REPUBLIC OF LEBANON

MINISTRY OF ENERGY AND WATER

COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION

PROJECT No

CONTRACT No

EL MINA REMAINING COASTAL SEWER COLLECTORS

VOLUME 4

PARTICULAR SPECIFICATIONS

Part 1 - General Requirements
Part 2 - Civil Works

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BUREAU TECHNIQUE POUR LE DEVELOPPEMENT (B.T.D.)
P.O.Box : 70-492 Antélias
Tel : 04/712157-712158
Fax: 04/712159
Email: : btd@btd-lb.com

MINISTRY OF ENERGY AND WATER

COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION

PART 1

GENERAL REQUIREMENTS

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PART 1

101. GENERAL REQUIREMENTS

101.1 APPLICATION OF PARTICULAR SPECIFICATION

This Particular Specification is to be read and construed together with the General Specification contained in Volume 3 of the Contract Documents for this Tender. In case of ambiguities or discrepancies between this Particular Specification and the General Specification, the Particular Specification shall prevail, except if and to the extent otherwise provided by the Contract or directed by the Engineer.

Whenever the term "Specification" without further qualification is used in the Contract Documents, it shall mean the General Specification together with the Particular Specification.

In addition, all the road works, which shall be executed by the Contractor, should be in compliance with the Decree No. 13495/98 and the Administrative Memorandum No. 21/F dated 1/3/2010, copy attached in Annex 1.

101.2 LOCATION OF WORKS

The Works cover the construction of El Mina Remaining Coastal Sewer Collectors: Line A & Line B (Line B1 and Line B2).

101.3 THE SITE

For work along pipelines within public roads and tracks, the limits of the Site (Conditions of Contract Sub-Clause 1.1) shall be the limits of land in public ownership which shall be taken to be any boundary fence or wall or if there is no such clearly identified boundary the width shall be taken as one meter beyond the edge of the carriageway.

For work along pipelines within private land or open country the Site shall comprise an easement width conforming to the relevant land acquisition documents.

For work in pumping stations sites within private land the site shall comprise an area and access conforming to the relevant land acquisition documents.

In some areas the width of the Site will be physically restricted by physical boundaries such as boundary wall or by natural topographic features. The Contractor shall have inspected the Site (Conditions of Contract Sub-Clause 1.1) and shall have included for the provision of any additional working area that he may require outside the limits of the Site (Conditions of Contract Sub-Clause 58.2).

101.4 SCOPE OF WORK

The works covered by this contract are divided into two parts: a compulsory part and an optional part. The works covered by each part include but not limited to the construction of several wastewater lines in El Mina area, namely:

Part 1 – Compulsory Part

- Supply and laying of 1.87 km of gravity wastewater lines diameter 500mm, 600mm, 800mm and 1000 mm.

Part 2 – Optional Part

- Supply and laying of 0.82 km of gravity wastewater lines diameter 500mm, and 800mm.

The objective of El Mina coastal sewer collectors project is to install wastewater conveyors along El Mina sea front Boulevard, with the goal of preventing the discharge of wastewater into the sea. The project aims to collect wastewater from El Mina area and transport it to the Tripoli WWTP via a connection to the existing micro-tunnel at shaft H17.

It has to be noted that these conveyors will be installed below the seawater level with invert levels varying from -0.71 m to -5.12 m, necessitating dewatering works.

To assess the flow for dewatering purposes, we requested from "ACTS" (Advanced Construction Technology Services) for carrying out the ground investigation works (attached El Main Coastal Wastewater Project Dewatering Design Report). This report and its Annexes is considered part of the Particular Specifications of this Project.

Refer to **Annex 2 – Dewatering Design Report**.

101.5 CONDITIONS PREVAILING AT SITE OF WORKS

The Contractor's attention is drawn to his obligation to satisfy himself, before submitting his Tender, as to the conditions prevailing at the Site of Works and its surroundings (Clause 11 of Conditions of Contract) and relevant sections of the General Specification for Civil Engineering Works.

101.6 PRIVATE LANDS

The Contractor shall not enter upon or occupy with men, tools, or materials of any nature, any lands other than the working areas shown on the Drawings, except after consent shall have been received by him from the proper parties and a certified copy of such consent shall have been furnished to the Engineer. Any rentals or damages paid for occupying private lands shall be at the Contractor's expense.

101.7 EXISTING SERVICES

In the course of works, the Contractor will encounter within the limits of the working areas and in the vicinity, miscellaneous above ground and underground services such as drains, pipes, cables, telephone and electric poles and lines, water supply and similar existing services. The Contractor's attention is directed to the provision of Clause 101.12.4 of the General Specification with regard to such existing services.

101.8 ACCESS ROADS

The necessity of construction Access Roads and/or temporary roads (other than the specified road in the contract) may arise, in which case such temporary roads shall be subject to the provisions of Clause 101.12.3 of the General Specification for Civil Engineering Works and shall be executed at the contractor responsibility and expenses in coordination with the concerned Authorities and according to the Engineer requirements.

