
 - a. Where variations in color, pattern, texture or other characteristics are inherent in the material or product represented by a sample, submit sets of multiple units of the sample (not less than 3 units), which show approximate limits of the variations.
 - b. Refer to other Specification sections for requirements for samples that illustrate workmanship, fabrication techniques, details of assembly, connections, operation and similar construction characteristics.
 - c. Refer to other Specification sections for samples to be returned to the Contractor for incorporation in the work, such samples must be in an undamaged condition at time of use. On the transmittal form, indicate such special requests regarding disposition of sample submittals.
3. Preliminary Submittals: where samples are specified for selection of color, pattern, texture or similar characteristics from a manufacturer's range of standard choices, submit a single, full set of available choices for the material or product.
 - a. Preliminary submittals will be reviewed and returned with the Engineers marking indicating selection and other action taken
4. Submittals: except for samples intended to illustrate assembly details, workmanship, fabrication techniques, connections, operation and other characteristics, submit sets of samples; one set will be returned marked with the action taken.
 - a. Maintain sets of samples, as returned by the Engineer, at the Project site, available for quality control comparisons throughout the course of construction activity.
 - b. Unless the Engineer observes non-compliance with provisions of the Contract Documents, the submittal may serve as the final submittal
 - c. Sample sets may be used to obtain final acceptance of the construction associated with each set.
5. Distribution of Samples: prepare and distribute additional set of samples to subcontractors,
6. suppliers, fabricators, manufacturers, installers, governing authorities, and other as required for performance of the work. Show distribution on transmittal forms.
7. Field Samples specified in individual Specification sections are special types of samples. Comply with sample submittal requirements to the fullest possible. Process transmittal forms to provide a record of activity.

4-10 Procedure Note 6

4-10-1 Part 1 - Final Cleaning

4-10-1-1 Final Cleaning

- A. This procedure note specifies administrative and procedural requirements for final cleaning at completion.
 1. Special cleaning requirements for specific elements of the work are included in appropriate sections of Parts 2 to 10.
- B. General Project close-out requirements are included in Procedure Note 7: Project Completion.
- C. Environmental Requirements: Conduct cleaning and waste disposal operations in compliance with local laws and ordinances. Comply fully with government and local environmental and anti-pollution regulations.

4-10-2 Part 2-Products

4-10-2-1 Materials

- A. Cleaning Agents: Use cleaning materials and agents recommended by the manufacturer or fabricator of the surface to be cleaned. Do not use cleaning agents that are potentially hazardous to health or property on that might damage finish surfaces.

4-10-3 Part 3 - Execution

4-10-3-1 Final Cleaning (where applicable)

- A. General. Provide final cleaning operations when indicated. Employ experienced workers or professional cleaners for final cleaning, at the discretion of the Engineer
- B. Complete the following cleaning operations before requesting inspection for Final Certificate of Completion for the entire Project or a portion of the Project.
 - 1. Clean the Project site, yard and grounds, in areas disturbed by construction activities, including landscape development areas, of rubbish, waste materials, litter and foreign substances. Sweep paved areas broom clean. Remove petrochemical spills, stains and other foreign deposit. Rake grounds that are neither planted nor paved, to a smooth even-textured surface.
 - 2. Remove tools, construction equipment, machinery and surplus material from the site.
 - 3. Clean exposed exterior and interior hard-surfaced finishes to a free condition, free of stains, films and similar foreign substances. Avoid disturbing natural weathering of exterior surfaces. Restore reflective surfaces to their original condition.
 - 4. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes and similar spaces.
 - 5. Broom clean concrete floors in unoccupied spaces.
 - 6. Remove labels that are not permanent labels.
 - 7. Touch-up and otherwise repair and restore marred exposed finishes and surfaces. Replace finishes and surfaces that cannot be satisfactorily repaired or restored, or that show evidence of repair or restoration. Do not paint over "UL" and similar labels, including mechanical and electrical name plate.
 - 8. Wipe surfaces of mechanical and electrical equipment, elevator equipment and similar equipment. Remove excess lubrication, paint and mortar droppings and other foreign substances.
 - 9. Clean plumbing fixtures to a sanitary condition, free of stains, including stains resulting from water exposure.
 - 10. Replace air disposable filters and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills. Clean ducts, blowers, and coils if units were operated without filters during construction.
 - 11. Clean light fixtures, lamps, globes and reflectors to function with full efficiency. Replace burned out bulbs, and defective and noisy starters in fluorescent and mercury vapor fixtures.
 - 12. Leave the Project clean and ready for use.
- C. Removal of Protection: Remove temporary protection and facilities installed during construction to protect previously completed installations during the remainder of the construction period.

- D. Compliance: Comply with governing regulations and safety standards for cleaning operations. Remove waste materials from the site and dispose of in a lawful manner.
- 1. Where extra materials of value remain after completion of associated construction have become the Employer's property, dispose of these materials as described.

4-11 Procedure Note 7

4-11-1 Part 1 - Project Completion

4-11-1-1 Summary

- A. This Section specifies administrative and procedural requirements for project completion including but not limited to:
 - 1. Inspection procedures
 - 2. Project record document submittal
 - 3. Operating and maintenance manual submittal
 - 4. Submittal of warranties
 - 5. Final cleaning.
- B. Close-out requirements for specific construction activities are included in the appropriate sections in Part-2 to Part-10.

4-11-1-2 Partial Completion

- A. Preliminary Procedures: before requesting inspection for taking over certificate of Final or Partial Completion, complete the following:
 - 1. Submit specified warranties, maintenance agreements, final certifications and similar documents.
 - 2. Obtain and submit releases enabling the Employer unrestricted use of the Work and access to services and utilities; include occupancy permits, operating certificates and similar releases.
 - 3. Deliver tools, spare parts, extra stock, and similar items.
 - 4. Make final change-over of permanent locks and transmit keys to the Employer. Advise the Employer's personnel of change-over in security provisions.
 - 5. Complete start-up testing of system, and instruction of the Employer's operating and maintenance personnel. Discontinue or change over and remove temporary facilities from the site, along with construction tools, mock-ups, and similar elements.

4-11-1-3 Final Completion

- A. Preliminary Procedures-. before requesting final inspection for certification of final acceptance complete the following. List exceptions in the request.
 - 1. Submit a certified copy of the Engineer's final inspection list of items to be completed or corrected, stating that each item has been completed or otherwise resolved for acceptance, and the list has been endorsed and dated by the Engineer.
 - 2. Submit final meter readings for utilities, a measured record of stored fuel, and similar data as of the date of substantial completion, or when the Owner took possession of and responsibility for corresponding elements of the Work.

3. Submit evidence of final, continuing insurance coverage complying with insurance requirements.
- B. Reinspection Procedure: The Engineer will reinspect the work upon receipt of notice that the work, including inspection list items from earlier inspections, has been completed, except items whose completion has been delayed because of circumstances acceptable to the Engineer.
 1. Upon completion of reinspection, the Engineer will prepare a certificate of final acceptance, or advise the Contractor or Work that is incomplete or of obligations that have not been fulfilled but are required for final acceptance.
 2. If necessary, reinspection will be repeated.

4-11-1-4 Record Document Submittals

- A. General: Do not use record documents for construction purposes; protect from deterioration and loss in a secure, fire-resistive location; provide access to record documents for the Engineer's reference during normal working hours.
- B. Record Drawings: Maintain a clean, undamaged set of blue or black line white-prints of Contract Drawings and Shop Drawings. Mark the set to show the actual installation where the installation varies substantially from the Work as originally shown. Mark whichever drawing is most capable of showing conditions fully and accurately; where Shop Drawings are used, record a cross-reference at the corresponding location on the Contract Drawings. Give particular attention to concealed elements that would be difficult to measure and record at a later date.
 1. Mark record sets with red erasable pencil., use other colors to distinguish between variations in separate categories of the Work.
 2. Mark new information that is important to the Employer, but was not shown on Contract Drawings or Shop Drawings.
 3. Note related change order numbers where applicable.
 4. Organize record drawing sheets into manageable sets, bind with durable paper cover sheets, and print suitable titles, dates and other identification on the cover of each set.
- C. Record Specifications: Maintain one complete copy of the Project Manual, including addenda, and one copy of other written construction documents such as Variations and modifications issued in printed form during construction. Mark these documents to show substantial variations in actual Work performed in comparison with the text of the Specifications and modifications. Give particular attention to substitutions, selection of options and similar information on elements that are concealed or cannot otherwise be readily discerned later by direct observation. Note related record drawing information and Product Data.
 1. Upon completion of the Work, submit record Specifications to the Engineer for the Employer's records.
- D. Record Product Data: Maintain one copy of each Product Data submittal. Mark these documents to show significant variations in actual Work performed in comparison with information submitted. Include variations in products delivered to the site, and from the manufacturer's installation instructions and recommendations. Give particular attention to concealed products and portions of the Work which cannot otherwise be readily discerned later by direct observation. Note related Variations and mark-up of record drawings and Specifications.
 1. Upon completion of mark-up, submit complete set of record Product Data to the Engineer for the Employer's records.

- E. Record Sample Submitted: Immediately prior to the date or dates of Substantial Completion, the Contractor will meet at the site with the Engineer and the Employer's personnel to determine which of the submitted samples that have been maintained during progress of the Work are to be transmitted to the Employer for record purposes. Comply with delivery to the Employer's Sample storage area.
- F. Miscellaneous Record Submittals. Refer to other Specification Sections for requirements of miscellaneous record-keeping and submittals in connection with actual performance of the Work. Immediately prior to the date or dates of Substantial Completion, complete miscellaneous records and place in good order, properly identified and bound or filed, ready for continued use and reference. Submit to the Engineer for the Employer's records.

4-11-2 Part 2 - Execution

4-11-2-1 Close-Out Procedures (where applicable)

- A. Operating and Maintenance Instructions: Arrange for each installer of equipment that requires regular maintenance to meet with the Employer's personnel to provide instruction in proper operation and maintenance. If Installers are not experienced in procedures, provide instruction by manufacturer's representatives. Include a detailed review of the following items, as directed by the Engineer:
 - a. Maintenance manuals
 - b. Record documents
 - c. Spare parts and materials
 - d. Tools
 - e. Lubricants
 - f. Fuels
 - g. Identification systems
 - h. Control sequences
 - i. Hazards
 - j. Cleaning
 - k. Warranties and bonds
 - l. Maintenance agreements and similar continuing commitments.
- B. As part of instruction for operating equipment, demonstrate the following procedures:
 - m. Start-up
 - n. Shutdown
 - o. Emergency operations
 - p. Noise and vibration adjustments
 - q. Safety procedures
 - r. Economy and efficiency adjustments
 - s. Effective energy utilization.

5- TEMPORARY WORKS AND SERVICES

5-1 Generally

5-1-1 Locations

The Engineer's Representative's approval is to be obtained for the intended Temporary Works and services.

5-1-2 Standards And Details

Temporary Works are to be constructed to recognized standards and codes of practice so that they are fit for their purpose. Drawings and details of proposed Temporary Works are to be provided by the Contractor if requested by the Engineer.

5-1-3 Temporary Works

Temporary Works and services are to be maintained, altered and adapted and as necessary and cleared away on completion or when no longer required. Work disturbed is to be made good.

5-1-4 General

The Contractor shall provide all Temporary Works and services and Contractor's Equipment and tools required for the efficient and safe execution of the Works, including but not limited to:

- Temporary roads, hard standings, sleeper tracks and the like
- Temporary fences, gates and barriers
- Temporary offices, stores, messrooms, latrines and compounds
- Scaffold, ladders, hoists, cranes and the like
- Temporary screens, chutes, coverings, roofs and rainwater pipes for protection of the Works and personnel.
- Transport and vehicles on and off Site
- Fixed and movable mechanical plant and equipment
- Small tools
- Temporary water and power supplies and site lighting
- Temporary drainage.

5-2 Temporary Site Facilities

5-2-1 Roads

Permanent roads, hard standings and footpaths on the Site may be used provided they are adequately maintained and thoroughly cleaned and made good after use and left in unimpaired condition.

5-2-2 Diversions

The Contractor shall:

- (i) Provide temporary detour roads, and other facilities to divert traffic through or around any part of the Works or for maintenance of traffic in locations affected by his works that warrant such temporary works. Location, standard, width, construction and maintenance of detour routes shall be approved by the Engineer's Representative, ensuring at all times that the routes are signed, striped, maintained and furnished with all traffic control devices as shown, directed and/or needed.
- (ii) Submit designs and detailed working drawings of the proposed temporary works for approval by the Engineer prior to commencement of the works. The design live load for temporary bridges related to roads exposed to heavy vehicles shall not be less than the design live load for permanent bridges, or as directed by the Engineer. Where measure are taken for continuously regulating and supervising traffic, provide temporary roads and bridges for one-way traffic.
- (iii) Phase the execution of temporary and permanent works to minimize the disruption to traffic
- (iv) Submit a phased program of temporary works one month before commencement of any part of the works.

5-2-3 Trench Crossings

Trench Crossings are to be provided for free and safe passage of vehicles and pedestrians over pipe trenches.

5-2-4 Temporary Site Fence

The Contractor shall provide a suitably secure temporary site fence where necessary or as directed by the Engineer. The design of the fence is to be submitted to the Engineer for approval.

5-2-5 Nameboard

The Contractor shall provide nameboards in both languages English and Arabic at suitable locations bearing the Employer's and Engineer's names, the name of the project, the Contractor's name and such other names and information as the Engineer may direct. Design of the name board shall be submitted for the Engineer approval prior to fabrication and erection.

5-3 Contractor's Temporary Offices

5-3-1 Contractor's Temporary Offices

The Contractor shall provide all necessary temporary sheds, offices, messrooms, sanitary accommodation and other temporary facilities required for his and subcontractors use.

5-3-2 Temporary Laboratory

The Contractor shall provide, furnish and equip a laboratory as necessary to carry out all testing of materials on Site required by the Specification, manned by suitably qualified staff.

5-4 Temporary Services

5-4-1 Water

The Contractor shall provide clean fresh water for the Works and make temporary arrangements for storing and distributing about the Site.

5-4-2 Electricity

The Contractor shall provide electric supply and all equipment for lighting and power for the Works and make temporary arrangements for distributing about the Site.

5-4-3 Power

The Contractor shall provide electric power for the Works including supplies for commissioning engineering services and plant, at the required voltages.

5-4-4 Lighting

The Contractor shall provide lighting for the Site and the Works for safety and security to the Works and to facilitate proper execution of work and to illuminate internal surfaces during finishing work and inspection. Spaces designed to be artificially lit during daylight hours are to have temporary illumination similar to that provided by the permanent installation.

5-4-5 Permanent Electric Supply And Lighting Installation

Permanent electric supply and lighting installation may be used for commissioning and to illuminate the Works subject to the following conditions:

- The employer does not guarantee that it will be available
- The Contractor must take responsibility for the operation maintenance and supervision of the system, indemnify the Employer against all damage and pay all costs and renew all used tubes and lamps
- The Contractor must indemnify the Employer against reduction in manufacturer's guarantee periods for equipment etc., due to its use before completion of the Works.

5-5 Temporary Facilities For The Engineer And/Or Employer

5-5-1 General

All facilities provided for the Engineer's and/or Employer's staff shall remain available until the end of the defect liability period or until such earlier time as the Engineer may instruct.

5-5-2 Representative's Site Offices

The Contractor shall provide prefabricated portable or demountable offices or other as may be approved by the Engineer, for the sole use of the Engineer's Representative and his staff, comprising:

- 2 offices size of each approximately 4m x 5m
- Meeting room for 12 people
- Secretary's room of approximately size 4m x 5m
- 1 Kitchenette.
- 2 Toilets.
- **1 Store room.**
- Car shades for 4 cars.

Offices are to be of a proprietary manufacture, with hard-wearing, mosquito proof, weather proof, easy-clean surfaces and robust and secure fittings. The offices shall have full partitions and all rooms shall have individual entrance doors. Corridor and entrance areas shall be additional to the office size. All rooms shall have glazed windows complete with flyscreens. The offices shall be provided with call bell system. The contractor shall submit full details to the Engineer's Representative for approval before delivery to the Site and erection.

5-5-2-1 Furniture and Equipment

Each office shall contain:

- 2 desks with lockable drawers and swivel chairs
- 2 lockable steel filing cabinets
- 2 office chairs
- 1 drawing hanger for 10 sets
- 2 shelves
- 2 pin boards
- 2 waste paper baskets
- 1 reference table

And, in addition, the following shall be provided for the Secretary's Office:

- Secretary's desk and swivel chair
- 2 large lockable sheet filing cabinets
- 2 reference tables
- 6 office chairs
- 10 calculators
- 1 photocopying machine with duplex, sorter and document feeder + consumables + all photocopying papers.
- Pinboards, shelves and waste paper baskets.
- All consumables and all stationery and office supplies.

5-5-2-2 Conference Room Furniture and Equipment

Details to be decided by the Engineer as needed and based on the following:

- 1 Conference table for 12 people
- 12 chairs
- 2 pinboards

- 2 shelves
- 2 waste baskets
- 1 reference table.

5-5-2-3 Kitchen Furniture and Equipment

Shall comprise for each pantry:

- 1 refrigerator 14cu. Ft. capacity
- 1 water filter and 20 liters water cooler/hot/cold
- 2 electric boiling rings
- 1 stainless steel sink and drainer
- 1 heat resistant worktop
- 1 set of storage cupboards
- 1 set of crockery and cutlery for each member of the staff
- 1 large waste basket with cover.

And all necessary consumables for the making of beverages for the duration of the contract.

5-5-2-4 Store Room Furniture and Equipment

Shall comprise:

- Shelve units
- Drawing hangers and racks.

5-5-2-5 Lavatory Furniture and Equipment

Shall comprise for each lavatory:

- 1 European wc suite
- 1 toilet roll holder
- 1 wash hand basin with shelf
- 1 mirror
- 1 paper towel holder
- 1 soap dispenser
- 1 waste basket with cover
- 1 extractor fan

And all necessary consumables

5-5-2-6 Services

The contractor shall provide and maintain the following minimum services:

- Heating and air – conditioning for each room office
- Electric lighting and power
- Water supply
- Drainage system

- Fire fighting appliances
- Cleaning facilities and general attendance

All bills charges related to the services shall be paid by the Contractor.

5-5-2-7 Telephones

The contractor shall provide **four** separate telephone connections, **two** which **are** mobile and two fixed for office use and facsimile. The contractor shall pay all installation, rental and call charges.

5-5-2-8 Car Ports

Car ports, complete with hard standings and all necessary adjoining walkways, shall be provided for a minimum of four vehicles. Covered car parking areas shall be adjacent to the offices.

5-5-3 Representative's Vehicles

The Contractor shall provide and maintain a new four-wheel Drive, air-conditioned vehicle, minimum 2400 CC for the sole use of the Engineer's Representative and his staff and shall supply all fuel and lubricants, repair and maintain the vehicle to keep it in good roadworthy condition at all times, comprehensively insure the vehicle for any driver at all times and replace with identical vehicle any vehicle removed for maintenance or repair or for any other reason.

At the end of the Project the above car shall remain the property of the Contractor.

5-5-4 Vehicle Driver

Not Applicable

5-5-5 Computer

The contractor shall provide on site for the use of the Engineer's Representative and his staff **three** latest model computers along with the necessary operating systems, softwares, A4 laser printer, A3 plotter and UPS, **with all consumables and all stationery and office supplies.**

5-5-6 Surveying Equipment and Assistance

The Contractor shall supply and maintain in full working order or shall replace whenever directed by the Engineer during the progress of the work the Surveying and other equipment schedule below for the safe use of the Engineer's Representative and his staff and shall provide a topograph and other assistants if required.

5-5-7 Thermometers

The following shall be provided on site:

- Maximum and minimum thermometer for measurement of atmospheric temperature
- Thermometer for measurement of concrete and ground temperature.

5-5-8 Test Equipment

The Contractor shall make available to the Engineer's Representative all test equipment and testing laboratories required for carrying out tests on materials, plant or finished work required by the specification.

5-5-9 Inspection Facilities

The contractor shall provide all ladders, access lighting facilities and assistance etc. required by the project manager representative / Engineer's Representative to inspect any part of the works.

5-5-10 Digital Camera

The contractor shall provide one digital camera latest model for the sole use of the Engineer's Representative and his staff.

5-6 Diversion of Public Utility Services

5-6-1 Temporary Diversion of Existing Public Utility Services

Where execution of the works involves the temporary diversion of existing public utility services, the contractor shall perform such temporary diversion and shall maintain the follow or service as directed by the engineer. Unless otherwise stated the cost will be deemed to be included in the contractor price.

5-6-2 Permanent Diversion of existing Public Utility Services

Where the works require the permanent diversion of existing public utility services, either where shown on the drawings or where shown on the drawings or where directed by the Engineer, the diversion shall be carried out by the contractor and shall be paid for the prices stated for such work in the Bill of Quantities.

SECTION 01050

SURVEYING

PART 1 - GENERAL

1.01 SUMMARY

- A. The Contractor shall provide all materials, items, operations or methods specified, listed, or scheduled on the Drawings and Specifications including all materials, labor, equipment and incidentals necessary and required to conduct proper surveys required to stake, layout, and control the work.
- B. The Contractor shall establish sufficient site monuments, at locations approved by the Owner's Representative, to control field surveying activities.
- C. The Contractor shall perform surveys to accurately measure the quantities of work performed for the payment of completed work.

1.02 RELATED SECTIONS

- A. Section 02200 - Earthwork
- B. Section 02210 - Structural Fill
- C. Section 02211 - Stone Cover
- D. Section 02221 - Trenching
- E. Section 02225 - Bedding Gravel
- F. Section 02226 - Site Roads
- G. Section 02235 - LCS Drainage Sand
- H. Section 02250 - Final Cover Protective Layer
- I. Section 02260 - Barrier Wall
- J. Section 02290 - Erosion and Sediment Control

1.03 QUALIFICATIONS

- A. All surveys, layouts, and related work shall be performed under the supervision of, and signed by, a qualified land surveyor registered in the Lebanon.

1.04 SUBMITTALS

- A. At the pre-construction meeting, the Contractor shall submit written qualifications for his proposed surveyor. These qualifications will be reviewed and evaluated by the Owner's Representative.

1.05 PROJECT RECORD DOCUMENTS

- A. The Contractor shall maintain on site a complete, accurate log documenting any and all changes and control of survey work as it progresses.
- B. Upon completion of the work, the Contractor shall submit Record Documents to the Owner's Representative.

1.06 QUALITY ASSURANCE

- A. The Contractor shall provide certified survey results to the Owner's Representative on a timely basis so that the results can be reviewed for conformance with the Drawings and Specifications prior to the start of subsection portions of the work. Failure to provide such results on a timely basis will result in delays in starting subsequent work. These delays shall

be the sole responsibility of the Contractor. Such delays will not result in an extension to the project schedule.

PART 2 - PRODUCTS

2.01 GENERAL

- A. The precision of horizontal and vertical controls shall meet or exceed LEBANON Standards or Third-Order Class I and Third-Order accuracies, respectively, as defined by the National Geodetic Survey Standards, USA.
- B. All conformance check surveys for elevation shall be ± 0.01 ft, for horizontal, control angles shall be ± 20 seconds and for measured distances shall be to ± 0.01 ft.
- C. All measurement surveys for elevation shall be to the nearest $0.1 \text{ ft} \pm 0.05 \text{ ft}$ and for horizontal distances shall be to $\pm 0.1 \text{ ft}$.

2.02 MATERIALS

- A. The Contractor shall provide all materials as required to properly perform the surveys, including, but not limited to, instruments, tapes, rods, measures, mounts, and tripods, stakes and hubs, nails, ribbons, other reference markers, and all else as required. All material shall be of good professional quality and in first-class condition.
- B. All lasers, transits, and other instruments shall be calibrated and maintained in accurate calibration throughout the execution of the work. Calibration certificates shall be submitted to the Owner's Representative prior to the use of any instrument.

PART 3 - EXECUTION

3.01 GENERAL

- A. The Contractor shall exercise extreme care during the execution of all phases of the work to minimize any disturbance to property surrounding the work site.

3.02 SITE REFERENCE POINTS

- A. Prior to starting work, the Contractor shall verify with the Owner's Representative locations of site reference and survey control points. The Contractor shall not relocate site reference points without prior written approval from the Owner's Representative. The Contractor shall promptly report to the Owner's Representative the loss, damage, or destruction of any reference point because of field activities or other reasons. Replacement of dislocated site reference points shall be performed by a licensed surveyor at no additional cost to the Owner.

3.03 SURVEY CONTROL POINTS

- A. The Contractor shall establish a survey grid to the satisfaction of the Owner's Representative. This grid shall be used to establish cut and fill requirements and quantities for payment. The Contractor shall establish other survey control points to the satisfaction of the Owner's Representative to adequately control his work and establish quantities for payment.
- B. The Contractor shall protect survey control points prior to starting, and for the duration of site work. During construction, the Contractor shall periodically verify the locations of survey control points. The Contractor shall replace dislocated survey control points based on original survey control at no additional cost to the Owner. Replacement of dislocated survey control points shall be performed by a licensed surveyor.

3.04 SURVEY REQUIREMENTS

- A. The Contractor shall reference survey and site reference points to the provided control

monuments and record locations of survey control points, with horizontal and vertical data, on Project Record Documents.

- B. The Contractor shall establish lines and levels, locate and layout by instrumentation or other appropriate means site features to be constructed including necessary stakes for cut, fill, placement, and grading operations and stakes for utility locations, slopes, and invert, elevations. When necessary to remove a grade marker for construction operations, the grade lines shall be maintained parallel and extend at least one grade marker adjacent on each side of the removed marker.
- C. The Contractor shall be responsible for establishing the working or construction lines and grades.
- D. The Contractor shall furnish all materials and accessories (i.e., grade markers, stakes, pins, spikes, etc.) required for the proper location of grade points and lines.
- E. All markers provided shall be carefully preserved and, if destroyed or removed without the Owner's Representative's approval, they shall be reset at the Contractor's expense.
- F. It shall be the responsibility of the Contractor to keep the Owner's Representative informed of the times and places at which he intends to work in order that the Owner's Representative may have an ample opportunity to furnish and/or to verify the lines and elevations with a minimum of inconvenience to the Owner's Representative or delay to the Contractor.

3.05 SURVEYS FOR MEASUREMENT

- A. The Contractor shall perform surveys, in a manner acceptable to the Owner's Representative, to determine quantities of work and percent of completed work, including surveys to establish measurement reference lines, and the Contractor shall notify the Owner's Representative prior to starting work.
- B. The Contractor shall calculate and certify quantities and submit survey results, calculations, and certification to the Owner's Representative for review, evaluation, and payment.

END OF SECTION

SECTION 01051

SOIL AND GEOTECHNICAL INVESTIGATION

PART 1 – GENERAL

The geotechnical and soil investigation will include drilling boreholes and excavating test pits. Laboratory and plate load tests will also be performed and a report will be issued.

PART 2 – APPLICABLE STANDARDS

Field investigations shall be carried out in accordance with British Standards BS 5930: 1981 “Code of practice for Site Investigation”.

Geotechnical borehole logging, handling, labeling, and preservation of samples shall be undertaken in accordance with British standards BS 5930: 1981 “Code of practice of Site Investigations”.

The laboratory testing program for samples obtained from test pits and boreholes shall be primarily directed towards determination of the physical, chemical and engineering characteristics of the subsurface soils represented by the samples obtained in the field.

Laboratory tests shall be conducted in accordance with the Standard Testing Procedures and shall be based on a detailed testing schedule and number of tests approved by the Engineer.

PART 3 – EXECUTION

The investigation will determine the nature and stratigraphy of subsurface soils, presence and level of groundwater, allowable bearing capacity to use in the design where applicable. Recommendations will also be provided to safeguard excavations during construction.

The investigation scope of services will include:

1. Drill borings as stated (Min. 4 bore holes).
2. Perform SPT test every 1.5-m in cohesionless soils with sampling and continuous coring .
3. Supply and install two standpipe piezometers to measure and monitor groundwater level,
4. Perform several (mini. 12) plate load tests (in waste, under gabion walls, etc...), with determination of vertical subgrade modulus k,
5. Excavate test pits (min. 5) down to 3m max with sampling, storing logging and photographing, reinstatement of pits with same backfill
6. Take soil samples for laboratory testing (min. 20 tests), and perform a laboratory testing program on representative samples,
7. Prepare a geotechnical report on the following:
 - a) subsurface conditions encountered during the field program with soil cross-sections, and levels of groundwater on site,
 - b) recommended foundation type, depth with allowable bearing pressure and estimated settlement where applicable
 - c) provide recommendations to safeguard excavations next to adjacent boundaries,
 - d) other pertinent conclusions and recommendations.

PART 4 – MEASUREMENT AND PAYMENT

PAY ITEMS

This item shall be measured as in Linear Meter of executed and approved boreholes. After due completion and approval of report, the payment shall be carried out.

UNIT OF MEASUREMENT

Linear Meter (m)

END OF SECTION

SECTION 02200

EARTHWORK

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and installation equipment necessary to perform all earthwork related work as specified herein, as shown on the Drawings, and in accordance with the Construction Quality Assurance (CQA) Plan.
- B. The Contractor shall be prepared to construct the earthworks in conjunction with other construction activities and subcontractors at the site.
- C. The work of this section shall include, but not necessarily be limited to: stripping, excavating, hauling, backfilling, compacting, and grading soil materials. The work of this section also includes dewatering and protection of on-going and completed work. Earthwork shall conform to the dimensions, lines, grades and sections specified on the Drawings.

1.02 RELATED SECTIONS

- A. Section 02210 - Structural Fill
- B. Section 02221 - Trenching
- C. Section 02235 - LCS Drainage Sand
- D. Section 02250 - Final Cover Protective Layer
- E. Section 01050 - Surveying
- F. Section 02711 - Geotextile Filter
- G. Section 03110 - Erosion Control
- H. Section 02260 - Barrier Wall
- I. Section 02226 - Site Roads
- J. Section 02250 - Final Cover Protective Layer

1.03 REFERENCES

- A. Construction Quality Assurance (CQA) Plan.
- B. Latest version of American Society for Testing and Materials (ASTM) standards:
 - 1. ASTM D 22. Standard Method for Particle-Size Analysis of Soils.
 - 2. ASTM D 698. Standard Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using a 5.5-lb Rammer and 12-in. Drop.
 - 3. ASTM D 1556. Standard Test Method for Density of Soil In Place by the Sand-Cone Method.
 - 4. ASTM D 1557. Standard Test Methods for Moisture-Density (Modified) Relations of Soils and Soil-Aggregate Mixtures Using a 10.0-lb Rammer and 18-in. Drop.
 - 5. ASTM D 2216. Standard Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures.
 - 6. ASTM D 2487. Standard Test Method for Classification of Soils for Engineering Purposes.
 - 7. ASTM D 2922. Standard Test Methods for Density of Soil and Soil-Aggregate In Place by Nuclear Density Methods (Shallow Depth).

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| 8. ASTM D 3017. | Standard Test Method for Water Content of Soil and Rock In Place by Nuclear Methods (Shallow Depth). |
| 9. ASTM D 4220. | Standard Practices for Preserving and Transporting Soil Samples. |
| 10. ASTM D 4318. | Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. |
| 11. ASTM D 2937. | In-Place Density as a Check on Nuclear Densometer Measurements. |

1.04 RESPONSIBILITY

- A. The Contractor shall be responsible for all earthwork related work as specified herein. The Contractor shall be a well-established firm with more than ten years experience in the performance of earthwork construction.
- B. The Contractor shall abide by all qualification requirements of the CQA Plan.

1.05 SUBMITTALS

- A. The Contractor shall submit a letter describing the proposed methods of construction, including stripping, dewatering, excavation, filling, compaction, and backfilling for the various portions of the work to the CQA Consultant for review. The review shall be for method only. The Contractor shall remain responsible for the adequacy and safety of the methods.
- B. For each soil type specified in Part 2.01 of this Section, the Contractor shall submit to the Owner the following information and samples a minimum of 14 days prior to starting construction:
 - 1. The proposed material source.
 - 2. The results of grain-size analyses conducted on the proposed material in accordance with ASTM D 422.
 - 3. The results of liquid and plastic limit tests conducted on the proposed material in accordance with ASTM D 4318.
 - 4. The results of a moisture-density relation test (ASTM D 698).
 - 5. A 50-pound sample of each of the proposed soils or authorization to access the proposed source(s) for sampling.
- C. The Contractor shall notify the CQA Consultant in writing at least 7 days in advance of intention to perform the work of this Section.
- D. If work is interrupted for reasons other than inclement weather, the Contractor shall notify the CQA Consultant a minimum of 24 hours prior to the resumption of work.

1.06 CONSTRUCTION QUALITY ASSURANCE

- A. All earthwork shall be performed in accordance with the requirements of this Specification and the Construction Quality Assurance (CQA) Plan.
- B. All earthwork shall be monitored as outlined in the (CQA) Plan.
- C. The Contractor shall be aware of the activities outlined in the CQA Plan and account for these CQA activities in the construction schedule.

1.07 EXISTING CONDITIONS

- A. The approximate locations of all known underground and above ground utility lines and structures are shown on the Plans. The Contractor shall immediately notify the CQA Consultant if other utility lines or structures, not shown on the plans, and are encountered in the excavation.

PART 2 - PRODUCTS

2.01 MATERIALS

Fill shall meet the material requirements of ~~Part 2.01~~ of Section 02210: Structural Fill.

PART 3 - EXECUTION

3.01 FAMILIARIZATION

- A. Prior to implementing any work described in this Section, the Contractor shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this Section and the CQA Plan.
- B. Inspection:
 - 1. Prior to implementing any of the work in this Section, the Contractor shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.
 - 2. If the Contractor has any concerns regarding the installed work of other Sections, he/she should immediately notify the CQA Consultant in writing within 48 hours of the site visit. Failure to notify the CQA Consultant or continuance with earthworks will be construed as Contractor's acceptance of the related work of all other Sections.

3.02 FIELD QUALITY CONTROL

- A. The minimum frequency and details of quality control testing are provided in the CQA Plan. The Contractor shall take this testing frequency into account in planning his construction schedule.
- B. Sampling locations shall be selected by the CQA Consultant. If necessary, the location of routine in-place moisture content and dry density test shall be determined using a non-biased sampling plan.
- C. A special testing frequency shall be used at the discretion of the CQA Consultant when visual observations of construction performance indicate a potential problem.
- D. All perforations resulting from testing the subgrade or embankment shall be filled with soil compacted to the satisfaction of the CQA Consultant.
- E. If a defective area is discovered in the earthwork, the CQA Consultant shall immediately determine the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the CQA Consultant shall determine the extent of the defective area by additional tests, observations, a review of records, or other means that the CQA Consultant deems appropriate. If the defect is related to adverse site conditions, such as overly wet soils or surface desiccation, the Engineer shall define the limits and nature of the defect.
- F. After determining the extent and nature of a defect, the Contractor shall correct the deficiency to the satisfaction of the CQA Consultant. The cost of corrective actions shall be borne by the Contractor.
- G. Additional testing shall be performed to verify that the defect has been corrected before any additional work is performed by the Contractor in the area of the deficiency.

3.03 SITE PREPARATION

- A. The Contractor shall develop access to the construction area in accordance with the requirements of the Drawings and any Supplemental Specifications.
- B. The Contractor shall install silt fences immediately down-slope of each area to be disturbed prior to the beginning of work in that area. The Contractor shall maintain the silt fences for the duration of construction. Accumulated sediment behind the silt fences shall be disposed of on-site by the Contractor in a manner approved by the Owner.
- C. All objectionable material shall be removed from the construction area and disposed of in

an area designated by the Owner.

- D. Diversion ditches, either permanent or temporary, shall be constructed in accordance with the Drawings. The Contractor shall be responsible for constructing diversion ditches as required to divert run-on around the construction area.
- E. Temporary access roads to the construction area shall be constructed and maintained in accordance with the Drawings.

3.04 STOCKPILING

- A. The Contractor shall perform all stockpiling in accordance with the landfill's Comprehensive Waste Management Plan.
- B. Excavated materials classified as fill shall be stockpiled in designated areas free of incompatible soil, debris, or other objectionable materials. Stockpile areas will be shown on the Drawings or designated by the Owner or CQA Consultant.
- C. Excavated material classified as spoil shall be segregated from fill disposed of in accordance with the landfill's Comprehensive Waste Management Plan.
- D. Stockpiles of fill shall be no steeper than 2:1 (horizontal: vertical) for sandy soils and 1:1 other slope approved by the CQA Consultant, graded to drain, sealed by tracking parallel to the slope with a dozer or other means approved by the Owner and CQA Consultant, and dressed daily during periods when fill taken from the stockpile. The Contractor may cover fill stockpiles with plastic sheeting or other material approved by the CQA Consultant in order to preserve the moisture content of the fill.

3.05 EXCAVATION AND SUBGRADE PREPARATION

- A. Upon completion of site preparation, the cell shall be excavated to the elevations and grades for the subgrade shown on the Drawings. All excavation work shall be carried out in compliance with the landfill's Comprehensive Waste Management Plan.
- B. After excavation or stripping to final grade, the CQA Consultant will inspect the subgrade of the cell. The subgrade shall be free of all boulders, and debris. The CQA Consultant will identify areas that require additional excavation of soft or permeable materials. Such excavation shall be backfilled with fill. Backfill shall be placed and compacted in accordance with the specifications requirements. The subgrade shall be prepared to provide a smooth workable surface on which to construct the liner.
- C. If required by the CQA Consultant, the Contractor shall scarify the portion of the subgrade on the base of the cell to a depth of not less than 0.2 m and compact it in accordance with the requirements for prepared subgrade.
- D. The subgrade surface shall be seal-rolled to prevent moisture infiltration unless fill is to be immediately placed on the compacted surface.
- E. Excavation shall not be considered complete, and no fill shall be placed on the subgrade, until the Owner's Surveyor confirms that the elevations and grades shown on the Drawings have been achieved in the field. The Contractor shall be responsible for notifying the CQA Consultant that the excavation (or a significant portion thereof) is complete and the Contractor shall plan for the time required for the Owner's Surveyor to confirm the elevations and grades of the excavation.
- F. Surplus excavated soils shall not be removed from the site or disposed of by the Contractor unless directed to do so by the Owner or CQA Consultant.

3.06 STRUCTURAL FILL

- A. Structural fill shall be constructed to the lines and grades shown on the Drawings.
- B. The fill shall meet the specifications requirements.
- C. The fill shall be placed in a loose lift that results in a compacted lift thickness of 0.15 to 0.2 meters, with the exception of the first lift which may have a compacted thickness of

no greater than 0.25 meters.

- D. Each lift shall be compacted to at least 95 percent of the maximum dry density as measured according to ASTM D 698 for Standard Proctor Density-Moisture relationship. The dry density and moisture content shall be measured in accordance with ASTM D 2922, Method B, and ASTM D 3017, respectively.
- E. If the moisture content of the fill is not suitable for proper compaction, the soil shall be moisture conditioned and reworked, as appropriate. Wetting shall be accomplished using a water truck and spray nozzle, unless the Owner or CQA Consultant approves an alternative method. During wetting or drying, the soil shall be regularly disked or otherwise mixed so that uniform moisture conditions are obtained.
- F. The Contractor shall moisture-condition the fill in either the stockpile area or work area. Any delays in progress due to the latter, however, are the responsibility of the Contractor.

3.07 SURVEY CONTROL

- A. The Contractor shall survey the location and elevation of the excavation. He shall also survey the location and elevation of the top of subgrade shown on the Drawings. Surveying shall be performed in general accordance with the CQA Plan.
- B. The Contractor shall provide Record Drawings of the location and elevation of the excavation and the top of subgrade, in accordance with the requirements of the CQA Plan. The Contractor shall submit this drawing to the CQA Consultant at least 48 hours prior to the start of fill placement. The Contractor may submit a partial Record Drawing to obtain approval for a portion of work. The CQA Consultant will define the minimum requirements for a partial submittal.
- C. The Owner may supply surveying for quality assurance (QA) purposes and Record Drawings. The Contractor provides surveying for quality control (QC) purposes.

3.08 FIELD QUALITY CONTROL

- A. The CQA Consultant will perform soil moisture, dry unit weight, and lift thickness tests in the field on each lift of fill material to evaluate compliance with this Specification. Testing will be carried out in accordance with the CQA Plan.
- B. If the CQA Consultant's tests indicate work does not meet the requirements of the specifications, the CQA Consultant will establish the extent of the nonconforming area. The non-conforming area shall be reworked by the Contractor at his own expense until acceptable test results are obtained.
- C. The Contractor shall be aware of all field CQA testing activities, as these may affect his schedule.

3.09 PROTECTION OF WORK

- A. The Contractor shall use all means necessary to protect all materials and all partially-completed and completed work of this section.
- B. In the event of damage, the CQA Consultant will identify areas requiring repair, and the Contractor shall make all repairs and replacements necessary to the approval of the CQA Consultant and at no additional cost to Owner.
- C. At the end of each day, the Contractor shall verify that the entire work area was left in a state that promotes surface drainage off and away from the area and from finished work. If threatening weather conditions are forecast, compacted surfaces shall be seal-rolled to protect finished work.

3.10 PUMPING AND DRAINAGE

- A. At all times during construction, the Contractor shall provide and maintain proper equipment and facilities to remove all water entering excavations and keep such excavations dry so as to obtain a satisfactory subgrade to allow the construction of the fill

and installation of the lining system.

- B. Water entering the excavation from surface runoff shall be collected in shallow ditches around the perimeter of the excavation, drained to sumps, and pumped from the excavation to the perimeter drainage ditch or to a pond in order to maintain the excavation bottom free from standing water.
- C. Drainage shall be disposed of only in an area approved by the Owner. Drainage shall be disposed of in a manner, which prevents flow or seepage back into the excavated area.
- D. The Contractor shall install and maintain all erosion control features (i.e., silt fences around all areas down slope of soil disturbance unless a drainage ditch exists at the boundary of the disturbed area). The Owner shall identify other areas requiring silt fences during the construction period. Silt fences shall not be removed until the contained areas are successfully re-vegetated.