101.9 PROGRAM AND MONITORING

It is a primary requirement of the Employer that a comprehensive knowledge of the status of progress to date, predicted progress, costs and cash flow forecasts is available at all times. The Contractor shall be responsible of the requisite information and shall be responsible for programming the Works, preparation of cash flow estimates and measuring and reporting the progress of the works in an approved format. In order that programming, progress measurements and reporting is executed in a timely and efficient manner, the Contractor shall program the Works, monitor progress and generate cost reports and cash flow projections by utilizing a recognized industry standard approved P.C. based Project Management software package.

The Contractor's master program and cash flow estimates and subsequent updates, submitted in accordance with Clause 14 of Conditions of Contract shall, as a minimum, detail the sequence of procurement, installing, testing and commissioning, and handing over for each of the works items including each item described in the Bill of Quantities.

At least 21 days prior to taking possession of any portion of the Site and starting of work, the Contractor shall submit a detailed construction program for that portion of the Site. The detailed construction program shall be to a level to adequately identify the intended sequence of working on each individual item of work. The minimum level of detail shall not be less than that needed to identify each individual payment item included in the Bill of Quantities.

The Engineer's obligation to measure the Works in accordance with Sub-Clause 56.1 of the Conditions of Contract shall be dependent on the Work being programmed and progress being monitored and reported in accordance with the requirements of the Contract.

101.10 LIST OF ABBREVIATIONS

In the Contract Documents, the following abbreviations have been employed :

uPVC	- Unplasticized Polyvinyl Chloride
D.I.	- Ductile Iron
R.C.	- Reinforced Concrete
C.I.	- Cast Iron
G.S.	- General Specification
C.O.C.	- Conditions of Contract
B.O.Q.	- Bill of Quantity
ID	- Inner Diameter
OD	- Outer Diameter

101.11 OR EQUAL CLAUSE

Wherever reference to Standard Specifications, such as British Standards are made they shall not be construed to restrict materials to British products. Materials from other scheduled

countries will be considered provided that the producer of the material certifies its conformity to the appropriate Standard Specification.

Similarly whenever a material or article required is specified or shown in the plans by using the name of the proprietary product or of a particular manufacturer or vendor; any material or article which will perform adequately the duties imposed by the general design will be considered equal and satisfactory provided the material or article so proposed is of equal substance and function in the Engineer's opinion. It shall not be purchased or installed without his written approval.

101.12 GOVERNMENT REGULATIONS

The Contractor shall comply with all provisions of the rules, regulations and orders of Government and Municipal agencies, such as the Public Works Department, Electricity of LEBANON, and Telecommunications Authority.

The Contractor shall co-operate with the Employer in promptly furnishing any information that may be required by such governmental agencies. It shall be the obligation of the Contractor to keep himself informed of these governmental rules, regulations, and orders and the Contractor shall make the requirements of this article a part of any sub-contract he may enter into.

101.13 FACILITIES FOR THE ENGINEER'S REPRESENTATIVE

The Contractor shall provide any necessary protective clothing and safety equipment for the use of authorized visitors to the site including the Employer and his staff and Representatives and those of any relevant authority who have reason to visit the site.

101.14 ACCESS TO WORK

The Engineer and his duly appointed representatives and the Employer or his representatives or agents may at any time and for any purpose whatsoever enter into and upon the work and the premises used by the Contractor. The Contractor shall provide free, proper, and safe facilities therefore.

101.15 SURVEY AND SETTING OUT

All levels used for construction shall be referred to the National Height Datum.
The Contractor shall be responsible for obtaining the location and values of the permanent bench Marks. In cases where such bench Marks do not exist, a site datum shall be agreed with the Engineer.

Prior to the commencement of the work the Engineer shall approve all plans showing benchmarks, limits of plot and auxiliary baselines. The Contractor, under the supervision of the Engineer, shall set out on-site and erect appropriate permanent markers where instructed by the Engineer.

The Contractor shall employ an experienced licensed Surveyor for the duration of the Contract. He shall furnish the Engineer with a duly signed map showing the various centerlines, baselines, reference points permitting the renewal of markers and boundaries of parcels and blocks, if destroyed. Before starting and during earthwork on the site, the Contractor shall set out a net of square coordinates at distances not exceeding 10 m in each direction. A peg shall be driven at

each intersection and at other relevant points and levels of peg tops and of ground at the same spot shall be measured.

The levels of the ground and the levels and dimensions of existing features shown on the Drawings are not guaranteed to be correct.

Wherever dimensions or levels are marked on the Drawings such dimensions or levels shall take precedence over dimensions scaled from the Drawings. Where no dimensions or levels are shown on the Drawings, instructions shall be obtained from the Engineer. Large scale drawings shall be taken in preference to drawings of smaller scale.

101.16 NOTICE BOARDS

The Contractor shall provide and erect sign boards at the sites where works are being executed, giving information to the public on the Project and the Employer and further details as will be prescribed by the Employer. The location, dimension and number of the sfign boards at the sites will be indicated by the Engineer. The Contractor shall maintain, alter, move and adapt the sign boards from time to time as instructed by the Engineer. The display of any named Subcontractors or any other information associated with the Works shall be to the approval of the Engineer.

101.17 MANUFACTURE'S CERTIFICATES

The Contractor shall furnish the Engineer with a manufactures certificate confirming compliance to the specification in respect of all items of equipment.

The original and one copy of the manufacturer's certificate shall be delivered to the Engineer not later than 14 days prior to the intended date of delivery of the Item to site.

101.18 PRECAUTIONS AGAINST CONTAMINATION OF THE ENVIRONMENT

The Contractor shall at all times take every possible precaution against contamination of the environment. The site and all permanent and temporary works shall be kept in a clean condition. The Contractor shall at all times take measures to avoid contamination of the existing water courses and drains by petrol, oil or other harmful materials.

101.19 ACCESS TO PROPERTIES

The Contractor shall not disrupt any private or public access way without first providing alternative arrangements.

101.20 TOPOGRAPHIC SURVEY

Where the Contractor get the approval of the Engineer to execute topographical survey, mapping shall be at 1:200 with contour lines at an interval of 1 metre. A ground profile along the centerline of the pipe route shall be provided and shall be at the same scale of the construction drawings relatives to the contract.

The extent of mapping shall be the width of roads or dual carriage ways up to the property lines on either side of the public land, or one metre from the edge of road which ever is nearer to the road centerline.

In open areas and along water courses the mapping corridor shall be 20 metres. The mapping shall be supplied on film plotted from digital data.

All control points, and heights shall be related to the National Height Datum in metres. Station Descriptions with distances to reference objects and a list of coordinates and heights shall be submitted to the Engineer.

Permanent bench marks shall be constructed from steel pins, road nails or painted marks on existing stable features. A minimum of two site bench marks shall be established on existing stable features.

All man-made hand detail features, road edges, kerbs, existing manholes, inspection covers, culverts, and underground service pipeline shall be surveyed in their true position and shown by conventional symbols. The detection of the existing services will be paid separately and must be approved by the Engineer.

All surveyor which will subcontract the Contractor for the topographicals works shall be approved by the Engineer and the responsibility still on the Contractor to satisfy the Engineer by the accuracy of the survey.

101.21 DRAWINGS AND DOCUMENTS

All drawing and documents submitted by the Contractor shall have been checked, signed and be ready for issue and shall bear the title of the drawing, the scale, the date, the Contract number and name, the document number complying with an approved numbering system, the name and references of the Contractor, the name of the Employer and the Engineer, the date of approval by the Contractor and the signature of the person responsible for approval.

Unless otherwise specified the Contractor shall allow a minimum of 15 days for approval of drawings and documents by the Engineer.

101.22 MEASUREMENT AND PAYMENT

Unless otherwise provided for in the B.O.Q, all costs incurred in complying with the requirements of this Division 101 shall be deemed to be included by the Contractor in his unit rates in Bill of Quantities and shall not be paid for separately.

PART 2

CIVIL WORKS

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201. CONCRETE WORKS

201.1 GENERAL

201.1.1 Span Life of Concrete Structure

New works are to be designed for a life of 60 years.

201.1.2 Codes and Standards

Complementary or new design shall as far as possible be carried out in compliance with relevant International Standards such as:

- BS Standards.
- ACI and Uniform Building code.
- BAEL 1992
- AFPS 90
  or equivalent standards

201.2 SOIL PARAMETERS

The Contractor shall carry out soil investigations to satisfy himself with the prevailing soil conditions for all sites.

201.3 MATERIALS

201.3.1 Grades of Concrete

The minimum grades of concrete for the various structures are given as follows:

Grade	Component
C30	Reinforced concrete for Reservoirs (400 Kg cement/cu.m)
C25	Reinforced concrete for Buildings and Structures and manholes (350 Kg cement/cu.m)
C20	Mass concrete (250 Kg cement/cu.m)
C20	Blinding concrete (250 Kg cement/cu.m)

Reinforced and mass concrete must be vibrated. Cement used for structures in contact with wastewater and buried surfaces in contact with underground water shall be sulfate resisting Portland cement (BS 4027). Cement for all other structures shall be ordinary or/and rapid hardening Portland cement. (BS 12).

Admixtures and mix design of the different Grades of concrete shall be submitted for approval prior to commencing the work.

201.3.2 Reinforcement

All reinforcing steels shall be Type 2 High Yield Bars and comply with the requirement of BS 8110 and shall have a specified characteristic strength of 420 N/mm^2 (yield strength; fe = 400 MP_2).