3.11 PRODUCT PROTECTION

- A. The Contractor shall use all means necessary to protect all prior work, including all materials and completed work of other Sections.
- B. In the event of damage, the Contractor shall immediately make all repairs and replacements necessary, to the approval of the CQA Consultant and at no additional cost to the Owner.

END OF SECTION

SECTION 02210

STRUCTURAL FILL

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and installation equipment necessary for the construction of the structural fill as specified herein, as shown on the Drawings, and in accordance with the Construction Quality Assurance (CQA) Plan.
- B. The Contractor shall be prepared to construct the structural fill in conjunction with other construction activities and subcontractors at the site.
- C. Notwithstanding the prequalification of any material sources for the structural fill, the Contractor shall be entirely responsible for meeting the requirements of this Section.

1.02 RELATED SECTIONS

- A. Section 02200 - Earthwork
- B. Section 02221 - Trenching
- C. Section 02270 - Gravel Road
- D. Section 02711 - Geotextiles
- E. Section 02290 - Erosion Control
- F. Section 03310 - Cast-in-Place Concrete
- G. Section 03320 - Precast Concrete Structures

1.03 PAYMENT AND MEASUREMENT

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1.04 REFERENCES

- A. Construction Quality Assurance (CQA) Plan.
- B. Latest version of American Society for Testing and Materials (ASTM) standards:
 - 1. ASTM D 422. Standard Method for Particle-Size Analysis of Soils.
 - 2. ASTM D 698. Standard Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using a 5.5-lb Rammer and 12-in. Drop.
 - 3. ASTM D 2216. Standard Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures.
 - 4. ASTM D 2487. Standard Test Method for Classification of Soils for Engineering Purposes.
 - 5. ASTM D 2922. Standard Test Methods for Density of Soil and Soil-Aggregate In Place by Nuclear Density Methods (Shallow Depth).
 - 6. ASTM D 3017. Standard Test Method for Water Content of Soil and Rock In Place by Nuclear Methods (Shallow Depth).
 - 7. ASTM D 4318. Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

1.05 SUBMITTALS

- A. The Contractor shall submit to the Owner and the CQA Consultant for review a letter describing the proposed methods of construction, including stripping, dewatering, excavation, filling, compaction, and backfilling for the various portions of the work. The

review shall be for method only. The Contractor shall remain responsible for the adequacy and safety of the methods.

- B. For each soil type specified in specifications, the Contractor shall submit to the Owner and the CQA Consultant the following information and samples a minimum of 14 days prior to starting construction:
 - 1. the proposed material source;
 - 2. the results of grain-size analyses conducted on the proposed material in accordance with ASTM D 422;
 - 3. for fine-grained materials, the results of liquid and plastic limit tests conducted on the proposed material in accordance with ASTM D 4318;
 - 4. the results of a moisture-density relation test (ASTM D 698); and a 20 kg sample of each of the proposed soils or authorization to access the proposed source(s) for sampling.
- C. The Contractor shall notify the Owner and the CQA Consultant in writing at least 7 days in advance of intention to perform the work of this Section.
- D. If work is interrupted for reasons other than inclement weather, the Contractor shall notify the Owner and the CQA Consultant immediately and provide a plan and schedule for resumption of the work.
- E. The Contractor shall abide by all qualification requirements of the CQA Plan.

1.06 CONSTRUCTION QUALITY ASSURANCE

- A. The construction of the structural fill shall be performed in accordance with the requirements of this section and the CQA Plan.
- B. The construction of the structural fill shall be monitored by the CQA Consultant as outlined in the CQA Plan.
- C. The Contractor shall be aware of the activities outlined in the CQA Plan and account for these CQA activities in the construction schedule.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. All laboratory testing to evaluate the suitability or conformance of soil materials for the structural fill shall be carried out in accordance with the test methods indicated in Section 1.04.
- B. Structural fill shall consist of relatively homogeneous, natural soils that are free of debris, foreign objects, large rock fragments, and organics. If geosynthetics are to be placed in contact with the structural fill, the upper 0.15 m of the structural fill layer shall not contain materials larger than 0.05 m. Otherwise, no materials larger than 0.15 m shall be allowed. The structural fill shall be classified according to the Unified Soil Classification System (USCS) as GP, GW, SP, SW, SM, SC, ML, CL, ML-CL, CH, or MH material.

PART 3 - EXECUTION

3.01 FAMILIARIZATION

- A. Prior to implementing any work described in this Section, the Contractor shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this Section and the CQA Plan.
- B. Inspection:
 - 1. Prior to implementing any of the work in this Section, the Contractor shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of the work specified in this Section may properly commence without adverse impact.
 - 2. If the Contractor has any concerns regarding the installed work of other Sections, the Owner should be immediately notified in writing within 48 hours of the site inspection. Failure to

notify the Owner or continuance with earthworks will be construed as Contractor's acceptance of the related work of all other Sections.

3.02 SITE PREPARATION

- A. The Contractor shall develop access to the construction area in accordance with the requirements of the Drawings and any supplemental Specifications.
- B. The Contractor shall install silt fences immediately down-slope of each area to be disturbed prior to the beginning of work in that area. The Contractor shall maintain the silt fences for the duration of construction. Accumulated sediment behind the silt fences shall be disposed of on-site by the Contractor in a manner approved by the Owner.
- C. All other objectionable material shall be removed from the construction area and disposed of in an area designated by the Owner.
- D. All soil removed from the construction area shall be stockpiled.
- E. Diversion ditches, either permanent or temporary, shall be constructed in accordance with the Drawings. The Contractor shall be responsible for constructing diversion ditches as required to divert potential run-on around the construction area. The construction of temporary ditches not shown on the Drawings shall not be undertaken until the Contractor's plan for constructing the ditches is approved by the Owner.

3.03 EXCAVATION AND STOCKPILING

- A. Excavated materials to be used as structural fill shall be stockpiled in designated areas segregated from soils not suitable for use as fill, clearing debris, or other objectionable materials. Stockpile areas will be designated by the Owner's Representative.
- B. Stockpiles of structural fill shall have side slopes no steeper than 2H:1V (2 horizontal:1 vertical) for sandy soils unless approved otherwise by the Owner. The stockpiles of structural fill shall be graded to drain, sealed by tracking parallel to the slope with a dozer or other means approved by the Owner, and dressed daily during periods when structural fill is taken from the stockpile. The Contractor may cover structural fill stockpiles with plastic sheeting or other material approved by the Owner in order to preserve the moisture content of the structural fill.
- C. Surplus excavated soils shall not be removed from the site or disposed of by the Contractor unless such removal or disposal is approved by the Owner.

3.04 STRUCTURAL FILL

- A. The structural fill used during this construction shall be constructed to the lines and grades shown on the Drawings using the appropriate material.
- B. The structural fill shall meet the specifications requirements.
- C. The structural fill shall be placed in a loose lift that results in a compacted lift thickness of no greater than 0.20 m.
- D. Each lift shall be compacted to at least 95 percent of the maximum dry unit weight as measured according to ASTM D 698 (e.g., Standard Proctor). The dry unit weight and moisture content shall be measured in place in accordance with ASTM D 2922 (Method B) and ASTM D 3017, respectively.
- E. If the moisture content of the structural fill is not suitable for proper compaction, the structural fill shall be moisture conditioned and reworked, as appropriate. Wetting shall be accomplished using a water truck and spray nozzle, unless the CQA Consultant approves an alternative method. During wetting or drying, the structural fill shall be regularly disked or otherwise mixed so that uniform moisture conditions in the appropriate range are obtained.

3.05 SURVEY CONTROL

- A. The Contractor shall survey the location and elevation of the structural fill, access road, drainage ditches, and drainage swales.

- B. The Owner may supply surveying for quality assurance purposes and Record Drawings.

3.06 PROTECTION OF WORK

- A. The Contractor shall use all means necessary to protect all materials and all partially-completed and completed work specified in this Section and prior work of other Sections.
- B. At the end of each day, the Contractor shall verify that the entire work area was left in a state that promotes surface drainage off and away from the area and from finished work. If threatening weather conditions are forecast, compacted surfaces shall be seal-rolled to protect finished work.
- C. In the event of damage to prior work or work completed as specified in this Section, the Contractor shall submit a repair plan to the Owner and CQA Consultant(s). The repair plan shall describe the areas requiring repair, and the Contractor shall make all repairs and replacements necessary to the approval of the Owner and CQA Consultant(s) and at no additional cost to the Owner.

3.07 PUMPING AND DRAINAGE

- A. At all times during construction, the Contractor shall provide and maintain proper equipment and facilities to remove all water entering excavations and keep such excavations dry so as to obtain a satisfactory condition for progress of work.
- B. Drainage shall be disposed of only in an area approved by the Owner. Drainage shall be disposed of in a manner, which prevents flow or seepage back into the excavated area.

END OF SECTION

SECTION 02221

TRENCHING

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and installation equipment to perform all trenching work as specified herein, as shown on the Drawings, and in accordance with the Construction Quality Assurance (CQA) Plan.
- B. The Contractor shall be prepared to construct all trenches in conjunction with the other aspects of the work.
- C. The work of this section shall include, but not necessarily be limited to: trenching for leachate transmission piping and culverts, providing pipe bedding and backfill materials, placing pipes, backfilling around and over the pipes, and excavating and backfilling the geosynthetics anchor trench.

1.02 RELATED SECTIONS

- A. Section 02200 - Earthwork
- B. Section 02210 - Structural Fill
- C. Section 02225 - Bedding Gravel
- D. Section 02711 - Geotextiles
- E. Section 02718 - High Density Polyethylene Pipe and Fittings
- F. Section 02730 - Geonets
- G. Section 02735 - Geocomposite Drainage Layer
- I. Section 02830 - Storm Water Drainage Pipes

1.03 REFERENCES

- A. Construction Quality Assurance (CQA) Plan

1.04 PAYMENT AND MEASUREMENT

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PART 2 - PRODUCTS

2.01 EXCAVATED MATERIALS

- A. Material to be excavated will include in-situ natural subgrade soils, embankment soils.

2.02 PIPE TRENCH CONSTRUCTION MATERIALS

- A. Bedding Material: Sand or gravel (SW, SP, or GW) having a maximum particle size of 0.05 m in largest dimension and a maximum of 15 percent particles passing the standard U.S. No. 200 sieve.
- B. Trench or Culvert Backfill: Structural fill material (as defined in Section 02210-2.04) or other material approved by the Engineer.
- C. Piping:
 - 1. Leachate collection piping and leachate transmission piping as specified in Section 02718; or
 - 2. Culverts as specified in Section 02830.

2.03 ANCHOR TRENCH CONSTRUCTION MATERIALS

- A. Anchor trench shall be backfilled using structural fill meeting the requirements described in Section 02210.

PART 3 - EXECUTION

3.01 PREPARATION

- A. The Contractor shall identify required lines, levels, contours, and datum.
- B. The Contractor shall maintain and protect existing utilities, which may pass through the work area.
- C. The Contractor shall protect bench marks and existing structures from excavation equipment and vehicular traffic.
- D. Protect above and below grade utilities which are to remain.

3.02 EXCAVATION

- A. Excavate subsoil to the depth required for placement of piping or geosynthetics.
- B. Cut trenches sufficiently wide to enable installation of piping or geosynthetics and to allow inspection; dewater trench if necessary. For anchor trenches, maintain trench in dry condition during geosynthetics installation.
- C. Cut out soft areas of subgrade that are not capable of in-situ compaction. Backfill with either bedding material or structural fill. Remove loose material from excavation. Stockpile excavated material in preapproved stockpile area.
- D. Correct unauthorized or mistaken excavation at no cost to Owner.

3.03 PIPE BEDDING

- A. Place bedding material to thicknesses shown on the Construction Drawings.
- B. Compact bedding material to either 90 percent of the material's standard Proctor maximum dry density (per ASTM D 698) or to 70 percent of the material's maximum relative density (per ASTM D 4254) as determined by the CQA Consultant based on bedding material characteristics.

3.04 BACKFILLING

- A. Trenches shall be backfilled to contours and elevations with approved fill materials. Backfilling over porous, wet, or spongy sub-grade surfaces is unacceptable.
- B. The Contractor shall employ a placement method that does not disturb or damage piping in the trench. Do not use heavy compaction equipment over piping or culverts that are covered by less than 1 ft of compacted trench backfill material. Compact material to the requirements of the Owner's Representative.
- C. Surplus backfill materials shall be removed to an approved stockpile area if material will not be used for further construction.

3.05 TOLERANCE

- A. Top Surface of General Backfilling: Plus or minus 0.5 ft from required elevations.

3.06 SAFETY PROVISION

- A. All trenching shall be performed in strict accordance with OSHA and all other applicable laws and regulations.

END OF SECTION

SECTION 02250

FINAL COVER PROTECTIVE LAYER

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and installation equipment necessary for the construction of the cover protective layer as specified herein, as shown on the Drawings, and in accordance with the Construction Quality Assurance (CQA) Plan.
- B. The Contractor shall be prepared to coordinate the construction of the cover protective layer with other construction activities and subcontractors at the site.
- C. Notwithstanding the prequalification of any material sources for the cover protective layer, the Contractor shall be entirely responsible for meeting the requirements of this Section.

1.02 RELATED SECTIONS

- A. Section 02210 - Structural Fill
- B. Section 02265 - Top soil

1.03 PAYMENT AND MEASUREMENT

[INTENTIONALLY LEFT BLANK]

1.04 REFERENCES

- A. Construction Quality Assurance (CQA) Plan.
- B. Latest version of American Society for Testing and Materials (ASTM) standards:
 - 1. ASTM D 422. Standard Method for Particle-Size Analysis of Soils.
 - 2. ASTM D 698. Standard Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using a 5.5 pound Rammer and 12-inch Drop.
 - 3. ASTM D 2216. Standard Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures.
 - 4. ASTM D 2487. Standard Test Method for Classification of Soils for Engineering Purposes.
 - 5. ASTM D 2922. Standard Test Methods for Density of Soil and Soil-Aggregate In Place by Nuclear Density Methods (Shallow Depth).
 - 6. ASTM D 3017. Standard Test Method for Water Content of Soil and Rock In Place by Nuclear Methods (Shallow Depth).
 - 7. ASTM D 4318. Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
 - 8. ASTM D 5084. Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

1.05 SUBMITTALS

- A. The Contractor shall submit the following information and samples to the Owner and the CQA Consultant a minimum of 14 days prior to the start of construction of the cover protective layer:
 - 1. the proposed material source or sources;

2. the results of grain-size analyses conducted on the proposed material in accordance with ASTM D 422;
3. a 50 kg sample of each proposed soil or authorization to access the proposed source(s) for sampling.
- B. The Contractor shall notify the Owner and the CQA Consultant in writing a minimum of 7 days prior to starting construction of the cover protective layer. The notice shall state the material to be used, the equipment to be used, the date and time that placement operations will start, and the name of the person in the field who will be in charge of the construction of the cover protective layer.
- C. If work is interrupted for reasons other than inclement weather, the Contractor shall notify the Owner and the CQA Consultant immediately and provide a plan and schedule for resumption of the work.

1.06 CONSTRUCTION QUALITY ASSURANCE

- A. The construction of the cover protective layer shall be monitored by the CQA Consultant as outlined in the CQA Plan.
- B. The Contractor shall be aware of the activities outlined in the CQA Plan and shall account for these activities in the construction schedule.

PART 2 - PRODUCTS

2.01 MATERIAL

- A. All laboratory testing to evaluate the suitability or conformance of stone material for the cover protective layer shall be carried out in accordance with the test methods indicated in Part 1.04 of this Section.
- B. The cover protective layer shall consist of relatively homogeneous, natural soils which are free of debris, foreign objects, large rock fragments, roots, and organics. No particles larger than 3 inches shall be allowed. The soil shall be classified according to the Unified Soil Classification System (USCS) as ML, MH, CL, CH, or SC material. This soil may be amended with up to 50% sludge and/or compost. Materials which do not meet all the requirements of this section shall be segregated at the source and will not be permitted at the work area. Any material which is found by the Owner to be unsuitable shall be removed from the work area by the Contractor at no extra cost to the Owner.

PART 3 - EXECUTION

3.01 FAMILIARIZATION

- A. Prior to implementing any work of this Section, the Contractor shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this Section and the CQA Plan.
- B. Inspection:
 1. Prior to implementing any work of this Section, the Contractor shall carefully inspect the installed work of all other Sections and verify that all such work is complete to the point where the installation of this Section may properly commence without adverse impact.
 2. If the Contractor has any concerns regarding the installed work of other Sections or the site, the Contractor shall notify the Owner or CQA Consultant in writing within 48 hours of the site inspection. Failure to notify the Owner or CQA Consultant of installation of the cover protective layer will be construed as Contractor's acceptance of the related work of all other Sections.

3.02 COVER PROTECTIVE LAYER PLACEMENT

- A. The Contractor shall construct the cover protective layer to the grades, slopes, and

elevations shown on the Drawings and as specified in this Section.

- B. No frozen or partially thawed cover protective layer material shall be placed, spread or compacted.
- C. No cover protective layer material shall be placed or spread while the surface on which the material is to be placed is frozen or thawing, during unfavorable weather conditions, or during periods of precipitation.
- D. The cover protective layer surface shall be made smooth and free from ruts or indentations at the end of every working day when precipitation is forecast and/or at the completion of the compaction operations in that area.
- E. Mixing of soil and sludge shall be done during placement using a bulldozer.
- F. The entire area shall be left in a manner to promote runoff at the end of each day.
- G. The cover protective layer shall be compacted using a sheepsfoot compactor or bulldozer. The equipment shall operate only over previously placed cover protective layer material. The Contractor shall not operate equipment directly on the geotextile filter.
- H. The cover protective layer material shall be placed in loose lifts which result in a compacted lift thickness of 8 inches, except for the first lift which may be placed in a loose lift which results in a compacted lift thickness of 12 inches minimum.
- I. The cover protective layer material on the sideslopes shall be compacted to at least 90 percent of the maximum dry unit weight as measured according to ASTM D 698. The dry unit weight and moisture content shall be measured in place in accordance with ASTM D 2922 (Method B) and ASTM D 3017, respectively.

3.03 SURVEY CONTROL

- A. The Contractor shall survey the location and elevation of the cover protective layer.
- B. The Owner may supply surveying for quality assurance purposes and Record Drawings.

3.04 PROTECTION OF WORK

- A. The Contractor shall use all means necessary to protect all prior work, including all materials and completed work specified in this and other Sections.
- B. In the event of damage to prior work or work completed as specified in this Section, the Contractor shall immediately make all repairs and replacements necessary to the approval of the Owner and CQA Consultant and at no additional cost to the Owner.

END OF SECTION

SECTION 02265

TOPSOIL

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and installation equipment, necessary to perform the work specified herein, as shown in the Drawings, and in accordance with Construction Quality Assurance (CQA) Plan.
- B. The Contractor shall coordinate the earthwork with other construction activities and subcontractors at the site.
- C. The work specified in this Section shall include, but not necessarily be limited to: mixing, loading, and hauling of topsoil from either an on-site or off-site source, and placing and grading the topsoil at locations shown on the Drawings, and applying weed control and/or soil amendments.

1.02 RELATED SECTIONS

- A. Section 02200 – Earthwork

1.03 PAYMENT AND MEASUREMENT

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1.04 REFERENCES

- A. CQA Plan.
- B. Latest Version of American Society for Testing and Materials (ASTM) standards:
 - 1. ASTM D 422 Standard Method for Particle-Size Analysis of Soils.
 - 2. ASTM D 2974 Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils.

1.05 SUBMITTALS

- A. The Contractor shall submit to the Owners' Representative or Engineer for review a letter describing the proposed procedure for placing topsoil at the site. The review shall be for method only. The Contractor shall remain responsible for the adequacy and safety of the methods.
- B. The Contractor shall submit to the Owner's Representative or Engineer for review a letter describing the specific method of spreading and blending the proper amount of compost or amendment mix in the top 0.15 m of topsoil.
- C. For each source of furnished topsoil, the Contractor shall submit to the Owner's Representative certification for the material properties including:
 - a. the proposed amendment mix design and required spreading rate supported by calculation showing the resulting macro-nutrient concentrations in the amended topsoil;
 - b. the source for the amendment mix or compost; and
 - c. the source of the topsoil including the location, site description, previous land use, previous vegetation, and topsoil depth.
 - d. the results of particle-size analysis conducted on the proposed material in accordance with ASTM D 422.
- D. The Contractor shall notify the Owner's Representative or Engineer in writing at least 7 days in advance of intention to perform the work of this Section.
- E. If work is interrupted for reasons other than inclement weather, the Contractor shall notify the Owner's Representative or Engineer immediately and provide a plan and schedule for

resumption of the work.

- F. The Contractor shall abide by all qualification requirements of the CQA Plan.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. The material for the topsoil layer shall consist of a natural loose, friable, fertile, fine sandy loam possessing the characteristics of representative topsoil of the region, and shall be from on-site or imported from off-site. The topsoil shall be free from subsoil, noxious weeds, stones larger than 25 mm in diameter, lime, cement, ashes, slag, or other deleterious matter. Topsoil shall be well drained in its original position and free from toxic quantities of acid or alkaline elements.
- B. For topsoil to be considered loamy, that fraction passing through the No. 10 sieve (ASTM D 422) shall contain not more than 40 percent clay.
- C. Acceptable topsoil shall contain not less than 3 percent or more than 25 percent organic matter as determined by loss on ignition (ASTM D 2974) of samples oven dried to constant weight at 100 °C.
- D. At least 14 days prior to anticipated start of topsoil operations, a 40-kg sample of topsoil material shall be delivered to the Owner's Representative or Engineer for testing and approval. If the topsoil is found unacceptable, the Contractor shall be responsible for identifying another source of topsoil and shall incur all expenses associated with testing additional samples at no additional cost to the Owner. All topsoil incorporated into the site work shall match the sample provided to the Owner's Representative or Engineer for testing.

PART 3 - EXECUTION

3.01 FAMILIARIZATION

- A. Prior to implementing any of the work described in this Section, the Contractor shall become thoroughly familiar with all portions of the work falling within this Section.
- B. Inspection:
 - 1. Prior to implementing any of the work in this Section, the Contractor shall carefully inspect the installed work of all other Sections, and verify that all work is complete to the point where the installation of this section may properly commence without adverse impact.
 - 2. If the Contractor has any concerns regarding the installed work of other Sections, he should notify the Owner's Representative or Engineer in writing within 48 hours of the site inspection. Failure to notify the Owner's Representative or Engineer, or continuance with topsoil placement will be construed as the Contractor's acceptance of the related work of all other Sections.

3.02 APPLICATION

- A. Topsoil shall be placed on those areas shown in the Drawings.

3.03 PLACEMENT

- A. Topsoil shall be placed over approved areas to a depth sufficiently greater than required so that after natural settlement and light rolling, the complete work will conform to the lines, grades, and elevations shown in the Drawings. No topsoil shall be spread in water. If soil or weather conditions are unsuitable, as determined by the Owner's Representative or Engineer, the Contractor shall cease placing topsoil until permission to resume topsoil operations is obtained from the Owner's Representative.
- B. After topsoil has been spread, it shall be carefully prepared by scarifying or harrowing and raking. All clods, lumps, roots, litter, and other foreign material shall be removed from the area and disposed of by the Contractor. The areas shall also be free of smaller stones, in excessive quantities, as determined by the Owner's Representative or Engineer.

3.04 PROTECTION OF WORK

- A. The Contractor shall use all means necessary to protect all prior work, including all materials and completed work specified in this and other Sections.
- B. In the event of damage to prior work or work completed as specified in this Section, the Contractor shall immediately make all repairs and replacements necessary to the approval of the Owner and CQA Consultant and at no additional cost to the Owner.

END OF SECTION

SECTION 02270

GRAVEL ROADS

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, installation equipment, and incidentals necessary for the construction of the gravel roads as shown on the Drawings and as described in these Specifications.
- B. The work includes, but it is not necessarily limited to, preparation and stabilization of sub-grade, installation of geotextile separator, and placement and compaction of suitable temporary road materials.
- C. The Contractor shall use materials for activities associated with this construction work and shall minimize usage of existing site access roads. The Contractor shall maintain the temporary roads in good condition throughout the construction project and shall leave the roads in good condition to the satisfaction of the Owner's Representative and Engineer at the end of construction activities.

1.02 RELATED SECTIONS

- A. Section 02200 - Earthwork
- B. Section 02110 - Clearing

1.03 MEASUREMENT AND PAYMENT

(Intentionally left blank)

1.04 REFERENCES

- A. Engineering Drawings
- B. Latest version of American Society for Testing and Materials (ASTM) standards:
 - 1. ASTM C 136 Standard Method for Sieve Analysis of Fine and Coarse Aggregate.
 - 2. ASTM D 422 Standard Method for Particle-Size Analysis of Soils.

1.05 QUALITY ASSURANCE

- A. It is the responsibility of the Contractor to ensure that the materials and methods used for gravel road construction meet the requirements of the Drawings and Specifications. Any material or method that does not conform to these documents, or to alternatives approved by the Owner's Representative or Engineer, will be rejected by the Owner's Representative or Engineer, and shall be repaired or replaced by the Contractor at no additional cost to the Owner.
- B. The Contractor shall be aware that monitoring and field/laboratory conformance testing may be required by the Owner. This monitoring and testing, including random conformance testing of construction materials and completed work, will be performed by the Owner's Representative, Engineer, or CQA Representative. If non-conformances or other deficiencies are found in the Contractor's materials or completed work, the Contractor will be required to repair or replace the deficiency at no additional cost to the Owner.

PART 2 – PRODUCT

2.01 MATERIALS

- A. All materials used for the construction of gravel roads shall be pre-approved by the Owner's Representative or Engineer. Materials' samples for Base Course and Wearing Course shall be

pre-approved before hauling to site.

2.02 EQUIPMENT

- A. The Contractor shall use appropriate road construction equipment for this work.
- B. The Contractor shall furnish, operate, and maintain grading and compaction equipment as is necessary to produce uniform compacted layers and sections, which are smooth graded for vehicles and drainage.
- C. The Contractor shall furnish, operate, and maintain tank trucks, pressure distributors, or other equipment designed to apply water to the surface of the gravel roads.

PART 3 - EXECUTION

3.01 FAMILIARIZATION

- A. Prior to implementing any of the work described in this Section, the Contractor shall become thoroughly familiar with the site, the site conditions, and all portions of the work falling within this Section.
- B. Inspection:
 - 1. Prior to implementing any of the work described in this Section, the Contractor shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.
 - 2. If the Contractor has any concerns regarding the installed work of other Sections, he should notify the Owner's Representative in writing prior to commencing the work. Failure to notify the Owner's Representative or continuance with installation of this Section will be construed as the Contractor's acceptance of the related work of all other Sections.

3.02 PREPARATION OF SUBGRADE

- A. The Contractor shall clear the areas along the alignment of the gravel roads in accordance with the Drawings.
- B. The Contractor shall grade and compact the subgrade beneath the gravel roads prior to placing construction materials. The Contractor may use general fill or cut soil from the road alignment for localized grading to fill low areas along the road alignment. Compaction of the subgrade shall be achieved to the satisfaction of the Owner's Representative or Engineer by multiple passes of a fully-loaded tandem-wheel dump truck, or other equipment approved by the Owner's Representative.
- C. The road subgrade will be evaluated by the Owner's Representative after it has been prepared by the Contractor. The Contractor shall not commence placement of the road aggregate until the Owner's Representative completes this evaluation.
- D. The Contractor shall grade the existing ground surface to the sides of the roads to promote surface-water runoff away from the roads and in the direction away from the landfill.

3.03 PLACEMENT OF DRAINAGE LAYER

- A. A drainage layer shall be laid under the surface of the road that surrounds the landfill. This drainage layer will be contiguous with the drainage layer constructed into the sideslopes of the landfill.
- B. The drainage layer shall consist of a 150 mm layer of 6 – 19 mm river gravel aggregates without fines, laid between two geotextile liners.
- C. The drainage layer shall be laid with a gradient of 3/100 so that any moisture will flow freely to away from the landfill

3.04 PLACEMENT OF AGGREGATE

- A. The surface aggregate shall be placed in a single lift to the required minimum compacted thickness and to the elevations and grades indicated on the Drawings. The required compacted thickness of

the surface aggregate is 300 mm.

- B. Tie-in between new and existing roads shall be smooth and free of significant bumps.
- C. The aggregate shall be compacted using a vibratory compactor, or other equipment approved by the Owner's Representative, to the satisfaction of the Owner's Representative.
- D. Unstable areas and areas requiring additional compaction, as identified by the Owner's Representative, shall be corrected by the Contractor to the satisfaction of the Owner's Representative.

3.05 SURVEY CONTROL AND CONSTRUCTION TOLERANCES

- A. The Contractor shall survey the elevation and centerline of the road constructed.

3.06 PROTECTION OF WORK

- A. The Contractor shall use all means necessary to protect completed work.
- B. In the event of damage to prior work, the Contractor shall make repairs and replacements to the satisfaction of the Owner's Representative and at no additional cost to the Owner.

END OF SECTION

SECTION 02390

ROCKS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes rubble mound with rocks.

1.2 REFERENCES

- A. American Association of State Highway and Transportation Officials:
1. AASHTO T90 - Standard Specification for Determining the Plastic Limit and Plasticity Index of Soils.
 2. AASHTO T99 - Standard Specifications for the Moisture-Density Relations of Soils Using a 2.5 kg (5.5 lb) Rammer and a 305 mm (12 in.) Drop.
 3. AASHTO T104- Standard Specification for Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate.
 4. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457 mm (18 in) Drop.
 5. AASHTO T236 - Standard Specification for Direct Shear Test of Soils under Consolidated Drained Conditions.
- B. ASTM International:
1. ASTM C295 - Standard Guide for Petrographic Examination of Aggregates for Concrete.
 2. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (5,600 kN.m/m³).
 3. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (2,700 kN.m/m³).
 4. ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
 5. ASTM D2922 - Standard Test Method for Density of Soil and Soil- Aggregate in Place by Nuclear Methods (Shallow Depth).
 6. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in place by Nuclear Methods (Shallow Depth).
 7. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
 8. ASTM D4992 - Standard Practice for Evaluation of Rock to Be Used for Erosion Control.
 9. ASTM D5121 - Standard Practice for Preparation of Rock Slabs for Durability Testing.
 10. ASTM D5312 - Standard Test Method for Evaluation of Durability of Rock for Erosion Control under Freezing and Thawing Conditions.
 11. ASTM D5313 - Standard Test Method for Evaluation of Durability of Rock for Erosion Control under Wetting and Drying Conditions.
 12. ASTM D6473 - Standard Test Method for Specific Gravity and Absorption of Rock for Erosion Control.
- C. British Standards:

1. BS812: Part 2 - Testing Aggregates: Methods for Determination of Density.
 2. BS812: Part 3 - Testing Aggregates: Methods for Determination of Mechanical Properties.
 3. BS6349-1-1: 2013 - Maritime Works. General. Code of Practice for Planning and Design for Operations.
 4. BS6349-1-3: 2012 - Maritime Works. General. Code of Practice for Geotechnical Design.
 5. BS6349-1-4: 2013 - Maritime Works. General. Code of Practice for Materials.
 6. BS6349-7 - Maritime Structures. Guide to the Design and Construction of Breakwaters.
- D. BS EN Standards:
1. BS EN 1097-2: 2010 - Tests for Mechanical and Physical Properties of Aggregates. Methods for the Determination and Resistance to Fragmentation.
 2. BS EN 1097-3: 1998 - Tests for Mechanical and Physical Properties of Aggregates. Determination of Loose Bulk Density and Voids.
 3. BS EN 1097-8: 2009 - Tests for Mechanical and Physical Properties of Aggregates. Determination of the Polished Stone Value.
- E. Coastal Engineering Manual: US Army Corps of Engineers. Engineer Research and Development Center.
- F. Shore Protection Manual: Volume I and Volume II - 1984: Department of the Army. US Army Corps of Engineers. Washington DC, 20314.

1.3 SUBMITALS

- A. General Requirements: Requirements for submittal procedures.
- B. Surveys and Investigations:
1. Detailed hydrographic survey of the site.
 2. Geotechnical investigation of the site.
 3. Wave height investigation where required.
 4. Any particular advanced site investigation needed to complete the design and construction of the breakwater.
- C. Design Review: Submit to the Engineer for approval, with all necessary shop drawings, additional documents and calculation notes, signed and sealed by professional Engineer.
- D. Shop Drawings:
1. Show complete layout plans.
 2. Indicate type of rocks, location, length, top level, natural ground level, water surface level, cross sections, details, etc.
 3. Include details for rock layers.
- E. Additional Documents:
1. Representative Rock Samples: Petro-graphic descriptions of representative rock samples prepared in accordance with ASTM C295.
 2. Rock Mass Discontinuities: A quantitative description of rock mass discontinuities prepared from rock outcrop and/or drill core in accordance with the suggested methods of the International Society of Rock Mechanics recommendations.
- F. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

- G. Manufacturer's Field Reports: Indicate field observations and conclusions as to compliance to specifications, action items, and resolution of installation issues.

1.4 SOURCE SAMPLING

- A. General Requirements: Quality requirements for Contractor's responsibilities.
- B. Inform the Engineer of proposed source of materials, and provide access for sampling at least two (2) weeks prior to commencing work.

1.5 CLOSEOUT SUBMITALS

- A. General Requirements: Execution requirements for submittals.
- B. Project Record Documents: Record actual location, layout and cross sections with all levels of the breakwater.

1.6 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing work of this section with minimum ten years documented experience.
- B. Installer: Company specializing in performing work of this section with minimum five years documented experience.
- C. Review the design and construct the rock layers under direct supervision of professional engineer experienced in design of this Work and approved by the Engineer.

PART 2 PRODUCTS

2.1 MATERIALS

- A. General Note: The Contractor shall follow closely the stone gradation and sizing shown on the drawings.
- B. Rock Materials - General: Rock used for construction shall be clean, sound, durable quarried rock free from earth or other soft or decomposed or injurious material, and shall show no cracks or fissures caused by the initial process of decomposition and shall not break down in the seawater existing at the site. The rock shall comply the following requirements:
 - 1. Shape of Pieces: The aspect ratio of the piece not greater than three (3).
 - 2. Specific Gravity: Rock material shall have an apparent specific gravity not less than 2.5.
 - a. Apparent Specific Gravity Ratio: $\frac{\text{Bulk density of the rock material at its natural moisture content in the quarry}}{\text{Density of pure water}}$
 - 3. Bulk Density: In accordance with the test for determination of relative density in BS812: Part 2.
 - 4. Water Absorption: When tested as set out in BS812: Part 2, rock for Armor shall not absorb more than two and a half percent (2.5 %) by weight.
 - 5. Aggregate Impact Value: When tested as set out in BS812: Part 3, rock for Armor shall have an aggregate impact value not greater than twenty percent (20 %) using the standard test fraction.
 - 6. Magnesium Sulfate Soundness: Rock materials shall not lose more than twelve percent (12 %) of its weight after five cycles.
 - 7. Slake Durability Index: Rock for Armor shall have a slake durability index of not less than ninety five percent (95 %) when using sea water at a temperature of 30°C.
 - 8. Grading: For classification grades of rock other than core materials, at least fifty percent (50 %) of the

pieces shall weigh more than the arithmetic mean of the limiting grading weight.

- C. Core Stone Underlayer: In addition to the general properties specified above, core stone material shall comply with the following requirements:
 - 1. It shall be free draining.
 - 2. If accepted by the Engineer to use pieces having a weight of less than 1 kg, they shall not be more than five percent (5%) of the material.
 - 3. The grading between the maximum and minimum sizes shall follow a smooth curve.
 - 4. The weight of the largest piece which will pass through the hole (i.e.: D50 size obtained from the grading curve) through which half the weight of the core material will pass, shall be as directed by the Engineer.
 - 5. The maximum dimension of any piece shall not exceed half the thickness of the layer or zone in which it is placed.
 - 6. Fine particles including dust and sand, should not be incorporated in the core.
- D. Armor Stone: In addition to the general properties specified above, armor stone material shall comply with the following requirements:
 - 1. Armor rock shall be durable, blasted limestone or granite. State and shale are not acceptable.
 - 2. Stones shall be fractured and angular. Field stone is not acceptable unless otherwise approved by the Engineer.
 - 3. Armor stone shall be free from cracks, seams and other defects which may impair durability.
 - 4. The largest dimension of each stone shall not exceed two times the smallest dimension.
 - 5. Los Angeles abrasion loss determined using ASTM procedures shall not exceed 35%.
- E. Breakwater Stone Weight and Armor Type:
 - 1. Quarry Run Material for the Core: As shown on the Drawings.
 - 2. Armor: As shown on the Drawings.
 - 3. Subject to the agreement of the Engineer, the maximum weight of pieces of core material may be varied provided all the specified requirements are met.

2.1 EQUIPMENT (IF REQUIRED)

- A. Land-Based Equipment:
 - 1. Crawler crane.
 - 2. Hydraulic excavators.
 - 3. Bulldozers.
 - 4. Tipper trucks.
- B. Floating Equipment:
 - 1. Floating crane.
 - 2. Tugboat.
 - 3. Hopper barge.

2.2 SAFETY PRECAUTIONS

- C. All personnel and equipment operators and drivers should wear hard hats.

- D. Crane driver, hydraulic excavator driver and bulldozer driver should wear soundproof earmuffs. Signaling system between each equipment driver and the other workers shall be provided.
- E. Crane load handlers should wear appropriate gloves.
- F. All floating equipment shall be equipped with the safety requirements stipulated for shipboard operations (life jackets, flares, raft, etc.) and including marine pollution (MARPOL) recommendations for the prevention of pollution.

PART 3 EXECUTION

3.2 EXAMINATION

- A. Verify site conditions.
- B. Note irregularities affecting Work of this section.
- C. Protect utilities and facilities from damage.

3.3 PREPARATION

- A. Identify required lines, levels, datum, etc.
- B. Remove any thin layer of loose or soft material existing above the hard foundation material, and expose the hard interface where the breakwater shall be built on.
- C. If the foundation material is very soft and thick, then place a geotextile filter mat under the breakwater construction area.

3.4 EXCAVATION

- A. If approved by the Employer to use materials excavated from site.
 - 1. Excavate and stockpile in approved area on site, fill material that is suitable for reuse as core material of the breakwater. Unsuitable material shall be disposed of off-site. Suitable fill material shall be clear of all foreign materials.
 - 2. Excavate and stockpile in approved area on site rock material that is suitable for reuse as armor stones of the breakwater.
 - 3. Make good all surfaces excavated to the satisfaction of the Engineer.

3.5 PLACEMENT OF CORE STONE

- A. Place core stone to lines, grades and dimensions as indicated on the drawings.
- B. Place core stone in thickness courses to total layer thickness, as shown on the drawing.
- C. Unless otherwise shown on the drawings, place core stone to the following slopes:
- D. Not steeper than 1.5 horizontal to 1 vertical.
- E. No allowance shall be made for material placed outside specified limits.

3.6 PLACEMENT OF ARMOR STONE

- A. Place armor stone to lines, grades and dimensions as indicated on the drawings.
- B. Place each armor stone in stable position.
- C. Place armor stone in thickness courses to total layer thickness, as shown on the drawing.

- D. Sort, fit and tightly key each rock to ensure stability of faces.
- E. Placement not deemed acceptable to the Engineer shall be removed and replaced at no additional cost.

3.7 TOLERANCES

- A. Completed component layers shall be within following tolerances of lines and grades as indicated:
 - 1. Armor: plus or minus 300 mm.
 - 2. Core and Underlayer: plus or minus 150 mm.

3.8 HAUL ROADS

- A. Construct and maintain necessary haul roads. Remove haul roads from site upon completion of works.
- B. Obtain approval from relevant local authorities and applicable agencies for using access roads to site.
- C. Repair any damage caused to roads or property as a result of hauling operations.

END OF SECTION

SECTION 02392

FABRICS (GEOTEXTILE AND GEOMEMBRANE)

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes Geotextile and Geomembrane.

1.2 REFERENCES

- A. ASTM International:
 - 1. ASTM D4355 - Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).
 - 2. ASTM D4491 - Standard Test Method for Water Permeability of Geotextiles by Permittivity.
 - 3. ASTM D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
 - 4. ASTM D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
 - 5. ASTM D4833 - Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
 - 6. ASTM D5199 - Standard Test Method for Measuring the Nominal Thickness of Geosynthetics.
 - 7. ASTM D6241 - Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile Related Products Using a 50 mm Probe.

1.3 SUBMITALS

- A. General Requirements: Requirements for submittal procedures.
- B. Design Review: Submit to the Engineer for approval, the review of design of the membranes (cross sections, length, levels, details, etc.) with all necessary shop drawings, additional documents and calculation notes, signed and sealed by professional Engineer.
- C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.
- D. Manufacturer's Field Reports: Indicate field observations and conclusions as to compliance to specifications, action items, and resolution of installation issues.

1.4 SOURCE SAMPLING

- A. General Requirements: Quality requirements for Contractor's responsibilities.
- B. Inform the Engineer of proposed source of materials, and provide access for sampling at least two (2) weeks prior to commencing work.

1.5 CLOSEOUT SUBMITTALS

- A. General Requirements: Execution requirements for submittals.
- B. Project Record Documents: Record actual location, layout and cross sections with all levels of the membranes.

1.6 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing work of this section with minimum ten

- years documented experience.
- B. Installer: Company specializing in performing work of this section with minimum five years documented experience.
 - C. Review the design and lay the membranes under direct supervision of professional engineer experienced in design of this Work and approved by the Engineer.

PART 2 PRODUCTS

2.1 MATERIALS

- A. General Note: The Contractor shall follow closely the stone gradation shown on the drawings.
- B. FPE (Flexible Polyethylene) geomembrane liner

Property	Test Method	Average Values 1.0mm
Thickness	EN 1849-2	1.0
Average Thickness Tolerance (%)	EN 1849-2*	±5
Tensile Strength at break MD (MPa)	ASTM D6693IV*	27 (-5%)
Tensile Strength at break TD (MPa)	ASTM D6693IV*	25 (-5%)
Elongation at break MD (%)	ASTM D6693IV**	1000 (-5%)
Elongation at break TD (%)	ASTM D6693IV**	1000 (-5%)
Puncture Resistance (N)	ASTM D 4833	240 (-5%)
Static Puncture (KN)	EN ISO 12236	2.4 (-5%)
Tear Resistance (N)	ASTM D1004	70 (-5%)
Modulus of Elasticity (MPa)	ASTM D6693	120 (±10%)

*Tensile properties:50mm/min, 33mm Gauge Length

**Tensile properties:50mm/min, 50mm Gauge Length

- C. Filter Fabric (Geotextile): Polypropylene; non-woven, non-biodegradable; resistant to biological and chemical sea water environment; and with the following minimum properties determined according to referenced standard test methods:

1.	Unit Weight	(ASTM D4533)	500 g/m².
2.	Thickness	(ASTM D5199)	4.2 mm.
3.	Grab Tensile Strength	(ASTM D4632)	1736 N.
4.	Grab Elongation	(ASTM D4632)	50 %.
5.	Puncture Strength	(ASTM D4833)	1112 N.
6.	Trapezoidal Tear	(ASTM D4533)	690 N.
7.	Water Flow Rate	(ASTM D4491)	2000 L/pm/m².
8.	UV Resistance	(ASTM D4355)	70 %.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify site conditions.
- B. Note irregularities affecting Work of this section.
- C. Protect utilities and facilities from damage.

3.2 PREPARATION

- A. Identify required lines, levels, datum, etc.
- B. Remove any thin layer of loose or soft material or any protrusions exceeding 10mm existing above the support.

3.3 TOLERANCES

- A. Overlaps: plus or minus 30mm.

PART 4 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide product by one of the following or approved equal:
 - 1. Afitex
- Or approved equal.

END OF SECTION

SECTION 02631

STORMWATER DRAINAGE SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes stormwater drainage concrete channels.
- B. Related Sections:
 - 1. Section 02315 - Excavation.
 - 2. Section 02320 - Backfill.
 - 3. Section 03200 - Concrete Reinforcement.
 - 4. Section 03300 - Cast-in-Place Concrete.

1.2 REFERENCES

- A. American Association of State Highway and Transportation Officials:
 - 1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.
 - 2. AASHTO M36/M36M - Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains.
 - 3. AASHTO M86M - Concrete Sewer, Storm Drain and Culvert Pipe (Metric).
 - 4. AASHTO M170M - Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric).
 - 5. AASHTO M196/M196M - Corrugated Aluminum Pipe for Sewers & Drains.
 - 6. AASHTO M198 - Joints for Circular Concrete Sewer and Culvert Pipe Using Flexible Watertight Gaskets.
 - 7. AASHTO M206M - Reinforced Concrete Arch Culvert Storm Drain, and Sewer Pipe (Metric).
 - 8. AASHTO M207M - Reinforced Concrete Elliptical Culvert, Storm Drain and Sewer Pipe (Metric).
 - 9. AASHTO M252 - Corrugated Polyethylene Drainage Tubing.
 - 10. AASHTO M264 - Acrylonitrile-Butadiene-Styrene (ABS) and Poly Vinyl Chloride (PVC) Composite Sewer Piping.
 - 11. AASHTO M278 - Class PS 50 Polyvinyl Chloride (PVC) Pipe.
 - 12. AASHTO M288 - Geotextiles.
 - 13. AASHTO M294 - Corrugated Polyethylene Pipe, 12- to 36-in Diameter.
- B. ASTM International:
 - 1. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 2. ASTM A746 - Standard Specification for Ductile Iron Gravity Sewer Pipe.
 - 3. ASTM C14M - Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe (Metric).
 - 4. ASTM C76M - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric).
 - 5. ASTM C443M - Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets (Metric).
 - 6. ASTM C564 - Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
 - 7. ASTM C969 - Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines.
 - 8. ASTM C969M - Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines (Metric).

9. ASTM C924 - Standard Practice for Testing Concrete Pipe Sewer Lines by Low-Pressure Air Test Method.
 10. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (5,600 kN.m/m³).
 11. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (2,700 kN.m/m³).
 12. ASTM D2235 - Standard Specification for Solvent Cement for Acrylonitrile- Butadiene-Styrene (ABS) Plastic Pipe and Fittings.
 13. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
 14. ASTM D2564 - Standard Specification for Solvent Cements for Poly Vinyl Chloride (PVC) Plastic Piping Systems.
 15. ASTM D2729 - Standard Specification for Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings.
 16. ASTM D2751 - Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings.
 17. ASTM D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly Vinyl Chloride (PVC) Pipe and Fittings.
 18. ASTM D2922 - Standard Test Method for Density of Soil and Soil- Aggregate in Place by Nuclear Methods (Shallow Depth).
 19. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
 20. ASTM D3034 - Standard Specification for Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings.
 21. ASTM D3350 - Standard Specification for Polyethylene Plastic Pipe and Fittings Materials.
 22. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
- C. LIBNOR Standards.

1.3 SUBMITTALS

- A. General Requirements: Requirements for submittals.
- B. Shop Drawings: Submit detailed shop drawings showing layout of each system, and connection details between different systems, if any.
- C. Product Data: Submit data indicating pipe and pipe accessories.
- D. Manufacturer's Installation Instructions: Submit special procedures required to install Products specified.
- E. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.4 CLOSEOUT SUBMITTALS

- A. General Requirements: Execution requirements for submittals.
- B. Project Record Documents:
 1. Accurately record actual locations of channels and pipes including runs, connections, manholes, inlets, outlets, and invert elevations.
 2. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with local relevant authorities' standards, as shown on drawings and to the satisfaction of the Engineer.
- B. Maintain one copy of each document on site.

1.6 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum ten years documented experience.
- B. Installer: Company specializing in performing work of this section with minimum five years documented experience.

1.7 PRE-INSTALLATION MEETINGS

- A. General Requirements: Administrative requirements for pre-installation meeting.
- B. Convene minimum one week prior to commencing work of this section.

1.8 DELIVERY, STORAGE AND HANDLING

- A. General Requirements: Product requirements for transporting, handling, storing and protecting products.
- B. Block individual and stockpiled pipe lengths to prevent moving.
- C. Do not place materials on private property or in areas obstructing pedestrian or vehicle traffic.
- D. Do not place pipe flat on ground. Cradle to prevent point stress.
- E. Store UV sensitive materials out of direct sunlight.

1.9 COORDINATION

- A. General Requirements: Administrative requirements for coordination.
- B. Coordinate unrecorded or variations in site conditions, and corresponding adjustments to construction requirements.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.
- B. Furnish materials as specified, as shown on the drawings, to the satisfaction of the Engineer, and in accordance with local relevant authorities' standards.

2.2 STORMWATER DRAINAGE CHANNELS

- C. Concrete: As specified in Section 03300.
- D. Reinforcement: As specified in Section 03200.
- E. Bituminous Paint to Concrete External Surfaces in Contact with Soil: Fluid, cold applied, quick setting. Primer type shall be compatible with the bituminous paint.
- F. Cast-In-Situ or Precast Concrete Covers: As specified in Section 03300; size and shape as directed by the Engineer.

2.3 BACKFILL MATERIALS

- G. Soil Backfill above Pipe Cover to Finish Grade: As specified in Section 02320.

PART 3 EXECUTION

3.2 EXAMINATION

- A. General Requirements: Administrative requirements for verification of existing conditions before starting work.
- B. Verify trench cut and excavation base is ready to receive work and excavations, dimensions, and elevations are as indicated on drawings.

3.3 PREPARATION

- A. Hand trim excavations to required elevations. Correct over excavation with lean concrete.
- B. Remove large stones and other hard or organic matter capable of damaging piping or impeding consistent backfilling or compacting.

3.4 EXCAVATION

- A. Excavate trenches for concrete channels in accordance with Section 02315.
- B. Hand trim excavation for accurate placement of earth channels, pipe, box culvert and concrete channels to elevations indicated. Remove water entering the site to maintain dry conditions and to preserve final grades at bottom of excavation.
- C. Provide sheeting and shoring, if required, in accordance with Section 02315.

3.5 INSTALLATION - CONCRETE CHANNEL

- A. Cast-in-place plain concrete for foundation beds and reinforced concrete channels in accordance with Section 03300.
- B. Prime and paint exterior surfaces in contact with soil with two cross coats of an approved bituminous paint. Spread to a minimum cured thickness and averaging thickness as recommended by the manufacturer.
- C. Install precast concrete covers and metal gratings (if any) with all necessary supports, angles, anchors and accessories.

3.6 BACKFILLING

- A. Backfill at sides of concrete channel to finished grade as per Section 02320.
- B. Maintain optimum moisture content of bedding to attain required compaction density.

3.7 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements and execution requirements for field inspecting, testing, adjusting and balancing.
- B. Request inspection prior to and immediately after placing pipe cover.
- C. Compaction Testing: In accordance with Section 02320.
- D. When tests indicate work does not meet specified requirements, remove work, replace and retest.
- E. Pipe Infiltration Test: Test in accordance with ASTM 969M.
- F. Pipe Deflection Test: Test in accordance with approved standard.
- G. Pipe Pressure Test: Test in accordance with ASTM C924 and ASTM 1103M, depending on size of pipe.

3.8 PROTECTION OF FINISHED WORK

- A. General Requirements: Execution requirements for protecting finished Work.
- B. Protect each stormwater drainage system from damage and/or displacement prior, during and until backfilling operation is complete. Repair channel and pipe that are damaged and/or displaced.

END OF SECTION

SECTION 02711

GEOTEXTILE FILTER

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and installation equipment necessary for the installation of the geotextile filter (geotextiles), as specified, herein, and as shown on the Drawings.
- B. The Contractor shall coordinate the installation of the geotextiles with other construction activities.
- C. Notwithstanding the prequalification of any geotextile material, the Contractor shall be entirely responsible for meeting the requirements of this Section.

1.02 RELATED SECTIONS

- A. Section 01050 - Surveying
- B. Section 02200 - Earthwork
- C. Section 02226 - Road Rock

1.03 MEASUREMENT AND PAYMENT

(Intentionally left blank)

1.04 REFERENCES

- A. Engineering Drawings
- B. Latest version of American Society for Testing and Materials (ASTM) standards:
 - 1. ASTM D 3776. Standard Test Method for Measuring Mass Per Unit Area of Geotextiles.
 - 2. ASTM D 3786. Standard Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabric –Diaphragm Bursting Strength Tester Method.
 - 3. ASTM D 4491. Standard Test Method for Water Permeability of Geotextiles by Permittivity.
 - 4. ASTM D 4533. Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
 - 5. ASTM D 4632. Standard Test Method for Breaking Load and Elongation of Geotextiles (Grab Method).
 - 6. ASTM D 4833. Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
 - 7. ASTM D 4751. Standard Test Method for Determining Apparent Opening Size of a Geotextile.

1.05 SUBMITALS

- A. The Contractor shall submit to the Owner's Representative at least ten days prior to geotextile placement the following regarding the geotextile material proposed for use:
 - 1. certified minimum property values of the proposed geotextiles and the tests used to determine those properties; and
 - 2. projected geotextile delivery dates for this project.
- B. At least two days prior to geotextile placement, the Contractor shall submit to the Owner's Representative the manufacturing quality control certificates for each shift's production of geotextiles. The certificates shall be signed by responsible parties employed by the geotextile manufacturer (such as the production manager), and notarized.
 - 1. The quality control certificates shall include:

2. lot, batch, or roll numbers and identification;
 3. sampling procedures; and
 4. results of quality control tests, including a description of the test methods used.
- C. If the work of this Section is interrupted for reasons other than inclement weather, the Contractor shall notify the Owner's Representative a minimum of 24 hours prior to his resumption of work.

1.06 QUALITY ASSURANCE

- A. It is the responsibility of the Contractor to ensure that the materials and methods used for construction of the geotextile separator or filter meet the requirements of the Drawings and Specifications. Any material or method that does not conform to these documents, or to alternatives approved by the Owner's Representative, will be rejected by the Owner's Representative and shall be repaired or replaced by the Contractor at no additional cost to the Owner.
- B. The Contractor shall be aware that monitoring and field/laboratory conformance testing may be required by the Owner. This monitoring and testing, including random conformance testing of construction materials and completed work, would be performed by the Owner's Representative. If nonconformance's or other deficiencies are found in the Contractor's materials or completed work, the Contractor will be required to repair or replace the deficiency at no additional cost to the Owner.

PART 2 - PRODUCTS

2.01 GEOTEXTILE PROPERTIES

- A. Unless otherwise noted on the Drawings, geotextiles suppliers shall furnish materials whose "Minimum Average Roll Values", as defined by the Federal Highway Administration (FHWA), meet or exceed the criteria specified in Table 02710-1. The manufacturer shall provide test results for these procedures, as well as a certification that the material properties meet or exceed the specified values. The geotextiles provided by the supplier shall be stock products. The supplier shall not furnish products specifically manufactured to meet the specifications of this project unless authorized by the Owner's Representative.
- B. The geotextiles shall be a nonwoven material, suitable for use in separation and filter applications.
- C. In addition to the property values listed in Table 02710-1, the geotextiles shall retain their structure during handling, placement, and long-term service. The geotextile shall also be resistant to ultra-violet (UV) light degradation due to 30 days exposure at the project site.
- D. The geotextile shall be manufactured from new, first quality polymers, with not more than 5% reclaimed polymer used in production.

2.02 MANUFACTURING QUALITY CONTROL

- A. The geotextile shall be manufactured with quality control procedures that meet or exceed generally accepted industry standards.
- B. The Contractor shall require that the geotextile manufacturer sample and test the geotextile to demonstrate that the material conforms to the requirements of this Construction Specification.
- C. Any geotextile sample that does not comply with this Construction Specification shall result in rejection of the roll from which the sample was obtained. The Contractor shall replace any rejected rolls at no additional cost to the Owner.
- D. If a geotextile sample fails to meet the quality control requirements of this Construction Specification or any Supplemental Specifications, the Contractor shall require that geotextile manufacturer sample and test each roll manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established.

- E. Additional sample testing may be performed, at the geotextile manufacturer's discretion and expense, to more closely identify any non-complying rolls and/or to qualify individual rolls.
- F. Sampling shall, in general, be performed on sacrificial portions of the geotextile material such that repair is not required. The Contractor shall require that the geotextile manufacturer sample and test the geotextile, at a minimum, once every 50,000 ft² to demonstrate that its properties conform to the values specified in Table 02710-1. At a minimum, the following manufacturing quality control tests shall be performed:

Procedure

Mass per unit area	ASTM D 3776
Grab strength	ASTM D 4632
Tear strength	ASTM D 4533
Puncture strength	ASTM D 4833

2.03 PACKING AND LABELING

- A. Geotextiles shall be supplied in rolls wrapped in relatively impermeable and opaque protective covers.
- B. Geotextiles rolls shall be marked or tagged with the following information:
 - 1. manufacturer's name;
 - 2. product identification;
 - 3. lot or batch number;
 - 4. roll number; and
 - 5. roll dimensions.
- C. If any special handling is required, it shall be so marked on the geotextiles itself; e.g., "This Side Up" or "This Side Against Soil to be Retained".

2.04 TRANSPORTATION

- A. Transportation of the geotextiles is the responsibility of the Contractor. The Contractor shall be liable for any damage to the materials incurred prior to and during transportation to the site.

2.05 HANDLING AND STORAGE

- A. Handling, storage, and care of the geotextiles prior to and following installation at the site, is the responsibility of the Contractor. The Contractor shall be liable for any damage to the materials incurred prior to final acceptance by the Owner's Representative.
- B. The Contractor shall be responsible for storage of the geotextiles material at the site.
- C. The geotextiles shall be protected from sunlight, moisture, excessive heat or cold, puncture, or other damaging or deleterious conditions. The geotextiles shall be protected from mud, dirt, and dust. Any additional storage procedures required by the geotextile manufacturer shall be the Contractor's responsibility.

PART 3 - EXECUTION

3.01 FAMILIARIZATION

- A. Prior to implementing any of the work described in this Section, the Contractor shall become thoroughly familiar with all portions of the work falling within this Section and general requirements as detailed in relevant Section of these Specifications.
- B. Inspection:
 - 1. Prior to implementing any work of this Section, the Contractor shall carefully inspect the installed work of all other Sections and verify that all such work is complete to the point where the installation of this Section may properly commence without adverse impact.
 - 2. If the Contractor has any concerns against the installed work of other Sections or the site, he shall notify the Owner's Representative prior to commencing the work. Failure to notify the Owner's

Representative of installation of the geotextiles will be construed as Contractor's acceptance of the related work of all other Sections.

3.02 HANDLING AND PLACEMENT

- A. Geotextile installation shall not commence until quality control and conformance evaluations by the Owner's Representatives of previous work are complete, including evaluations of the Contractor's survey results to confirm that the previous work was constructed to the required grades, elevations, and thicknesses. Should the Contractor begin the work of this Section prior to the completion of quality control and conformance evaluations, he does so at his own risk. The Contractor shall account for the quality control and conformance evaluations in his schedule.
- B. The Contractor shall handle all geotextiles in such a manner as to ensure they are not damaged in any way.
- C. The Contractor shall take any necessary precautions to prevent damage to underlying layers during placement of the geotextiles.
- D. After unwrapping the geotextiles from its opaque cover, the geotextiles shall not be left exposed for a period in excess of 10 days unless a longer exposure period is approved by the Owner's Representative.
- E. If white colored geotextiles is used, precautions shall be taken against "snowblindness" of personnel.
- F. The Contractor shall take care not to entrap stones, excessive dust, or moisture in the geotextiles during placement.
- G. The Contractor shall anchor or weight all geotextile with sandbags, or the equivalent, to prevent damage from wind. Such sandbags shall be installed during placement and shall remain until replaced with excavated soil for the temporary storage area.
- H. The Contractor shall examine the entire geotextiles surface after installation to ensure that no potentially harmful foreign objects are present. The Contractor shall remove any such foreign objects and shall replace any damaged geotextiles.

3.03 SEAMS AND OVERLAPS

- A. Nonwoven geotextiles shall be continuously sewn (i.e., spot sewing is not allowed) using either a "double prayer" or "single-J" seam. Geotextiles shall be overlapped a minimum 6 inches prior to seaming.
- B. Nonwoven geotextiles shall be sewn with polymeric thread, having chemical resistance properties equal to or exceeding those of the geotextiles, shall be used for all sewing. The seams shall be sewn using Stitch Type 401.

3.04 REPAIR

- A. Any holes or tears in the geotextiles shall be repaired using a patch made from the same geotextiles. Geotextiles patches shall extend a minimum of 1 ft beyond the damaged area. Geotextiles patches will be sewn into place no closer than 1 in. from any panel edge. Should any tear exceed 50% of the width of the roll, that roll will be removed from the slope and replaced.
- B. Care shall be taken to remove any soil or other material which may have penetrated the torn geotextiles.
- C. The Owner's Representative will observe any repair and note any noncompliance with the above requirements.

3.05 PLACEMENT OF SOIL MATERIALS

- A. The Contractor shall place soil materials on top of geotextiles in such a manner as to ensure that:
 - 1. the geotextiles are not damaged; and
 - 2. excess stresses are not produced in the geotextiles.
- B. Equipment shall not be driven directly on the geotextile. Unless otherwise specified by the Owner's Representative, all equipment operating on materials overlying the geotextile filter only shall

comply with the following:

Maximum Allowable Equipment Ground Pressure (psi)	Thickness of Overlying Fill (in inches)
<5	12
<10	18
<20	24
>20	36

A. PROTECTION OF WORK

- A. The Contractor shall use all means necessary to protect all completed work.
- B. In the event of damage to prior work, the Contractor shall make repairs and replacements to the satisfaction of the Owner's Representative and at no additional cost to the Owner.

Table 02710-1. Required Property Values for Geotextile Filter.

<u>PROPERTIES</u>	<u>QUALIFIER</u>	<u>UNITS</u>	<u>SPECIFIED VALUES (4)</u>	<u>TEST METHOD</u>
Type	---	nonwoven needlepunched	---	---
Polymer composition	minimum	%	95 polypropylene or polyester by weight	----
M~ per unit area	minimum	oz/yd ²	7	ASTM D 3776
<u>Filter Requirements</u>				
Apparent opening size	maximum	(mm)	0 ₉₅ _ 0.21 mm	ASTM D4751
Permittivity	minimum	(sec ⁻¹)	0.5	ASTM D4491
<u>Mechanical Requirements</u>				
Grab strength	minimum	lb	180	ASTM D 4632(1)
Tear strength	minimum	lb	60	ASTM D 4533(2)
Puncture strength	minimum	lb	80	ASTM D 4833(3)
Burst strength	minimum	psi	300	ASTM D 3786

Notes:

- (1) Minimum of values measured in machine and cross machine directions with 1 inch clamp on Constant Rate of Extension (CRE) machine.
- (2) Minimum value measured in machine and cross machine direction.
- (3) Tension testing machine with a 1.75-inch diameter ring clamp, the steel ball being replaced with 0.31-inch diameter solid steel cylinder with flat tip centered within the ring clamp.
- (4) All values represent minimum average roll values (i.e., any roll in a lot should meet or exceed the values in this table)

END OF SECTION

SECTION 02718

HIGH DENSITY POLYETHYLENE PIPE AND FITTINGS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and installation equipment necessary for installation of all high density polyethylene (HDPE) pipe, fittings and appurtenances as specified herein, as shown on the Drawings.
- B. The Contractor shall coordinate the installation of the HDPE pipe and fittings with other construction activities and subcontractors at the site.

1.02 RELATED SECTIONS

- A. Section 02200 - Earthwork
- B. Section 02210 - Structural Fill
- C. Section 02225 - Bedding Gravel
- D. Section 02290 - Erosion and Sediment Control
- E. Section 02221 -Trenching
- F. Section 02225 - Pipe Bedding Material
- G. Section 02718- Corrugated High Density Polyethylene Pipe and Fittings

1.03 MEASUREMENT AND PAYMENT

(Intentionally left blank)

1.04 REFERENCES

- A. Engineering Drawings
- B. Latest version of the American Society for Testing and Materials (ASTM) standards:
 - 1. ASTM D 1248 Standard Specification for Polyethylene Plastics Molding and Extrusion Materials.
 - 2. ASTM D 1603 Standard Test Method for Carbon Black in Olefin Plastics
 - 3. ASTM D 1693 Standard Test Method for Environmental Stress- Cracking of Ethylene Plastics
 - 4. ASTM D 2657 Standard Practice for Heat-Joining for Polyolefin Pipe and Fittings
 - 5. ASTM D 2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials
 - 6. ASTM D 3350 Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
 - 7. ASTM F 714 Standard Specification for Polyethylene (PE) Plastics Pipe (SDR-PR) Based on Outside Diameter

1.05 WARRANTY

- A. The Contractor shall furnish the Owner's Representative written warranties obtained from the Manufacturer and the Installer against defects in materials and workmanship in accordance with ASTM D 3350 and ASTM F 714. Warranty conditions proposed by the Manufacturer or Installer concerning limits of liability will be evaluated and must be acceptable to the Owner's Representative.

1.06 RESPONSIBILITY

- A. The Contractor shall provide the services of a HDPE pipe and fittings manufacturer (Manufacturer),

and installer (Installer). The Contractor shall, however, accept and retain full responsibility for all materials and installation and shall be held responsible for any defects in the completed HDPE pipe and fittings.

- B. The Manufacturer shall be responsible for the production and delivery of the HDPE pipe and fittings and shall be a well-established firm with more than two years experience in the manufacture of HDPE pipe and fittings.
- C. The Installer shall be responsible for field handling, storing, installing, and other site aspects of the installation of the HDPE pipe and fittings.

1.07 SUBMITTALS

- A. The Contractor shall submit to the Owner's Representative for approval within 14 days after signing of the Contract and at least 28 days before the start of work, complete, detailed shop drawings of all HDPE pipe and fittings, a list of materials to be furnished, the names of the suppliers and the proposed dates of delivery of the materials to the site.
- B. The Contractor shall submit to the Owner's Representative the HDPE pipe Manufacturer's certification of compliance with these Specifications for all materials delivered to the site, and shall comply with the HDPE pipe Manufacturer's recommendations for handling, storing, and installing HDPE pipes and fittings.
- C. The Contractor shall submit to the Owner's Representative in writing the following documentation from the HDPE pipe Manufacturer on the raw materials used to manufacture the HDPE pipe and fittings prior to transporting any HDPE pipe or fittings to the site:
 - 1. certificate stating the specific resin, its source and the information required by ASTM D 1248; and
 - 2. certification that no recycled compound has been added to the resin.
- D. The Contractor shall submit certification from the HDPE pipe Manufacturer that stress regression testing has been performed on the specific product in accordance with ASTM D 2837. The Manufacturer shall supply HDPE pipe having a minimum Hydrostatic Design Basis (HDB) of 1,600 psi, as determined in accordance with ASTM D 2837.

1.08.1 QUALITY ASSURANCE

- A. It is the responsibility of the Contractor to ensure that the materials and methods used for construction meet the requirements of the Drawings and Specifications. Any material or method that does not conform to these documents, or to alternatives approved by the Owner's Representative, will be rejected by the Owner's Representative and shall be repaired or replaced by the Contractor at no additional cost to the Owner.
- B. The Contractor shall be aware that monitoring and field/laboratory conformance testing may be required by the Owner. This monitoring and testing, including random conformance testing of construction materials and completed work, would be performed by the Owner's Representative. If non-conformances or other deficiencies are found in the Contractor's materials or completed work, the Contractor will be required to repair or replace the deficiency at no additional cost to the Owner.

.PART 2 - PRODUCTS

2.01 HIGH DENSITY POLYETHYLENE COMPOUND

- A. The HDPE pipe and fittings shall be manufactured from new, high performance, high molecular weight, HDPE resin conforming to ASTM D 1248 (Type III, Class C Category 5, Grade P 34), ASTM D 3350 (Cell Classification PE 345434C), and having a Plastic Pipe Institute (PPI) Rating of PE 3408. The resin shall be pre-compounded. In plant blending of non-compounded resins shall not be permitted.
- B. The polyethylene compound shall contain a minimum of 2% carbon black.
- C. The polyethylene compound shall have a minimum resistance of 125 hours when tested for environmental stress crack in accordance with requirements of ASTM D 1693, Procedure B

2.02 HIGH DENSITY POLYETHYLENE PIPES AND FITTINGS

- A. All HDPE pipe and fittings shall comply with the ASTM F 714.
- B. All HDPE pipe and fittings shall have a minimum Standard Dimension Ratio (SDR) of 15.5 unless otherwise stated on the Drawings.
- C. HDPE pipe shall be supplied in standard laying lengths not exceeding 50 feet.
- D. HDPE pipes and fittings shall be homogeneous throughout and free of visible cracks, holes (other than intentional manufactured perforations), foreign inclusions, or other deleterious effects, and shall be uniform in color, density, melt index and other physical properties.
- E. Fittings at the ends of pipes shall consist of HDPE end caps unless indicated otherwise on the Drawings.

2.03 IDENTIFICATION

- A. The following shall be continuously indent printed on the pipe, or spaced at intervals not exceeding 5 feet:
 - 1. name and/or trademark of the pipe manufacturer;
 - 2. nominal pipe size;
 - 3. standard dimension ratio (SDR);
 - 4. the letters PE followed by the polyethylene grade per ASTM D 1248, followed by the Hydrostatic Design Stress in 100's of psi (e.g., PE 3408);
 - 5. manufacturing Standard Reference (e.g., ASTM F-714-1); and
 - 6. a production code from which the date and place of manufacture can be determined.

2.04 PIPE BEDDING MATERIAL

- A. Pipe bedding material shall be as specified in Section 02225.

PART 3 - EXECUTION

3.01 FAMILIARIZATION

- A. Prior to implementing any of the work described in this Section, the Contractor shall become thoroughly familiar with all portions of the work falling within this Section.
- B. Inspection:
 - 1. Prior to implementing any of the work in this Section, the Contractor shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this section may properly commence without adverse impact.
 - 2. if the Contractor has any concerns regarding the installed work of other Sections, the Contractor shall notify the Owner's Representative in writing within 48 hours of the site inspection. Failure to inform the Owner's Representative in writing or proceeding with installation of the polyethylene pipes and fittings will be construed as Contractor's acceptance of the related work of all other Sections.

3.02 HANDLING AND PLACEMENT

- A. The Contractor shall exercise care when transporting, handling and placing HDPE pipe and fittings, such that they will not be cut, kinked, twisted, or otherwise damaged.
- B. Ropes, fabric or rubber-protected slings and straps shall be used when handling HDPE pipe. Slings, straps, etc. shall not be positioned at butt-fused joints. Chains, cables or hooks shall not be inserted into the pipe ends as a means of handling pipe.
- C. Pipe or fittings shall not be dropped onto rocky or unprepared ground. Under no circumstances shall pipe or fittings be dropped into trenches, or dragged over sharp and cutting objects.
- D. HDPE pipe shall be stored on clean level ground, preferably turf or sand, free of sharp objects, which could damage the pipe. Stacking shall be limited to a height that will not cause excessive deformation of the bottom layers of pipes under anticipated temperature conditions. Where

- necessary, due to ground conditions, the pipe shall be stored on wooden sleepers, spaced suitably and of such width as not to allow deformation of the pipe at the point of contact with the sleeper or between supports. The pipes should be stored out of direct sunlight.
- E. The maximum allowable depth of cuts, gouges or scratches on the exterior surface of HDPE pipe or fittings is 10 percent of the wall thickness. The interior of the pipe and fittings shall be free of cuts, gouges and scratches. Sections of pipe with excessive cuts, gouges or scratches shall be removed and the ends of the pipe rejoined at no cost to the Owner.
- F. Whenever pipe laying is not actively in progress, the open end of pipe that has been placed shall be closed using a watertight plug.

3.03 INSTALLATION

- A. General:
1. All HDPE pipe and fittings shall be installed in accordance with the Manufacturer's instructions.
 2. The Contractor shall carefully examine all pipe and fittings for cracks, damage or defects before installation. Defective materials shall be immediately removed from the site and replaced at no cost to the Owner.
 3. The interior of all pipe and fittings shall be inspected, and any foreign material shall be completely removed from the pipe interior before it is moved into final position.
 4. Field-cutting of pipes, where required, shall be made with a machine specifically designed for cutting pipe. Cuts shall be carefully made, without damage to pipe or lining, so as to leave a smooth end at right angles to the axis of pipe. Cutter ends shall be tapered and sharp edges filed off smooth. Flame cutting will not be allowed.
 5. All pipe and fittings shall be laid or placed to the lines and grades shown on the Drawings with bedding and backfill shown on the Drawings and as specified in this Section.
 6. No pipe shall be laid until the Owner's Representative has approved the bedding conditions.
 7. No pipe shall be brought into position until the preceding length has been bedded and secured in its final position.
 8. Blocking under piping shall not be permitted unless specifically accepted by the Engineer for special conditions.
 9. The Contractor shall provide all necessary adapters and/or connection pieces required when connecting different types and sizes of pipe or when connecting pipe made by different manufacturers.

3.04 JOINTS AND CONNECTIONS

- A. HDPE pipe shall be joined with thermal butt-fusion joints. All joints shall be made in strict compliance with ASTM D 2657 and the manufacturer's recommendations and shall be performed by the manufacturer's authorized, trained fusion personnel. Mechanical connections of HDPE pipe to auxiliary equipment such as valves, flow meters, pumps and tanks shall consist of the following unless otherwise specified by the Owner or the Owner's Representative:
1. An HDPE flange connection, called a stub end, shall be butt-fused to the HDPE pipe. Outside diameter and drillings shall comply with ANSI B16.1.
 2. A 316 stainless steel back-up flange shall be provided. Outside diameter and drillings shall comply with ANSI B16.6.
 3. Other mechanical couplings, such as 360 degree full circle clamps, shall only be used if approved by the Owner or Owner's Representative.
- B. Polyethylene stub ends and flanges must be at the ambient temperature of the surrounding soil at the time they are bolted tight to prevent relaxation of the flange bolts and loosening of the joint due to thermal contraction of the polyethylene. Bolts shall be drawn up evenly and in line.

3.05 TESTING OF HDPE PIPE AND FITTINGS

- A. General:
 - 1. All non-perforated pipe and fittings shall be pressure tested by the Contractor prior to placing fill over the pipe.
 - 2. The Project Manager and CQA Consultant shall be notified a minimum of 24 hours in advance of any testing.
 - 3. The Contractor shall provide all testing apparatus, including pumps, hoses, gauges, taps, plugs, drains, temporary connections, and fittings.
 - 4. All tests shall be performed in the presence of the CQA Consultant.
 - 5. HDPE pipe with thermal butt-fusion type joints shall be tested at 1 1/2 times the working pressure.
 - 6. Test duration shall be a minimum of three hours after the pressure in the pipe stabilizes. The test duration does not include the initial expansion phase after the pipe is first pressurized. The duration of the expansion phase will be in keeping with the pipe Manufacturer's recommendations.
 - 7. Criteria for acceptance of the pressure-test results shall be established using the pipe Manufacturer's recommendations. Criteria must be approved by the Owner's Representative.
- B. Repair
 - 1. Installed pipes or pipe joints that leak, according to the test results, shall be either repaired to the satisfaction of the Owner's Representative or replaced at no cost to the Owner.
 - 2. Repaired or replaced pipe shall be successfully pressure-tested prior to filling over the pipe.

3.06 PRODUCT PROTECTION

- A. The Contractor shall use all means necessary to protect all prior work and materials and completed work of other Sections.
- B. In the event of damage to prior work or work completed as specified in this Section, the Contractor shall immediately make all repairs and replacements necessary, to the approval of the Owner's Representative at no additional cost to the Owner.

END OF SECTION

SECTION 02735

GEOCOMPOSITE LAYERS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and installation equipment necessary for the installation of a geocomposite drainage layer as specified herein, as shown on the Drawings, and in accordance with the Construction Quality Assurance (CQA) Plan.
- B. The Contractor shall coordinate the installation of the geocomposite layer (drainage, gas, ...) with other construction activities and subcontractors at the site.

1.02 RELATED SECTIONS

- A. Section 02392 - Fabrics
- B. Section 02265 – Top Soil
- C. Section 02250 - Final Cover Protective Layer

1.03 PAYMENT AND MEASUREMENT

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1.04 REFERENCES

Design Reports

- A. Construction Quality Assurance (CQA) Plan.
- B. Latest version of American Society for Testing and Materials (ASTM) standards:
 - 1. ASTM D 1238. Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.
 - 2. ASTM D 1505. Standard Test Method for Density of Plastics by the Density-Gradient Technique.
 - 3. ASTM D 4716. Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile Related Products.
 - 4. ASTM D 1603. Standard Test Method for Carbon Black in Olefin Plastics.
 - 5. ASTM D 3786. Standard Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabric -Diaphragm Bursting Strength Tester Method.
 - 6. ASTM D 4491. Standard Test Method for Water Permeability of Geotextiles by the Permittivity Method.
 - 7. ASTM D 4533. Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
 - 8. ASTM D 4632. Standard Test Method for Breaking Load and Elongation of Geotextiles (Grab Method).
 - 9. ASTM D 4751. Standard Test Method for Determining Apparent Opening Size of a Geotextile.
 - 10. ASTM D 4833. Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
 - 11. ASTM F 904. Standard Test Method for Comparison of Bond Strength or Ply Adhesion of Similar Laminates Made from Flexible Materials.
 - 12. ASTM D 1777. Standard Method for Measuring Thickness of Textile Materials.
 - 13. ASTM D 3776. Standard Test Method for Measuring Mass Per Unit Area

(Weight) of Woven Fabric.

1.05 WARRANTY

- A. The Contractor shall furnish the Owner written warranties obtained from the Manufacturer and the Installer against defects in materials and workmanship. Warranty conditions proposed by the Manufacturer or Installer concerning limits of liability will be evaluated and must be acceptable to the Owner.

1.06 RESPONSIBILITY

- A. The Contractor shall provide the services of a geocomposite layer manufacturer (Manufacturer), fabricator (Fabricator), and installer (Installer), who shall meet the following qualifications specified in relevant Section. The Contractor shall, however, accept and retain full responsibility for all materials and installation and shall be held responsible for any defects in the underlying materials.
- B. The Manufacturer shall be responsible for the production and delivery of geocomposite rolls and shall be a well-established firm with more than ten years experience in the manufacture of geocomposite.
- C. The Fabricator, if used, shall be responsible for the fabrication of geocomposite layer panels. The Fabricator shall be a well established firm with more than ten years experience in the fabrication of geocomposite panels.
- D. The Installer shall be responsible for field handling, storing, deploying, seaming or connecting, temporary restraining (against wind), anchoring, and other site aspects of the geocomposite layer.

1.07 SUBMITTALS

- A. The Contractor shall submit to the Owner in writing the following documentation on the raw materials used to manufacture the geonet prior to the confirmation of any contractual agreements:
 - 1. Copies of quality control certificates issued by the resin supplier including production dates of the resin.
 - 2. Results of tests conducted to verify the quality of the resin used to manufacture the geonet for the geocomposite layer rolls assigned to the project.
 - 3. Certification that no reclaimed polymer is added to the resin during the manufacture of the geonet to be used in this project. The use of polymer recycled during the manufacturing process may be permitted if performed with appropriate cleanliness and if the recycled polymer does not exceed 2% by weight of the total polymer weight.
- B. The Contractor shall submit to the Owner and CQA Consultant the following information on the geotextile:
 - 1. Copies of quality control certificates issued by the geotextile manufacturer the certificate should include roll number and identification.
 - 2. The quality control certificate shall include:
 - a. roll numbers lot or batch numbers and identification;
 - b. sampling procedures; and
 - c. results of quality control tests, including descriptions of test methods used.
- C. The Contractor shall submit to the Owner the following regarding the Manufacturer prior to the confirmation of any contractual agreements:
 - 1. certified minimum property values of proposed geocomposite layer material and the tests used to determine those properties; and
 - 2. production capacity available and projected delivery dates for this project.
- D. The Contractor shall submit to the Owner the following information regarding the Installer prior to the confirmation of any contractual agreements:
 - 1. corporate background and information;
 - 2. copy of Installer's letter of approval or license by the Manufacturer; and
 - 3. a list of at least ten completed facilities for which the Installer has installed a minimum of 500,000

- square meters of geocomposite layer.
- E. The Contractor shall submit to the Owner and CQA Consultant the following information on geocomposite production:
1. Manufacturing quality control certificates for each shift's production, signed by responsible parties employed by the Manufacturer (such as the production manager), and notarized.
 2. The quality control certificate shall include:
 - a. roll numbers and identification;
 - b. sampling procedures; and
 - c. results of quality control tests, including descriptions of test methods used.

1.08 CONSTRUCTION QUALITY ASSURANCE

- A. The installation of the geocomposite layer shall be monitored by the CQA Consultant as specified in this Section and as outlined in the CQA Plan.
- B. The Contractor shall be aware of the activities outlined in the CQA Plan and shall account for these CQA activities in the installation schedule.

PART 2 - PRODUCT

2.01 GEOCOMPOSITE PROPERTIES

- A. The Manufacturer shall furnish geocomposite having properties that comply with the required property values shown in Table 02735-1. The Manufacturer shall provide test results for these procedures, as well as certification that the materials meet or exceed the specified values.
- B. In addition to the property values listed in Table 02735-1, the geocomposite shall:
1. Retain its structure during handling, placement, and long-term service.
 2. Be capable of withstanding outdoor exposure for a minimum of 30 days with no measurable deterioration.
- C. During shipment and storage, the geocomposite shall be protected from mud, dirt, dust, cutting, or other damaging or deleterious conditions.

2.02 MANUFACTURING QUALITY CONTROL

- A. The geocomposite shall be manufactured with quality control procedures that meet generally accepted industry standards.
- B. The Geocomposite Manufacturer shall sample and test the geocomposite to demonstrate that the material conforms to the requirements of this General Specification.
- C. Any geocomposite sample that does not comply with this General Specification shall result in rejection of the roll from which the sample was obtained. Any rejected rolls shall be replaced at no additional cost to the Owner.
- D. If a geocomposite sample fails to meet the quality control requirements of this General Specification, the Geocomposite Manufacturer shall sample and test each roll manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established.
- E. Additional sample testing may be performed, at the Geocomposite Manufacturer's discretion and expense, to more closely identify any non-complying rolls and/or to qualify individual rolls.
- F. Sampling shall, in general, be performed on sacrificial portions of the geocomposite material such that repair is not required. The Geocomposite Manufacturer shall sample and test the geocomposite, at a minimum, once every 2,000 m² demonstrate that its properties conform to the values specified in Table 02740-1. The only exception is the geocomposite hydraulic transmissivity testing, which shall be performed for every 4,000 m² of geocomposite produced for the project. At a minimum, the following manufacturing quality control tests shall be performed:

<u>Test</u>	<u>Procedure</u>
specific gravity	ASTM D 1505
nominal thickness	ASTM D 1777
carbon black content	ASTM D 1603
hydraulic conductivity	ASTM D 4491
mass per unit area	ASTM D 3776

- G. The Geocomposite Manufacturer shall comply with the certification and submittal requirements of this specification and the CQA Plan.

2.03 PACKING AND LABELING

- A. The geocomposite shall be supplied in rolls wrapped in relatively impermeable and opaque protective covers.
- B. Geocomposite rolls shall be labeled with the following information.
1. manufacturer's name;
 2. product identification;
 3. lot or batch number;
 4. roll number; and
 5. roll dimensions.
- C. If any special handling is required, it shall be so marked on the geotextile component e.g., "This Side Up" or "This Side Against Soil To Be Retained".

2.04 TRANSPORTATION

- A. Transportation of the geocomposite shall be the responsibility of the Contractor. The Contractor shall be liable for all damages to the materials incurred prior to and during transportation to the site.

2.05 HANDLING AND STORAGE

- A. Handling, storage, and care of the geocomposite prior to and following installation at the site, is the responsibility of the Contractor. The Contractor shall be liable for all damages to the materials incurred prior to final acceptance by the Owner.
- B. The Contractor shall be responsible for storage of the geocomposite at the site. The geocomposite shall be stored off the ground and out of direct sunlight, and shall be protected from excessive heat or cold, mud, dirt, and dust. Any additional storage procedures required by the Manufacturer shall be the Contractor's responsibility.