Dowel bars and stirrups shall be Mild Steel grade 25, fy = 250 N/mm$^{2.}$ (yield strength; fe = 235 MP$_2$)

Lap lengths shall be 50 diameters. Mechanical bending for $\phi \geq 12$ mm is required.

201.3.3 Minimum Cover of Reinforcement

The concrete cover for all steel bars including stirrups shall not be less than 40 mm in structures where concrete surfaces are in contact with water.

Where concrete surfaces are in contact with soil, the cover of reinforcement shall not be less than 35 mm.

The cover of reinforcement in external surfaces of structures, and all elements of buildings shall not be less than 30 mm.

Formwork for all concrete surfaces in contact with water and/or soil and internal surface (walls and ceilings) of technical rooms shall be of form panels (marine plywood or metallic formwork) in order to obtain a regular and smooth finish.

201.3.4 Classes of Exposure and Crack Width

External and internal walls, columns and beams are to be considered as subject to severe exposure as defined in Sub-Clause 3.3.4 of BS 8110.

The faces of structures in contact with ground shall also be considered as subject to severe exposure.

Concrete surfaces in contact with water are designed for a maximum crack width of 0.2 mm.

201.3.5 Admixtures

Admixtures (retarders, mass waterproofing, silica fume, ...) are to be added to concrete in contact with liquid. Technical sheets and the mix design of concrete shall be submitted for approval.

202. PIPELINES AND PIPEWORK

202.1 TRENCH EXCAVATION

202.1.1 Excavation Works

Excavation for pipelines shall be carried out and in accordance with Sub-Section 201.3.2 of the General Specifications. During the pipelaying, jointing, testing of pipes and backfilling, the trench shall be completely dry.

The trench shall be as per Drawing No. 451W-STDP01.

The Contractor shall excavate the trenches without damaging existing pipes, cables and any other structure. In this respect, the Contractor shall excavate the necessary depth or change the route in order to avoid damaging the pipes, cables and culverts that cross the roads.

In case the modification of the pipe depth or route is impossible, the Contractor shall, after the approval of the Engineer, undertake all the necessary works including preparation of drawings, excavation, fill and concrete works, etc... to modify the culvert in a way to maintain the passing section of the culvert, the cost of these works, after getting the approval of the Engineer should be measured as a concrete works (according to concrete works item).

The Contractor shall clear **away within the same day, all excavated material arising from trenches and headings on asphalted roads as the work proceeds**, and shall keep these roads free from any accumulations and clear in a good condition, to the satisfaction of the Engineer.

In addition to Sub-Section 201.3.2 of the General Specifications, Earthwork shall not be classified in accordance with the hardness of the excavated material. All excavation will be classified as common excavation and the Contractor shall take the whole responsibility for his assessment of excavated material and conditions. The Contractor should also use all suitable materials in the permanent construction required under the contract. However, the trenches types shall be classified according to the sewer diameter and to the average ‘depth to invert’ of sewer, which means depth to the internal invert of the pipe, listed in Table 217.1.

202.2 DEWATERING WORKS

202.2.1 Scope of Work

The Work of this Section includes site dewatering necessary to lower and control groundwater levels and hydrostatic pressure to permit excavation and construction to be performed properly under dry conditions.

The groundwater shall be lowered and maintained to an absolute minimum of 50cm below the lowest formation level of the trench as required to place pipe bedding and manhole bedding (Refer to **Annex 2 – Dewatering Design Report)**.

Dewatering operations shall be adequate to assure the integrity of the finished project. The responsibility for conducting the dewatering operation in a manner which will protect adjacent structures and facilities remains solely the responsibility of the Contractor. The cost of repairing any damage to adjacent structures and restoration of facilities shall be the responsibility of the Contractor and at his own expenses.

The Contractor shall bear the sole responsibility for the design, installation, operation, monitoring, and removal of the dewatering system to comply with the requirements of this section and any applicable regulatory agencies. The Contractor shall be required to install additional dewatering equipment as may be required throughout the duration of the project to maintain groundwater level as described in the above Paragraph.

The Contractor shall be responsible for submitting the Method Statement for the applications and obtaining the required permits for the pit/well construction including obtaining approval from the local authorities.

202.2.2 Schedule and Plan

Prior to commencement of construction, the Contractor shall submit a detailed dewatering plan including: dewatering method, a list of equipment, estimated pumping rates and a schedule of values.

Attached for the Contractor's information in **Annex 2 – Dewatering Design Report** is geotechnical information collected for the project This report was prepared for design purposes only and may not be adequate to evaluate construction conditions or design the dewatering system. The Contractor should independently interpret the soil/groundwater conditions taking into consideration their intended means and methods of construction, and the Contractor may perform additional exploration at their own expense as necessary for design of the dewatering system.

Due to possible variations of site and soil conditions and groundwater levels between soil bore locations the Contractor shall be responsible for changing or modifying the dewatering system to accommodate such variations.