2.06 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide product by one of the following or approved equal:
1. Afitex
- Or approved equal.

PART 3 - EXECUTION

3.01 FAMILIARIZATION

- A. Prior to implementing any of the work described in this Section, the Contractor shall become thoroughly familiar with all portions of the work falling within this Section and the CQA Plan.
- B. Inspection:
1. Prior to implementing any of the work in this Section, the Contractor shall carefully inspect the

installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

2. If the Contractor has any concerns regarding the installed work of other Sections, the Contractor shall notify the Owner or CQA Consultant in writing within 48 hours of the site inspection. Failure to inform the Owner or CQA Consultant in writing of installation of the geocomposite will be construed as Contractor's acceptance of the related work of all other Sections.

3.02 CONFORMANCE TESTING

- A. Upon delivery to the site or prior to delivery at the location of the Manufacturer, samples of the geocomposite shall be removed by the CQA Consultant and sent to the laboratory selected by the Owner for testing to ensure conformance to these Specifications.
- B. Samples shall be selected by the CQA Consultant in accordance with this Section and the procedures outlined in the CQA Plan.
- C. Samples shall be taken at a frequency of 1 sample per lot or 1 per 4,000 square meters, whichever is less.
- D. The CQA Consultant may increase the frequency of sampling as outlined in the CQA Plan in the event that test results do not comply with this Section. This additional testing shall be performed at the expense of the Contractor.
- E. Any geocomposites that are not certified in accordance with this Section, or that conformance testing indicates do not comply with this Section shall be rejected and replaced with new material in accordance with the CQA Plan, at no additional cost to the Owner.

3.03 HANDLING AND PLACEMENT

- A. The Contractor shall handle the geocomposite in such a manner as to ensure the geocomposite is not damaged in any way.
- B. The Contractor shall take any necessary precautions to prevent damage to underlying layers during placement of the geocomposite.
- C. The geocomposite shall only be cut using Manufacturer's recommended procedures.
- D. In the presence of wind, all geocomposite panels shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material.
- E. Care shall be taken during placement of geocomposite not to entrap dirt or excessive dust in the geocomposite that could cause clogging of the drainage system, and/or stones that could damage the adjacent geosynthetic. Care shall be exercised when handling sandbags, to prevent rupture or damage of the sandbags.
- F. Unless otherwise specified, geocomposite shall not be welded to liners.
- G. If necessary, the geocomposite shall be positioned by hand after being unrolled to minimize wrinkles.
- H. Tools shall not be left on, in, or under the geocomposite.
- I. After unwrapping the geocomposite from its opaque cover, the geocomposite shall not be left exposed for a period in excess of 30 days unless a longer exposure period is approved by the Engineer, based on a formal demonstration from the Contractor that the geotextile component of the geocomposite is stabilized against U.V. degradation for a period in excess of 30 days.

3.04 SEAMS AND OVERLAPS

- A. The components of the geocomposite (i.e., geotextile, geonet, and geotextile) are not bonded together at the ends and edges of the rolls. Each component will be secured or seamed to the like component at overlaps.
- B. Geonet Components:
 1. The geonet components shall be overlapped by at least 0.10 meter. These overlaps shall be secured by tying.
 2. Tying shall be achieved by plastic fasteners or polymer braid. Tying devices shall be white or yellow for easy inspection. Metallic devices shall not be used.
 3. Tying shall be every 1.5 meters along the slope, every 0.60 meter across the slope, every 0.15 meter in

the anchor trench and every 1.80 meters on horizontal surfaces.

- C. Geotextile Components:
 - 1. The bottom layers of geotextile shall be overlapped. The top layers of geotextiles shall be continuously sewn (i.e., spot sewing is not allowed). Geotextiles shall be overlapped a minimum of 0.15 meter prior to seaming.
 - 2. No horizontal seams shall be allowed on slopes steeper than 10 horizontal to 1 vertical.
 - 3. Polymeric thread, with chemical resistance properties equal to or exceeding those of the geotextile component, shall be used for all sewing. The seams shall be sewn using Stitch Type 401. The seam type shall be Federal Standard Type SSN-1.

3.05 REPAIR

- A. Any holes or tears in the geocomposite shall be repaired by placing a patch extending 0.60 meter beyond the edges of the hole or tear. The patch shall be secured by tying fasteners through the bottom geotextile and the geonet of the patch, and through the top geotextile and geonet on the slope. The patch shall be secured every 0.15 meter with approved tying devices. The top geotextile component of the patch shall be heat sealed to the top geotextile of the geocomposite needing repair. If the hole or tear width across the roll is more than 50 percent of the width of the roll, the damaged area shall be cut out and the two portions of the geocomposite shall be joined in accordance with Subsection 3.04 above.
- B. All repairs shall be performed at no additional cost to the Owner.

3.06 PLACEMENT OF SOIL MATERIALS

- A. The Contractor shall place all soil materials in such a manner as to ensure that:
 - 1. the geocomposite and underlying geosynthetic materials are not damaged;
 - 2. minimal slippage occurs between the geocomposite layer and underlying layers; and
 - 3. excess tensile stresses are not produced in the geocomposite layer.
- B. Equipment used for placement of soil materials above the geocomposite layer shall be limited to the following:

:

<u>Maximum Allowable Equipment Ground Pressure (psi)</u>	<u>Thickness of Overlying Fill (in.)</u>
<5	12
<10	18
<20	24
>20	36

3.07 PRODUCT PROTECTION

- A. The Contractor shall use all means necessary to protect all prior work, and all materials and completed work of other Sections.
- B. In the event of damage to prior work or work completed as specified in this Section, the Contractor shall immediately make all repairs and replacements necessary, to the approval of the Owner and CQA Consultant and at no additional cost to the Owner.

Gas Drainage Geocomposite

Description & Composition					
The product is composed with a filter layer, a drainage mat and mini-pipes					
The component are joint together by needle-punching					
Mini-pipes are 100% polypropylene made of granules, and perforated					
Mechanical Characteristics					
Charactarestics	Standards	Reference	Values	Tolerances	Units
Mass per unit area	NF EN 9864	Geotextile	300	270≤Val.≤330	g/m ²
	Geotextile + mini pipes		343	NR	g/sqm
Thickness	NF EN 9863-1	Under 2 kPa	3.50	2.8≤Val.≤4.2	mm
		Under 20 kPa	3.00	2.4≤Val.≤3.6	
Tensile Strength	NF EN ISO 10319	Machine direction	15.0	13.05≤Val.≤NR	KN/m
		Cross direction	15.0	13.05≤Val.≤NR	
Tensile Elongation	NF EN ISO 10319	Machine direction	>50	50≤Val.≤NR	%
		Cross direction	>50	50≤Val.≤NR	
Pyramidal puncture resistance	NF G 38-019	1.4		0.98≤Val.≤NR	KN
Dynamic Perforation resistance	NF EN ISO 13433	12.0		NR≤Val.≤15	mm
CBR resistance	NF EN ISO 12236	2.50		2≤Val.≤NR	KN
Mini – Pipes Characteristics					
Diameter	NF EN 61386-1	Outside diameter	16	15.68≤Val.≤NR	mm
Pipe stiffness st 5% deflection	ASTM D2412		5000	5000≤Val.≤NR	Kpa
Spacing of mini pipess	1 mini pipe every one meter widthways				
Hydraulic Characteristics					
Opening size	NF EN ISO 12956	Nappe filtrante	110	77≤Val.≤143	μm
		Filter layer			
Water permeability	NF EN ISO 11058	Nappe filtrante	100	70≤Val.≤NR	l/s/m ²
		Filter layer			
In plane flow capacity (mini pipes)	NF EN ISO 12958	i=0.1 under 20 kPa	0.25	0.18	l/s/m
		i=0.1 under 100 kPa	0.25	0.18	
		i=0.1 under 400 kPa	0.22	0.15	
		Under 400 kPa, during 100h	0.19	0.13	
		i=0.3 under 20 kPa	0.40	0.28	l/s/m
		i=0.3 under 100 kPa	0.40	0.28	
		i=0.3 under 400 kPa	0.40	0.28	
		Under 400 kPa, during 100h	0.35	0.25	
		i=1 under 20 kPa	0.80	0.56	l/s/m
		i=1 under 100 kPa	0.80	0.56	
		i=1 under 400 kPa	0.80	0.56	
		Under 400 kPa, during 100h	0.70	0.56	
Roll Dimension					
Packaging	Standard Roll	Length Variable	120 ml		
		Width	3.9 m		
		Weight of Roll	167.5 kg		
		Tube inside diameter	100mm		

Water Drainage Geocomposite

Description & Composition				
The product is composed with a filter layer, a drainage mat and mini-pipes				
The component are joint together by needle-punching				
Mini-pipes are 100% polypropylene made of granules, and perforated				
Mechanical Characteristics				
Charactarestics	Standards	Reference	Values	Units
Mass per unit area	NF EN 9864	Geotextile	500	g/sqm
	Mass per unit ara Total mass (geotextile + mini pipes)		562	
Thickness	NF EN 9863-1	Under 2 kPa	5.0	mm
		Under 20 kPa	4.0	
Tensile Strength	NF EN ISO 10319	Machine direction	20	KN/m
		Cross direction	20	
Tensile Elongation	NF EN ISO 10319	Machine direction	90	%
		Cross direction	90	
Pyramidal puncture resistance	NF G 38-019	1.9		KN
Dynamic Perforation resistance	NF EN ISO 13433	12		mm
CBR resistance	NF EN ISO 12236	3.0		KN
Mini – Pipes Characteristics				
Diameter	NF EN 61386-1	Outside diameter	20	mm
Pipe stiffness st 5% deflection	ASTM D2412		4000	Kpa
CE Conformity	NF EN 61386-1	CE is printed every 1m30		
Spacing of mini pipes	1 mini pipe every one meter widthways			
Hydraulic Characteristics				
Opening size	NF EN ISO 12956	Filter layer	90	µm
Water permeability	NF EN ISO 11058	Filter layer	100	l/s/m ²
In plane flow capacity (mini pipes)	NF EN ISO 12958	i=0.1 under 20 kPa	0.25	l/s/m
		i=0.1 under 100 kPa	0.25	
		i=0.1 under 400 kPa	0.25	
		Under 400 kPa, during 100h	0.25	
		i=0.3 under 20 kPa	0.45	l/s/m
		i=0.3 under 100 kPa	0.45	
		i=0.3 under 400 kPa	0.45	
		Under 400 kPa, during 100h	0.45	
		i=1 under 20 kPa	1.00	l/s/m
		i=1 under 100 kPa	1.00	
		i=1 under 400 kPa	1.00	
		Under 400 kPa, during 100h	1.00	
Roll Dimension				
Packaging	Standard Roll	Length Variable	50 m	
		Width	3.9 m	
		Weight of Roll	117 g	
		Tube inside diameter	100mm	

END OF SECTION

SECTION 02740

FLEXIBLE PAVEMENT

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes asphaltic concrete binder and wearing courses, and surface sealer.
- B. Related Sections:
 - 1. Section 02230 - Site Clearing.
 - 2. Section 02320 - Backfill.
 - 3. Section 02339 - Sub-Grade Preparation.
 - 4. Section 02721 - Aggregate Sub-Base and Base Courses.

1.2 REFERENCES

- A. Asphalt Institute:
 - 1. AI MS-2 - Mix Design Methods for Asphalt Concrete and Other Hot- Mix Types.
 - 2. AI MS-19 - Basic Asphalt Emulsion Manual.
- B. ASTM International:
 - 1. ASTM D946 - Standard Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction.
 - 2. ASTM D3381 - Standard Specification for Viscosity-Graded Asphalt Cement for Use in Pavement Construction.

1.3 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Product Data: Submit product information and mix design.
- C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.4 QUALITY ASSURANCE

- A. Perform Work as per the standards and regulations of the relevant local authorities having jurisdiction and/or Municipality, as specified, as shown on the drawings and to Engineer's satisfaction.
- B. Mixing Plant: Conform to relevant authorities' standards.
- C. Obtain materials from approved same source throughout the Work.
- D. Maintain one copy of each document on site.

1.5 QUALIFICATIONS

- A. Installer: Company specializing in performing work of this section with minimum ten years documented experience.

1.6 ENVIRONMENTAL REQUIREMENTS

- A. General Requirements: Product requirements for environmental conditions affecting products on site.
- B. Do not place asphalt when ambient air or base surface temperature is less than 5°C, or surface is wet.

PART 2 PRODUCTS

2.1 MATERIALS - GENERAL

- A. All materials shall be in accordance with the standards and regulations of the relevant local authorities having jurisdiction and/or Municipality.

2.2 BITUMINOUS PRIME AND TACK COATS

- A. General: Furnish and apply MC cutback bitumen prime coat to a previously constructed subgrade, aggregate base course, highway shoulders, or concrete pavement; and furnish and apply RC cutback bitumen or emulsified bitumen as a tack coat to a previously constructed bituminous base or wearing surface to provide a bond for a superimposed bituminous course.
- B. Medium-Curing Cutback Bitumen: MC cutback bitumen (for prime coats) shall be as recommended by ASTM D2399-83. MC 70 shall be used unless otherwise specified.
- C. Rapid-Curing Cutback Bitumen: RC cutback bitumen (for tack coats) shall be Grades RC-70 or RC-250 as appropriate, as specified and as shown on the Drawings.
- D. Slow-Curing Emulsified Bitumen: Slow-setting emulsified bitumen (for tack coats) shall be slow-setting Grade SS-1, SS-1h, CSS-1, or CSS-1h, as appropriate, as specified, and as shown on the Drawings.

2.3 AGGREGATES FOR BITUMINOUS PAVING MIXES

- A. Aggregates for use in bituminous base course, leveling course, macadam and cold mix courses shall consist of crushed rock or crushed gravel. Aggregates for use in wearing courses shall consist of crushed rock.
- B. Coarse aggregate shall be the fraction of crushed aggregate material retained on a
- C. 4.75 mm (No. 4) sieve. Fine aggregate shall be the fraction of crushed aggregate material passing a 4.75 mm (No. 4) sieve. Mineral filler shall be added when the combined grading of coarse and fine aggregates is deficient in material passing a 0.075 mm (No. 200) sieve.
- D. The material from hot bins passing the number 40 sieve (0.425mm) when tested in accordance with AASHTO T90 shall be non-plastic. In addition, the material from cold bins shall not have a PI larger than 4.
- E. Aggregates shall not contain more than 1% gypsum and the coarse fraction of the aggregate shall not contain more than 5% chert.
- F. Aggregates shall be of uniform quality, free from decomposed stone, organic matter, and shale.
- G. The percentage by weight of friable particles, clay lumps, and other deleterious matter shall not exceed 1% as determined by AASHTO T112.
- H. Aggregate particles shall be clean, hard, durable and sound. Crushing shall result in a product such that, for particles retained on a 4.75 mm (No. 4) sieve, at least 90% by weight shall have 2 or more fractured faces.
- I. The flakiness index and the elongation index tests shall be conducted in accordance with BS EN 933-3:1997 with the following maximum limits:

	Wearing Course	Binder and Base Course
Flakiness Index (FI).	20	35
Shape Index (SI).	25	30

- J. Aggregates shall be washed to remove any clay lumps, organic matter, adherent dust, clay film or other extraneous or deleterious matter that may prevent or detract from proper adhesion of bitumen to the aggregate particles.
- K. Mineral filler shall consist of finely divided mineral matter such as limestone dust, hydrated lime, other non-plastic mineral filler free from clay and organic impurities and Portland cement, conforming to AASHTO M 17.
- L. Combined coarse and fine aggregates for bituminous mixes, including mineral filler, when tested in accordance with AASHTO T 27 and T11, shall conform to the grading shown in the following table.

SIEVE SIZE	PERCENT PASSING	
	Base Course	Wearing Course
1" (25.0 mm)	100	---
3/4" (19.0 mm)	65-100	100
3/8" (9.5 mm)	47-72	56-80
No. 4 (4.75 mm)	30-56	35-56
No. 10 (2.00 mm)	19-36	22-36
No. 40 (0.425 mm)	8-20	8-20
No.200 (0.075 mm)	2-8	2-8

- M. The loss in weight of aggregate after 500 revolutions, when tested in accordance with AASHTO T 96, shall not exceed 35%.
- N. When tested for soundness in accordance with AASHTO T104 the coarse aggregate (retained on No.4 sieve) shall not show signs of disintegration and the loss by weight after 5 cycles shall not exceed 10% in the case of the sodium sulphate test and 12% in the case of the magnesium sulphate test.
- O. When testing for resistance to stripping in accordance with AASHTO T-182 at least 95% coated particles shall remain.

2.4 BITUMEN PRODUCTS

- A. Penetration Graded Bitumen: Penetration graded bitumen shall conform generally to the requirements of AASHTO M 20 as given in the following table.

	Penetration Grade					
	40 -50		60 - 70		80 - 100	
	Min	Max	Min	Max	Min	Max
Ductility at 25°C (cm)	100	-	100	-	100	-
Penetration at 25°C (0.1 mm)	40	50	60	70	85	100
Softening Point (°C)	50	58	48	56	45.8	48
Specific Gravity at 25°C	1.01	1.06	1.01	1.06	1.0	-
Loss on heating 163°C	-	0.8	-	0.8	-	1.0
Penetration of residue % of original	58	-	54	-	50	-
Solubility in Trichloroethylene (% wt)	99	-	99	-	99	-
Ash content % wt	-	1.0	-	1.0	-	1.0
Flashpoint (Cleveland Open Cup) (°C)	250	-	250	-	225	-

- B. Sampling and testing shall be to AASHTO standard method listed in AASHTO M 20.
- C. The penetration bitumen application temperature range shall be determined to ensure that the appropriate viscosity range for each application is achieved. If the viscosity curves are not available the values given in the following table shall be used.

Bitumen Grade	40/50	60/70	80/100
Application Temperature °C	150-170	145-165	140-160

- D. The penetration grade for the project shall be either **60/70 or 80/100**.

2.5 BITUMINOUS BASE COURSE

- A. Job Mix: The job mix for bituminous base course shall conform to the following composition limits shown in the following:
1. Marshall Stability at 60°C: 700 kg.
 2. Flow: 2 - 3.5 mm.
 3. Minimum Voids in Mineral Aggregate (VMA): 12%.
 4. Air Voids: 4 - 8 %.
- B. Compacted Density: The compacted density of bituminous base course shall be equal to or greater than 97% of the average Marshall Bulk density for each day production.

2.6 BITUMINOUS WEARING COURSE

A. Mix Design:

1. The bituminous mixture shall be designed using procedures contained in Chapter 5, Marshall Method of Mix Design, of the Asphalt Institute's Manual Series No. 2 (MS-2), sixth edition, and shall meet the following requirements:
 - a. Number of Blows: 75.
 - b. Stability: 900 kg.
 - c. Flow: 2 - 3.5 mm.
 - d. Air Voids:
 - 1) 3% Normal Traffic (< 1 m ESAL).
 - 2) 4% Heavy Traffic (1- 5 m ESAL).
 - 3) 5% Very Heavy Traffic (>5 m ESAL).
 - e. VFA:
 - 1) Normal to Heavy Traffic: 65 – 75%.
 - 2) Very Heavy Traffic: 65-73%.
 - f. Dust to Bitumen Ratio: 1.2 maximum.
 - g. Minimum Voids in Mineral Aggregate (VMA):

ASTM Sieve	Maximum Particle Size	Percent Design Air Voids		
(mm)	(mm)	3%	4%	5%
13	12.5	13 %	14 %	15 %
18	19.0	12 %	13 %	14 %
25	25.0	11 %	12 %	13 %
37	37.5	10 %	11 %	12 %

2. The Contractor shall prepare a series of test specimens with a range of different binder contents so that the test data show a well-defined curve. Tests shall be scheduled on the basis of 0.5% increments of binder content, with at least two binder contents above optimum and at least two below optimum.
3. Triplicate test specimens shall be prepared for each binder content mix to be tested.
4. The mineral aggregate shall be of such a size that the percentage composition by weight, as determined by laboratory sieves, shall conform to the gradation or gradations specified in the following table, when tested in accordance with ASTM C136 (dry sieve only). The percentage by weight for the bituminous material shall be within the limits specified.

ASTM Sieve Size	Percentage by Weight Passing Sieves		
38 mm	100	-	-
25 mm	90-100	100	-
18 mm	-	90-100	100
13 mm	56-80	-	90-100
No 4	-	56-80	-
No 8	29-59	35-65	44-74
No 16	19-45	23-49	28-58
No 30	-	-	-
No 50	-	-	-
No 100	5-17	5-19	5-21
No 200	1-7	2-8	2-10
Bitumen Content	4.5-7.0 %	5.0-7.5 %	5.5-8.0 %
Course Type	Binder	Binder or Wearing	Wearing

5. Bitumen content shall be calculated by weight of total mixture.
6. The compacted thickness of any layer shall be at least twice the maximum nominal size of the aggregate band for wearing course unless otherwise directed by the Engineer.
7. In considering the total grading characteristics of a bituminous paving mixture, a higher percentage

of material passing the № 8 (2.36 mm) sieve will result in pavement surfaces having a comparatively fine texture, while coarse grading approaching the minimum amount passing the № 8 sieve will result in surfaces with comparatively coarse texture.

- B. Compacted Density: The compacted density of the bituminous wearing course shall be not less than 97% of the average Marshall Bulk Density for each day production.

2.7 ASPHALT PAVING MIX

- A. At least 30 days prior to the date the Contractor intends to begin production at the mixing plant and after receiving approval of the aggregates and delivery to the Site of the bitumen specified, the Contractor shall submit for the Engineer's approval his proposed Job Mix Formula.
- B. The Job Mix Formula shall stipulate a single combined grading of all aggregate and filler materials showing the specific percentages by weight passing each sieve size and of each material to be used in the total mix.
- C. The Job Mix Formula shall be established by the Contractor, under the supervision of the Engineer, in the field laboratory. Mix design procedures shall conform to the Marshall method of mix design and relevant procedures contained in Asphalt Institute Manual MS-2, Sixth Edition. All trial mixes shall be prepared and tested by the Contractor in the presence of the Engineer.
- D. The Job Mix Formula shall specify a combination of mineral aggregates including filler and bitumen (plus bitumen modifier if required) in such proportions to produce a Job Mix which is within the limits of the specified grading and bitumen content ranges and which meets the Marshall test requirements, as prescribed for each particular type of bitumen course. It shall also stipulate the mixing temperature at discharge from the mixer which, unless otherwise agreed by the Engineer, shall be 170°C.
- E. The Marshall Test procedure shall be used to determine the percentage of bitumen to be incorporated in the mix. The Job Mix Formula shall take into consideration the absorption of bitumen into the aggregates. Air voids shall be calculated in accordance with the procedure given in the Asphalt Institute Manual, MS-2.
- F. When compacting specimens in accordance with the Marshall Test procedure, the number of blows applied with the compaction hammer shall be 75 on each side, unless otherwise specified on the Drawings or instructed by the Engineer.
- G. In order to meet the requirements, an approved additive such as Portland cement, hydrated lime or liquid antistripping agent, may be used in the Job Mix. Portland cement shall meet the requirements of AASHTO M 85. Hydrated lime shall meet the requirements of ASTM C207, Type N. Cement or hydrated lime will normally be required in the approximate range of 2-3% by weight of the aggregates and shall be added at the cold feed in dry or slurry form as directed. Liquid antistripping agent shall be provided in the range of 0.6-1.0% by weight of the bitumen, or according to the manufacturer's specifications.
- H. Upon receipt of approval of the Job Mix Formula, the Contractor shall adjust his mixing plant to supply in the correct proportion the individual aggregates, mineral filler and bitumen to produce a final project mix within the job mix gradation limits given in the following table.

Sieve Designation (Square Openings)	Specified Tolerances
9.5 mm and above	+/- 5.0%
4.75 mm (No. 4)	+/- 4.0%
2.00 mm (No. 10)	+/- 4.0%
0.425 mm (No. 40)	+/- 4.0%
0.18 mm (No. 80)	+/- 4.0%
0.075 mm (No. 200)	+/- 1.0%
Bitumen Content	to be recommended by designer
Temperature of Mix on discharge	+/- 5°C

- I. Conformance to gradation requirements shall be determined on the extracted aggregate in accordance with AASHTO T30. The bitumen content shall be determined in accordance with AASHTO T164.
- J. The Engineer shall test the project mix at least twice daily during plant operation and, if necessary, direct the Contractor to readjust the plant to conform to the Job Mix Formula. If, due to differing cold feed or hot bin gradations, the Contractor cannot consistently produce a project mix meeting the Job Mix requirements, production shall cease, the Job Mix shall be redesigned and re-approved by the Engineer and the plant readjusted to produce a new Job Mix.

- K. The participation of the Engineer in the preparation of the Job Mix Formula shall not relieve the Contractor of his responsibility for producing project mixes meeting the specified requirements.

2.8 SPEED BUMPS

- A. Asphalted-Type Speed Bump:
1. Tack Coat: Liquid asphalt for tack coat shall be rapid curing type cutback grades RC-250 or RC-3000 as directed, and shall conform to the relevant requirements of Bituminous Prime and Tack Coats.
 2. Bituminous Mix: The bituminous mix for speed bumps shall conform to the relevant requirements of Bituminous Binder and Wearing Courses for a wearing course mix unless otherwise shown on the Drawings.
 3. Dimension: As shown on drawings.
- B. Paved-Type Speed Bump:
1. Paver Type: As shown on drawings, and as specified in Section 02783 and/or Section 02784.
 2. Dimension: As shown on drawings.

2.9 SOURCE QUALITY CONTROL AND TESTS

- A. General Requirements: Quality requirements for testing, inspection and analysis requirements.
- B. Submit proposed mix design of each mix class for review prior to beginning of Work.
- C. Test samples in accordance with AI MS-2, and in accordance with the standards and regulations of the relevant local authorities having jurisdiction and/or the Municipality.
- D. Minimum Tests Required for Bituminous Pavements at Source of Materials:

Item	Tests at Source of Materials	Frequency
Materials used in Asphalt Mix at Batching plant	<ol style="list-style-type: none"> 1. Specific Gravity and Water Absorption. 2. Absorption Test. 3. Chert content. 4. Clay Lumps and Friable Particles. 5. Flaky and Elongated Particles. 6. Soundness. 	For each source, and when material quality changes, and when requested by the Engineer
Materials Used in Asphalt Mix from Hot Bins	<ol style="list-style-type: none"> 1. Gradation. 2. Specific Gravity and Water Absorption. 3. Plasticity Index. 4. Sand Equivalent. 5. Stripping with Asphalt. 	For each source, and when material quality changes, and when requested by the Engineer
Asphalt Mix Design for Each Layer at Batching Plant	<ol style="list-style-type: none"> 1. Complete Mix Design. 2. Loss of Stability. 	For each Project, and when material quality changes, and when results are not consistent with the mix design results, and when requested by the Engineer
Asphalt for Each Layer at Batching Plant	<ol style="list-style-type: none"> 1. Stability. 2. Flow. 3. Binder Content & Gradation. 4. Air Voids. 5. Voids in Mineral Aggregates. 6. Daily Marshall Density. 	Every 3 working days, and for each batching plant, and when requested by the Engineer
	<ol style="list-style-type: none"> 7. Loss of Stability. 	Every week, and when requested by the Engineer

E. Minimum Tests Required for Bituminous Pavements at Road Site:

Item	Test at Road Site	Frequency
Asphalt for Each Layer	Behind Spreader: 1. Stability. 2. Flow. 3. Binder Content & Gradation. 4. Air Voids. 5. Voids in Mineral Aggregates. 6. Marshall Density.	Every working day, and Test for each batch, and when requested by the Engineer
	Core Samples: 7. Density and Thickness. 8. Bitumen Penetration Grade Verification.	Every 200m per lane, and each layer, and when requested by the Engineer

- F. The Marshall Bulk specific gravity shall be determined in accordance with AASHTO T166. The Marshall specimens shall be prepared from the same material used in the construction, taken from samples of fresh bituminous mix at the mixing plant or from trucks delivering mix to the Site. Oven heating for up to 30 minutes to maintain the heat of the sample is permissible.
- G. The bulk specific gravity of the mix as placed and compacted in situ shall be determined from 100 mm nominal diameter core samples or slab samples cut from each compacted layer on the road at locations selected by the Engineer. The Engineer reserves the right to instruct additional tests to determine the limits of areas deficient in density or for verification.
- H. Core samples for in-situ bulk specific gravity determination and verification of bitumen binder penetration grade shall be taken in sets of two from each pavement location. The minimum frequency of sampling for each bituminous layer shall be one set/lane/500 m, with a minimum of one set per day of placed bituminous layers.
- I. The Contractor shall cut the samples with an approved core drill in the presence of the Engineer. The equipment shall be capable of cutting the mixture without shattering the edges or otherwise disturbing the density of the specimen.
- J. The Contractor shall, when necessary, furnish and apply cold water, ice, or other cooling substance to the surface of the pavement to prevent the sampling from shattering or disintegrating. The Contractor shall fill and compact all test holes at his own expense.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for verification of existing conditions before starting work.
- B. Verify compacted sub-grade, granular, or stabilized soil sub-base is dry and ready to support paving and imposed loads.
- C. Verify gradients and elevations of base are correct.
- D. Verify gutter drainage grilles and frames, manhole frames and the like are installed in correct position and elevation.

3.2 BITUMINOUS PRIME AND TACK COATS

- A. Construction of Trial Sections:
- The Engineer shall, if necessary, instruct trial sections to be constructed prior to the commencement of on-site prime or tack coat applications. The Contractor shall construct trial sections using varying application rates of bitumen as selected by the Engineer. Each trial section shall be two lanes wide by 50 meters long, at approved locations on or close to the Site.
 - Each trial section shall be constructed using the same materials, mixing and spraying equipment and construction procedures proposed for use in the Works.

3. The objectives of these trials shall be to determine the adequacy of the Contractor's equipment and the most suitable application rates for cutback bitumen prime and tack coats.
4. The Contractor shall not proceed with site coat applications until the methods and procedures established in the trials have been approved by the Engineer.
- B. General Application Procedures:
 1. All equipment used for surface cleaning, heating bitumen and application of prime and tack coats shall be suitable for the purposes intended and shall be approved by the Engineer before use.
 2. All surfaces to receive prime or tack coats shall conform to the specified tolerances and compaction requirements and shall be properly cleaned using power brooms or power blowers. Surfaces shall be approved before applying any bitumen material.
 3. Prime coats and tack coats shall be applied only when the surface to be treated is sufficiently dry for tack coats and sufficiently moist for prime coats and when the ambient temperature is above 10°C for the application of tack coat and above 15°C for the application of prime coat. Prime and tack coats shall not be applied during fog, rain, strong winds, generally dusty conditions or dust storms.
 4. The surfaces of all structures, curbs, gutters and other highway appurtenances shall be protected from being splattered or stained with bitumen or damaged during equipment operation. The Contractor shall be responsible for making good any such staining or damage to the satisfaction of the Engineer.
 5. Traffic shall not be permitted on surfaces cleaned and prepared for prime or tack coat application.
 6. If there are undue delays in applying prime or tack coats or subsequent paving thereafter, the surface tolerances and compaction of the granular course shall be re-verified, the deficient areas shall be corrected and/or replaced, and the prime and tack coats shall be re-applied in accordance with the Engineer's instructions and at the Contractor's expense.
 7. The Contractor shall maintain prime coats and tack coats intact until they are covered by the subsequent pavement course. Any area where the coats have been damaged shall be cleaned of all loose material, all surface defects shall be repaired, and the coat shall be re-applied at the Contractor's expense.
- C. Prime Coat Application:
 1. If required by the Engineer, when the surface is an untreated subgrade or a granular surface, the cleaned surface shall be given a light application of water and allowed to dry to the condition deemed appropriate by the Engineer before the bituminous material is applied.
 2. Heating of MC cutback bitumen and its temperature at the time of application shall be as specified.
 3. Areas to be primed shall be as shown on the Drawings and shall include 200 mm wide outside the edges of the pavement.
 4. Application rates for prime coat shall be determined by the Engineer from the trial sections and shall be generally within the following ranges:
 5. Untreated subgrade surfaces, shoulders base course: 0.75-2.0 liter/m².
 - a. Bridge wearing surfaces, concrete pavements: 0.1 - 0.4 liter/m².
 - b. Other Surfaces: As determined from field tests or trials.
 6. The Engineer may order additional trial sections and/or alter the previously established rates of application during progress of the Works.
 7. Prime coat shall be applied using pressure distributors operated by skilled workmen. The spray nozzles and spray bar shall be adjusted and frequently checked so that a uniform distribution is ensured. Spraying shall cease immediately if any nozzle ceases to spray and corrective measures shall be taken before spraying is resumed.
 8. Hand spraying shall be used only for priming small patches or inaccessible areas that cannot be primed by normal operation of the pressure distributor.
 9. Application of prime coat between separate areas of priming shall not be excessive. Any excess prime coat shall be removed from the surface using clean sand to blot excess primer, and any skipped areas or recognized deficiencies shall be corrected using hand sprays.
 10. When required by the Engineer, a light covering of blotting material shall be applied to the prime coat 48 hours after spraying and when it has not dried sufficiently to withstand damage by traffic. The blotting material shall be a smooth fine sand or other material approved by the Engineer.
 11. Prime coats shall be cured for 3 days before traffic is allowed on it or before the succeeding pavement layer is placed, or as directed by the Engineer.
- D. Tack Coat Application:
 1. Tack coat application shall be as shown on the Drawings and on clean dry surfaces, and the application rate shall be as instructed by the Engineer. Emulsified bitumen shall be diluted and thoroughly mixed with an equal amount of water before application.

2. Heating of RC cutback bitumen and its temperature at the time of application shall be as specified. Where slow-curing emulsified bitumen (SS or CSS Type) is used for tack coat, it shall not require heating except in temperatures below 20°C.
3. The rate of application shall be approved by the Engineer between 0.1 and
4. 0.6 kg/m² depending on whether RC cutback or emulsified bitumen is used, and on the surface condition of the bituminous course on which the tack coat is to be sprayed. The Engineer shall alter the previously established rates of application during progress of the Works if he deems it necessary.
5. The tack coat shall be allowed to dry only until it is in a suitable tacky condition to receive the superimposed bituminous course. Tack coat applications shall not proceed so far in advance of the following course that it dries out completely.
6. Spraying procedures shall be as specified for prime coat application.
7. Blotting material shall not be applied to tack coats.
8. Apply tack coat to contact surfaces of curbs, gutters and the like.
9. Coat surfaces of manhole and catch basin frames with oil to prevent bond with asphalt pavement. Do not tack coat these surfaces.

3.2 PLACING ASPHALT PAVEMENT - SINGLE COURSE

- A. Install Work in accordance with the standards and regulations of the relevant local authorities having jurisdiction and/or Municipality.
- B. Place asphalt within 24 hours of curing primer coat.
- C. Place asphalt wearing course to compacted thickness shown on the drawings.
- D. Compact pavement by rolling to specified density. Do not displace or extrude pavement from position. Hand compact in areas inaccessible to rolling equipment.
- E. Perform rolling with consecutive passes to achieve even and smooth finish without roller marks.

3.3 PLACING ASPHALT PAVEMENT - DOUBLE COURSE

- A. Place asphalt binder course within 24 hours of curing prime coat. Place binder course to compacted thickness shown on drawings.
- B. Apply tack coat on binder course and allow to dry 2 hours before placing wearing course.
- C. Place wearing course within 8 hours of applying tack coat. Place wearing course to compacted thickness shown on the drawings.
- D. Compact each course by rolling to specified density. Do not displace or extrude pavement from position. Hand compact in areas inaccessible to rolling equipment.
- E. Perform rolling with consecutive passes to achieve even and smooth finish, without roller marks.

3.4 SPEED BUMPS

- A. Asphalted-Type Speed Bump:
 1. Prior to the application of the tack coat, the bituminous surface shall be cleaned free of all dirt, dust and other foreign substances which, in the opinion of the Engineer, would prevent proper bonding of the tack coat.
 2. Immediately after the surface has been cleaned and approved by the Engineer the tack coat shall be applied by pressure distributor, or by hand-spraying equipment which shall achieve uniform mist type coverage without blotches or streaks. The rate of application shall be between 0.2 and 0.3 liters per square meter unless otherwise required by the Engineer.
 3. When the tack coat has set and has been approved by the Engineer, the Contractor shall place the speed bump form in position. The hot bituminous mix shall be placed in the forms and consolidated by hand flush with the top of the form.
 4. After the bituminous mix has been placed in the form and consolidated, the form shall be carefully lifted and removed and rolling operations shall commence. Rolling shall be performed with a suitable type of pneumatic roller initially traveling parallel to the roadway centerline and finally at right angles to the centerline until the speed bump is compacted to the required cross section. The height of speed bumps above the pavement surface shall not exceed 100mm.
 5. Speed bump shall be painted with white reflectorized paint as shown on the drawings.
- B. Paved-Type Speed Bump:

1. Install paving as specified in relevant paving section and as shown on the drawings.
2. Speed bump shall be painted with white reflectorized paint as shown on the drawings.

3.5 TOLERANCES

- A. General Requirements: Quality requirements for tolerances.
- B. Flatness: Maximum variation of 6 mm measured with 3 m straight edge.
- C. Scheduled Compacted Thickness: Within 4 mm.
- D. Variation from Indicated Elevation: Within 6 mm.

3.6 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for field inspecting, testing, adjusting and balancing.
- B. Take samples and perform tests in accordance with AI MS-2, and in accordance with the standards and regulations of the relevant local authorities having jurisdiction and/or Municipality.

3.7 PROTECTION OF FINISHED WORK

- A. General Requirements: Execution requirements for protecting finished work.
- B. Immediately after placement, protect pavement from mechanical injury for 24 hours or until surface temperature is less than 60°C.

END OF SECTION

SECTION 02750

GEOGRID REINFORCEMENT LAYER

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and installation equipment necessary for the installation of the geogrid reinforcement layers (geogrids), as specified herein, as shown on the Drawings, and in accordance with the Construction Quality Assurance (CQA) Plan.
- B. The Contractor shall coordinate the installation of the geogrids with other construction activities and subcontractors at the site.

1.02 RELATED SECTIONS

- A. Section 02110 – Clearing
- B. Section 02200 – Earthwork
- C. Section 02210 – Structural Fill
- D. Section 02711 – Geotextiles
- E. Section 02735 - Geocomposite Drainage Layer
- F. Section 02740 - Flexible Pavement

1.03 PAYMENT AND MEASUREMENT

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1.04 REFERENCES

- ASTM D4355 Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus)
- ASTM D4595 Tensile Properties of Geotextiles by the Wide-Width Strip Method
- ASTM D5262 Evaluating the Unconfirmed Tension Creep Behavior of Geosynthetics

Geosynthetics Research Institute – GRI

GRI-GG4(b) Standard Practice for Determination of the Long Term Design
Strength of Flexible Geogrids

GRI-GG5 Test Method for Geogrid Pullout

GRI-GG6 Geotextile Pullout

GRI-GG7 Determination of Long-Term Design Strength of Geotextiles

Federal Highway Administration – FHWA

FHWA/SA-93-025

Guidelines for Design, Specification, and Contracting of
Geosynthetic Mechanically Stabilized Earth Slopes of Firm
Foundations

1.05 WARRANTY

- A. The Contractor shall furnish the Owner written warranties obtained from the Manufacturer and the Installer against defects in materials and workmanship. Warranty conditions proposed by the Manufacturer or Installer concerning limits of liability will be evaluated and must be acceptable to the Owner.

1.06 RESPONSIBILITY

- A. The Contractor shall provide the services of a geogrid manufacturer (Manufacturer) and installer

(Installer) who shall meet the following qualifications specified in specifications. The Contractor shall, however, accept and retain full responsibility for all materials and installation and shall be held responsible for any defects in the underlying materials.

- B. The Manufacturer shall be responsible for the production and delivery of geogrid rolls and shall be a well established firm with more than five years experience in the manufacture of geogrid.
- C. The Installer shall be responsible for field handling, storing, deploying, connecting, temporary restraining (against wind), anchoring, and other site aspects of the geogrid installation.

1.07 SUBMITTALS

- A. The Contractor shall submit to the Owner in writing the following documentation on the raw materials used to manufacture the geogrids prior to the confirmation of any contractual agreements:
 - 1. Copies of quality control certificates issued by the resin supplier including production dates of the resins.
 - 2. Results of tests conducted to verify the quality of the resins used to manufacture the geogrid rolls assigned to the project.
 - 3. Certification that no reclaimed polymers are added to the resins during the manufacture of the geogrids to be used in this project.
- B. The Contractor shall submit to the Owner the following regarding the Manufacturer prior to the confirmation of any contractual agreements:
 - 1. certified minimum property values of the proposed geogrid and the tests used to determine those properties; and
 - 2. production capacity available and projected delivery dates for this project.
- C. The Contractor shall submit to the Owner the following information regarding the Installer prior to the confirmation of any contractual agreements:
 - 1. corporate background and information;
 - 2. copy of Installer's letter of approval or license by the Manufacturer; and
 - 3. a list of at least ten completed facilities for which the Installer has installed a minimum of 1,000 square meters of geogrid.
- D. The Contractor shall submit to the Owner and the CQA Consultant manufacturing quality control certificates for each shift's production. The certificates shall be signed by responsible parties employed by the Manufacturer (such as the production manager), and shall be notarized.
- E. The quality control certificate shall include:
 - 1. roll numbers and identification;
 - 2. sampling procedures; and
 - 3. results of quality control tests, including descriptions of test methods used.

1.08 CONSTRUCTION QUALITY ASSURANCE

- A. The installation of the geogrid shall be monitored by the CQA Consultant as specified in this section and as outlined in the CQA Plan.
- B. The Contractor shall be aware of the activities outlined in the CQA Plan and shall account for these CQA activities in the installation schedule.

PART 2 - PRODUCTS

2.01 GEOGRID PROPERTIES

- A. The Geosynthetic shall be dimensionally stable and able to retain its geometry under construction stresses and shall have resistance to damage during construction, to ultraviolet degradation, and to all forms of chemical and biological degradation encountered in the soil being reinforced.
- B. Certification. Prior to construction the Contractor shall submit to the Engineer the Manufacturer's certification that the geosynthetic has been evaluated in full compliance with this Specification and is fit for use in Long-term, critical soil reinforcement applications. The Contractor's submittal package shall include, but not be limited to, actual tests results for tension/creep, durability/aging, construction damage, pullout and quality control. The Manufacturer shall also provide written certification that all resin used to produce the primary geosynthetic is virgin and classified as high molecular weight polyester or high density polyethylene and is capable of withstanding direct exposure to sunlight for 14 days with no measurable deterioration as per ASTM D 4355.
- C. Primary Geosynthetic. The primary geosynthetic shall provide the following minimum allowable

properties:

1. Long-Term Design Strength (LTDS, or α_d)—LTDS is determined using the standard practice GRI-GG4(b) or GRI-GT7 where;

$$\text{LTDS or } T_a = \frac{T_{ULT}}{(F_{SCRa}) (F_{SID}) (F_{SCD}) (F_{SBD}) (F_{SJNT})}$$

2. T_a : The allowable long-term strength of a geosynthetic is used in a traditional factor of safety formulation and compared directly to the design requirement for strength. Note that the allowable strength is typically always less than the ultimate tensile strength (T_{ULT}).
3. T_{ULT} : Ultimate Tensile Strength (α_u), shall be the minimum average roll value (MARV) ultimate tensile strength as tested per ASTM D4595.
4. F_{SCR} : Partial Factor of Safety for Creep Deformation, is the ratio of TULT to creep limited strength determined in accordance with ASTM D5262. The results shall be extrapolated for a 75 year design life using elevated temperature and/or stress rupture testing for 10,000 hours or room temperature testing for 65,700 hours per GRI-GG4(b) or GRI-GT7. Total reinforcement strain shall be less than 10% over the 75-year design life.
5. F_{SID} : Partial Factor of Safety for Installation Damage, shall be determined from construction damage tests for each product proposed for use with project specific, representative or more severe backfill materials and construction techniques. The backfill soil used, if other than project specific, shall have a D_{50} of 0.60 mm (No. 30 sieve). Testing shall be consistent with GRI-GG4(b) or GRI-GT7. A default F_{SID} value of 2.0 shall be used if such testing has not been conducted. The minimum F_{SID} shall not be less than 1.10.
6. F_{SCD} : Partial Factor of Safety for potential chemical degradation, shall be determined by testing before and after immersion in the specific liquid environment under consideration. The immersion procedure to be used follows the EPA 9090 Test Method. This testing method shall only be performed by an independent testing laboratory. F_{SCD} shall be determined for polymer specific (PET as identified by molecular weight, CEG, and intrinsic viscosity and HDPE and PP as identified by specific gravity and melt flow index) durability testing covering the range of expected soil environments per EPA 9090 testing at temperatures of 23°C and 50°C. In no case shall a chemical degradation factor less than 1.1 be used. In absence of adequate chemical degradation testing and long-term extrapolation a default F_{SCD} value of 2.0 shall be used.
7. F_{SBD} : Partial Factor of Safety for potential biological degradation, shall be determined by testing before and after incubation in the site-specific environmental medium under consideration. The incubation procedure to be used follows ASTM G22, "Determining Resistance of Synthetic Polymer Materials to Bacteria", or equal. This testing method shall only be performed by an independent testing laboratory.
8. Soil Interaction Coefficient, C_i value shall be determined from short-term effective stress pullout tests per GRI-GG5 over the range of normal stresses encountered. The maximum pullout force used to determine C_i shall be limited to the lesser of T_a or the force that yields approximately 4 cm of displacement. The minimum C_i value in sand shall be 0.90 where the C_i value is determined as follows:

$$C_i = \frac{F}{2L\sigma_N \tan \phi}$$

Where F = Pullout Force (kN/m), per GRI-GG5

L = Geosynthetic Embedment Length in Test (m)

σ_N = Effective Normal Stress (kPa)

ϕ = Effective Soil Friction Angle, Degrees

- D. Secondary Geosynthetic Reinforcement. Secondary Geosynthetic Reinforcement shall meet the following minimum average geosynthetic properties:

<u>PROPERTY</u>	<u>METHOD</u>	<u>VALUE (kN/m)</u>
Ultimate Tensile Strength ¹	ASTM D4595	35.0

Note: (1) In direction perpendicular to the direction of primary reinforcement.

2.02 MANUFACTURING QUALITY CONTROL

Manufacturing Quality Control. The purpose of the QC testing program is to verify that the geosynthetic being supplied to the project is representative of the geosynthetic use for performance testing described above. The geosynthetic manufacturer shall have a manufacturing quality control program that includes the following QC testing and average production frequency:

<u>PROPERTY</u>	<u>TEST METHOD</u>	<u>FREQUENCY</u>
Ultimate Tensile Strength	ASTM D4595	4,000 sq m
Specific Gravity	ASTM D4595	16,000 sq m
Intrinsic Viscosity (PET only)	ASTM D4595	16,000 sq m

2.03 ACCEPTABLE GEOGRID MATERIALS

- A. The Geogrid Reinforcement Layers shall be installed in accordance with the plans, and specifications. As shown in the plans, the Geogrid Reinforcement Layers shall meet the following minimum properties:

<u>Geogrid Type</u>	<u>Process</u>	<u>Polymer</u>	<u>LTDS (kN/m)</u>	<u>T_{ULT} (kN/m)</u>
Miragrid 7XT	Woven	PET	22.9	63.5
Miragrid 10XT	Woven	PET	43.6	121.1
Miragrid 18XT	Woven	PET	49.2	136.6
Miragrid 20XT	Woven	PET	65.2	181.2
Miragrid 24XT	Woven	PET	133.3	370.3

- B. Alternate material not listed above will be considered. Alternate material must be pre-approved in writing by the Engineer a minimum of 7 days prior to the bid date. Submittal package documenting alternate material conformance with the requirements and elevations procedures of this specification must be submitted to the Engineer a minimum of 21 days prior to the bid date.

PART 3 - EXECUTION

1.01 DELIVERY

- A. The Contractor shall check the geosynthetic upon delivery to ensure that the proper material has been received during all periods of shipment and storage. The geosynthetic shall be protected from temperatures greater than 140oF, and all deleterious materials that might otherwise become affixed to the geosynthetic and adversely affect its performance. Follow manufacturer's recommendations in regards to protection from direct sunlight.

3.02 INSTALLATION

- A. A qualified and experienced Civil Engineer employed by the geosynthetic manufacturer. If needed, the Manufacturer may supply an engineer for a minimum of one day of site assistance at the start of

- installation to assist the Contractor and the Engineer in the proper construction/installation techniques. Thereafter, the representative shall be available on an as needed basis, as requested by the Engineer, during the construction of the remainder of the project.
- B. Foundation soil shall be excavated to the line and grades as shown on the construction drawings or as directed by the Engineer. Over-excavated areas shall be filled with compacted backfill material as per project specifications or as directed by the Engineer.
 - C. As a minimum, foundation soil shall be proof rolled prior to backfill and geosynthetic placement.
 - D. Geosynthetics shall be laid at the proper elevation and orientation as shown in the construction drawings or as directed by the Engineer. Correct orientation of the geosynthetic is of extreme importance and shall be verified by the Contractor. Geosynthetic may be temporarily secured in-place with staples, pins, sandbags, or backfill as required by fill properties, fill placement procedures, or weather conditions, or as directed by the Engineer.
 - E. Primary geosynthetic may not be overlapped or connected mechanically to form splices in the primary strength direction. Single panel lengths are required in the primary strength direction. Not overlapping is required between adjacent rolls unless a wrap-back facing system is specified. In the case of a wrap-back facing, a minimum 45 cm over-lap is recommended.
 - F. Backfill material shall be placed in lifts and compacted as directed under the project specifications. Backfill shall be placed, spread and compacted in such a manner as to minimize the development of wrinkles in and/or movement of the geosynthetic. Tracked construction equipment shall not be operated directly upon the geosynthetic. A minimum fill thickness of 6 inches is required prior to the operation of tracked vehicles over the geosynthetics. Turning of tracked vehicles should be kept to a minimum to prevent tracks from displacing the fill and damaging the geosynthetics. Rubber tired equipment may pass over the geosynthetic reinforcement at slow speeds. Less than 15 kph. Sudden braking and sharp turns shall be avoided.
 - G. Any geosynthetic damaged during installation shall be replaced by the Contractor at no additional cost to the owner.

END OF SECTION

SECTION 02761

ROCK FILLED GABIONS WALLS

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

- A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and installation equipment necessary for the installation of the rock filled gabion walls (gabions), as specified herein, as shown on the Drawings, and in accordance with the Construction Quality Assurance (CQA) Plan.
- B. The Contractor shall coordinate the installation of the geogrids with other construction activities and subcontractors at the site.

1.02 RELATED SECTIONS

- A. Section 02110 – Clearing
- B. Section 02200 – Earthwork
- C. Section 02220 – Compacted Clay
- D. Section 02750 – Geogrid Reinforcement Layer
- E. Section 03310 – Cast-In-Place Concrete

1.03 PAYMENT AND MEASUREMENT

- A. For items of work for which specific unit prices are established in the Contract; the volume of rock will be measured within the neat lines of the gabion structure and computed to the nearest cubic meter. Payment for gabions will be made at the contract unit price, and includes the wire mesh and rock. Such payment will be considered full compensation for all labor, materials, equipment, and all other items necessary and incidental to completion of the work.
- B. No deduction in volume will be made for any void or embedded item. Compensation for any item of work described in the contract, but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary.

1.04 REFERENCES

ASTM A1064	Steel Wire Reinforcement
ASTM A974	Wire fabric Gabions and Mattresses
ASTM A641	Zinc - Coated
ASTM D792	Specific Gravity
ASTM D1242	Abrasion Resistance
ASTM D746	Brittleness Temperature
ASTM D412	Tensile Strength of Extruded Coating
ASTM D638	Tensile Strength of Fusion Bonded Coating
ASTM G23	Ultraviolet Light Exposure
ASTM B117	Salt Spray Test

1.05 WARRANTY

- A. The Contractor shall furnish the Owner written warranties obtained from the Manufacturer and the Installer against defects in materials and workmanship. Warranty conditions proposed by the

Manufacturer or Installer concerning limits of liability will be evaluated and must be acceptable to the Owner.

1.06 RESPONSIBILITY

- A. The Contractor shall accept and retain full responsibility for all materials and installation and shall be held responsible for any defects in the underlying materials.
- B. The Manufacturer shall be responsible for the production and delivery of Gabions and shall be a well established firm with more than five years experience in the manufacture of Gabions.
- C. The Contractor shall be responsible for field handling, storing, deploying, connecting, temporary restraining (against soil pressure), anchoring, and other site aspects of the Gabion installation.

1.07 SUBMITTALS

- A. The Contractor shall submit to the Owner in writing the following documentation on the raw materials used to manufacture the Gabions prior to the confirmation of any contractual agreements:
 - 1. Copies of quality control certificates issued by the Manufacturer.
 - 2. Results of tests conducted to verify the properties of the Gabion materials.
- B. The Contractor shall submit to the Owner the following regarding the Manufacturer prior to the confirmation of any contractual agreements:
 - 1. certified minimum property values of the proposed Gabions and the tests used to determine those properties; and
 - 2. projected delivery dates for this project.
- C. The Contractor shall submit to the Owner and the CQA Consultant manufacturing quality control certificates for each shift's production. The certificates shall be signed by responsible parties employed by the Manufacturer (such as the production manager).
- D. The quality control certificate shall include:
 - 1. production identification;
 - 2. sampling procedures; and
 - 3. results of quality control tests, including descriptions of test methods used.

1.08 CONSTRUCTION QUALITY ASSURANCE

- A. The installation of the Gabions shall be monitored by the CQA Consultant as specified in this section and as outlined in the CQA Plan.
- B. The Contractor shall be aware of the activities outlined in the CQA Plan and shall account for these CQA activities in the installation schedule.

PART 2 - PRODUCTS

2.01 GABION PROPERTIES

- A. The wire mesh shall be Galfan / Zinc – Aluminum finish before forming into mesh.
- B. The dimension tolerance shall be plus or minus 5 percent.
- C. Baskets shall have a height of 1 m;
- D. Baskets shall have a width of 1 m;
- E. Baskets shall have a length of 2.0 m, with cross pieces every 1.0 m;
- F. Gabions shall be fabricated, assembled, and installed in accordance with the nominal wire sizes and dimensions summarized below:

Type of Wire	Mesh Size (mm)	Wire Diam (mm)
Lacing Wire		2.7
Mesh Wire	100 by 120	2.7
Spiral Binder		2.7

- G. Wire for fabrication and assembly shall be low carbon steel wire of Galfan / Zinc aluminum finish. The wire shall have a minimum tensile strength of 360,000 kPa. Steel wire shall conform to ASTM A641 and ASTM A974, abiding by the quality inspection (SGS, BV).
- H. The wire shall be of Galfan / Zinc aluminum finish. The wire shall be colored black, gray, green, or silver. The initial properties of the shall meet the following minimal and indicative requirements:
1. The percentage weight loss shall be less than 2 percent, when abrasion resistance is tested according to ASTM D1242, Method B at 200 cycles, CSI-A Abrader Tape, 80 grit.
 2. The brittleness temperature shall not be higher than -9 degrees C, ASTM D746.
 3. The tensile strength of the extruded coatings shall be greater than 50,000 kPa at 100 percent strain (ASTM D412). The tensile strength of fusion bonded coatings shall be greater than 25,000 kPa at 100 percent strain (ASTM D638).
 4. The modulus of elasticity of extruded coatings shall be greater than 29,000 kPa at 100 percent strain (ASTM D412). The modulus of elasticity of fusion bonded coatings shall be greater than 23,500 kPa at 100 percent strain (ASTM D638).
 5. A test period of not less than 3,000 hours, using apparatus type E at 63 degrees C shall be used to evaluate ultraviolet light exposure (ASTM G23);
 6. The test period of the salt spray test shall be greater than or equal to 3,000 hours (ASTM B117).
- I. After exposure to ultraviolet light and the salt spray test as specified above, the finish shall not show cracks, blisters, splits, nor noticeable change of coloring (surface chalk). In addition, the specific gravity shall not change more than 2 percent, resistance to abrasion shall not change more than 5 percent, and tensile strength shall not change more than 15 percent from their initial values.
- J. Spiral binders are the standard fastener for mesh Gabion baskets, and shall be formed from wire meeting the same quality and coating thickness requirements as specified for the Gabion baskets.
- K. Alternate fasteners used with wire mesh Gabions, such as ring fasteners, shall be formed from wire meeting the same quality and coating thickness requirements as specified for the Gabions. Test results must be provided to certify that the ring fasteners provide the joint strength required.
- L. Standard fasteners and alternate fasteners must provide a minimum strength of 20.4 kN/m for Gabion baskets. When used to interconnect Gabion baskets, ring fasteners shall be made of stainless steel and spiral fasteners shall be with low carbon steel with galfan / zinc aluminum finish. All fasteners shall meet all of the coating requirements of the Gabion manufacturer.
- M. Rock shall conform to the quality requirements as follows and at least 85 percent of the rock particles, by weight, shall be within the predominant rock size range. Recycled concrete may be used in lieu of the specified aggregate at the engineer's discretion.
- Minimum Rock Dimension 100 mm; and
 - Maximum Rock Dimension 200 mm.

PART 3 - EXECUTION

3.01 DELIVERY

- A. At least 30 days prior to delivery to the site, the Contractor shall inform the engineer in writing of the source from which the rock will be obtained, and include the test data and other information by which the material was determined by the Contractor to meet the specification. The contractor shall provide the engineer free access to the source for the purpose of obtaining samples for testing and source approval.

3.02 INSTALLATION

- A. Foundation Preparation:
1. The foundation on which the Gabions are to be placed shall be graded to the lines and grades shown on the drawings. Surface irregularities, loose material, vegetation, and all foreign matter shall be removed from the foundation surface area.

2. The reinforced concrete leveling pad shall not be placed until the foundation preparation is completed, and the subgrade surfaces have been inspected and approved by the engineer or the engineer's representative.
 3. The leveling pad shall be a minimum of 1.4 m wide, and shall have a minimum thickness of 0.10 m.
- B. Assembly and Placement:
1. Assembly:
 - a. Rotate the Gabion panels into position and join the vertical edges with fasteners for Gabion assembly.
 - b. Where lacing wire is used, wrap the wire with alternating single and double half hitches at intervals between 100 and 125 mm. Where spiral fasteners are used, crimp the ends to secure the spirals in place.
 - c. Use the same fastening procedures to install interior diaphragms where they are required.
 - d. Interior diaphragms will be required at 1.0 m intervals.
 2. Placement:
 - a. Place the empty Gabions on the foundation and interconnect the adjacent Gabions along the top, bottom, and vertical edges using lacing wire or spirals.
 - b. Wrap the wire with alternating single and double half hitches at intervals between 100 and 125 mm.
 - c. Spiral fasteners shall be used for the assembly and interconnection of mesh Gabions.
 - d. Spirals shall be screwed down at the connecting edges then each end of the spiral shall be crimped to secure in place.
 - e. Interconnect each layer of Gabions to the underlying layer of Gabions along the front, back, and sides.
 - f. Stagger vertical joints between the Gabions of adjacent rows and layers by at least one-half cell length.
- C. Filling Operation:
1. After adjacent empty wire Gabion units are set to line and grade and common sides properly connected, they shall be placed in straight-line tension to gain a uniform alignment. Staking of the Gabions may be done to maintain the established proper alignment prior to the placement of rock. Connecting lacing wire and other fasteners (as allowed) shall be attached during the filling operation to preserve the strength and shape of the structure.
 2. Internal connecting cell diaphragm members shall be spaced at 1.0 m. Two internal connecting wires shall be placed concurrently with rock placement.
 3. Cross-ties and stiffeners in mesh Gabions shall be placed across the corners of the Gabions (at least 0.3 m from corners) providing diagonal bracing. Lacing wire or preformed wire stiffeners may be used.
 4. The Gabions shall be carefully filled with rock, either by machine or hand methods, ensuring alignment, avoiding bulges, and providing a compact mass that minimizes voids. At no point in the filling process may rock be mechanically placed from a height of over 1 m from the machine to the fill area. Machine placement will require supplementing with handwork to ensure the desired results. The cells in any row shall be filled in stages so that the depth of the rock placed in any one cell does not exceed the depth of rock in any adjoining cell by more than 0.3 m. Along the exposed faces, the outer layer of stone shall be carefully placed and arranged by hand to ensure a neat, compact placement with a uniform appearance.
 5. The last layer of rock shall be uniformly leveled to the top edges of the Gabions. Lids shall be placed over the rock filling using only approved lid closing tools as necessary. The use of crowbars or other single point leverage bars for lid closing is prohibited due to the potential for damage to the baskets.
 6. The Gabion lid shall be secured to the sides, ends, and diaphragms with spiral binders, approved alternate fasteners, or lacing wire wrapped with alternating single and double half-hitches in the mesh openings.

7. Any damage to the wire or coatings during assembly, placement, and filling shall be repaired promptly in accordance with the Manufacturer's recommendations, or shall be replaced with undamaged Gabion baskets at no additional cost to the Owner.

END OF SECTION

SECTION 02923

LANDSCAPE GRADING

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes final grade topsoil for finish landscaping.
- B. Related Sections:
 - 1. Section 02320 - Backfill.

1.2 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures
- B. Samples: Submit, in air-tight containers, 4.5 kg sample of each type of fill to testing laboratory.
- C. Materials Source: Submit name of imported materials source.
- D. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.3 QUALITY ASSURANCE

- A. Furnish each topsoil material from single source throughout the Work.
- B. Perform Work in accordance with the drawings and to the approval of the Engineer.
- C. Maintain one copy on site.

PART 2 PRODUCTS

2.1 MATERIAL

- A. Agricultural Topsoil: Fertile, agricultural soil, typical for locality, capable of sustaining vigorous plant growth, taken from drained site; free of subsoil, clay or impurities, plants, weeds and roots; minimum pH value of 5.4 and maximum 7.0; organic matter to exceed 1.5%, magnesium to exceed 100 units; phosphorus to exceed 150 units; potassium to exceed 120 units; soluble salts/conductivity not to exceed 900 ppm/0.9 mmhos/cm in soil.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for verification of existing conditions before starting work.
- B. Verify building and trench backfilling have been inspected.
- C. Verify substrate base has been contoured and compacted.

3.2 PREPARATION

- A. Protect landscaping and other features remaining as final Work.
- B. Protect existing structures, fences, sidewalks, utilities, paving and curbs (if any).

3.3 SUBSTRATE PREPARATION

- A. Eliminate uneven areas and low spots.
- B. Remove debris, roots, branches, stones, in excess of 13 mm in size. Remove contaminated subsoil.
- C. Scarify surface to depth of 150 mm where topsoil is scheduled. Scarify in areas where equipment used for hauling and spreading topsoil has compacted subsoil.

3.4 PLACING TOPSOIL

- A. Place topsoil in areas where seeding, sodding and planting is required and to the required thickness. Place topsoil during dry weather.
- B. Fine grade topsoil to eliminate rough or low areas. Maintain profiles and contour of subgrade.
- C. Remove roots, weeds, rocks and foreign material while spreading.
- D. Manually spread topsoil close to plant material or to building to prevent damage.
- E. Lightly compact or roll placed topsoil as directed by the Engineer.
- F. Remove surplus subsoil and topsoil from site.
- G. Leave stockpile area and site clean and raked, ready to receive landscaping.

3.5 TOLERANCES

- A. General Requirements: Quality requirements for tolerances.
- B. Top of Topsoil: Plus or minus 13 mm.

3.6 PROTECTION OF INSTALLED WORK

- A. General Requirements: Execution requirements for protecting finished Work.
- B. Prohibit construction traffic over topsoil.

END OF SECTION

SECTION 03310

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and installation equipment necessary for the manufacture, storage, delivery, and installation of cast-in-place concrete, as specified herein, as shown in the Drawings and in accordance with the Construction Quality Assurance (CQA) Plan.
- B. The work shall include, but not be limited to, vehicle posts, equipment pads, inlet structures, and support structures.
- C. The Contractor shall coordinate the installation of the cast-in-lace concrete with other construction activities and subcontractors at the site.

1.02 RELATED SECTIONS

- A. Section 02210 – Structural Fill
- B. Section 02225 – Bedding Material
- C. Section 02270 – Gravel Roads
- D. Section 02718 – High Density Polyethylene Pipe and Fittings
- E. Section 03320 – Precast Concrete Structures

1.03 PAYMENT AND MEASUREMENT

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1.04 REFERENCES

- A. CQA Plan.
- B. Latest version of American Society for Testing and Materials (ASTM) standards:
 - 1. ASTM A 185 Specification for Welded Steel Wire Fabric for Concrete Reinforcement.
 - 2. ASTM A 427 Specification for Welded Deformed Steel Wire Fabric for Concrete Reinforcement.
 - 3. ASTM A 615 Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
 - 4. ASTM C 31 Standard Methods of Making and Curing Concrete Test Specimens in the Field.
 - 5. ASTM C 33 Standard Specification for Concrete Aggregates.
 - 6. ASTM C 39 Standard Method of Compressive Strength of Cylindrical Concrete Specimens.
 - 7. ASTM C 94 Standard Specification for Ready-Mixed Concrete.
 - 8. ASTM C 143 Standard Test Method for Slump of Portland Cement Concrete.
 - 9. ASTM C 150 Standard Specification for Portland Cement.
 - 10. ASTM C 171 Standard Specification for Sheet Materials for Curing Concrete.
 - 11. ASTM C 172 Standard Test Method for Sampling Freshly Mixed Concrete.
 - 12. ASTM C 231 Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
 - 13. ASTM C 260 Specification for Air – Entraining Admixtures for Concrete.
 - 14. ASTM C 494 Specifications for Chemical Admixtures for Concrete.

- 15. ASTM C 618 Specification for Fly Ash and Raw or Calcined Pozzolans for use in Portland Cement Concrete.
- C. Latest Version of American Concrete Institute (ACI) standards:
 - 1. ACI 211.1 Selecting Proportions for Normal Weight Concrete.
 - 2. ACI 214 Evaluation of Compression Test Results of Field Concrete.
 - 3. ACI 301 Specifications for Structural Concrete Buildings.
 - 4. ACI 304 Measuring, Mixing, Transporting, and Placing Concrete.
 - 5. ACI 305 Hot Weather Concreting.
 - 6. ACI 318 Requirements for Reinforced Concrete.

1.05 SUBMITTALS

- A. The Contractor shall provide the following to the Owner for approval prior to placement of concrete:
 - 1. certifications as required by ASTM C 94;
 - 2. shop drawings for all reinforcing steel;
 - 3. Certificates of Compliance for the following items:
 - a. cement,
 - b. aggregates,
 - c. admixtures, and
 - d. reinforcing steel; and
 - 4. Design Mixes: At least 30 days prior to the start of placing concrete, the Contractor shall submit design mixes for each Class and Type of concrete specified, indicating that the concrete ingredients and proportions will result in a concrete mix meeting the requirements specified.
- B. Compression Test Data:
 - 1. Compression test cylinders from all concrete used on the project, except for the precast concrete items, will be made by the Owner and tested in accordance with the ACI Code and ASTM C 39.
 - 2. Concrete that does not meet the specifications will be required to be removed and replaced at the Contractor's expense or may be subjected to a load test, also at Contractor's expense.
- C. Batch Tickets:
 - 1. Submit Certificate to the Owner before unloading concrete at the site or submit a delivery ticket to the Owner from the concrete supplier for each batch of concrete delivered to the site. The certificated or delivery ticket shall set forth the following information:
 - a. name of supplier,
 - b. name of batching plant and location,
 - c. serial number of ticket or Certificate,
 - d. date,
 - e. truck number,
 - f. specific job designation (contract number and location),
 - g. volume of concrete (cubic meters),
 - h. specific Class and type of concrete (in conformance with the Specifications),
 - i. time loaded,
 - j. type and brand of cement,
 - k. weight of cement,
 - l. maximum size of aggregates,
 - m. weights of coarse and fine aggregates, respectively,
 - n. type of aggregate,
 - o. amount of water added at the plant and maximum amount of water to be added at the site, if any, and kind and amount of admixtures; and
- D. Following installation, the Contractor shall submit a Placement Log for all cast-in-place concrete

items, including the following information:

1. date of placement;
2. location and extent of placement;
3. quantity of concrete;
4. air temperature; and
5. tests and samples taken.

1.06 CONSTRUCTION QUALITY ASSURANCE

- A. Ready Mixed Concrete Plant shall be approved by the Municipality of Tripoli.
- B. Testing and Inspection Agency or Company shall be approved by the Municipality of Tripoli.

PART 2 - PRODUCTS

2.01 CONCRETE MATERIALS

- A. Concrete Mix. Concrete mix shall conform with ASTM C94, and shall be ready mixed, formal weight, air entrained, minimum compressive strength 24,000 kPa at 28 days, except concrete for anti-flotation collars, buttresses, and pipe encasement shall have a minimum compressive strength of 17,000 kPa. The concrete slump shall be 75 ± 25 mm.
- B. Cement. Cement shall conform to ASTM C 150, Type I or II, or as specified in Drawings.
- C. Aggregate. Aggregate shall conform to ASTM C33. Maximum size of coarse aggregate shall be the smallest of 38 mm, $\frac{3}{4}$ of the minimum clear spacing between reinforcing bars, or $\frac{1}{3}$ of the thickness of the slab.
- D. Water. Water shall be potable.
- E. Reinforcing Steel. All deformed billet steel shall conform to ASTM A 615 Grade 60. All wire fabric shall be welded steel in conformance with ASTM A 185

2.02 CONCRETE MIXING

- A. The Ready Mix Concretes shall comply with requirement of ASTM C 94 for mixing time and water addition. Total mixing time for concrete shall be determined in accordance with ASTM C 94 for type of mixing equipment used. Concrete that has been in truck for more than 1.5 hours after addition of water, or had more than 300 revolutions, or concrete that has become hard or non-plastic, shall not be used. When concrete arrives at the site with a slump below that specified herein, water may be added only if neither the maximum specified water/cement ratio nor the maximum specified slump is exceeded. The additional water should be incorporated into the mix by increasing the mixing time at least 1.5 times the total mixing time required by ASTM C 94. However, the Contractor shall bear total responsibility for the effects of adding water on the quality and strength of the concrete.
- B. During hot weather, or under conditions contributing to rapid setting of concrete, a shorter mixing time than specified in ASTM C 94 may be required.

- C. Prepare and submit Mix Design and Test Results of Mix Trials to the approval of the Engineer for the following different types/classes of concrete:

Structures and Beds	ASTM C150 Cement	Minimum Compressive Strength at 28 days on		Maximum Slump (± 20 mm) (mm)	Maximum Water to Cement Ratio	Minimum Cement Content (kg/m ³)	Notes
		cylinders (MPa)	cubes (MPa)				
Blinding.	Type I, II or V (as indicated)	14	18	180	0.60	250	Normal weight Mix.
Cyclopean concrete and reinforced concrete works.	Type I, II or V (as indicated)	30	38	180	0.42	350	Normal weight Mix.
Precast concrete works.	Type I, II or V (as indicated)	40	50	180	0.42	430	Normal weight Mix.

CYCLOPEAN CONCRETE

- A. Cyclopean concrete shall comprise 60% of the specified concrete and 40% "spalls" ranging in size from 100 to 250 mm.
- B. Stone and concrete shall be placed in alternate layers and in such a way that no stone shall be in contact with another or with shuttering sides. All faces of the cyclopean concrete shall show sound well compacted concrete.
- C. Spalls or boulders shall be free from sharp or angular edges, clean and free from dirt or earth, and soaked in water prior to incorporated into the concrete.

2.03 NON-SHRINK GROUT

- D. Non-shrink grout shall conform to Corps of Engineers Specification CRD C 621 (588).

PART 3 - EXECUTION

3.01 FAMILIARIZATION

- A. Prior to implementing any of the work described in this Section, the Contractor shall become thoroughly familiar with all portions of the work falling within this section.
- B. Inspection:
 1. Prior to implementing any of the work in this Section, the Contractor shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.
 2. If the Contractor has any concerns regarding the installed work of other Sections, the Contractor shall notify the Owner in writing within 48 hours of the site inspection. Failure to inform the Owner in writing or installation of cast-in-place concrete shall be construed as the Contractor's acceptance of the related work of all other Sections.

3.02 EXAMINATION AND PREPARATION

- A. Reinforcement shall be placed to the dimensions shown on the Drawings.
- B. Stirrups and tie bars shall be bent around a pin having a diameter not less than two times the minimum thickness of the bar. Bends for other bars shall be made around a pin having a diameter not less than six times the minimum thickness except for bars larger than 25 mm, in which case the bends shall be made around a pin of eight bar diameters. All bars shall be bent cold.
- C. Reinforcement shall be shipped to the site with bars of the same size and shape securely fastened in bundles with wired metal identification tags containing the bar size. The identification tags shall be labeled with the same designation as shown on submitted bar schedules and shop drawings.
- D. All bars shall be stored off the ground and shall be protected from moisture and kept free from dirt, oil, and other foreign substances.

- E. Unless otherwise shown on the Drawings, splices in reinforcement bars shall be lapped not less than 24 bar diameters. All bar splices shall be staggered wherever possible. When splicing bars of different diameters, the length of lap is based on the larger bar.
- F. Before placing in position, reinforcement shall be thoroughly cleaned of loose mill and rust scale, dirt, and other coatings that may reduce or destroy bond. Where there is delay in depositing concrete after reinforcement is in place, bars shall be inspected and cleaned when necessary.

3.03 PLACING CONCRETE

- A. Formwork and joints shall be erected, and accessories shall be installed in accordance with the Drawings.
- B. Concrete shall not be placed until the forms, reinforcement, and other conditions are approved for pouring by the Owner's Representative or Engineer, and until all pipes, conduits, sleeves, thimbles, hangers, anchors, flashing, and other work required to be placed in the concrete have been properly installed.
- C. Water shall be removed from the space to be occupied by concrete, and any continuous flows of water shall be diverted to a sump or removed by pumping.
- D. Hardened concrete and foreign materials shall be removed from the inner surfaces of mixing and conveying equipment before concrete is mixed. Before depositing concrete, forms shall be thoroughly wetted and all debris removed.
- E. Concrete Placement:
 - 1. Practices shall comply with ACI 304 and as herein specified.
 - 2. Concrete shall be deposited in horizontal layers not deeper than 0.6 m in such a manner as to prevent flow of concrete. Concrete shall be deposited to maintain a plastic surface that is approximately horizontal and in a manner to avoid inclined construction joints.
 - 3. Where placement consists of several layers, each layer shall be placed while the preceding layer is still plastic to avoid cold joints.
 - 4. Concrete shall be consolidated by internal mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping in accordance with ACI 304 during and immediately after placing.
 - 5. Reinforcing, inserts, embeds, and joints shall be maintained in proper position during concrete placement.
 - 6. Pumping placement of concrete shall be done with pumps, pipelines, and accessory equipment provided in accordance with ACI 304 and ACI 304-2R.
- F. concrete shall be deposited continuously, or in layers of such thickness that no concrete will be deposited against concrete that has hardened. If a section cannot be placed continuously, construction joints may be located at points as provided for in the Drawings or approved by the Owner's Representative or Engineer. Before depositing new concrete against old concrete, the forms shall be retightened, the hardened surfaces cleaned and covered with a coating of neat cement grout.
- G. In the event of rain during concrete placement, the placement shall be terminated as soon as practicable at a point approved by the Owner's Representative or Engineer, and freshly placed concrete shall be protected with a waterproof covering that shall prevent marring or damage of surfaces.
- H. Concrete shall not be placed without consent of the Owner's Representative or Engineer when the temperature is 10 °C or less, or when there is reason to expect a drop in temperature below 10 °C within 12 hours of the conclusion of the pour. Concrete placed at air temperatures below 4 °C shall have a minimum temperature of 15 °C. When the air temperature is below 4 °C or near 4 °C and falling, the water and aggregates shall be heated before mixing. Accelerating chemicals shall not be used to prevent freezing.

- I. Hot weather placement of concrete shall comply with ACI 305.

3.04 CONCRETE CURING AND PROTECTION

- A. Freshly placed concrete shall be protected from premature drying and excessive cold or hot temperatures.
- B. Curing procedures shall begin immediately after placement in accordance with ACI 301 procedures to provide continuous moist curing above 10 °C for at least 7 days.
- C. Curing of concrete shall be performed by moist curing and by moisture retaining cover curing, as herein specified. Moisture curing shall be provided by one of the following methods: covering with water, sprinkled with water, continuous water fog spray, and covering concrete surface with specified absorptive cover, thoroughly saturating cover with water, and keeping continuously wet. The Contractor shall submit for approval by the Owner's Representative or Engineer the methods proposed for use against low temperatures. No salt, manure, or other chemicals shall be used for protection.
- D. Protection of Completed Work:
 1. Concrete shall be protected from damaging mechanical disturbances, water flow, loading, shock, and vibration during the entire curing period.
 2. Concrete surfaces shall be kept free from all foot and vehicular traffic and all other sources of abrasion for not less than 72 hours after finishing.
 3. Any protective coverings shall be maintained continuously during entire curing period, and damage to coverings shall be repaired immediately at no additional expense to the Owner.
 4. Finished surfaces and slabs shall be protected from the direct rays of the sun to prevent checking and crazing.

3.05 REPAIRS

- A. The Owner shall employ a testing laboratory to perform tests and to submit test reports, except as designated otherwise.
- B. Sampling fresh concrete shall be performed in accordance to ASTM C 172, except modified for slump to comply with ASTM C 94:
 1. Slump test according to ASTM C 143 shall be measured according to:
 - a. one test at point of discharge for each set of compression cylinders taken;
 - b. additional tests when concrete consistency appears to have changed; and
 - c. one test on each truck load of concrete delivered to the site.
 2. Molded concrete compression cylinders shall be sampled in accordance with ASTM C 172, processed and cured in accordance with ASTM C31, and prepared and tested in accordance with ASTM C 39:
 - a. One set of 4 cylinders shall be obtained for each 50 cubic meters, or fraction thereof, for each day's placement of each mix design;
 - b. One cylinder shall be tested at age 3 days or 7 days, as required by job conditions, and 2 cylinders for one valid strength test at 28 days; and
 - c. The fourth cylinder shall be cured and held for testing at 42 days of 28-day test indicated deficient results, or as a spare in case of cylinder damage.
- C. Certified written reports shall be promptly submitted with the following additional data:
 1. time concrete batched and time sampled;
 2. water added at site;
 3. strength class;
 4. delivery ticket number;
 5. concrete suppliers mix designation; and
 6. location of concrete in the work.

7. concrete suppliers mix designation; and location of concrete in the work.

3.06 PRODUCT PROTECTION

- A. The Contractor shall use all means necessary to protect all prior work, including all materials and completed work of other Sections.
- B. In the event of damage to prior work specified in this Section, the Contractor shall immediately make all repairs and replacements necessary to the approval of the Owner and at no additional cost to the Owner.

END OF SECTION

SECTION 03320

PRECAST CONCRETE STRUCTURES

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and installation equipment necessary to install precast concrete structures, frames, covers, manhole rungs, appurtenances, and related work, as specified herein and as shown in the Drawings.
- B. The Contractor shall coordinate the installation of the precast concrete structures with other construction activities and subcontractors at the site.

1.02 RELATED SECTIONS

- A. Section 02210 – Structural Fill
- B. Section 02225 – Bedding Material
- C. Section 02270 – Gravel Roads
- D. Section 02718 – High Density Polyethylene Pipe and Fittings
- E. Section 03310 – Cast-In-Place Concrete

1.03 PAYMENT AND MEASUREMENT

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1.04 REFERENCES

- A. Construction Quality Assurance (CQA) Plan.
- B. Latest version of American Society for Testing and Materials (ASTM) standards:
 - 1. ASTM A 48 Specification for Gray Iron Castings
 - 2. ASTM A 185 Specifications for Welded Steel Wire Fabrics
 - 3. ASTM A 615 Specification for Steel Reinforcement
 - 4. ASTM C 150 Specification for Portland Cement
 - 5. ASTM C 160 Specifications for Air-Entraining Agents

1.05 SUBMITTALS

- A. The Contractor shall submit the following to the Owner at least 28 days prior to starting the work of this Section:
 - 1. shop drawings showing, as a minimum, the layout and details of all precast concrete structures, including reinforcing, joints, pipe connections, rungs, frames, and covers; shop drawings shall be sealed by a Professional Engineer;
 - 2. design calculates bearing the seal of a Professional Engineer;
 - 3. materials list; and
 - 4. Manufacturer's product data and recommended methods of installation.

1.06 CONSTRUCTION QUALITY ASSURANCE

- A. The installation of precast concrete structures may be subjected to CQA monitoring.
- B. The Contractor shall account for the possibility of CQA activities in the installation schedule.
- C. The quality of all materials, the process of manufacture, and the finished sections shall be subject to inspection and approval by the Owner. Such inspections may be made at the place of manufacture, or at the site after delivery, or at both locations. The materials shall be subject to rejection for failure to meet any of the requirements of these specifications even though samples may have been accepted as satisfactory at the place of manufacture. Material rejected after delivery to the site shall

be marked by the Contractor for identification. The Contractor shall immediately remove the rejected materials from the job site and shall replace them with new materials at no cost to the Owner. All materials damaged after delivery to the site will be rejected, and if already installed, shall be acceptably repaired, if permitted, or removed and replaced with new materials, entirely at the Contractor's expense.

- D. The materials will be examined for compliance with ASTM standards, these Specifications, and the approved Manufacturer's Drawings. Precast concrete sections shall be inspected for general appearance, dimensions, "scratch-strength", blisters, cracks, roughness, soundness, etc. The surface shall be dense and close-textured.
- E. Imperfections in precast concrete sections may be repaired, subject to the approval of the Owner, after demonstration by the Manufacturer that strong and permanent repairs result. Repairs shall be carefully inspected before final approval. Cement mortar used for repairs shall have a minimum compressive strength of 27,500 kPa after 7 days, and 34,500 kPa after 28 days, when tested in 75-mm by 150-mm cylinders stored in the standard manner. Epoxy mortar may be used, subject to the approval of the Owner.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Products used in the work of this Section shall be produced by Manufacturers regularly engaged in the production of similar items and with a history of successful production acceptable to the Owner.
- B. Precast concrete barrel sections with precast top slabs and precast concrete transition sections shall be designed for a minimum of H-20 loading plus the weight of the soil above.
- C. The date of manufacture and the name and trademark of the manufacturer shall be clearly marked on the inside of each precast section.

2.02 MATERIALS

- A. Portland Cement. Cement shall conform to ASTM C 150, Type II. The same brand, type, and source of supply shall be used throughout.
- B. Air-Entraining Agent. Air-Entraining Agents shall conform to ASTM C 260.
- C. Aggregates. Aggregates shall conform to ASTM C 33.
- D. Water. Potable water shall be used in concrete mix.
- E. Reinforcing Steel. All deformed billet steel shall conform to ASTM A 615, Grade 60. All wire fabric shall be welded steel in accordance with ASTM A 185.
- F. Grout for repair of units. Grouts used for repairs shall be mixed at a rate of one part Portland cement to two parts sand (by volume). The amount of water shall be kept to a minimum, and the sand and cement shall be as specified for use in concrete.
- G. Bonding Agent. All bonding agents shall be moisture insensitive, epoxy-resin bonding agent. The bonding agent shall be used as specified for repair of units and in conformance with Manufacturer's printed instructions.

2.03 MIXES

- A. The concrete mix shall achieve a minimum 27,500 kPa compressive strength at 28 days.

2.04 FABRICATION

- A. Formwork shall be designed and constructed so as to maintain precast concrete units within their specified tolerances. Anchorage devices shall be securely attached to formwork in locations not affecting position of main reinforcement or placing of concrete.
- B. Concrete shall be placed in a continuous operation to prevent formation of seams.
- C. Placed concrete shall be consolidated by vibration without dislocation or damage to reinforcement and built-in items.