202.2.3 Control and Observation

Adequate control shall be maintained by the Contractor to ensure that the stability of excavated slopes are not adversely affected by water, that erosion is controlled and that flooding of excavation or damage to structures does not occur. The Contractor is solely responsible for site excavation safety and compliance with the required regulations. The Engineer assumes no responsibility for site safety; the above information is provided for consideration by the Contractor only.

When directed by the Engineer, the Contractor will be required to excavate a pothole to determine if the groundwater is at the acceptable absolute minimum level or lower as defined above.

When observation of the groundwater level is complete the pothole shall be backfilled with clean crushed limestone.

202.2.4 Inspection

During or after any trench excavation. If the Contractor observes sufficient soil instability present that may prevent proper installation of pipe bedding, pipelines, backfill and compaction, then the Contractor shall call for inspection of conditions by the Engineer. The Engineer shall inspect the conditions and determine if they are unacceptable for pipe installation.

If after dewatering has lowered the groundwater level as specified and unacceptable trench conditions are found by the Engineer, then the Contractor may be directed to increase dewatering pumping rates or install additional pits/wells to lower the groundwater to an acceptable level lower than that defined above. If more extensive dewatering is required the Contractor must achieve the revised acceptable groundwater level before construction may continue.

202.2.5 Execution

The Contractor shall be responsible for ensuring a continuous power supply and providing a back-up generator throughout the dewatering period, consequently, the Contractor shall furnish, install, and operate pumps (including a sufficient number of stand-by pumps), pipes, appliances, and equipment of sufficient capability to maintain the absolute minimum or lower groundwater elevation described in Paragraph 202.2.1 within the trench excavation limits until the trench is backfilled, unless otherwise authorized by the Engineer.

The Contractor shall provide any temporary ground surface piping necessary to convey dewatering well water discharge to an acceptable storm sewer intake with the capacity to convey said discharge. Any rerouting of temporary ground surface piping, necessary to complete the project, will be provided by the Contractor. Discharge directly onto the ground surface shall not be allowed unless approved by the Engineer. The Contractor shall supply a clean tapping device at each pit/well location to allow easy discharge water sampling by the Engineer, if required.

An adequate system shall be designed, installed and maintained to lower and control the groundwater elevations as described in Paragraph 202.2.1 to permit excavation, construction of structures, and placement of fill materials to be performed under dry conditions.

The system shall be placed into operation, prior to beginning excavating below the natural groundwater level, to lower the groundwater to the elevation as described in Paragraph 202.2.1 and shall be operated continuously 24 hours a day, 7 days a week until sewers have been constructed and backfill materials have been placed to the top of the trench.

If the dewatering system shuts down or if pumping is suspended, the groundwater levels will need to be lowered below the required level, as described in Paragraph 202.2.1, and verified by the Engineer before continuing any construction, including excavation or backfilling. The Engineer will also require any compaction, moisture and/or other soils testing, as determined necessary, of any backfill that is prematurely subjected to groundwater to verify said soils stability prior to placement of additional backfill. If said soils are determined to be unacceptable the Contractor will be required to remove and replace damaged soils at his own expense.

Dewatering shall at all times be conducted in such a manner as to preserve the undisturbed bearing capacity of subgrade soils at the bottom of the proposed excavation.

Diversion ditches and dikes shall be used, where necessary, to prevent surface water from entering the excavation.

202.2.6 Measurement for Payment

The measurement and payment for all work covered under this section will be made by linear meter of trench type for “DEWATERING” which shall constitute full compensation for obtaining any necessary permits and furnishing all equipment (pumps, generators, control

panels, cables, pipes, fuel, etc… and any material or equipment needed for the complete dewatering system), labor, and materials to install, operate, maintain, and remove the dewatering system in accordance with all applicable regulations.

No payment shall be made to the Contractor until copies of the permits are submitted to the Engineer.

The Contractor shall be required to submit a schedule of values to the Engineer. The following list contains items that should be used, at a minimum, for the schedule of values:

- Obtaining permits and complying with permit requirements
- Drilling the wells
- Installing the pumps
- Installing power supply
- Discharge and/or manifold piping
- Removal

202.3 BACKFILLING OF PIPE TRENCHES

Backfilling shall be carried out in accordance with the Ministry of Public Works decree No. 13495 dated 5/11/98 and the Administrative Memorandum No. 21/F dated 1/3/2010 (Refer to Annex 1 of this volume) and in accordance with related general specifications of Volume 3.

In case of ambiguities or discrepancies between the content of the above-mentioned decree and the general specifications, the decree shall prevail.

All pipes shall be placed in granular material (fine coarse) bedding and surround if the pipeline is above water table, and in gravel bedding and surround if the pipeline is below water table.

Backfilling of pipes trenches on main roads should be executed using imported clean granular material and should be compacted by layers of 30 cm thick each.

a) Material unsuitable for filling:

   Shall mean material other than suitable material and unless accepted by the Engineer shall include:

   – Material from swamp, marshes, or bogs and solid containing more than 12% organic matter when tested in accordance with Test 8 of BS 1377, and which occurs below the top soil layer.

   – Clay-based materials of liquid limit exceeding 40 and/or plasticity index exceeding 10 as and if directed by the Engineer,

   – Boulders.

   – Maximum granular diameter > 5 cm.

   Where the pipe slope is greater than 25% suitable anchors blocks shall be installed as described in drawings N° 451W-STDP01 and 451W-STDP07.

TABLE 217.1 TYPE OF TRENCHES FOR SEWER PIPES

TRENCH TYPE	SEWER DIAMETER (mm)	AVERAGE DEPTH TO INVERT (m)
T1-H1	200-250-300	0<H<=1.5
T1-H2	200-250-300	1.5<H<=2.5
T1-H3	200-250-300	2.5<H<=3.5
T1-H4	200-250-300	3.5<H<=4.5
T1-H5	200-250-300	4.5<H<=5.5
T1-H6	200-250-300	5.5<H<=6.5
T1-H7	200-250-300	6.5<H
T2-H1	350-400-450	0<H<=1.5
T2-H2	350-400-450	1.5<H<=2.5
T2-H3	350-400-450	2.5<H<=3.5
T2-H4	350-400-450	3.5<H<=4.5
T2-H5	350-400-450	4.5<H<=5.5
T2-H6	350-400-450	5.5<H<=6.5
T2-H7	350-400-450	6.5<H
T3-H1	500-600-700	0<H<=1.5
T3-H2	500-600-700	1.5<H<=2.5
T3-H3	500-600-700	2.5<H<=3.5
T3-H4	500-600-700	3.5<H<=4.5
T3-H5	500-600-700	4.5<H<=5.5
T3-H6	500-600-700	5.5<H<=6.5
T3-H7	500-600-700	6.5<H
T4-H1	800-900	0<H<=1.5
T4-H2	800-900	1.5<H<=2.5
T4-H3	800-900	2.5<H<=3.5
T4-H4	800-900	3.5<H<=4.5
T4-H5	800-900	4.5<H<=5.5
T4-H6	800-900	5.5<H<=6.5
T4-H7	800-900	6.5<H

TRENCH TYPE	SEWER DIAMETER (mm)	AVERAGE DEPTH TO INVERT (m)
T5-H1	1000-1100-1200	0<H<=1.5
T5-H2	1000-1100-1200	1.5<H<=2.5
T5-H3	1000-1100-1200	2.5<H<=3.5
T5-H4	1000-1100-1200	3.5<H<=4.5
T5-H5	1000-1100-1200	4.5<H<=5.5
T5-H6	1000-1100-1200	5.5<H<=6.5
T5-H7	1000-1100-1200	6.5<H
T6-H1	1300-1400-1500-1600	0<H<=1.5
T6-H2	1300-1400-1500-1600	1.5<H<=2.5
T6-H3	1300-1400-1500-1600	2.5<H<=3.5
T6-H4	1300-1400-1500-1600	3.5<H<=4.5
T6-H5	1300-1400-1500-1600	4.5<H<=5.5
T6-H6	1300-1400-1500-1600	5.5<H<=6.5
T6-H7	1300-1400-1500-1600	6.5<H
T7-H1	1800-2000	0<H<=1.5
T7-H2	1800-2000	1.5<H<=2.5
T7-H3	1800-2000	2.5<H<=3.5
T7-H4	1800-2000	3.5<H<=4.5
T7-H5	1800-2000	4.5<H<=5.5
T7-H6	1800-2000	5.5<H<=6.5
T7-H7	1800-2000	6.5<H

202.4 PIPELINES AND MATERIALS

Corrugated HDPE pipes SN8 shall be used in the construction of the conveyors:

CORRUGATED HDPE PIPES WT IB (Watertight Integral Bell) (PER AASHTO) SPECIFICATION

Scope

This specification describes 4- through 60-inch (100 to 1500 mm) WT IB pipe (per AASHTO) for use in gravity-flow land drainage applications.

Pipe Requirements

WT IB pipe (per AASHTO) shall have a smooth interior and annular exterior corrugations.

- 4- through 10-inch (100 to 250 mm) pipe shall meet AASHTO M252, Type S.
- 12- through 60-inch (300 to 1500 mm) pipe shall meet AASHTO M294, Type S or ASTM F2306.
- Manning's "n" value for use in design shall be 0.012.

Joint Performance

Pipe shall be joined using a bell & spigot joint meeting the requirements of AASHTO M252, AASHTO M294, or ASTM F2306. The joint shall be watertight according to the requirements of ASTM D3212.
Gaskets shall meet the requirements of ASTM F477. Gaskets shall be installed by the pipe manufacturer and covered with a removable, protective wrap to ensure the gasket is free from debris. A joint lubricant available from the manufacturer shall be used on the gasket and bell during assembly. 12- through 60inch (300 to 1500 mm) diameters shall have an exterior bell wrap installed by the manufacturer.