- D. Permanent marking shall be provided in precast unit to identify pick-up points and location in structure.
- E. Precast units shall be cured until 70 percent of the minimum 28-day compressive strength has developed before removing the units from the forms.

2.05 OTHER MATERIALS

- A. All materials, not specifically described, but required for a complete and proper installation of precast concrete sections, shall be selected by the Contractor subject to the approval of the Owner.

PART 3 - EXECUTION

3.01 FAMILIARIZATION

- A. Prior to implementing any of the work described in this Section, the Contractor shall become thoroughly familiar with all portions of the work falling within this Section.
- B. Inspection:
 - 1. Prior to implementing any of the work specified in this Section, the Contractor shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of the work specified in this Section may properly commence without adverse impact.
 - 2. If the Contractor has any concerns regarding the installed work of other Sections, the Contractor shall notify the Owner's Representative or Engineer in writing within 48 hours of the site inspection. Failure to inform the Owner's Representative or Engineer in writing of installation of precast concrete structures will be construed as Contractor's acceptance of the related work of all other Sections.

3.02 INSTALLATION

- A. General:
 - 1. Care shall be taken in loading, transporting, and unloading to prevent damage to precast structures and components. The Contractor shall examine all materials before installation. The Contractor shall not install any material that is defective. The Owner may reject defective materials. Defective materials shall be removed and replaced with new materials by the Contractor at no cost to the Owner.
 - 2. Precast concrete structures shall be constructed to the dimensions shown in the Drawings and as specified in these Specifications.
 - 3. All work shall be protected against flooding and flotation.

3.03 PRODUCT PROTECTION

- A. The Contractor shall use all means necessary to protect all prior work, materials, and completed work of other Sections.
- B. In the event of damage to prior work or work specified in this Section, the Contractor shall immediately make all repairs and replacements necessary, to the approval of the Owner and at no additional cost to the Owner.

END OF SECTION

SECTION 03321

SHOTCRETE

PART 1 - GENERAL

1.01 SCOPE

The work shall consist of furnishing, mixing, applying and curing shotcrete. Except as otherwise specified, either a dry mix or wet mix process may be used.

1.02 MATERIALS

Portland cement shall conform to the requirements of Concrete Section for the specified type.

Aggregates shall conform to the requirements of Concrete Section. Gradation shall be one of the three options specified by ACI 506R, unless otherwise directed by the Engineer.

Admixtures, if specified, shall meet the requirements indicated in Concrete Section. Non-chloride chemical admixtures shall conform to ASTM C 494. Air-entraining admixtures shall conform to ASTM C 260. Fly ash or pozzolanic materials shall conform to ASTM C. 618. Calcium chloride shall conform to ASTM D 98 and shall be in flake or pellet form.

Water used in mixing or curing shotcrete shall be clean and free from injurious amounts of oil, salt, acid, alkali, organic matter or other deleterious substances.

Curing compound shall conform to the requirements of Concrete Section.

1.03 STRENGTH AND QUALITY

The compressive strength of shotcrete at the age of 28 days shall be not less than specified in Concrete Section of these specifications.

Shotcrete shall be uniform and dense, free from "drummy" areas that indicate laminations, voids, safld pockets, or disbanded material.

1.04 CONSISTENCY

The proportion of water added to the mixture shall be accurately controlled to produce thorough and uniform hydration of the shotcrete. The consistency of the shotcrete shall be such that the surface of the shotcrete in place shall have a rich, glossy appearance and that the shotcrete shall adhere to the supporting surface without flowing, slumping or sloughing. For application to vertical or overhanging surfaces the mix proportions shall be adjusted so that the placed shotcrete will adhere to a minimum thickness of ¾ inch without sagging or sloughing. For adjustment of consistency the addition of fly ash or pozzolanic material to the mixture in amounts not greater than 20 percent (by weight) of cement in the mixture will be permitted.

1.05 INSPECTION AND TESTING

Procedures for preparing shotcrete test panels and the testing specimens sawed or cored from panels will be performed in accordance with ASTM Method C 1140. The compression test specimens will be cores taken from the test panels or from the structure.

Similar panels not less than 18 inches square and not less than six (6) inches thick shall be made periodically as directed by the Engineer during the progress of the work.

Cores, taken from the test panels, shall receive standard curing in lime saturated water within 24 hours after removal. Cores shall continue to receive the prescribed initial cure treatment until standard curing is commenced.

For each strength test, three (3) cores will be tested in compression. The test result will be the average of the strengths of the three (3) specimens, except that if one specimen shows manifest evidence of improper sampling, coring, or testing, it will be discarded and the strengths of the remaining two (2) specimens will be averaged. If more than one (1) specimen representing a test shows such defects, the entire test will be discarded.

The Contractor shall furnish the forms and make the required test panels and shall provide such facilities, materials and assistance as may be necessary for curing, handling, and protecting the panels. Test panels shall be cast only when the Engineer is present.

1.06 OPERATOR QUALIFICATIONS

The operator shall be able to document a minimum of 3000 hours of experience operator and shall have completed at least one (1) similar application.

The operator and application crew members shall be required to meet preconstruction testing requirements administered by the Engineer on a test panel or an area as follows:

The Engineer will carefully observe shooting of the test panel or area and evaluate the following operations:

- a) Cleans the shooting surface with air and water prior to shooting.
- b) Applies a bonding coat on the shooting surface ahead of the heavier shotcrete applications.
- c) Directs shotcrete application around reinforcement in a manner which prevents buildup on the face of the reinforcement and allows the shotcrete to flow and compact tightly around the back of the reinforcement.
- d) If applicable, directs the finisher or nozzle helper to cutout any sags, sand or rebound pockets.
- e) If applicable, and where necessary, directs the finisher or nozzle helper to broom the shotcrete surface prior to application of additional layers.

1.07 PROPORTIONING MATERIALS

The proportions of the shotcrete mix shall be controlled on the basis of the weight of each component material, except that water may be measured by volume. Materials shall have following batch tolerances of their mix proportion weights: Cement, plus or minus two (2) percent; Aggregate, plus or minus four (4) percent; Admixtures, plus or minus six (6) percent. Weighing equipment used shall be accurate to within 0.4 percent of scale capacity.

1.08 EQUIPMENT

The Contractor shall furnish all equipment necessary for batching, mixing and placing the shotcrete. The equipment shall meet the following requirements.

The placing equipment for dry mix shotcrete shall be designed and equipped to receive the dry mix, introduce the mix into a stream of compressed oil free dry air, convey the mix pneumatically through a delivery hose to a nozzle at the point of discharge, inject water under pressure into the suspended stream of dry sand and cement within the nozzle, and spray the resulting shotcrete mix onto the surface of the work at a uniform rate and at a controlled velocity. The placing equipment shall be equipped with accurate gauges to indicate the air pressure and water pressure and with devices capable of accurately controlling the air pressure at any level between 50 psi and 80 psi, the water pressure at any level between 50 psi and 100 psi, and the rate of application of water at the nozzle.

The placing equipment for wet mix shotcrete shall be designed and equipped to receive the shotcrete from the mixer, convey it through a delivery hose to a nozzle at the point of discharge, accelerate it in the nozzle by means of compressed oil free dry air, and spray it onto the surface of the work. It shall be capable of delivering shotcrete to the nozzle uniformly and continuously and discharging it from the nozzle at a uniform rate and at a controlled velocity sufficient for all parts of the work.

Batch and continuous mixing equipment shall include: a power driven mixer capable of thoroughly mixing the materials at a rate adequate to insure uniform feeding of the mixture to the placing equipment at an adequate and uniform rate.

1.09 MIXING

Dry Mix Shotcrete The cement and admixtures and other additives (except accelerator) shall be mixed into a predampened homogeneous mass that thoroughly coats the aggregate before being fed through a vibratory screen into the placing equipment. Proper pre-dampening shall be indicated by the "ball-in-hand" test as follows: When a small amount of mix is tightly squeezed the resulting ball will hold together or crack slightly but essentially remain whole. The mix has too little pre-dampening moisture if the ball crumbles into discrete particles when the hand is opened and/or color is light gray. If moisture comes off on the hand, too much pre-dampening moisture is in the mix. The properly pre-dampened dry mix shall be used within 45 minutes after mixing (15 minutes in hot weather conditions with temperatures over 850 F) and any material that becomes dried out or caked after mixing shall be wasted. Rebound material shall not be remixed or reused. **Wet Mix Shotcrete** Air-entrainment and chemical admixtures may only be used in wet mix concrete. The cement, sand, admixtures (except accelerator) and water shall be thoroughly mixed in the mixer drum sufficiently to produce shotcrete of the required consistency that is uniform within each batch and uniform from batch to batch when discharged into the placing equipment.

Accelerators, if specified, shall be mixed at the nozzle. Ready-mix concrete shall conform to the requirements of ASTM C 94 unless otherwise specified.

The entire contents of the mixer shall be discharged from the drum before materials for a succeeding batch are placed therein. A mix that becomes difficult to pump shall be discarded; otherwise, a batch shall be gunned within 1 1/2 hours of batching in normal weather and within 45 minutes during hot weather conditions. Rebound material shall not be remixed or reused.

1.10 FORMS

Forms shall be structurally adequate and of such design that rebound or accumulated loose sand can freely escape or be readily removed. Shooting strips shall be used at corners, edges, and on surfaces-where necessary to obtain true lines and proper thickness. Where practicable, ground wires shall be installed as guides to accurately establish the specified contour of the finished surface of shotcrete & Ground wires shall be set and used as guides for templates in forming curved and molded surfaces. When shotcrete is to be placed on horizontal or sloping surfaces, headers and ground wires shall be provided to the extent necessary to insure control of slab thickness. Ground wires shall be tightened and kept taut, secure, and true to line and plane during placement of shotcrete and shall be removed when placement is completed. .

Header boards will be required where the drawings indicate a square edge and at required joints. Form surfaces shall be thoroughly cleaned and a form release agent applied before shotcrete is placed.

1.11 PREPARATION OF SURFACES TO RECEIVE SHOTCRETE

All surfaces to receive or support shotcrete shall be carefully prepared and conditioned. All such prepared surfaces shall be inspected and approved by the Engineer prior to the application of shotcrete.

Earth surfaces to which shotcrete is to be applied shall be firmly compacted and neatly trimmed to line and grade.

Asphaltic concrete surfaces shall be thoroughly cleaned of any growths, earth, or any other material that would affect bond, or be detrimental to the shotcrete.

Concrete, mortar, or rock surfaces shall be thoroughly cleaned by water blasting or sand blasting to remove all dirt, laitance, Weak or unbonded mortar, loose material, grease or other deleterious substances.

Surfaces on which the shotcrete is to be placed shall be sufficiently rough to insure the adherence of the shotcrete. Offsets which would cause an abrupt and substantial change in thickness of the shotcrete shall be removed or tapered.

All surfaces shall be maintained in a moistened condition for three (3) hours before application of shotcrete. Shotcrete shall not be applied to mud, dried earth, uncompacted fill, rebound material, or surfaces on which free water exists. All ice, snow and frost shall be removed and the temperature of all surfaces, to be in contact with the new shotcrete shall be no colder than 40 F.

1.12 PLACING

The Contractor shall have all equipment and materials required for curing available at the site and ready for use before placement of shotcrete begins. No shotcrete shall be placed except in the presence of the Engineer or authorized representative. The Contractor shall give reasonable notice to the Engineer each time shotcrete placement is scheduled. Such notice shall be far enough in advance to give the Engineer adequate time to inspect the surfaces to which the shotcrete is to be applied, the forms, steel reinforcement, and other preparations for compliance with the specifications prior to the start of placement operations.

During placement of shotcrete the air pressure shall be adjusted as required to control rebound and density of shotcrete. For a given application, once the optimum operating pressures have been established they shall be maintained constant throughout the application. For dry mix shotcrete, the air pressure at the material outlet or air-inlet on the gun shall be not less than 40 psi plus 5 psi for each 50 feet of length of the discharge hose greater than 100 feet and 5 psi for each 25 feet the nozzle is above the gun (shotcrete delivery equipment). The water pressure at the nozzle shall be not less than 15 psi greater than the air pressure at the material outlet or air inlet on the gun.

For most applications the placing nozzle shall be held between two (2) and six (6) feet from and approximately normal to the surface of the work. At longer distances it may be necessary to increase the nozzle velocity so that the impact velocity will suit the requirements of the application. Corners shall be filled first.

Shotcrete shall be applied in a single thickness or to a layer thickness no greater than that which will cause sagging, or dropout. Sags and sloughs will be cut out and regunned. Replacement shall be accomplished before the previously placed shotcrete has completely set. When shotcrete is placed on a vertical surface, application shall be started at the bottom and be completed at the top.

In any case when the placing of shotcrete is interrupted for more than one (1) hour, the edge of the layer shall be sloped off at an angle of approximately 45 degrees to the surface being shot, and the sloped portion shall be covered with a double layer of six (6) ounce burlap and kept continuously moist until the application of shotcrete is resumed. Before applying new material, the sloped portion shall be thoroughly cleaned and wetted by means of an air and water blast or an equally effective method approved by the Engineer.

Material that rebounds and accumulates on forms, subgrade surfaces or reinforcing steel ahead of the shotcrete being placed shall be removed and discarded.

1.13 FINISHING

Rebound material shall be carefully swept off the finished shotcrete surface and discarded before it becomes too hard for removal. After the shotcrete has been placed to the depth required, the surface shall be checked with a straightedge or template and any low spots shall be brought up to grade by placing additional shotcrete. The finished surface of the shotcrete shall be left as a natural gun finish unless requested otherwise by the Engineer.

When specified screeding shall be accomplished as follows: Place shotcrete a fraction beyond the guide strips, ground wires or forms. Allow the surface of the shotcrete to stiffen to the point it will not pull or crack under screeding or troweling. Trim, slice, or scrape excess material to true line and grade and remove the placing guides.

A natural rod finish shall consist of the removal, by floating, of the impressions left after the guide strips or ground wires have been removed.

A natural broom finish shall be that finish resulting from brooming the natural rod finish.

A float finish shall be that finish resulting from floating the natural rod finish with a wood or rubber float.

1.14 CURING

Shotcrete shall be prevented from drying for a curing period of at least seven (7) days after it is placed. Exposed surfaces shall be kept continuously moist for the entire period or until curing compound is applied as specified below. Moisture shall be maintained by sprinkling, flooding or fog spraying, or by covering with continuously moistened canvas, cloth mats, straw, sand or other approved material. Wood forms left in place during the curing period shall be kept wet. Formed surfaces shall be thoroughly wetted immediately after forms are removed and shall be kept wet until patching and repairs are completed. Water or covering, shall be applied in such a way that the shotcrete surface is not eroded or otherwise damaged.

Water for curing shall be clean and free from any substances that will cause discoloration of the shotcrete where finished surfaces will be exposed to view.

Shotcrete may be coated with curing compound as an alternative to the continued application of moisture.

The compound shall be sprayed on the moist shotcrete surfaces as soon as rebound has been removed and any required repairs are completed, or as soon as water curing is discontinued.

The curing compound shall be thoroughly mixed immediately before applied and continuously agitated during application. It shall be applied at a uniform rate of not less than one (1) gallon per 100 square feet of surface for natural gun finishes. Curing compound shall be applied in two (2) applications, one (1) in each direction. If a natural rod, broom, or float finish is specified, the curing compound application rate shall be at least one (1) gallon per 150 square feet. Curing compound shall not check, crack or peel, and shall be free from pinholes or other imperfections.

Curing compound shall not be applied to subgrade surfaces or other surfaces requiring bond with subsequently placed shotcrete, such as construction joints, reinforcing steel and other embedded items.

Surfaces subjected to heavy rainfall or running water within three (3) hours after the compound has been applied, or surfaces damaged by subsequent construction operations during the curing period shall be resprayed in the same manner as for the original applications.

Surfaces covered by the membrane shall not be trafficked unless protected from damage and/or wear.

1.15 MEASUREMENT AND PAYMENT

PAY ITEMS

UNIT OF MEASUREMENT

Shotcrete including surface preparation, materials, admixtures, mixing, placing, curing, forms, scaffolding, finishing, testing, etc...

Cubic Meters (m³)

END OF SECTION

SECTION 15200

SUBMERSIBLE LEACHATE PUMPING SYSTEM

15200.1 SCOPE OF WORK

The leachate pumping system as outlined in this section shall consist of riser pipe, pump, motor, control panel, level sensor, power cable, electrical wiring, control wiring, and related associated discharge pipe and fittings, complete and per the operating conditions as shown on drawings and specifications.

15200.2 QUALITY ASSURANCE

All equipment listed in this section shall be provided by a single supplier who has complete responsibility for the system. The supplier must have a minimum of five years experience in providing complete systems for side slope leachate removal applications.

The supplier of the leachate removal system will provide all warranty services which shall be one year from date of installation or eighteen months from date of shipment.

15200.3 SUBMITTALS

The submittal package shall include a complete list of components provided, pump curves, motor data, layout drawing, control electrical schematic, controller bill of materials, and warranty statement.

A fabrication drawing of the side slope riser and sump assembly shall be provided to the pump manufacturer with the approved submittal package.

15200.4 EQUIPMENT - PUMPS

The contractor shall furnish and install leachate pumping systems as manufactured by Geotech, Grundfos, or approved equal.

The pumps shall be modified as required for suitable service in landfill leachate applications.

Pumps shall be as shown on drawings (Schedule of Equipment).

Operating voltage shall be three phase, 60 hertz, 460 volts.

Pump design shall include the following feature:

1. Integral check valve of 304 series stainless steel.
2. All series 304 stainless steel construction shall include impellers, bowls, guide vanes, and inlet screen
3. Each impeller shall have a E-Glide seal ring to reduce hydraulic losses, and shall consist of 304 stainless steel.
4. All shaft bearing shall be 304 stainless steel.
5. A stainless steel flow inducer shall be provided at the pump inlet.

15200.5 EQUIPMENT - MOTOR DESIGN

The motor shall be a Franklin motor, suitable for submersible operation.

All materials in contact with leachate shall be 304 series stainless steel.

The motor shall not use any oils or greases for lubrication.

A jacketed power cable suitable for leachate service and properly sized shall be provided, with a suitable length such that splices are not needed.

15200.6 EQUIPMENT - CARRIAGE

The pumps shall be mounted in a (patented) 304 series stainless steel carriage.

The carriage shall provide a low center of gravity and all wheels shall remain in contact with the contour of the riser pipe. The wheels shall be of non-corrosive materials with self-lubricating qualities and the unit must be able to travel over welding beads as typically found in riser pipe fabrications. A stainless steel inlet suction screen shall be provided to prevent debris from entering carriage and pump inlet.

The pump and motor must be easily removed from the carriage in the field should the pump or motor require service.

15200.7 EQUIPMENT - DISCHARGE HOSE ASSEMBLY

Discharge hose shall be 65mm hose, rated 300 PSI and -20 to +180 degrees Fahrenheit. Each section shall be provided with threaded stainless steel couplings. The pipe shall be properly selected for the pump performance and shall be able to handle surge conditions of the system.

All hose fittings shall be 304 series stainless steel. Hose fitting shall be long shank type and suitable for the application. All hose bands shall be hi-torque 304 series stainless steel.

A riser side exit disconnect will be provided, which will allow quick connection/disconnection of the pump discharge hose and allow the pump to be removed without interference of the stationary fittings. The exit arrangement shall thread through the riser pipe as to provide a gas tight connection. The exit connection will penetrate the riser wall approximately 6" from the top of the riser pipe.

All side exit components shall be 304 series stainless steel.

A stainless steel liquid filled pressure gauge sized to the range of the pump shall be provided with fitting outside the riser pipe. The gauge is to be shipped separately and installed in the fitting provided by the pump manufacturer at the time of installation and start up.

A 2" PVC ball type check valve with threaded unions shall be provided and mounted within the side slope riser pipe.

A 3" polypropylene full port ball valve shall be provided to provide isolation of the system. The system shall terminate inside the riser pipe.

15200.8 CONTROLS - CONTROL PANEL

The control panel shall provide level control, pump operation, and motor protection.

Control panel shall consist of NEMA 4 X 14 gauge 304 stainless steel enclosure with a rain guard and lockable outer cover. The door shall open a minimum of 180 degrees. A window on the outer door shall allow a view of all indicators without entering the enclosure. The inner door shall be an aluminum dead front mounted on a continuous aircraft type hinge. The dead front door shall contain cutouts for the mounted equipment and operator accessible equipment and provide protection of personnel from live internal wiring.

Operator accessible components mounted on the dead front door shall include the following:

1. H-O-A switch
2. STAND-BY indicating light (amber).
3. RUN indicating light (green).
4. OVERLOAD indicating light (red).

5. DIGITAL READ OUT level indicator.
6. ELAPSED RUN TIME meter (mechanical non-reset type).
7. MAIN disconnect breaker.
8. PUMP MOTOR breaker.
9. CONTROL CIRCUIT breaker.
10. OVERLOAD RE-SET button.
11. FAULT indicating light (red).
12. LOW LEVEL indicating light (red).

The back plate shall consist of 12 gauge sheet steel and finished with a primer coat and two coats of baked on enamel. All hardware mounted to the subpanel shall be accomplished with machine thread tapped holes.

Sheet metal screws are not acceptable. All devices shall be permanently identified with phenolic engraved nameplates.

The panel power distribution shall include all necessary components and shall be completely wired with standard copper conductors. Control wiring shall be properly sized and installed in Panduit type wiring trays.

An individual circuit breakers shall be provided for main power, pump, and control circuits. All circuit breakers shall be heavy duty thermal magnetic or motor circuit protectors similar and equal to Square D type FAL. Circuit breakers shall be indicating type, providing ON-OFF-TRIP positions. When the breaker is tripped automatically, the handle shall assume a middle position indicating TRIP.

Thermal magnetic breakers shall be quick-make and quick-break on manual and automatic operation and have inverse time characteristics secured through the use of bi-metallic tripping elements supplemented by a magnetic trip.

Breakers shall be designed so that an overload on one pole automatically trips and opens all legs. Field installed handle ties shall not be acceptable.

Motor starter shall be open frame, across the line, NEMA rated with individual overload protection in each leg. Motor starter contact and coil shall be replaceable from the front of the starter without removing it from its position. Overload heaters shall be block type, utilizing melting alloy spindles and shall provide visual trip indication and an alarm contact for alarming signals. The overload shall be sized for the full load amperage draw of the pump. Adjustable type overloads, definite purpose contractors, fractional size starters, and horsepower rated contactors or relays shall not be acceptable.

A fused type control transformer shall be used to provide the 120 VAC for control circuits. Surge protection for incoming main power and control circuit, and a plug in type indicating phase monitor shall be provided.

A thermostat controlled heater shall be provided to control the inside temperature below the dew point and alleviate the buildup of condensate in the control enclosure.

A corrosion inhibitor shall be provided within the enclosure.

A top-mounted red visual high level alarm beacon, which shall be weatherproof, shatterproof, shall be provided with a 40 watt light.

A low level relay shall be provided, which shall provide positive pump lock out and indication should the liquid level drop below the transducer (in case of a false reading due to gas pressure). This device shall provide protection from dry run conditions.

Panel mounted intrinsically safe barriers shall be provided for all sump probes. The control panel shall have the capability to accept an external interlock for the purpose of stopping the leachate pumps.

15200.9 CONTROLS - LEVEL CONTROL

A panel mounted controller digital readout display shall provide level indication of the side slope sump with 4 1/2 digits. The pump "ON-OFFHIGH LEVEL" selection shall be through set point located on the indicator.

All Pumps controls shall be set to the following: Pump Off - 6" above bottom of sump; Pump On - 12" above bottom of sump; both Pumps On - 18" above bottom of sump; High Water Alarm - 36" above bottom of sump; High Water Off - 30" above bottom of sump. Pumps shall alternate on successful starts.

The controller unit will accept a 4 to 20 ma signal from the transducer and provide a level indication readout of 0 to 138.6 inches of liquid.

A submersible transducer shall be provided with a length of cable sufficient to reach the control panel without splices. Cable splices within the riser pipe are not acceptable. The transducer shall be all 316 stainless steel and shall be mounted to the pump carriage. The unit shall provide a 4-20 ma signal output to the control unit. Static accuracy rating shall be no less than 1.0 percent.

A filter/dryer shall be provided to be mounted in control panel or properly sized junction box to prevent moisture in the vent tube.

A low level sensor shall be provided with a length of cable sufficient to reach the control panel without splices. Cable splices within the riser pipe are not acceptable. The probe shall be non-corrosive construction and have no moving parts.

15200.10 MISCELLANEOUS ITEMS - CABLE FITTINGS

Non-metallic gas tight cable exit fittings properly sized for the power and control cables shall be provided.

A stainless steel eye bolt shall be provided and installed in the riser. A stainless steel snap hook will be provided as part of the safety cable assembly.

15200.11 EXECUTION - START-UP

The manufacturer of the system shall provide field supervision assistance to insure proper system installation and start-up of the system. The scheduling of this service shall be coordinated with the Contractor to insure the riser is in place and the control panel is connected to power prior to arrival of the factory field technician. Installation and start-up typically requires one day to complete.

15200.12 EXECUTION - OPERATIONAL TEST

The system shall be tested for proper operation at the time of start-up.

15200.13 EXECUTION - WORK BY CONTRACTOR

Mounting control panel mounting posts and control panel to posts.

Assembly and installation of the leachate system. This includes installation of discharge and cable exit fittings.

Provide power to the leachate pump control panel from the electrical panel located at the leachate storage lagoon.

All electrical wiring, control wiring, conduit work and junction boxes between the leachate pump and control panel.

Electrical heat tracing and insulation of piping as required.

Connection of discharge piping from system termination point. This should be completed at the time of system installation so the system may be tested.

Assistance in the operational testing including providing or removing water in the sump as required to allow for tests during the visit of factory technicians.

15200.14 EXECUTION - SIDE SLOPE RISER PIPE

An "AS BUILT" of the riser pipe and sump assembly shall be provided to the Engineer and made available to the pump system manufacturer prior to start-up.

END OF SECTION

SECTION 16060

GROUNDING AND BONDING (EARTHING)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including Conditions of Contract and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes complete installations to earth every source of energy and to provide protective earthing and equipotential bonding, based on the TN-S system arrangement to achieve an earth resistance value: less than 5 ohms, including:
 - 1. Transformer neutral earthing.
 - 2. Main earthing terminals or bars
 - 3. Exposed conductive parts of electrical equipment.
 - 4. Extraneous conductive parts
 - 5. Standby generator neutral earthing
 - 6. Feeder and branch circuits
 - 7. Motor and appliance branch circuits
 - 8. Signal and communication systems
 - 9. Bonding to the lightning protection system.
- 10. Earthing requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

1.3 DEFINITIONS

- A. The following terms used on the Drawings and in the Specification are equivalent and may be used interchangeably: "earth" and "ground"; "earthing" and "grounding".
- B. Earth: Conductive mass of the Earth whose electric potential at any point is conventionally taken as zero.
- C. Earth Electrode: Conductor or group of conductors in initial contact with, and providing electrical connection to, Earth.
- D. Exposed Conductive Part: Any part which can be readily touched and which is not a live part, but which may become live under fault conditions.
- E. Extraneous Conductive Part: Any conductive part not forming part of the electrical installation such as structural metalwork of a building, metallic gas pipes, water pipes, heating tubes etc. and non-electrical apparatus electrically connected to them i.e. radiators, cooking ranges, metal sinks etc. and non-insulating floors and walls.
- F. Protective Conductor: Conductor used for some measure of protection against electric shock and intended for connecting together any of the following parts:
 - 1. Exposed conductive parts.
 - 2. Extraneous conductive parts.
 - 3. Earth electrode(s).
 - 4. Main earthing terminal or bar(s).

- 5. Earthed point of the source(s).
- G. Electrically Independent Earth Electrodes: Earth electrodes located at such distance from one another that maximum current likely to flow through one of them does not significantly affect the potential of the other(s).
- H. Main Earthing Terminal or Bar: The terminal or bar provided for the connection of protective conductors, including equipotential bonding and functional earthing conductors if any to the means of earthing.
- I. Equipotential Bonding: Electrical connection to put exposed and extraneous conductive parts at a substantially equal potential.
- J. Earthing Conductor: Protective conductor connecting main earthing terminal or bar of an installation to earth electrode or to other means of earthing.

1.4 SUBMITTALS

- A. Product Data: Prior to ordering materials, submit data for approval including, but not limited to, manufacturer's catalogues for each type of product indicated including the following:
 - 1. Ground rods.
 - 2. Connecting clamps.
 - 3. Earthing conductors, protective conductors, and bonding conductors.
 - 4. Connectors and other accessories.
 - 5. Exothermic welding kits and tools.
- B. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects/engineers and owners, and other information specified or required by Engineer.
- C. Field Test Reports: Submit written test reports to include the following:
 - 1. Test procedures used and test conditions.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- D. Shop and Construction Drawings: Submit drawings for approval including, but not limited to, the following:
 - 1. Exact location of earth pits, rods and details of installation and connections.
 - 2. Exact routing of buried earthing conductors with indication of cross-section, depth of laying and covering.
 - 3. Cross sectional area of all earthing, protective and bonding conductors.
 - 4. Layout and details of earthing provisions at substations, generator rooms, switchgear, distribution panelboards etc., indicating fittings used, insulation, plates and marking, passage and routing of earthing conductors, conduit, sleeves, grooves, niches etc., giving sizes and dimensions of component parts.
- E. Records: Submit the following:
 - 1. Scaled drawings, as-installed, showing actual layout and specification of all components of earthing system.
 - 2. Nature of soil and any special earth arrangements etc.
 - 3. Date and particulars of soil conditioning method and agents if used.
- F. Samples: Submit samples of conductors, as requested by Engineer.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer who has specialized in installing lightning protection systems similar in material, design and extent to those indicated for this Project and whose work has resulted in installations with a record of successful in-service performance.
- B. Standards: Carry out work in accordance with the following:
 - 1. IEC 364-3 and 364-4-41: Electrical Installations in Buildings.
 - 2. Latest edition IEE Regulations for Electrical Installations in Buildings – London.
- C. Comply with BS 6651 when interconnecting with lightning protection system.

PART 2 - PRODUCTS AND SYSTEMS

2.1 MANUFACTURERS:

- A. Approved Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
 - 1. BICC (England)
 - 2. Copperweld (U.S.A.)
 - 3. Furse (England)
 - 4. G.E.C. (England)
 - 5. wallis (England)

2.2 GENERAL REQUIREMENTS

- A. Component parts of earthing system are to include the following:
 - 1. Earth electrode (rods, tapes etc.)
 - 2. Main earthing terminals or bars.
 - 3. Earthing conductors.
 - 4. Protective conductors.
 - 5. Equipotential bonding conductors.
 - 6. Electrically independent earth electrodes for special systems.
 - 7. Accessories and termination fittings, bonding, welding kits and other materials.
- B. Earth electrode is to consist of one or more earth rods, interconnected by buried earthing tape or cable, which is to have a total combined resistance value, during any season of the year and before interconnection to other earthed systems or earthing means, not exceeding 5 ohms. Distance between two rods is not to be less than twice the length of one rod driven depth.
- C. Ring type earth electrode is to consist of earthing conductors, in a closed loop, buried in exterior wall foundations underneath the water-proofing, or alternatively at 0.6 m around the perimeter of the building foundations, as shown on the Drawings. Connect all earthing conductors to this ring. Insulated connection flags into the building, of same material as earthing conductors, are to be located at positions of service entrance and main switchboard rooms, terminating in bolt-type earth points (studs) or test- links for connection of main earth bar(s). Additional earth rods connecting with the earth ring are to be provided, as necessary, to bring down earth electrode resistance to an acceptable value.
- D. Functional earth electrode is to be provided separately from, but interconnected to, other earth electrode(s) through suitably rated (470 V) spark gap. Functional earth electrodes are to be used for earthing electronic equipment (communication equipment, digital processors,

- computers etc.) as required by the particular Section of the Specification and recommendation of manufacturer.
- E. Alternative Earth Electrode: other types of earth electrode may be used, after approval, including:
1. Cast iron pipes with special surround material
 2. Copper plate(s)
 3. Tape mats (strips).
- F. Main earthing bar is to be provided at the main LV distribution room, and as described in the Specification or shown on the Drawings. Connect all earthing conductors, protective conductors and bonding conductors to the main earthing bar. Provide two insulated main earthing conductors, one at each end of the bar, connected via testing joints to the earth electrode at two separate earth pits. Conductor is to be sized to carry maximum earth fault current of system at point of application with final conductor temperature not exceeding 160 deg. C for at least 5 seconds. Main earthing conductors are to be minimum 120 mm² or as otherwise required by the particular Section of the Specification.
- G. Testing joints (test links) are to be provided, in an accessible position, on each main earthing conductor, between earthing terminal or bar and earth electrode.
- H. Protective conductors are to be separate for each circuit. Where protective conductor is common to several circuits, cross-sectional area of protective conductor is to be the largest of the conductor sizes.
1. Selection of sizes is to be in accordance with Table 54F of IEE Regulations.
- I. Protective conductors are not to be formed by conduit, trunking, ducting or the like. Where armored cable is specified and armor is steel, it may be used as a protective conductor, if approved and if not otherwise shown on the Drawings.
- J. Continuity of Protective Conductors: Series connection of protective conductor from one piece of equipment to another is not permitted. Extraneous and exposed conductive parts of equipment are not to be used as protective conductors, but are to be connected by bolted clamp type connectors and/or brazing to continuous protective conductors which are to be insulated by molded materials.
- K. Earth Fault Loop Impedance: For final circuits supplying socket outlets, earth fault impedance at every socket outlet is to be such that disconnection of protective device on over-current occurs within 0.4 seconds. For final circuits supplying only fixed equipment, earth fault loop impedance at every point of utilization is to be such that disconnection occurs within 5 seconds.
1. Use appropriate tables and present same for approval by the Engineer (IEE Regulations: Tables 41A1 and 41A2, Appendix 7 and Regulation 543).
- L. Supplementary Equipotential Bonding: Connect all extraneous conductive parts of the building such as metallic water pipes, drain pipes, other service pipes and ducting, metallic conduit and raceways, cable trays and cable armor to nearest earthing terminals by equipotential bonding conductors. Cross-section of protective bonding conductor shall not be less than half of the protective conductor connected to respective earthing terminal with a minimum of 4-mm².
- M. Main Equipotential Bonding: Main incoming and outgoing water pipes and any other metallic service pipes are to be connected by main equipotential bonding conductors to main earth terminal or bar. Bonding connections are to be as short as practicable between point of entry/exit of services and main earthing bar. Where meters are installed, bonding is to be made on the premise side of the meter. Cross-sections of conductors are not to be less than half that of the earthing conductor connected thereto, and minimum 6 mm².
- N. Identification: Connection of every earthing conductor to earthing electrode and every bonding conductor to extraneous conducting parts is to be labeled in accordance with the Regulations, as follows:
1. SAFETY ELECTRICAL CONNECTION - DO NOT REMOVE.

- O. Identification: Protective and earthing conductors are to be identified by combination of green-and-yellow colors of insulation or by painting bar conductors with these colors, as approved.
- P. Identification: Source earthing conductor (or neutral earthing conductor) is to be identified along its entire length by continuous black insulation labeled 'neutral earthing'.

2.3 GROUNDING CONDUCTORS

- A. Buried Earth Conductors: Bare annealed copper strip conductors 25 x 2.5 mm, or annealed stranded copper conductors 95 mm² cross-section.
- B. Earthing Conductors: Insulated or bare copper conductor as described in the Specification for the particular application.
- C. Protective Conductors: Single core stranded annealed copper, PVC insulated cables, having rated insulation grade compatible with circuit protected, or to be a conductor forming part of a multi-core cable, color coded.
- D. Protective Bonding Conductors: Bare copper strip conductor, annealed stranded copper cable or flexible strap (flexible braid) of cross-sectional area as described in Article "General Requirements" hereof.
- E. Main Earthing Bar: Hard drawn copper, 40 x 4 mm where formed into a closed loop, and 50 x 6 mm where open-ended. Earth bar is to be labeled 'Main Earth Bar' and is to be drilled, for connection of conductors, at a spacing not less than 75 mm, and is to be supplied with copper alloy bolts, nuts and washers and wall mounting insulators.
- F. Testing Joints (Test Links): Copper or copper alloy, with bolted end connections, disconnectable by use of a tool, and suitably sized for earthing conductors or earth bar connection. Links are to be fixed to porcelain or other approved insulating supports. Contact surfaces are to be tinned.

2.4 CONNECTOR PRODUCTS AND EARTHING ACCESSORIES

- A. Copper or copper alloy, purpose made, of approved design, compatible with points of connection, and of adequate cross-section and current carrying capacity.
- B. Bolted Connectors and Clamps: Bolted-pressure-type connectors and clamps, or compression type. Bolts, nuts and washers are to be high quality phosphor bronze or copper silicon alloys.
- C. Welded Connectors: Exothermic-welded type, in kit form, and selected per manufacturer's written instructions.

2.5 GROUNDING ELECTRODES

- A. Ground Rod: 16-mm diameter high strength, low carbon steel core of high tensile strength (600 N/mm²), with 99.99% pure electrolytic copper molecularly bonded into steel core, 0.25 mm minimum thickness. Driving head is to be high strength steel. Couplings are to be long length silicon bronze, internally threaded. Threads are to be rolled onto rod to ensure uniform layers of copper and strength. Earth rod is to be complete with couplings, head and bolted connector of sufficient size, and number of bolted clamps to connect all cables terminated thereto.
 - 1. Minimum Length of Rod: 2.4 m, extendible as necessary to obtain required earth resistance
- B. Tape Mats: Where earth rods are not likely to be used, earth electrode is to consist of parallel and perpendicular copper strip, 2.4 m apart, welded together by exothermic welds to form a grid. Tape is to be 25 x 2.5-mm strip conductor.
- C. Earth Pit: Precast, square or circular section concrete handhole (minimum 450 mm internal diameter), with concrete cover, and extending to about 150 mm below top of earth rod. Earth pit is to be provided for each earth rod where connected to an earthing conductor. Cover is to have inset brass plate with inscription 'Earth Pit - Do Not Remove'.

PART 3 - EXECUTION

3.1 EARTHING OF MAIN DISTRIBUTION BOARDS, PANELBOARDS, LIGHTING INSTALLATIONS AND WIRING ACCESSORIES

- A. Main earthing bar is to be provided in main distribution room and connected to earth electrode by two insulated conductors (minimum 120 mm²) via testing joints.
- B. Earthing bars of main distribution boards are to be connected, by bare earthing conductor, directly to main earthing bar at main distribution room and by protective conductor run with incoming feeder from respective supply point.
- C. Distribution, lighting and power panelboards are to be connected by protective conductors run together with incoming feeder cable, connecting earth terminals in panelboards with respective main distribution board earthing bar.
- D. Socket outlets are to be earthed by protective conductor looped around with the branch circuit and connected to earth terminal within socket outlet box and to which socket outlet terminal is to be connected.
- E. Final Ring Sub-Circuits: Protective conductor of every final ring sub-circuit is to be in the form of a ring having both ends connected to earth terminal at origin of circuit in panelboard.
- F. Lighting fixtures and other exposed conductive parts of electrical installations, such as switches, heaters, air conditioning units etc. are to be connected by protective earth conductors to earthing terminals of respective panelboards.

3.2 GENERATOR PLANT EARTHING

- A. Generator neutral (star point) is to be connected by insulated earthing conductor through the neutral earthing link or device to main earthing bar. Neutral earthing conductor is to be suitably sized to carry maximum earth fault current for time it takes the system protection to operate with final conductor temperature not exceeding 160 deg. C, but not less than 30 mm² per 100 kVA of generator rating, with a minimum of 50 mm².
- B. Generator earthing terminal is to be connected to main earthing bar by bare copper conductor of cross section not less than 20 mm² per 100 kVA of generator size, with a minimum of 35 mm².
- C. Switchgear (ATS) and Control Gear: Earthing terminals or bars of switchgear and control gear are to be connected by separate protective conductors to respective normal and emergency main distribution board earth bars.
- D. Extraneous conductive parts including steel frames, battery racks, day-tank, pumps and piping are to be connected by bare copper earthing conductors to main earth bar in compliance with bonding regulations.

3.3 MECHANICAL PLANT ROOMS AND FIXED MACHINERY

- A. Main earthing bar or loop is to be conveniently located in mechanical plant rooms, and connected by earthing conductors to exposed conductive parts of motor control centre at its earthing bar, and to motors, switches and other electrical equipment etc. at their earthing terminals, using 20 x2mm bare copper strips or 35 mm² bare copper conductor (minimum size) or as required to carry maximum earth fault current for 1 second with final conductor temperature not exceeding 200 deg. C. Conductors are to be securely fixed, recessed in floor grooves or niches, or fixed to walls by appropriate staples. Earth bar or loop is to be securely fixed to building wall with copper or brass saddles.
- B. Main earthing bar or loop is to be connected at two extremely separate points to earth electrode, directly through two test joints by insulated earthing conductors, or connected to main earth bar by protective conductors.
- C. Motor and other equipment earth terminals are to be connected also by protective earth conductors of each branch circuit to earth terminal/bar at motor control centre, panel or distribution unit.

3.4 OUTDOOR LIGHTING

- A. Earthing Cables: separate protective earthing cables for lighting column circuits are to be run with power circuit, terminated at LV supply position in lighting control panel and looped into column earthing terminals. The last column is to be bonded via an earthing bolt to a single 14 mm diameter copper covered steel rod, 2.5 m long, driven into ground adjacent to column. Bonding is to be 16 mm² stranded bare copper conductor.
- B. Connections between rods and earthing conductors are to be made by the Cadweld process producing a fused joint. Bolted connections may be used for connection to removable items of equipment only.

3.5 SIGNAL AND COMMUNICATION SYSTEMS

- A. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide 16mm² minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
 - 1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 6.4-by-50-by-300-mm grounding bus.
 - 2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.6 INSTALLATION

- A. Continuity: Ensure that complete earthing system is electrically continuous and mechanically secure.
- B. Earth Rods: While citing earth rods, ensure that resistance areas associated with individual rods do not overlap. Earth rods are to be located at a distance greater than 600 mm from foundations of buildings. Where rock is encountered, a hole of sufficient size is to be drilled before lowering the rod. Conductive filler such as Marconite or Bentonite or equal filler that will not corrode, is to be provided around the rod.
- C. Buried earthing conductors are to be laid at a depth not less than 0.8 m from ground surface.
- D. Earthing conductors are to follow shortest path between earth rods and main earthing terminals or bars, and are to run in PVC conduit (duct) fastened to building structure by approved supports and extending 0.2 m above level, and are to be protected against mechanical damage and corrosion.
- E. Protective Conductors: Separate protective conductors, which are not part of a cable, are to be fixed on same support or drawn into same conduit as circuit conductors.

- F. Protective Bonding: Remove any non-conductive paint, enamel or similar coating at threads, contact points and surfaces and ensure that bonding is made by fittings designed to make secure bonds.

3.7 CONNECTIONS

- A. Protection against Corrosion: Protect bolted connections against corrosion either by filling with vaseline or coating with a special anti-corrosion compound and proper capping.
- B. Connections: Earth connections are to be readily accessible. If inaccessible earth connection is permitted, approved exothermic welding or brazing technique is to be employed.
- C. Connections: Where earth connections between dissimilar metals must be made, use bimetallic fittings and protect by coating with moisture resisting bituminous paint or compound, or by wrapping with protective tape to exclude moisture.
- D. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.
- E. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in applicable Standards.

3.8 FIELD QUALITY CONTROL

- A. Combined resistance of earth electrodes is to be measured during dry season and checked against specified resistance.
- B. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.
- C. Electrical continuity of all earthing and protective conductors including main and supplementary equipotential bonding conductors is to be checked.
- D. Earth fault loop impedance of all circuits is to be measured and checked against calculated impedance figures.
- E. Operation of residual current protective devices is to be checked.

3.9 GRADING AND PLANTING

- A. Restore surface features, including vegetation, at areas disturbed by Work of this Section. Reestablish original grades, unless otherwise indicated. If sod has been removed, replace it as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, and other activities to their original condition. Include application of topsoil, fertilizer, lime, seed, sod, sprig, and mulch. Comply with Division 2 Section "Landscaping." Maintain restored surfaces. Restore disturbed paving as indicated.

END OF SECTION

SECTION 16120

CONDUCTORS AND CABLES

PART 1- GENERAL

The section shall cover all wires and cables.

The Contractor shall supply and install all wires and cables necessary for the complete Electrical System, as indicated on the Drawings, as required, and as specified herein.

1.1 SCOPE OF WORKS

- The Scope of works shall be read in conjunction with the description of works, attached detailed specifications and requirements, drawings and BOQ and shall not necessarily be limited to the following items.
- The details mentioned in the proposed system are tentative only to facilitate the contractor to understand the system and scope of works. However the actual accessories required shall be determined by the contractor based on complete design calculation for a cable and wiring sizing system whether shown in the attached drawings or mentioned in the specification or not.
- Contractor shall Replace existing low voltage cables with new ones by using aluminum instead of copper, low smoke fume type and fire rated of 1.5 hours (minimum) complete but not limited to, including the connection cables outgoing from electrical feeder panels to the branch circuits.
- Contractor shall submit simulation, drawings and calculation notes for the proposed new design to the approval of the engineer based on the relevant codes and standards
- The contractor shall submit the proposed design complete with catalogues, technical details of the system and other accessories including cables for Testing and commissioning of the complete system to the Engineer's approval.

PART 2- WIRES & CABLES - LIGHTING & POWER

- A. Single Core Wires AL/XLPE/LSF with fire rated minimum of 1.5 hours.
 - 1. This specification covers single core, XLPE insulated wires, intended for internal wiring in dry locations, concealed in conduits.
 - 2. Conductors shall be of high conductivity annealed plain aluminum with concentric stranded conductors, to IEC 228/ BS 6360, or approved equal.
 - 3. Minimum conductor size used shall not be less than 1.5mm².
 - 4. All wires for lighting and power systems pulled inside conduits shall be single core, insulated with XLPE compound, of grade not less than 450/ 750 volts, to IEC 227/ BS 6004.
- B. Multicore Cables AL/XLPE/LSF with fire rated minimum of 1.5 hours.
 - 1. cables shall be used installed in underground ducts for supply of power to lots.
 - 2. This specification covers two, three or four core cables, XLPE insulated and sheathed, rated at 600V unarmoured type.
 - 3. Conductor shall be plain, annealed electrolytic aluminum, circular or sectoral stranded, conforming to the applicable requirements of IEC 228/ BS 6360.

4. The insulation shall be XLPE based thermoplastic material conforming to the applicable requirements of IEC 502/ BS 6622.
5. The assembly shall consist of insulated conductors filled where necessary with non-hygroscopic material and covered with an additional layer of extruded thermoplastic material or non-hygroscopic binding tape.
6. The sheath shall be XLPE based thermoplastic material, conforming to the applicable requirements of IEC 502/ BS 6622.
7. Flexible cords for connection of fixtures to circuit-wiring shall have finely stranded aluminum Conductor with a XLPE insulation, type NYFAF, 380 V grade.
8. Wires and cables shall be manufactured by BICC (UK), Pirelli (UK) Liban Cables (Lebanon)

PART 3- FLEXIBLE CORDS

Cords used for water heater connections shall be of high conductivity tinned aluminum wires, (2.5mm² unless otherwise indicated) insulated with ethylene propylene rubber, three cores twisted together, filled and sheathed with chlorosulphonated polyethylene (EPR CSP), 300/500 V rated, and shall withstand an operating temperature of 85 C, to BS 6500.

Cords used for pendant lighting points and between lighting outlet above false ceiling to lighting fixture shall be circular two core (1.5mm²) silicon rubber insulated, glass fiber braided 300/300 V rated, shall withstand an operating temperature of 150 C, to BS 6500.

Cords used for extract fans shall be of plain annealed aluminum conductor (1.5mm²), XLPE insulated, circular twin cores twisted together, XLPE overall sheathed 300/ 500 V rated, shall withstand an operating temperature of 70 C, to BS 6500.

Cords shall be manufactured by BICC (England), AEI (England) Pirelli (England), Liban Cables (Lebanon) or approved equal.

PART 4- WIRES AND CABLES - TELEPHONE / IT

- A. Telephone cables shall have the following characteristics of construction:
- a) Aluminum conductor, tinned, 0.6mm diameter.
 - b) XLPE colored insulation with surface ring marking for identification.
 - c) Pair Twisting.
 - d) Concentric assembling including earth continuity tinned wire, protected with overlapped non hygroscopic tape.
 - e) Aluminium foil screen applied with overlap.
 - f) Outer XLPE sheath, grey color, with a rip cord laid up under sheath for easy stripping.
 - g) Maximum conductor resistance = 70 ohms per Km.
 - h) Mutual capacitance at 1000 Hz maximum 100 nF/ Km.
 - i) Minimum insulation resistance = 500 Mega ohms/Km.

Telephone cables used for long control distances shall have 0.8mm or 0.9mm diameter as indicated on drawings. Conductor shall be electrolytic aluminum insulation twisting shall be PE complying with ASTM D1248 1A-5 grade E4 colored for identification twisting shall be by pair or quad screen shall be plastic coated aluminium, Assembling shall be concentric or oscillated units.

Outer jacket shall be black PE complying with ASTM D1240.

- B. IT coaxial cables shall have the following characteristics of construction:

- a) Quad-Shield Coaxial Cable:
- Turin or Aluminum Clad Steel Conductor
 - Gas Expanded PE Dielectric
 - Bonded AP Laminate Shield
 - Aluminum Braid 60%
 - Un-bonded APA Laminate Shield
 - Aluminum Braid 40%
 - Flooding Compound (Jelly Floodant)
 - Black XLPE or PE Jacket, Outdoor
 - Galvanized Steel Wire Messenger
- b) Coaxial Cable: Aluminum Clad Steel Center Wire – Dual, Tri and Quad shield needed to block out extreme Radio Frequency and Electromagnetic Interferences. Cable is high bandwidth and high-performance cable for high-speed broadband internet, SMATV network infrastructure, video surveillance, etc. designed for high performance and low signal loss over distances up to approximately 100 meters.
- c) Electrical Characteristics:
- Characteristic Impedance (Ω) 75 \pm 3
 - Return Loss dB \geq

VHF	22
UHF	20
 - Capacitance (pf/m) 52 \pm 2
 - Velocity of Propagation (Min.) 83%
- Attenuation (20°C, dB/100m \pm 5%)**
- 500 MHz 4.8
 - 200 MHz 9.7
 - 300 MHz 12.2
 - 400 MHz 14.09
 - 500 MHz 16.02
 - 800 MHz 20.67
 - 2150 MHz 33.88

PART 5- CONTROL CABLES

Control cables where used underground direct burial shall comprise stranded annealed aluminum conductor of minimum 2mm² cross-section insulated with high dielectric polyvinyl chloride, nylon sheathed with a tape binder applied over the assembly, overall XLPE jacketed.

Number of conductors shall be equal to the maximum number of functions plus 20% spare.

Cable shall be 300/ 500V insulated grade.

Junction boxes shall include all necessary terminal connector boards with proper labels.

Contractor shall make sure that the cross-sectional area of the conductors is sufficient to cater for the voltage drop due to the long runs involved.

Control cables where used in ducts underground or in conduits above ground shall comprise stranded annealed aluminum conductor of minimum 2mm² cross-section for

cables in ducts and 0.75mm² for cables in conduits insulated with high dielectric polyvinyl chloride, and XLPE sheathed.

PART 6- INSTALLATION OF WIRES & CABLES

All wires shall be installed in accordance with the applicable provisions of the approved codes and as indicated on the Drawings.

The number of wires and sizes of conduits indicated on the Drawings are a guide only and are not necessarily the correct number and sizes necessary for actual equipment installed. The Contractor shall install as many wires and conduits as required and necessary for a complete electrical system, and shall provide adequately for the equipment actually to be installed.

Where more than one conductor is used per phase, each phase, neutral if any and ground wires shall be run in each metallic or non metallic conduit.

Conductors shall be continuous from outlet to outlet and no splices shall be made except within outlet or junction boxes.

At every outlet and pull box, wires and cables passing through, shall be left slack by an amount equivalent to 15cm of cable length to allow inspection and connection to be made therein.

No cable bend shall have a radius of less than eight times its diameter.

The Contractor shall not change any circuit number, especially from a phase to a different phase. If such a change is necessary due to modification on site, the Contractor shall bring this matter to the attention of the Consultant.

All conductors to be contained within a single conduit shall be drawn in at the same time.

A wire pulling compound shall be applied to conductors being drawn through conduit. Pulling compound shall be soap tone or other approved material.

Only cables forming part of a lift installation if any may be run in a lift shaft.

Wires and cables for feeders, sub-feeders, control, and branch circuit wiring shall be color coded as follows:

Color	Phase
Red	A or 1
Yellow	B or 2
Blue	C or 3
Black	Neutral
Green	Equipment grounding

Wire and cable sizes shall be as indicated on the Drawings; however, in no case shall their size be smaller than required by the approved Code.

Unless otherwise indicated, no conductor for lighting and power wires shall be smaller than 2.5mm².

All branch circuits for lighting and appliances shall be single conductor cables run inside conduits, unless otherwise indicated.

Feeders and sub-feeders with cross-sectional area smaller than 16mm² shall be single conductor wires pulled inside conduits and from 16mm² and larger multi-conductor cables run exposed on walls in trenches as shown on the Drawings.

Single cables shall be fixed directly to walls or ceilings. Where 2 or more cables are run in parallel, they shall be fixed on galvanized steel perforated trays or no other approved special cable supporting and protecting arrangement.

Cables shall be fixed to supporting structures with approved galvanized cast steel clamps at distances not exceeding 20 diameters.

No joints or splices shall be accepted on main feeders.

PART 7- IDENTIFICATION OF WIRES & CABLES

Individual conductor or circuit identification shall be carried throughout, with circuit numbers or other identification clearly stamped on terminal boards and printed on directory cards in distribution cabinets and panelboards.

In junction boxes, cabinets, and terminal boxes where the total number of control, indicating, and metering wires is three or fewer and no terminal board is provided, each wire including all power wires, shall be properly identified by means of a plastic-coated, self-adhesive, wire marker.

Wires including motor leads and other power wires too large for connection to the terminal boards shall be identified by wire markers as specified above.

In manholes, handholes, pull boxes, junction boxes and at both terminals each wire and cable shall be properly identified by a laminated plastic tag located so as to be easily seen. Wires and cables shall be identified by cable number indicated on the Drawings.

PART 8- CONNECTORS AND TERMINAL BLOCKS

For the wiring of circuits consisting of wire sizes 6mm² and smaller such as for lighting branch circuits, self insulated pressure type connectors shall be utilized for all splices or joints.

For the wiring of circuits consisting of wire sizes 10mm² and larger shall be of the bolted pressure type, with a preinsulated sleeve.

Connectors shall be manufactured from high conductivity aluminum, electro tin-plated.

Connector bodies shall be manufactured from Polyamide.

PART 9- CABLE TRAYS AND SUPPORTS

Cable trays shall be manufactured from mild steel of a minimum thickness of 2mm. They shall be light or heavy-duty type as required with return flanges, and hot-dip galvanized finish. Bends, corners, etc... Shall be specially manufactured for the purpose.

All supports and accessories like hangers, channels, bolts, nuts, cable ties, conduit clamps, shall be furnished as to function, to the manufacturer's standard. Metallic elements shall be hot dip galvanized.

The contractor shall provide technical catalogues and shop drawings to illustrate the sufficiency of the supports and tray sections thicknesses.

The installation shall have a design assuming double at the actual load in addition to the safety factor recommended by the tray manufacturer.

Cable trays, supports, and accessories shall be manufactured by BICC (England) or approved equal.

PART 10- CABLE GLANDS

Cable glands shall be provided at the termination of armored cables at the enclosure of a distribution board or any other equipment.

Cable glands shall be indoor or outdoor type, ordinary or weatherproof according to the location of the termination, to the approval of the Consultant.

1.2 MANUFACTURERS

- A. Approved Manufacturers: Subject to compliance with requirements, provide product by one of the following or approved equal:
1. Liban Cable
Or approved equal.

END OF SECTION

SECTION 16442

DISTRIBUTION, SUBDISTRIBUTION AND FINAL BRANCH CIRCUIT PANELBOARDS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. General provision of the Contract including user/operating manual for panel board, MCC and other control system.

1.2 SUBMITTALS

- A. Electrical Work Generally is to be in accordance with the requirements of Sections 16010 of the Specification.
- B. Description of Work: panel boards for distribution and sub distribution of electric power and for protection of circuits, including fixing and supporting materials and materials for termination of feeders, sub circuits and branch circuits, the works will also include the DDC panels including the implementation of the data points to meet the requirement of the system description as user / operating manual for CO/VIS sensors and TCMS requirement.
- C. Standards: panel boards generally are to comply with the requirements of IEC 439, Factory-Built Assemblies of Low Voltage Switchgear and Control Gear.
- D. Designations: panel boards are designated on the Drawings and in the Schedules as follow:
 - 1. MCC and other control system.
 - 2. Final branch circuit panel boards, power panel boards and sub distribution panel boards respectively, for secondary lighting and power distribution with either miniature circuit breaker (MCB) or molded case circuit breaker (MCCB) protection on sub feeder or branch circuits, as shown on the Drawings.
- E. Equipment Data: submit data for approval including, but not limited to, the following:
 - 1. Manufacturers' catalogues indicating specific equipment selected.
 - 2. Types of panel boards and circuit breaker characteristics including duties and ratings compensation at and above 40 deg. C ambient conditions and corresponding temperatures within the enclosures.
 - 3. Dimensions of panels and specific contents of each panel board
 - 4. Integrated equipment tabulations for coordinated short- circuit series combinations of circuit breakers.
- F. Tests and Certificates: submit complete certified manufacturer's type test and routine test records in accordance with the Standards.
- G. Shop and Section Construction Drawings: submit drawings for approval including, but not limited to, the following:
 - 1. Exact composition of each panel board, indicating bus bar rating, frame or continuous rating and trip ratings of circuit breakers

2. Typical installation details of panel boards, indicating main feeder and branch circuit conduit connections, terminal provisions, tags, labels, mounting methods and materials used.
- H. Electrical Closets are to be checked for clearances, spaces and ventilation, for the installation of proposed equipment, prior to starting construction.
- I. Approved Manufacturers: obtain panel boards from one of the following:
 1. Merlin Gerin (France)
 2. Siemens - ITE (Germany)
 3. Schneider Electric
 4. LEGRAND (France)
 5. or other equal and approved.

PART 2 PRODUCTS AND SYSTEMS

2.1 Distribution, Subdistribution And Final Branch Panelboards

2.1.1 General Requirements

- A. Rated Insulation Voltage is to be in accordance with the respective Standards.
- B. Panelboards are to be totally enclosed, dead front type, protection code IP 42 for indoor installations and IP 55 for outdoor installations, in accordance with IEC 144, and are to be factory designed and assembled.
- C. Earthing Bar is to be provided in every panel board.
- D. Protection is to be fully rated throughout the systems.
- E. Series (Cascade) Coordinated Protection (integrated equipment short-circuit ratings) will not be acceptable.
- F. Circuit Breakers are to be non-fused type.
- G. Circuit Breaker Arrangement: panel boards are to have one main incoming circuit breaker and the required number of branch circuit breakers, arranged as shown on the Schedules, including spare circuit breakers and spaces for future expansion. Three-phase panel boards are to be designed for sequence phase connection of branch circuit devices.
- H. Type: general purpose type, suitable for relevant ambient conditions, flush or surface mounted as shown on the Drawings, comprising box, trim, or trim and door to approved manufacturer's standards and sizes.
- I. Construction: box, trim and doors where required, are to be electro-galvanized sheet steel of gauges not less than specified and in accordance with the Standards. Welded joints are to be galvanized after manufacture. Gutter spaces are to conform to the Standards, but are not to be less than 100 mm on all sides. Enclosure is to have predesigned angles or threaded end studs to support and adjust mounting of interior panel board assembly.
- J. Trims are to cover and overlap front shield, covering all terminals and bus compartments, to form a dead front panel. Trims are to be fixed to cabinet/box by quarter-turn clamps engaging flange of box (use of screws engaging holes in flange of box is not acceptable). Screws where used are to be oval-head, countersunk and flush. Trims for flush mounted panel boards are to overlap box and front shields by at least 20 mm. Trims for surface mounted panel boards are to be exactly sized to form flush fit to box.

- K. Doors are to have concealed hinges integral with trim, and flush combination cylinder lock and catch. Doors over 1000 mm high are to have vault-type handle and multiple point latch mechanism. Locks are to be keyed alike.
- L. Finish: inner and outer surfaces of cabinet/boxes, trims, doors etc. are to be cleaned, phosphatized, chrome passivity and treated with final thermosetting epoxy powder modified by polyester resins providing high resistance to mechanical injury, heat, acid and alkali solvents, grease, ageing and corrosion and of standard grey colour to the approval of the Engineer.
- M. Directories under glass, or an approved alternative durable arrangement, are to be provided on inside face of doors, or in metal label holders when trim without doors is specified. Directories are to be typed to identify panel boards and clearly indicate circuit number and description of load.
- N. Outdoor Enclosures are to be heavy duty sheet steel cabinets, minimum 1.5 mm thick, fully weatherproofed (IP 55), without knockouts, but with removable sealed/gasketed bottom gland plates and gasketed doors.

2.1.2 Busbars

- A. Type: one piece, 98% pure electrolytic copper, based on maximum total temperature rise of 40 deg. C over an ambient of 50 deg. C at full continuous rating. Bolted or clamped contact surfaces are to have maximum current density not exceeding requirements of the approved standards. Aluminum is not to be used for bus bars or panel board parts.
- B. Design: bus bars are to be shrouded/insulated and rigidly designed so that branch circuit devices can be removed without disturbing adjacent units or changed without additional machining, drilling or tapping. Busing is to be full size without reduction. Busing and blank plates are to allow installation of future circuit devices, where indicated on the Drawings.
- C. Rating: bus bar rating is to be at least equal to main-circuit breaker frame size. Where no main circuit breaker is required, bus bars are to have main lugs or disconnect switch, with nominal rating equal to standard circuit breaker frame sizes, and as shown on the Drawings.
- D. Short-Circuit Duty: bus bars are to carry maximum short-circuit duty of main protective device, which is to be at least maximum short-circuit at point of application for one second, without showing any signs of degradation.
- E. Terminals And Connections are to be anti-turn, solder less screw-pressure type. Screws and bolts used for making copper/copper connections are to be hard copper alloy with lock washers (riveted bus connections are not acceptable).
- F. Neutral Bar is to be solid and fully insulated from cabinet or box. One solder less box type set-screw connector is to be provided for neutral wire of each branch circuit and one bolted clamp-type connector or anti-turn lug with set-screw for main incoming neutral wire. Neutral is to be fully sized and rated as for phase bus bars.
- G. Earthing Bar is to be copper, brazed to panel board cabinet, with bolted pressure connector for main conductor and one set-screw-type tunnel terminal for each outgoing conductor, to provide secure and reliable contact with all metal parts and enclosure.

2.1.3 Moulded Case Circuit Breakers (MCCBs)

- A. Type: tested to approved standards, totally enclosed, moulded case, constructed from high quality, high temperature resistant, tropicalized, moulded insulating materials, for normal operation at maximum temperature within enclosures at point of application, and provided with front operated single toggle type handle mechanism for manual operation of main contacts in addition to automatic operation under over current conditions. Multi-pole breakers are to have common integral trip bar for simultaneous operation of all poles. Ampere rating is to be clearly visible. All terminals are to be box lug or clamp type with set screws, suitable for copper or aluminium conductors.

- B. Circuit Breaker Trip Units: unless otherwise specified or shown on the Drawings, circuit breakers up to and including 300A frame size, are to be thermal-magnetic type, having bi-metallic inverse time delay over current element for small overloads and instantaneous magnetic over current trip element for operation under short-circuit conditions on each pole. Circuit breakers 200 A and larger are to have adjustable instantaneous trips. Where solid state electronic trip circuit breakers are required these are indicated in the Schedules suffixed with the letter e.
- C. Switching Mechanism: quick-make, quick-break type, with positive trip-free operation so that contacts cannot be held closed against excess currents under manual or automatic operation. Contacts are to be non-welding silver alloy with approved arc-quenching devices of metallic grid construction.
- D. Trip Current Rating (AMPS) indicates nominal maximum rating at which overload element is set to operate.
- E. MCCBs For MDB: To comply with IEC947-2 test sequences I, II, II, utilization category A, and are to have rated ultimate short circuit breaking capacities (Sequence III) to meet the electrical requirements at the panelboard location, with preferred ratings in accordance with following tables.
- F. MCCBs For other: are to be rated for maximum voltage of 600V a.c., 250 V d.c. and utilization category B (with an intended short time withstand capability), and are to have rated service short circuit breaking capacities (Sequence II) with suitably selected frame sizes and trip ranges to meet the electrical requirements at the distribution panel board location and schedules shown on the drawings, with declared ratings as percentage (100%, 75% or 50%) of the ultimate ratings as quoted by the circuit breaker manufacturer marked on the circuit breaker rating plate.
- G. Tripped Position: when tripped automatically by over current condition, operating mechanism of circuit breaker is to assume an intermediate position clearly indicated by the handle between on and off positions.
- H. Interchangeable Trips: thermal-magnetic trip circuit breakers 250A frame size to 300 A frame size is to have interchangeable trip units.
- I. Sealing: circuit breakers with non-interchangeable trip units are to be sealed. Circuit breakers with interchangeable trip units are to have trip unit covers sealed to prevent tampering.
- J. Compensation: thermal over current trips are to be ambient temperature compensated between 25 and 50 deg. C.
- K. Electronic Trips Units, applicable to circuit breakers 400 A frame size and larger, are to be solid state with long time delay settings between 0.5 and 1.0 times maximum trip rating, short time delay range of 3 to 10 times maximum trip rating with a maximum clearing time of 0.2 seconds, and instantaneous protection adjustable from 5 to 10 times continuous rating. Solid state trip units are to be insensitive to changes in ambient temperature between -20 and +55 deg. C. Earth fault protection is to be built into trip unit where specified, and is to be suitable for connection to external current sensor. Push-to-trip button is to be provided on cover for testing the trip unit.
- L. Accessories: circuit breakers are to be designed to accommodate standard attachments including shunt-trip, under-voltage release, combined auxiliary and alarm switches, and electrical operator to any circuit breaker of rating (frame size) 100 A and over. Padlocking devices are to be provided, where shown on the Drawings.
- M. RESIDUAL CURRENT OPERATED EARTH LEAKAGE TRIP DEVICES (Rcds) are provided as add-on or built-in earth leakage accessories, where required and as shown on the Drawings. Protection against earth fault current, in addition to overcurrent and short-circuit protection, is to be in accordance with the Regulations. Trip current sensitivity on breakers for branch circuits is to be 30 mA, and for main breakers ratings are to be as shown on the Drawings. Circuit breakers are to include current transformer with tripping coil assembly, test button and trip free mechanism to ensure circuit breaker cannot be

held closed against earth faults.

- N. Current Limiting Circuit Breakers: moulded case type without fusible elements. When operating within current limiting range, the I_{2t} of let-through current is to be less than 1/2 cycle wave of symmetrical protective short-circuit current as compatible with breaker construction.
- O. Current Limiting Circuit Breakers are to have, on each pole, adjustable inverse time-delay over-current characteristics for overload protection and instantaneous trip for short-circuit protection. Operation of main contacts is to be based on electro-magnetic repulsion forces between contacts created by fault current. Ratings are specified at rated voltage for an rms value of prospective short-circuit current.

2.1.4 Miniature Circuit Breakers (Mcbs)

- A. Type: thermal magnetic non-adjustable type, tested in accordance with BS 3871, Part 1.
- B. Minimum Short-Circuit Breaking Capacities are to be 6 - 100 A MCB: 6, 10 or 16 kA at 240/415 V a.c.
- C. Construction: MCBs are to be tropicalized for operation at ambient temperatures up to 70 deg. C within panelboard enclosure and humidities up to 95%, and are to be constructed from high quality, high temperature, moulded insulating materials. Guaranteed duties and characteristics are to be submitted for temperatures above 40 deg. C. MCBs and combinational devices are to be modular, of unified profile and mounted to a standard DIN rail.
- D. Operation: under overload conditions, thermal tripping is to provide close protection of insulated conductors. Under short-circuit conditions, magnetic trip is to operate at 7 – 10 times normal rated current (type 3 characteristic). Magnetic operation is to be in the current limiting region and opening time is not to exceed 5 milli-seconds.
- E. Ratings: preferred rated currents are to be 6, 10, 15, 20, 25, 30, 40, 50, 60, 80 and 100 A, calibrated at 40 deg.C, available as 1, 2, 3 and 4-pole circuit breakers. Derating above 40 deg. C is not to exceed 1% per deg.C, and loading is not to exceed 70% of circuit breaker rating.
- F. Residual Current Devices for earth leakage protective circuit breakers are to be add on devices, or built-in and integral with the standard circuit breaker. Non-adjustable sensitivities of 30 mA, 100 mA and 300 mA are to be available for all ratings of 2-pole and 4- pole circuit breakers.
- G. Auxiliaries, where required or shown on the Drawings, are to include alarm switch, auxiliary switch, shunt trip, under voltage trip and similar units which are to be modular additions to the circuit breakers.

2.2 Panelboards - Generally

- A. Arrangement: to comprise set of homogeneous branch circuit breakers with unified profile and base, and one main circuit breaker. Single and multi-pole circuit breakers or other devices are to occupy modular spaces. Accommodation of contactors and split-bus arrangement or other devices is not to change regularity of standard box width.
- B. Indoor Enclosure: sheet steel, minimum 1.0 mm thick for box/cabinet and minimum 1.5 mm thick for front shield, trim and door. Fixings for flush trim are to be adjustable to allow for mis-alignment between box and wall surface. Wiring spaces (gutters) are to be at least 100 mm wide. Larger gutters are to be provided where tap-off insulated split connectors are required. Knockouts are to be provided in top or bottom of enclosures and are to provide a neat and uniform conduit/cable terminal arrangement.

2.2.1 Final Branch Circuit, Power And Subdistribution: SDB Panel boards - Type MCCB

- A. Type: 240 V a.c. or up to 480 V a.c. service voltages, lighting and distribution type (lighting and appliance type, NFC15 100 or to N.E.C.), single-phase and neutral (SPN) or

- 3-phase and neutral (TPN), with bolted 1, 2, or 3-pole
- B. Branch Circuit Breakers are to be 1, 2 or 3-pole, rated 100 A frame size, with trip ratings between 15 A and 100 A, and compatible ICs, selected from normal (N), high-break (H) or current-limiting (L) range.
 - C. Circuit Breakers are to be Merlin Gerin or LEGRAND, lighting circuit breaker types, or other equal and approved.
 - D. Main Circuit Breaker is to be 2 or 3-pole 100 A, or 2, 3 or 4-pole 160 A, 225/250 A or 400 A continuous rating (frame size), with trip ratings and fully rated non-current limiting ICs of normal (N) or high-break (B) ranges, with or without residual current device (RCD) as indicated on the Drawings.
 - E. Short-Circuit Rating: panelboards may only have integrated equipment (series) short-circuit rating in accordance with calculation.
 - F. Assembly: busbars are to be rigidly fixed on moulded insulators to back pan in vertical arrangement. Branch circuit breakers are to be bolted in twin arrangement to rigid copper cross and centre bus connectors. Back pan assembly is to be removable and fixed to four threaded studs integral with cabinet.

2.2.2 Final Branch Circuit Panelboards - Type MCB

- A. Internal Assembly: to comprise removable back plate or back pan of rigid construction, attached to enclosure by four captive screws through keyhole fixings, and provided with DIN rails in horizontal arrangement for SPN panels and in vertical arrangement for TPN panels. Assembly is to be complete with neutral terminal block, earthing bar and one piece insulated bolt-on/comb-type phase busbar. Busbars are to be single-phase or 3-phase with spade connectors for fixing by tightening a single screw on circuit breaker. Insulation is to be high thermal rating, capable of carrying maximum short-circuit current for one second without overheating beyond acceptable limits required by the Standards. Panelboards are to comply with NFC 15-100 or BS 5486 Part 12.
- B. Spn Type Panelboards are to be suitable for 240 V maximum service voltage, single-phase and neutral, with MCBs on branch circuits and main incoming.
- C. Spn Type Main Circuit Breaker is to be double-pole MCB, with or without earth leakage device (RCD).
- D. Single-Pole And Double-Pole MCBs for 240 V service, are to have trip ratings between 6 A and 50 A.
- E. Tpn Type Panelboards are to be suitable for up to 415 V a.c. maximum service voltage, 3-phase and neutral, with MCBs on branch circuits and 3 or 4-pole MCB or MCCB main incoming, as shown in the Schedules or on the Drawings.
- F. Tpn Type Panelboard Main Circuit Breakers are to be MCB or MCCB, 100A continuous current rating, with trip range from 25 A to 100 A, or 225 A MCCB with trip range 70 A to 225 A, normal (N) or high-break (B) duty with/without RCD.
- G. Short-Circuit Rating: TPN panelboards may only have an integrated equipment (series) short-circuit rating in accordance with calculations.

PART 3 FIELD AND INSTALLATION WORK

3.1. Installation

- A. Fixing Generally:
 - Align, level and securely fasten panelboards to structure
 - Fix surface mounted outdoor panelboards at least 25mm from wall ensuring supporting members do not prevent flow of air.

- Do not use connecting conduits to support panelboards
- Close unused openings in panelboard cabinets.
- B. Panelboard Interiors: do not install in cabinets until all conduit connections to cabinet have been completed.
- C. Wiring Inside Panelboards: to be neatly arranged, accessible and strapped to prevent tension on circuit breaker terminals. Tap-off connections are to be split and bolted type, fully insulated.
- D. Trim: fix plumb and square prior to painting. Fix trim for flush mounted cabinets flush with wall surface finish.
- E. Protection: treat concealed surfaces of recessed cabinets with heavy field application of water-proof compound prior to installation.

PART 4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 30Km of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association, and that is acceptable to authorities having jurisdiction.
- C. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or one of the National Engineering Control Audit Institute for Certification in Safety Engineering Technologies to supervise on-site testing.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with NFPA 70.
- F. Product Selection for Restricted Space: Drawings indicate maximum dimensions for system, including clearances between, and for adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.
- G. System Design and Standards: The Specification and the Drawings are a guide to the selection of system characteristics, giving general features of construction, materials, method of installation and conditions of operation. Unless otherwise specified, system items are to be as per manufacturer's standard series, designed and manufactured for the purpose and application required, generally in accordance with the international standards.

PART 5 INSTALLATION

- A. The installation shall meet, as applicable, all United States Underwriters Laboratories (UL) Standards, all National Fire Protection Association (NFPA) requirements, all National Electrical Code (NEC) requirements, and applicable state and local codes.
- B. It shall be the Security Contractor's responsibility to see that the equipment is installed to manufacturer's specifications and that the correct power is supplied to each different type of equipment.
- C. It shall be the Security Contractor's responsibility to obtain necessary equipment manufacturer's installation specifications and drawings to complete all installation and contract work.
- D. All electronic equipment shall be grounded as specified herein and as required by

manufacturer's specifications. All cabinets, junction boxes, control cabinets, etc. Shall be grounded.

- E. The Contractor shall note the locations of system on drawings with the preferred areas of placement according to the international standards and under the approval of the consultant engineer. However, the Contractor shall be responsible for the final location of each equipment for optimal coverage and stability.

PART 6 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each component of the system, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
 - 1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
 - 2. To assist in field testing of equipment including pretesting and adjusting of solid-state controllers.
 - 3. Report results in writing.
- C. Testing Agency: Owner will have the right to engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.
- D. Perform the following field tests and inspections and prepare test reports:
 - 1. Perform each electrical test and visual and mechanical inspections, Certify compliance with test parameters.
- E. Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.

PART 7 DEMONSTRATION

- A. Train Employer's maintenance personnel to adjust, operate, and maintain the system installation.

PART 8 MAINTENANCE CONTRACTS

- A. A complete offering of preventative and full service maintenance contracts for the system shall be available.

PART 9 TRAINING:

- A. A system service training workshop shall be available from the manufacturer. The service training workshop shall include a combination of lecture and practical instruction with hands-on laboratory sessions. The service training workshop shall include instruction about safety procedures, sub-assembly identification and operation, preventive maintenance, and troubleshooting.

1.3 WARRANTY

- A. System Warranties: Specified form in which manufacturer and Installer agree to repair or replace any system that fail in materials or workmanship within specified warranty period.

END OF SECTION

Annex 1

Landfill Leachate Management Systems

Annex 1 - Landfill Leachate Management Systems Technical and Performance Specifications

1. Leachate Collection and Drainage

The Contractor shall supply and install / construct a leachate collection (drainage) system including leachate collection pipes, collection sumps or tanks, and leachate pumping sets.

The leachate collection system shall be designed to minimize the head of leachate above the liner. The leachate head is a function of leachate generation, bottom slope, pipe spacing, and hydraulic conductivity of the drainage blanket.

- *Basal shape (Where needed)*

The base of cells shall be sloped to facilitate gravitational flow of leachate to leachate collection sumps. The following shall be considered:

- Minimum fall of 1.5-2% towards leachate collection sump shall be ensured. This gradient also promotes self-cleansing and reduces blockages in the leachate collection pipe(s); and
- Gradient towards the main leachate collection pipe(s) shall, at minimum, be 1%.

- *Drainage Layer (sand or gravel)*

The Drainage Layer shall consider the following:

- Thickness of 500 mm with minimum hydraulic conductivity of 1×10^{-3} m/sec;
- Rounded drainage media, pre-washed, non-calcareous stone (less than 10% CaCO_3);
- Particle size compatible with the proposed geo-membrane.
- Drainage Layer of documented durability and mechanical strength proportionate with the proposed loading; and
- Standard aggregate tests (e.g. Slake Durability Test BS882, Acid Immersion Test, Magnesium Sulfate Soundness Test).

- *Leachate Collection/Drainage Pipes*

Knowing that the drainage layer piping is the component that is considered the most vulnerable to compressive strength failure, the proper design of leachate collection pipes shall consider the following three main conditions:

- Required capacity and pipe spacing;
- Pipe size and maximum slope; and
- Structural strength of the pipe.

Leachate collection/drainage pipes shall, at minimum, meet the following requirements:

- A network of perforated smooth bore, minimum diameter of 200 mm (high density polyethylene, or polypropylene) laid to a self-cleansing gradient;
- Intake area of at least 0.01m²/m length of pipe;
- Crush strength shall be equal to the waste loading and operating equipment; and shall not be vulnerable to chemical attack by the leachate.

Leachate collection/drainage pipe spacing may be determined by the Mound model. In the Mound Model, the maximum height of fluid between two parallel perforated drainage pipes is equal to (U.S. EPA, 1989):

$$h_{\max} = \frac{L}{2} \frac{q}{c} \left[\frac{\tan^2 \alpha + 1}{c} - \frac{\tan^2 \alpha}{c} \sqrt{\tan^2 \alpha + c} \right]$$

Where:

h_{\max} = maximum allowable head on the liner $c = q/K$

q = inflow rate K = permeability α = slope

The 2 unknowns in the equation are: L = distance between the pipes and c = amount of leachate.

The estimated amount of leachate generated can be obtained from the water balance calculations. The equation can then be solved to calculate the spacing of pipes.

During the early stages of leachate drainage pipe installation, protection is considered of great significance given that the piping system is most likely to be prone to damages. As such, it is advised that the first 2 meters of waste, free of bulky or sharp objects, are left un compacted above the drainage blanket. This will not only protect it from equipment damage but also will enhance drainage in the lower regions of the waste and provide extra filtering for suspended material being transported by leachate.

2. **Leachate Removal and Pumping**

Leachate can be removed/pumped from the landfill through leachate collection sumps or via a leachate collection header pipe system. The Contractor shall consider either one of the following leachate removal systems:

- A leachate collection sump or tank with a manhole extension rising vertically through the waste and final capping system. The sump is made either in situ or prefabricated off site. The vertical riser is either a concrete or plastic standpipe. It is extended as the waste is placed in the facility; or
- A leachate collection sump or tank with a solid wall pipe riser coming up the side slope where it eventually penetrates the final capping system.

- *Liner Penetration*

Penetration of the basal liner system shall be avoided where possible. A high degree of care shall be exercised by the Contractor in both the design and construction of the penetration. The penetration shall be designed and constructed in a manner that allows nondestructive quality control testing of the seal between the pipe and the geo-membrane liner.

- *Sumps*

Sumps are located at low points in cells to allow gravitational drainage of leachate. Leachate is removed from the sumps by pumping. In the past, low volume sumps have been constructed successfully from reinforced concrete pipe on a concrete footing (typically minimum 1m diameter). More recently high density polyethylene pipes have been used, welded to a thick HDPE baseplate using a series of supporting webs. The minimum size shall be approximately 300 mm to facilitate pump insertion if necessary. These structures (HDPE) may be suitable for replacing the concrete components of the sump and have the advantage of being lighter in weight.

- *Vertical Chambers*

Vertical leachate collection chambers shall be surrounded by a permeable drainage media, not deposited wastes, to assist in vertical percolation of leachate to the chamber. The Contractor shall give consideration to installing telescopic HDPE manhole shafts where the waste height will be extensive and the stresses on the shaft due to settlement could cause collapse of the shaft.

- *Sidewall pipes*

The use of low angled leachate risers which are laid parallel to the side of the site shall be considered. Although not suitable for sites with steep sides, the system exerts much lower pressures on the liner system. A second advantage is that vertical chambers often suffer from sideways movement due to settlement although the effects of this can be reduced/mitigated by the adoption of telescopic HDPE shafts. The low angle riser system is less prone to damage from the filling process as they are located at the perimeter of the phase.

- *Pumps*

Pumps used to remove leachate from the sumps shall be sized to ensure removal of leachate at the maximum rate of generation. These pumps shall have a sufficient operating head to lift the leachate to the required height from the sump to the access port. One of the most common pump types used is the submersible pumps.

Pumps shall exhibit the following characteristics:

- Easy to install and remove;
- Robust manufacture;
- Minimum moving parts;
- Low maintenance requirements;
- Capable of variable flow rate (varying seasonal conditions). A range from about 60 liters an hour to greater than 1m³/h would be realistic for a pump located within a borehole;
- Capable of running dry with no harm being done to its operation;
- Capable of handling varying quantities of fine material and sludge that often accompanies leachate production, perhaps with additional protection being afforded by filtration; and
- Designed with sufficient head.

3. **Leachate Storage**

Leachate storage facilities shall consider the following key criteria:

- Concrete tanks designed to BS8007;
- Prefabricated units; and
- Geo-synthetic lined, e.g. HDPE lined facilities.

Such facilities shall be sized to accommodate the calculated leachate volume and shall be designed to prevent overflowing. All units shall be designed to prevent leakages. When using concrete tanks or prefabricated units consideration shall be given to the provision of storage bunds. In situations where it is proposed to line the storage facility with a geo-synthetic material the design/construction and associated quality control/assurance shall follow the general guidance given under Lining Systems.

4. Leachate Treatment

Leachate generated from municipal solid waste initially contains high concentrations of organic compounds (of the order of 10,000-40,000 mg/l COD). They also have a low pH, a high ammonia level and an unpleasant odor. To avoid severe environmental impact, the control and disposal of leachate is essential. Discharge limits would normally be specified by the appropriate regulatory agency. Treatment strategies should meet individual discharge conditions and will inevitably be site specific for discharge to municipal sewer, watercourse, land or tidal water.

The Contractor shall ensure that the leachate treatment facility satisfies the following design criteria:

- Be adequate for the varying volumes and composition generated through all stages of development and restoration,
- Be robust, to ensure that performance requirements are maintained throughout and beyond the operational life of the landfill.