Fittings

Fittings shall conform to AASHTO M252, AASHTO M294, or ASTM F2306. Bell and spigot connections shall utilize a welded bell and valley or saddle gasket meeting the watertight joint performance requirements of AASHTO M252, AASHTO M294, or ASTM F2306.

Field Pipe and Joint Performance

To assure watertightness, field performance verification may be accomplished by testing in accordance with ASTM F2487. Appropriate safety precautions must be used when field-testing any pipe material.

Material Properties

Material for pipe and fitting production shall be high-density polyethylene conforming with the minimum requirements of cell classification 424420C for 4- through 10-inch (100 to 250 mm) diameters, and 435400C for 12- through 60-inch (300 to 1500 mm) diameters, as defined and described in the latest version of ASTM D3350, except that carbon black content should not exceed 4%. The 12- through 60inch (300 to 1500 mm) pipe material shall comply with the notched constant ligament-stress (NCLS) test as specified in Sections 9.5 and 5.1 of AASHTO M294 and ASTM F2306 respectively.

Installation

Installation shall be in accordance with ASTM D2321 recommended installation guidelines, with the exception that minimum cover in trafficked areas for 4- through 48-inch (100 to 1200 mm) diameters shall be one foot. (0.3 m) and for 60-inch (1500 mm) diameter the minimum cover shall be 2 ft. (0.6 m) in single run applications. Backfill for minimum cover situations shall consist of Class 1 (compacted), Class 2 (minimum 90% SPD) or Class 3 (minimum 95%) material. Maximum fill heights depend on embedment material and compaction level; please refer to Technical Note 2.01

Pipe Dimensions

Pipe I.D. in (mm)	4 (100)	6 (150)	8 (200)	10 (250)	12 (300)	15 (375)	18 (450)	24 (600)	30 (750)	36 (900)	42 (1050)	48 (1200)	60 (1500)
Pipe O.D.* in (mm)	4.8 (122)	6.9 (175)	9.1 (231)	11.4 (290)	14.5 (368)	18 (457)	22 (559)	28 (711)	36 (914)	42 (1067)	48 (1219)	54 (1372)	67 (1702)

*Pipe O.D. values are provided for reference purposes only, values stated for 12 through 60-inch are ±1 inch

The pipes diameters specified in the B.O.Q are inner diameters (ID).
The class or series of all pipes specified for gravity sewer pipelines is the minimum required. However, for some diameters in certain depths of trenches, this minimum is not sufficient and the Contractor should supply transport and install the pipes having the adequate pressure class without any change of unit prices. The Contractor should submit for approval the choice of pipes materials and pressure class in function of pipes diameter and depths of trenches.

As for the materials used, they shall comply with the requirements of Section 101.9 of the General Specifications. Any unsuitable material not satisfying the specifications shall be rejected by the Engineer, removed from the Site and replaced by the Contractor at his own expense.

202.5 WARNING TAPES

Warning tapes shall be placed on well compacted Backfill at 450mm below the finished level and directly above the center-line of the pipeline.

Warning tapes shall be made of pigmented low density polyethylene and aluminium foil in a bright colour or other approved material not less than 100 mm wide for pipes diameter ≤ 200mm and 2 x 100mm for pipes diameter > 200 mm and 0.15 mm thick. When laid, the tapes shall provide a continuous band detectable with a metal detector if the pipe itself is not detectable. The tapes shall be continuously and alternatively labeled in Arabic and English.

Where possible, tapes shall also be laid above ducts and concrete protection slabs as directed by the Engineer.

202.6 MANHOLES

Manholes shall be constructed as specified in Sub-Sections 202.11.2, 202.14.2 and 202.14.5 of the General Specifications and a sulfate resistance cement should be used. As for classifying

the manholes, it will be the basis of the sewer diameter and the depth to invert of the manhole, which means depth to the internal invert of the manhole, as specified in the Table 217.2

Manholes shall be constructed as per Drawing No. 451W-STDP02, P03, P04, P05 and P06.

Manholes covers and frames shall be suitable for heavy duty and shall be made of cast-iron or ductile iron and capable to carry a test load of 40 tons. Manholes covers and frames shall comply with BS EN 124.

All manholes shall receive internal water proofing treatment with coal tar epoxy (2 layers) in accordance with the General Specifications.

All concrete faces in contact with the soil shall receive a waterproofing treatment consisting of one layer of bituminous coating in accordance with Sub-Section 213.2.1 of the General Specifications.

The connection between pipe and manholes should be watertight by means of using swelling bar or similar approved by the Engineer.

Manholes covers for wastewater collectors should be ventilated.

The type of manhole shall be integrally casted on the manhole cover, in Arabic and/or English.