A wide range of treatment processes has been adopted for leachate including most of those which have been used for the treatment of domestic and industrial wastewaters.

Table 1 below provides an outline of the most commonly used leachate treatment processes (physical and biological).

Table 1

Leachate Treatment Process	Application
<u>Physical Treatment</u>	
Sedimentation / Flotation	Removal of suspended matter
Filtration	Removal of suspended matter
Air stripping	Removal of ammonia or volatile organics
Steam stripping	Removal of volatile organics
Adsorption	Removal of organics
Ion exchange	Removal of dissolved inorganics
Ultrafiltration	Removal of bacteria and high-molecular-weight organics
Reverse osmosis	Dilute solutions of inorganics
Neutralization	pH control
Precipitation	Removal of metals and some anions
Oxidation	Removal of organics; detoxification of some inorganic species
Evaporation	Where leachate discharge is not permissible
Wet air oxidation	Removal of organics
<u>Biological Treatment</u>	
Activated Sludge	Removal of organics from leachate
Sequencing batch reactors	Removal of organics
Aerated stabilization basins	Removal of organics
Fixed film processes (trickling filters, rotating biological contractors)	Removal of organics
Anaerobic lagoons and contractors	Removal of organics
Nitrification / de-nitrification	Removal of organics

Source: Tchobanoglous 2002

The Contractor shall select the leachate treatment process considered most appropriate to achieve the given objectives.

Treated leachate that is to be disposed of into the receiving environment shall comply with the Environmental Limit Values (ELVs) stipulated in the Ministry of Environment Decision 8/1 (dated 2001) for either one of the disposal pathways:

- Treated wastewater discharged into the sewerage network (in case treated leachate is transferred to the Al Ghadir Wastewater Treatment Plant).
- Treated wastewater discharged into the sea (in case onsite leachate treatment unit directly discharges treated effluent into the sea)

Table 2 below presents the ELVs set by the MoE Decision 8/1 (2001) for treated wastewater discharged into the sea and sewerage system from new facilities.

Table 2

Parameter	ELV for wastewater discharge into sea	ELV for wastewater discharge into sewerage system
pH	6 – 9	6 – 9
Temperature	35°C	35°C
BOD5 (mgO2/L)	25	125
COD (mgO2/L)	125	500
Total Phosphorous (mgP/L)	10	10
Total Nitrogen (mgN/L)	30	60
Suspended Solids (mg/L)	60	600
AOX	5	5
Coliform Bacteria 37°C in 100 ml ³	2,000	Not available
Salmonellae	Absence	Absence
Hydrocarbons (mg/L)	20	20
Oil and Grease (mg/L)	30	50
Total Organic Carbon (TOC) (mg/L)	75	750
Ammonia (NH4 ⁺) (mg/L)	10	-
Silver (Ag) (mg/L)	0.1	0.1
Cadmium (Cd) (mg/L)	0.2	0.2
Chromium total (Cr) (mg/L)	2	2
Copper total (Cu) (mg/L)	1.5	1
Mercury total (Hg) (mg/L)	0.05	0.05
Manganese (Mn) (mg/L)	1	1
Nickel total (Ni) (mg/L)	0.5	2
Lead total (Pb) (mg/L)	0.5	1
Zinc total (Zn) (mg/L)	5	10
Nitrate (NO3) (mg/L)	90	-
Phosphate (PO4) (mg/L)	5	-
Sulfates (SO4) (mg/L)	1,000	1,000

Source: MoE Decision 8/14, 2001

Annex 2

Landfill Gas Collection and Flaring Systems

Annex 2 - Landfill Gas Collection and Flaring Systems

Technical and Performance Specifications

1. Landfill Gas Management

The main objectives of landfill gas management are:

- To eliminate the risk of migration of landfill gas within and beyond the perimeter of the landfill site such that there is no risk of explosion, combustion, asphyxiation, odors or vegetation damage on adjoining property,
- To prevent unnecessary air ingress into the landfill and minimize the risk of underground fires,
- To eliminate the need to vent unburned landfill gas to the atmosphere.

Landfill Gas Management is realized by installing Gas Collection and Flaring Systems. The Contractor shall ensure that the landfill gas collection and flaring systems have the following features in order to meet the above objectives:

- A containment system which will retain the gas within the site,
- Gas monitoring boreholes outside the waste boundary where possible,
- Use of safe practices to avoid hazardous concentration of gases in temporary and permanent working areas.

2. Gas Collection Systems

Given that horizontal wells can suffer blockage and dislocation due to differential settlement, gas wells shall be vertical boreholes passing through the waste installed in the waste lifts / layers as landfilling progresses.

The gas extraction system shall consist of vertical extraction wells in the waste, linked by pipework in the cap to a gas pumping and flaring compound. The wells may be constructed as waste filling progresses or drilled retrospectively.

The layout of the wells will be landfill cell specific but normally at not more than 50 m centers together with the positioning of any perimeter migration control system. The wells shall be spaced so that their radii of influence overlap (radius not exceeding 15 m). The spacing can reach 30 m in landfills with clay and/or soil covers and 45 to 60 m in deep landfill cells with a composite cover containing a geomembrane).

The radius of influence for wells shall be determined by conducting on-site gas drawdown tests. The number and spacing between each extraction well will depend on the waste type, compaction and depth, the well depth, the leachate levels, the pressure gradients created by the vacuums, the moisture content of the gas as well as the type of daily cover and the presence of a final cap.

The characteristics of the landfill gas extraction well shall be the following:

- 4 to 6 in. pipe (made of HDPE or PVC) casing surrounded by permeable material (such as gravel) and impermeable seal near the top, placed in an 45 to 90 cm borehole made through waste layers,
- The bottom one third to one half of the well is perforated and placed in a gravel backfill
- The remaining length is not perforated and should preferably be placed in soil, although it can also be set in solid waste backfill,
- A bentonite plug to prevent air infiltration from the surface into the well,
- A wellhead incorporating valves to regulate gas flow and serve as sampling ports, as well as a pressure gauge,

a flow monitoring device and a thermometer,

- Pumps/gas blowers to supply the flaring system with landfill gas. The size, type and number of pumps depend on the amount of gas expected to be produced within the landfill,
- Collection header pipes to connect the vertical extraction wells to the gas blowers / pumps,
- Condensate handling equipment placed at low spots in the line where needed and at specific spacing.

The depth of the well shall depend on the depth of the waste and typically terminates at 3 to 5 meters above the base of the waste mass. An area shall also be allocated for standby provision.

The design of the gas management system shall be integrated with other elements of the landfill elements and components considering the following:

- Whether there is sufficient depth in the subsoil component of the capping layers to accommodate well heads and extraction pipes, and
- Whether settlement will disrupt the cap around the well or cause downdrag to push the well against the liner.

3. Pumps and Flares

The flaring system shall be of type enclosed flame flare. The gas extraction pumps and flares shall be designed to meet with emission standards and to comply with national regulations on air quality. Furthermore, Table 1 sets the emission concentrations for landfill gas flares under normal temperature and pressure (NTP: 0°C and 1,013 mbar) and 3% oxygen.

Table 1

Landfill Gas	Emission Standard (mg/Nm ³)
Carbon Monoxide (CO)	50
Oxides of Nitrogen (NOx)	150
Unburned Hydrocarbons/ Total volatile organic compounds	10

Source: Emission standards for landfill gas flares (UK Environment Agency, 2010)

The flaring system shall include the following items:

- A purge reduction device to prevent flashback
- A knockout drum to remove and store condensable and entrained liquids
- A flare header to collect the gas
- A liquid seal to prevent flashback
- A flare stack (made of carbon steel with ¼" minimum thickness)
- An externally removable spark ignited pilot
- A steam or air-assist for smokeless flaring
- Auxiliary equipment includes: smoke-suppression control and monitors (for monitoring flow and gas composition)

Table 2 sets basic operational conditions (performance specifications) and physical components that shall be considered for the flaring units.

Table 2

Requirement Type	Requirement	Specification
Operational / Performance	Combustion temperature	minimum of 1000°C
	Residence time	0.3 to 0.5 s
Physical requirement	Automatic pilot restart system	Ensures continuous operation
	Failure alarm with an automatic isolation system	Isolates the flare from the landfill gas supply line, shuts off the blower and notifies the shutdown
	Automatically controlled combustion air louvers	Control the amount of combustion air and the flame temperature
	Source test ports with adequate and safe access	Monitor the combustion process and air emissions sampling
	View ports	Should be available in sufficient numbers to allow visual inspection of the temperature sensor location within the flare
	Heat shield	Placed around the top of the flare shroud and used during source testing

Source: SCS Engineers, 1989; Environment Agency, 2010

Annex 3

Legal Framework

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**MoE Environmental Guidelines and Requirements for the Design and
Operation of Sanitary Landfills**
(Refer to Annex 4)

Environmental Guidelines for Operation of Sanitary Landfills
(Refer to Annex 5)

1 Legal Framework

This Appendix provides a synthesis of the legal framework related to solid waste management in Lebanon. Relevant policies, regulations, and standards are also outlined.

1.1 Overview on Legal Framework

To date, there is no final legislative framework that directly deals with solid waste management in Lebanon. While the government often relies on indirectly related legislation such as public health acts or anti-litter decrees and the Environment Code Law No. 444 (2002), enforcement of these laws is relatively weak and responsibilities are not well-defined (Table 1 below). Generally, the regulations lack clarity and precision, while coordination between authorities is minimal and enforcement is practically non-existent due mostly to staffing constraints, lack of proper training, low percentages of penalties and fines, and political interferences. Equally important is the lack of awareness of existing regulations amongst personnel who are responsible for enforcing them such as public health inspectors and police officers. In short, the lack of a solid waste legislation constitutes a major obstacle to implement a proper MSW management system in Lebanon.

In year 2005, the Ministry of Environment (MoE) prepared a Draft Law on Integrated Solid Waste Management (ISWM), as part of the Regional Solid Waste Management Project (RSWMP) funded by the EU in the Mashreq and Maghreb countries. The RSWMP was implemented through the Mediterranean Technical Assistance Program (METAP) and managed by the World Bank.

The Draft Law text places a premium on waste “prevention and reduction” in addition to “material reuse, recovery and power generation” and embraces private sector participation in the delivery of SWM services. The main objectives outlined in the Draft Law include:

- Setting the general framework for cost recovery systems,
- Need for preparing and issuing applicable decrees for the Draft Law related to financing and cost recovery systems, and
- Need for strengthening the financial capabilities of the municipalities to accommodate for their responsibilities pertaining to waste collection and treatment, monitoring, and awareness.

The Draft law on ISWM was presented to the Council of Ministers (CoM) in October 2005 and presently awaits the enactment and approval by the Parliament.

Table 1 below outlines and summarizes a list of selected legislations related to the solid waste management sector in Lebanon.

Table 1

Legislation	Date	Official Gazette	Brief description
Decree 2775	1928		<ul style="list-style-type: none"> • Prohibiting the dumping of pollutants into public watercourses.
Decree 7975	5/5/1931		<ul style="list-style-type: none"> • Household sanitization. • Waste should not be dumped around houses, but be buried or removed by the municipality.
Decree 21	22/7/1932	8/8/1932	<ul style="list-style-type: none"> • Classification of establishments that are dangerous or may pose public health problems or cause nuisance. • Definition of associated penalties and fines (penalties and fines updated later).
Decree 2761	19/12/1933		<ul style="list-style-type: none"> • Regulations for disposal of sewage and dirty substances. • Listing of the penalties involved in illegal disposal of municipal and industrial wastes.
Decree 340	01/03/1943		<ul style="list-style-type: none"> • Law on Sanctions and Penalties.
Decree 8377	30/12/1961		<ul style="list-style-type: none"> • Organization of the Ministry of Public Health.
Decision 425/1	8/9/1971		<ul style="list-style-type: none"> • Garbage must be placed in plastic bags for disposal. • Waste must not be dumped on the street or other public places. • Municipalities are responsible for the collection of waste.

Legislation	Date	Official Gazette	Brief description
Decree 8735	23/8/1974	Issue 72 dated 9/9/1974	<ul style="list-style-type: none"> • Preservation of public cleanliness. • Municipalities are responsible for collection and disposal of domestic wastes. • Household and Construction wastes may not be dumped in public places or private land adjacent to roads and residential districts. • It is an offense to drop litter in streets, government buildings, and public areas. • Only tightly closed containers should be used for the storage of refuse. Municipalities may not pile waste on the roadside before it is collected. • Wastes should not be transported in open vehicles, but in vehicles that are tightly covered. • Disposal sites must have the approval of the Health Council of the Mohafaza.
Decree 118	30/06/1977		<ul style="list-style-type: none"> • Law of Municipalities.
Decree 1917	06/04/1979		<ul style="list-style-type: none"> • Specifications on the distribution of assets and the rules of the Independent Municipal Fund finances that has been modified as per Decree No 1783 (10/10/1991).
Decree 11	1978		<ul style="list-style-type: none"> • No insecticide may be imported into Lebanon if it is banned for use in the country of origin.
Law 64	12/8/1988		<ul style="list-style-type: none"> • Preservation of the environment against pollution from hazardous waste and toxic substances • It is the duty of every person to preserve the safety of the environment from pollution. • A list of hazardous waste materials was published (based on English Law). • Import or possession of radioactive or poisonous wastes was prohibited. In extreme cases the death penalty could be applied.
Decision 1292	6/11/1993	Issue 47 dated 25/11/1993	<ul style="list-style-type: none"> • Ministry of Municipal and Rural Affairs (MoMRA) decision related for the organization of construction and demolition waste within the city of Beirut.

Legislation	Date	Official Gazette	Brief description
Law 197	18/2/1993	Annex to Issue 7 18/2/1993	<ul style="list-style-type: none"> • Creation of the Ministry of Municipal and Rural Affairs (MoMRA). • The MoE is responsible of the development of the municipal sector in areas such as strategic planning, budgeting, and programming, as well as auditing the functions of the various municipalities in Lebanon. • Law 247 of 9/8/2000 (Issue 35 dated 14/8/93) cancels the MoMRA and merges its departments into the Ministry of Interior, thus creating the Ministry of Interior and Municipalities (MoIM).
Law 387	4/11/1994	Issue 45 dated 10/11/1994	<ul style="list-style-type: none"> • Ratification of Basel Convention for the Transport of Hazardous Waste by Lebanon.
Law 359	1/7/1994	Issue 32 dated 11/8/1994	<ul style="list-style-type: none"> • Ratification of the Climate Change Convention by Lebanon (this means that greenhouse gas emissions should be reduced; i.e. methane and carbon dioxide in the case of solid waste landfills).
Decree 4917	24/3/1994	Annex to Issue 13 31/3/1994	<ul style="list-style-type: none"> • Amendment of Table 1 (Item 204) in Decree 21 dated 22/7/1932, Classification of establishments that are dangerous or may be public health issue or cause nuisance.
Law 501	6/6/1996	Issue 24 dated 17/6/1996	<ul style="list-style-type: none"> • Establishes an agreement to accept a loan from the World Bank to implement a Solid Waste Environmental Management Project (SWEMP) in Lebanon. • Components of the project include establishing sanitary landfills nationwide and institutional capacity building for the government relating to solid waste management.
Decision 52/1	29/6/1996	Issue 45 dated 12/9/21996	<ul style="list-style-type: none"> • Revised standards for water, air and soil pollution (partly updated in Decision 8/1 dated 30/1/2001).
Law 667	29/12/1997	Issue 59 dated 30/12/1996	<ul style="list-style-type: none"> • Creation of Ministry of Environment (MoE). • Amendment of Law 216 (dated 8/4/1993).
Decision 71/1	19/5/1997	Issue 28 dated 7/6/1997	<ul style="list-style-type: none"> • Amendment of Decision 22 /1 of 17/12/1996. • Regulates the import of waste and defines associated penalties.

Legislation	Date	Official Gazette	Brief description
Council of Ministers (CoM) Decision 58	2/1/1997	In effect since 1997	<ul style="list-style-type: none"> Provides a framework for SWM in Beirut and most of Mount Lebanon (Kesrouan, Metn, Baabda, Aley, and Chouf) excluding the Caza of Jbeil.
Law 247	9/8/2000	Issue 35 dated 14/8/2000	<ul style="list-style-type: none"> Annuls the MoMRA and merges its departments into the Ministry of Interior thus, creating the Ministry of Interior and Municipalities (MoIM).
MoE Decision 4/1	12/01/2001	NA	<ul style="list-style-type: none"> Setting environmental guidelines to authorize the establishment and/or operation of slaughterhouses.
MoE Decision 8/1	30/1/2001		<ul style="list-style-type: none"> Amendment to part of MoE Decision 52/1 dated 29/6/1996. Revised standards for air stack emissions, liquid effluents, and wastewater treatment plants (National Standards for Environmental Quality - NSEQ).
Decree 8006	21/6/2002	Issue 36 dated 21/6/2002	<ul style="list-style-type: none"> Definition of waste categories generated by medical establishments and treatment and disposal options.
Decree 9093	15/11/2002	Issue 63 dated 21/11/2002	<ul style="list-style-type: none"> Amendment of Decree 1917 dated 6/4/1979. States that any municipality that constructs a sanitary landfill or a waste treatment facility on its lands will get 5 times its allotted share of municipal funds from the Independent Municipal Fund, and if this municipality accepts wastes from 10 other municipalities its share will be 10 fold its allotted share.

Legislation	Date	Official Gazette	Brief description
Law 444	29/7/2002	Issue 44 dated 8/9/2002	<p>Environment Protection Law (7 parts, 68 articles) outlining the:</p> <ul style="list-style-type: none"> • Fundamental principles and public rules, • Organization of environmental protection, • Environmental information system and participation in the management and protection of the environment, • Environmental Impact Assessment, • Protection of environmental media, • Responsibilities and fines, and • Other regulations (miscellaneous, institutional).
Draft Decree	2003		<ul style="list-style-type: none"> • Management of industrial and hazardous waste Decree. • The Decree pertains to the classification of industrial and hazardous waste. • MoE is responsible for enforcement and monitoring. • Identification, handling, storage, transport, treatment, disposal, record keeping procedures are addressed. • MoE is responsible for plans and strategies, enforcement and monitoring. • Producer is responsible for waste treatment/disposal. • Sanctions placed in cases of violations.
Draft Decree	2003		<ul style="list-style-type: none"> • Permitting institutions managing industrial and hazardous waste. • MoE grants permits. • Procedures for requesting permits for transport, storage, treatment and disposal of industrial and hazardous waste are addressed. • MoE is responsible for enforcement and monitoring. • Sanctions placed in cases of violation. • Provides guidelines for disposal operations. • Provides guidelines for industrial and hazardous waste landfill sites.

Legislation	Date	Official Gazette	Brief description
Decree 13389	18/09/2004		<ul style="list-style-type: none"> Amends Decree No 8006 (dated 11/06/2002). Identifies the types of healthcare waste and disposal methods.
Draft Law	2005		<ul style="list-style-type: none"> Reducing the quantity of waste for landfilling to the highest extent possible. Assisting in the management of solid waste and the promotion of recycling and composting. Specifying the institutional framework for solid waste management.
Law 690	2005	26/08/2005	<ul style="list-style-type: none"> Sets the jurisdiction, role, and organization of the MoE.
Decree 2275	2009	15/06/2009	<ul style="list-style-type: none"> Organization of the services and departments of the MoE. Specifies the role of each service / department and the enrollment conditions.
CoM Decree 2366	20/06/2009		<ul style="list-style-type: none"> Council of Ministers approved the National Physical Master Plan for the Lebanese Territory (NPMPLT) for Lebanon which describes the physical realities affecting land use, future challenges, alternative configurations for land use and development, land use principles and sectorial action plans (Chapter 6, State and Trends of the Lebanese Environment). The NPMPLT proposes a unified set of land use categories covering the entire territory, and delineated several protection zones of ecological significance. The categories are as follows: U: Urban, R: Rural, A: Agricultural, N1: Natural/Peaks, N2: Natural/Cedars, N3: Natural/Corridor P: View area of natural sites, S1: 500 radius around classified sites, S2: 500 radius around special natural sites, F: Prone to flooding, G: Prone to landslides and rock fall-down, W: Prone to undergroundwater pollution.

Legislation	Date	Official Gazette	Brief description
Council of Ministers (CoM) Decision 55	01/09/2010	NA	<ul style="list-style-type: none"> • Consider the National Municipal Solid Waste Management Plan for Lebanon in 2006. • Establish Waste-to-Energy plants in large cities. • Enact legislations through the Ministry of Energy and Water to allow the production and selling of power produced at the Waste-to-Energy plants. • Include private sector participation (PSP) in the solid waste management across Lebanon through a Turn- key contract (collection and treatment including landfilling) or 2 different operations (collection and treatment). • Implementation of incentives to municipalities where solid waste treatment facilities are to be located.
Ministry of Environment Decree No 8633	2012	16/08/2012	<ul style="list-style-type: none"> • Sets the procedures and principles for the preparation of an Environmental Impact Assessment (EIA) study. • Categorizes establishments and projects according to the needed environmental assessment studies (Environmental Impact Assessment, Initial Environmental Examinations, etc.).

Legislation	Date	Official Gazette	Brief description
Council of Ministers (CoM) Decision 46	30/10/2014	NA	<ul style="list-style-type: none"> • CDR to prepare TOR for an open tender to contract sweeping and collecting solid waste within Beirut, most of Mount Lebanon and North Lebanon governorates. • CDR to prepare TOR for a tender to contract solid waste management services that include separation, composting, energy recovery, and landfilling of non-organic waste in Beirut, most of Mount Lebanon and North Lebanon governorates. • Service Lots divided as follows: <u>Beirut Mohafaza and Most of Mount Lebanon Mohafaza</u> <ul style="list-style-type: none"> - Chouf Caza, Aaley Caza, and Part of Baabda Caza - Most of Southern Suburbs of Beirut - Beirut City and Part of Baabda Caza - Metn Caza and Kesrouan Caza <u>North Lebanon Mohafaza</u> <ul style="list-style-type: none"> - North Lebanon Mohafaza • Decisions defining the roadmap for an Integrated Solid Waste Management Plan including: <ul style="list-style-type: none"> - OMSAR in coordination with MoE to continue with the management of MSW sorting and co posting facilities that have been already established and to establish new integrated solid waste management facilities through donations funded by the European Union to OMSAR. - Assign the CDR to request from the international consultant RAMBOLL to proceed with Phase 2 of its contract, which involves the preparation of the tender documents for a MSW incinerator, that are to be adopted by the cabinet. - Assign MoE to several tasks including: initiate awareness source separation and decentralized solid waste management; Prepare a Strategic Environmental Assessment for a draft long-term solid waste management strategy; Prepare a health risk assessment of the Naameh Landfill and the Tripoli Controlled Dumpsite; Prepare a long-term program for environmental monitoring after the closure of Naameh Landfill and the Tripoli Controlled Dumpsite. <p><u>This CoM Decision (46, 2014) has been amended by the CoM Decision 1, 2015.</u></p>

Legislation	Date	Official Gazette	Brief description
Council of Ministers (CoM) Decision 1	12/01/2015	NA	<ul style="list-style-type: none"> • Amendment of CoM Decision 46 (30/10/2014). • Some of the main articles/issues addressed in the Decision: <ul style="list-style-type: none"> - 60% waste recovery from the sorting, recycling, composting and energy recovery during the first three (3) years of contract, and 75% in the following years up to thermal treatment (including Refuse-derived Fuel RDF or incineration or others). - Disposal of MSW refuse through the rehabilitation of degraded sites (quarries) and/or other uncontrolled dumpsites or other sites that might require rehabilitation to be defined by the CoM based on the MoE recommendations, on the basis of having at least one (1) sanitary landfill within each Service Area/Lot (proposed landfill site/s for Service Lot 1 shall be located outside the boundaries of this Lot). - Assign the CDR to request from the international consultant RAMBOLL to proceed with Phase 2 of its contract, which involves the preparation of the tender documents for a MSW incinerator, to be completed within 6 months at most and subsequently, to be discussed by the cabinet. - Request the CDR to temporarily resume operations as per the current MSW Plan no longer than 3 months that may be extended for one last time, 3 additional months. • Service Lots divided as follows: <ul style="list-style-type: none"> - Beirut City and Northern and Southern Suburbs - Metn Caza, Kesrouan Caza, and Jbeil Caza - Chouf Caza, Aaley Caza, and Part of Baabda Caza - North Lebanon Mohafaza and Aakkar Mohafaza - South Lebanon Mohafaza and Nabatieh Mohafaza - Bekaa Mohafaza and Baalbeck – Hermel Mohafaza

Legislation	Date	Official Gazette	Brief description
Council of Ministers (CoM) Decision 1	09/09/2015	NA	<p>Some of the Decision's main clauses include:</p> <ul style="list-style-type: none"> • Adopt the principle of treatment decentralization and offer the municipalities and union of municipalities a role in upholding the responsibility of the MSW management, as part of the MSW Treatment Plan. • Adopt two sanitary landfills to be set up and made operational in accordance with environmental standards in the area of Srar in Akkar and Masnaa area in the Anti-Lebanon Mountains, and the use of Saida waste treatment plant to receive part of the solid waste during the interim period. • CDR to prepare the necessary studies with the Ministry of Environment to rehabilitate the Ras El Ain dumpsite. • Notify the current operator for the Beirut and Mount Lebanon service area of the non-renewal of the treatment and landfilling contracts, and the non-renewal of the supervision contract on the treatment and landfilling works. • CDR to extend the sweeping, collection and transportation contract with the current operator for a period that does not exceed 18 months from the date the Council of Ministers accedes the extension.

Legislation	Date	Official Gazette	Brief description
Council of Ministers (CoM) Decision 1	21/12/2015	NA	<p>Some of the Decision's main clauses include:</p> <ul style="list-style-type: none"> • For a transitional phase, CDR charged to handle the waste export process according to relevant local laws and international treaties. • Provisional approval for signing a service agreement with Chinook Urban Mining International and HOWA BV to export the wastes. • Contracting with a consulting firm to supervise the export works after approval of the Council of Ministers. • Negotiating with Chinook Urban Mining International to operate the sorting and treatment facilities within Beirut area and part of Mount Lebanon during the contract period (18 months). • Current operator and supervisor to continue carrying on sorting and treatment operations until reaching an agreement with Chinook Urban Mining International for the operation of existing treatment facilities. • Confirmation of Decision 46 (30/10/2014) to prepare a tender document for sweeping and collection after the expiry of contracts with Chinook Urban Mining International and HOWA BV. • Confirmation of Decision 55 (01/09/2010) to adopt Waste-to-Energy and commission CDR to prepare the necessary tender document to be completed within 2 months from the date of CoMDecision.
Legislation	Date	Official Gazette	Brief description

Council of Ministers (CoM) Decision 1	17/03/2016	NA	<p>Some of the Decision's main clauses include:</p> <ul style="list-style-type: none"> • Amendment of CoM Decision 1 (12/03/2016). • The establishment of a temporary sanitary landfill in Bourj Hammoud, Jdeideh - Al Bouchriyah - Al Sadd, a temporary sanitary landfill and a treatment facility in the proximity of Al Ghadir river outlet, the removal of Bourj Hammoud dumpsite and the demolition wastes near Al Ghadir river outlet. The daily quantity of waste to landfill in Bourj Hammoud and Jdeideh - Al Bouchriyah - Al Sadd center should not exceed 1,200 tons. • Treatment and disposal centers in Bourj Hammoud and Jdeideh - Al Bouchriyah - Al Sadd should not be established after 4 years. • Re-opening of Nehmeh landfill for only 2 months before its final closure equally dispense the deducted percentage from the Independent Municipal Fund to the municipalities of Nehmeh, Aabey, Ain Drafil, Baawerta and Aramoun. • Establishment and improvement of treatment and sorting centers and sanitary landfills in compliance with scientific and environmental requirements and regulations and in collaboration with concerned municipalities, especially with regard to the control and monitoring of filters, solid waste rejects and continuous electricity provision. • Other clauses related to the securing of funds and other administrative issues.
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2. Environmental Standards

The Ministry of Environment (MoE) has introduced national quality standards for air, water, soil, and noise in the context of Decision No. 52/1 dated July 1996. In addition, Decision No. 8/1 dated March 2001 included emission standards for air emissions and wastewater quality and discharge, presented in the National Standards for Environmental Quality (NSEQ) reference book.

3. MoE Environmental Requirements and Guidelines for the Design and Operation of Sanitary Landfills

The Ministry of Environment has prepared and outlined design requirements and environmental guidelines for the operation for sanitary landfills. MoE Environmental Guidelines are presented hereinafter.

Annex 4

Design Requirements for Sanitary Landfills

Design Requirements for Sanitary Landfills

The Ministry of Environment approves, from the environmental point of view, the design of landfills (defined in article 1) after giving its approval on the relevant environmental impact assessment studies, provided it makes sure that all the corrective measures suggested in the environmental impact assessment studies as well as the design requirements for sanitary landfills (defined in article 2) have been taken into consideration.

Article one

Definition of sanitary land filling and sanitary landfills

1-1 Land filling

It is the eco-friendly means of getting rid of solid domestic waste which cannot be managed in another way and which resulted from the refuses of recycling, composting, burning, and other operations related to solid domestic waste.

Land filling is one of the essential elements in any strategy and plan aiming at achieving an integrated solid domestic waste environmental management.

1-2 Landfills

They are the lands or special land, set areas used to dispose of waste resulted from the refuses of recycling, composting, burning, and other operations related to solid household waste. After designing it and equipping with the suitable technical and engineering devices, these landfills can receive the waste, shrink its volume and cover it with a sand layer regularly without causing any negative impacts on the environment, health, and public safety.

Article two

Landfills design requirements

According to the Ministry of Environment's solid domestic waste management strategy, the design of a sanitary landfill requires that:

- 2-1 The landfill capacity be large enough to receive the volume of the waste resulting from the area population served by the landfill, for thirty years, taking into consideration the following points:
 - 2-1-1 Demographic growth during that period which increases solid domestic waste quantity, in addition to the changes in commercial, industrial, and touristic activity in the area.
 - 2-1-2 Quality of the waste to be land filled resulted from the different stages and elements of the solid domestic waste management plan in the area. (Sorting, composting...)
 - 2-1-3 Quantity of daily-required soil for covering, as well as the final top isolating layer.
 - 2-1-4 Reduction of the different layers of the landfill due to the decomposition and the compression of the landfilled waste caused by the weight of layers above it.
- 2-2 The landfill be designed in a way to ensure the isolation of its floor so the leachate resulting from the decomposition of the waste can be gathered and prevented from leaking to underground and surface water. The landfill floor-isolating liner should be composed of a clay liner, covered by HDPE

- membrane liners, a cushion liner, and a highpermeability layer:
- 2-2-1 Clay liner: many tests must be carried out to determine the permeability of the isolating clay liner, the best moisture level; the-required pressure to compress this layer, and its pitch level, before adopting it in order to ensure a permeability speed less than 10^{-7} /sec. This liner should be placed on compacted bedrock of more of 3-meter thickness.
 - 2-2-2 Membrane liners: they must be compatible with the nature of landfilled waste to prevent lecheate leaking through it. Its effectiveness must not be affected by the chemical characteristics of that lecheate and of the waste quality.
 - 2-2-3 Cushion liner to protect the above mentioned membrane liner.
 - 2-2-4 High permeability layer usually composed of basalt.
- 2-3. The landfill design shall be based on cell system. That way, the work will be done gradually and/or according to the type of the landfilled waste. This is aimed to organize work in the landfill according to the suggested design, to facilitate monitoring of land filling and to calculate the remaining life of the landfill to compare it to the original timetables accordingly any deviation will be subject to corrective measures.
- 2-4 Design a complete management system for the lecheate resulting from waste decomposition and polluted rainwater, entitling collection till treatment, it should include the following equipments:
- 2-4-1 Perforated pipes (with 1% incline) placed on the membrane layers with the suitable incline (2-4%) at their lowest level to ensure the lecheate flowing in the pipes and reaching the collection tanks.
 - 2-4-2 A treatment station designed to treat the lecheate and ensure that the characteristics of water -once treated- comply with the national environment standards.
 - 2-4-3 Underground wells fitted in the landfill area to determine underground water quality prior to operating the landfill, to monitor any landfill leakage towards them, and to ensure that underground water characteristics remain in agreement with the ones set before landfill exploitation. The number, position, and depth of the wells are to be determined according to the landfill's location and geological and hydrogeological nature.
 - 2-4-4 Design a management system of the gases resulting from the decomposition of the organic material present in the waste, entailing the collection recapturement and/or burning of gases avoid any explosions due to the increase of methane concentration beyond the allowed limit, in addition to avoid any damage that this gas causes to the environment. The gas management system shall depends on the following type of equipments and methods:
- 2-5-1 Suitable engineering methods (isolating layers) inside the landfill in a way to prevent gas dispersion into the lands surrounding the landfill.
 - 2-5-2 Perforated pipes that allow the capturing of the gas and conveying it to the landfill rooftop through an exhaust.
 - 2-5-3 A gas burner or a gas collection and purification system
 - 2-5-4 Probes set within the landfill surroundings to monitor gas outflow from the landfill to the surrounding lands.
- 2-6 The final use of the landfill following its closure it be set in addition to the design of its upper layer. This should be done through studying of the landfill location and its original surroundings nature enabling to define the kind of plants that can be planted in it and the kinds of animals which can survive in that area. After that, a final use proposal should be set provided it will be composed of the

following items: isolating layer, agricultural soil layer, rainwater and running water draining system.

- 2-6-1 The isolating layer aims at stopping or reducing rainwater leaking to filled waste. It is composed of two parts:
- Part one: membrane liners placed on the sand layer that covers the last layer of landfilled waste
 - Part two: clay liner, 60 to 100 cm thick, placed above the above mentioned membrane liner.
- 2-6-2 The agricultural soil layer, which is the soil layer, placed on the top of the landfill to make it cultivable. It is composed of two parts:
- A 30-cm thick sand layer placed directly over the above-mentioned clay liner (an additional membrane layer can be placed to separate this layer from the clay liner)
 - Agricultural soil layer, no less than 70-cm thick, whose characteristics are in agreement with the characteristics of the agricultural soil surrounding the landfill.
- 2-6-3 Rainwater drainage system: it relies on providing suitable inclines in the landfill's final upper layer. The inclines allow rainwater to flow into aqueducts built in the lower levels of the inclined layers and to lead it to nearby winter water aqueducts or to special tanks in order to be collected when necessary.
- 2-7 The required infrastructure for the landfill's functioning be designed., such as:
- 2-7-1 Inner roads: their width, incline.... in a way suiting the used trucks and the expected work rate.
- 2-7-2 Rainwater and water draining networks.
- 2-7-3 Lecheate treatment plant
- 2-7-4 Balance for trucks: suiting the type of trucks used or might be used. 2-7-5 Building(s) of the management, guards, restrooms, and other...
- 8-2 The surrounding of the real estate shall be tree-planted as well as the roads leading to and from the landfill.

Article three

The Ministry of Environment studies the complete submitted during a 15- working day period and informs the side responsible for the file about its notes in order that they can be modified it as required before construction of the landfill takes place.

Article Four:

The party responsible for the establishment of the landfill pledges not to adopt any major change in the design approved by the Ministry of Environment, before getting new approval.

Article Five:

The Ministry of Environment reserves its right to perform regular monitoring throughout the establishment of the landfill and to ask for the modifications that it deems necessary to safeguard the environment and preserve natural resources.

Annex 5

Environmental Guidelines for Operation of Sanitary Landfills

Environmental Guidelines for the Operation of Sanitary Landfills

The Ministry of Environment approves, from the environmental point of view, the establishment and operation of sanitary landfills (defined in article 1) in view of safeguarding the environment, preserving natural resources and limiting the impact of pollutants generated by those landfills (defined in article 2), through the implementation of certain environmental guidelines (detailed in article 3).

Article one

Definition of land filling and landfills

1-1 Landfilling

It is the eco-friendly means of getting rid of solid domestic waste which cannot be managed in another way and which resulted from the refuses of recycling, composting, burning, and other operations related to solid domestic waste.

Landfilling is one of the essential elements in any strategy and plan aiming at achieving an integrated solid domestic waste environmental management.

1-2 Landfills

They are the lands or special land, set areas used to dispose of waste resulted from the refuses of recycling, composting, burning, and other operations related to solid household waste. After designing and equipping it with the suitable technical and engineering devices, these landfills can receive the waste, shrink its volume and cover it with a sand layer regularly without causing any negative impacts on the environment, health, and public safety.

Article two

Definition of general pollutants resulting from the operation of sanitary landfills

The operation of sanitary landfills produces the following waste:

- 2-1 Liquid waste. It is the leachate resulting from the degradation of landfilled solid domestic waste itself, in addition to polluted rainwater due to its mixing with landfilled solid waste. The liquid waste contains dissolved organic materials, suspended solid materials, and characterized by high biological and chemical demand for oxygen, and a variation in the Ph.
It comes also from oil and greases resulting from machines, equipments, and power generators maintenance.
- 2-2 Solid waste, basically waste which is not allowed to be landfilled (i.e. hazardous waste)
- 2-3 Air pollution: a mix of gases resulting from the decomposition of the organic material in waste in anaerobic conditions. This mixture mainly contains methane and carbon dioxide.
In addition, dust is produced from the daily covers used in the landfill as well as combustion gases from machines, equipments, and power generators used.
- 2-4 Noise pollution. It results from the machines and equipments used in the landfill and liquid waste treatment plant, and from power generators and truck movement from and to landfill site.

Article three

Required general environmental guidelines in operating sanitary landfills

3-1 Water management

- 3-1-1 Rationalizing water usage to maintain the sustainability of water resources.

3-2 Liquid waste management

- 3-2-1 Ensure no liquid waste leakage into nature and surface and underground waterways.
- 3-2-2 Providing a closed and independent tank to drain liquid waste resulting from the -landfill and handle it in a way that guarantees that its characteristics- once treated- comply with the national environmental standards.
- 3-2-3 Draining treated water into the sea or surface water, the flow of which is no less than 0.1 m³/sec according the national environmental standards. When impossible, supply the Ministry of the Environment with a document that sets the water-disposal method in order to discuss it and get approval for it before applying it.
- 3-2-4 Construct underground wells in the landfill area to determine underground water quality prior to operating the landfill, to monitor any landfill leakage towards them, and to ensure that underground water characteristics remain in agreement with the ones set before landfill exploitation.
- 3-2-5 Running regular tests on samples taken from treated liquid waste and from surface and underground water, as follows:
- After treating liquid waste: **test frequency:** every three months.
Indications that should be monitored: the biological and chemical demand for oxygen, **PH**, dissolved material, suspended solid material.
 - Surface and underground water: **test frequency:** every 6 months.
Indications that should be monitored: the biological and chemical demand for oxygen, **PH**, suspended solid material.
- 3-2-6 Keeping clear records showing test results of the different samples of liquid waste before and after treatment, and of underground and surface water.
- 3-2-7 Providing the Ministry of Environment with regular tests of different sample results to monitor the extent of the compliance of its characteristics with national environmental standards.
- 3-2-8 Taking all suitable corrective measures when any error in the tests mentioned in paragraph 3-2-5 appears after taking the approval of the Ministry of Environment.
- 3-2-9 Collecting greases and oil resulting from the maintenance of used power generators, machines and equipments in closed special containers in preparation for its delivery to the recycling sites.

3-3 Solid waste management

- 3-3-1 Receiving solid domestic waste in well-packed bails and 111 closed containers to prevent waste falling and dispersing.
- 3-3-2 Monitoring a representative number of packed solid waste before land filling it in order to check that it does not contain unauthorized waste to be land filled .e. hazardous waste)
- 3-3-3 Notifying the Ministry of Environment of any waste unauthorized to be land filled, especially hazardous waste, so that its quality, the responsible sender, and the eco-friendly way to dispose of it can be determined.

3-4 Air pollution management

- 3-4-1 Fitting a management system of the gases resulting from the decomposition of the organic material present in the waste, in order to collect them, recapture them, or burn them using the proper technical methods which guarantee the compliance of its characteristics with national environmental standards.
- 3-4-2 Fitting the landfill with suitable engineering- methods (isolating- layers) in a way to prevent gas leakages in addition to ensure that solid domestic waste are covered with a sand layer of an adequate thickness to prevent the dispersion of gases that cause foul odors.
- 3-4-3 Fitting the landfill with probes to monitor gas leakage from the landfill into nearby lands.
- 3-4-4 Monitoring methane concentration level in the air to ensure of the efficiency of the gas management system mentioned in paragraph 3-2-1.
- 3-4-5 Tree-planting the landfill area with tall forest trees that go with the nature of the area to isolate odors and dusts from the landfill's outer surroundings.
- 3-4-6 Asphaltting the roads leading to the landfill and showering them regularly with water to prevent the spreading of dusts due to the running trucks and vehicles.
- 3-4-7 Placing power generators in closed special rooms and fitting their exhausts with filters that guarantee the compliance of their emission characteristics with national environment standards.
- 3-4-8 Maintaining trucks and vehicles engines regularly to ensure efficient combustion of fuel.
- 3-4-9 Compliance of air pollutant characteristics with national environment standards.

3-5 Noise pollution management

- 3-5-1 Fitting machines that are considered noise polluting with mufflers and placing them in soundproof rooms as well as maintaining them constantly.
- 3-5-2 Fitting the power generator with a muffler that guarantees the compliance of the resulting noise level characteristics with national environmental standards.

3-6 Other general conditions:

- 3-6-1 Ensure the appropriate quantities of soil used in the daily coverage process, in a way to guarantee the isolation of the waste layer and its compliance with the design requirements;
- 3-6-2 Provide workers and technicians with the proper personal protection equipment (masks,

special clothes, proper shoes);

3-6-3 Prohibit smoking and put warning signs against it;

3-6-4 Applying sound environmental practices continuously;

Article Four:

The Ministry of Environment specifies the final required environmental guidelines for the operation of landfills based on the location of each site, the adopted processing stages and the produced pollutants (through modification of certain conditions stated in article 3).

Article Five:

The Ministry of Environment reserves its right to impose additional environmental guidelines when needed and to perform regular monitoring to verify the continuous implementation of the required environmental guidelines.