TABLE 217.2 TYPE OF MANHOLES FOR SEWER PIPES

MANHOLE TYPE	SEWER DIAMETER (mm)	DEPTH TO INVERT (m)
M1-H1	200-250-300	0<H<=1.5
M1-H2	200-250-300	1.5<H<=2.5
M1-H3	200-250-300	2.5<H<=3.5
M1-H4	200-250-300	3.5<H<=4.5
M1-H5	200-250-300	4.5<H<=5.5
M1-H6	200-250-300	5.5<H<=6.5
M1-H7	200-250-300	6.5<H
M2-H1	350-400-450	0<H<=1.5
M2-H2	350-400-450	1.5<H<=2.5
M2-H3	350-400-450	2.5<H<=3.5
M2-H4	350-400-450	3.5<H<=4.5
M2-H5	350-400-450	4.5<H<=5.5
M2-H6	350-400-450	5.5<H<=6.5
M2-H7	350-400-450	6.5<H
M3-H1	500-600-700	0<H<=1.5
M3-H2	500-600-700	1.5<H<=2.5
M3-H3	500-600-700	2.5<H<=3.5
M3-H4	500-600-700	3.5<H<=4.5
M3-H5	500-600-700	4.5<H<=5.5
M3-H6	500-600-700	5.5<H<=6.5
M3-H7	500-600-700	6.5<H
M4-H1	800-900	0<H<=1.5
M4-H2	800-900	1.5<H<=2.5
M4-H3	800-900	2.5<H<=3.5
M4-H4	800-900	3.5<H<=4.5
M4-H5	800-900	4.5<H<=5.5
M4-H6	800-900	5.5<H<=6.5
M4-H7	800-900	6.5<H

MANHOLE TYPE	SEWER DIAMETER (mm)	DEPTH TO INVERT (m)
M5-H1	1000-1100-1200	0<H<=1.5
M5-H2	1000-1100-1200	1.5<H<=2.5
M5-H3	1000-1100-1200	2.5<H<=3.5
M5-H4	1000-1100-1200	3.5<H<=4.5
M5-H5	1000-1100-1200	4.5<H<=5.5
M5-H6	1000-1100-1200	5.5<H<=6.5
M5-H7	1000-1100-1200	6.5<H
M6-H1	1300-1400-1500-1600	0<H<=1.5
M6-H2	1300-1400-1500-1600	1.5<H<=2.5
M6-H3	1300-1400-1500-1600	2.5<H<=3.5
M6-H4	1300-1400-1500-1600	3.5<H<=4.5
M6-H5	1300-1400-1500-1600	4.5<H<=5.5
M6-H6	1300-1400-1500-1600	5.5<H<=6.5
M6-H7	1300-1400-1500-1600	6.5<H
M7-H1	1800-2000	0<H<=1.5
M7-H2	1800-2000	1.5<H<=2.5
M7-H3	1800-2000	2.5<H<=3.5
M7-H4	1800-2000	3.5<H<=4.5
M7-H5	1800-2000	4.5<H<=5.5
M7-H6	1800-2000	5.5<H<=6.5
M7-H7	1800-2000	6.5<H

202.7 TEMPORARY AND/OR PERMANENT RESTORATION OF PAVED ROADS

In all paved roads, trenches shall be refilled and compacted to the underside of the original road surface.

A sub-base and base layers shall be laid and compacted and shall be carried out in accordance with the Ministry of Public Works decree No. 13495 dated 5/11/98 and the Administrative Memorandum No. 21/F dated 1/3/2010 (Refer to Annex 1 of this volume) and in accordance with related general specifications of Volume 3.

In case of ambiguities or discrepancies between the content of the above-mentioned decree and the general specifications, the decree shall prevail.

Main roads subject to a permit from the Ministry of Public Works and Transport, the Contractor at his own expenses and sole responsibility should deal to obtain and receive this permit, and the asphalt reinstatement works should be carried out in accordance with the specifications and conditions (if any) of the permit.

As for narrow roads not exceeding 3m width, the asphalt reinstatement should be executed to cover the entire width of the road.

202.8 REMARKS

The Contractor shall lay pipes on one side of the streams and on one side of the roads (even if this is not shown of the drawings) and if possible, outside the carriageway in order to avoid damaging the roads. The Contractor shall coordinate with the Administration and the Engineer and the relevant Authorities in order to obtain official authorization prior to any construction work.

203. CONSTRUCTION, AS-BUILT DRAWINGS

Construction Drawings, design calculation notes and all necessary material technical specification shall be submitted to the Engineer for approval at least 21 days before starting of the work.

As-built drawings shall be prepared after completion of the work and shall be also submitted to the Engineer for approval.

It is the duty of the Contractor to undertake all the Engineer’s recommendations, modifications and corrections at his own expense until complete satisfaction of the Engineer.

All the modifications to the design drawings coming out during execution of the works, or after ordering the relating materials (specially for pumping stations building dimensions) should be done by the contractor and approved by the Engineer.

204. HOUSE CONNECTIONS

The locations of inspection chambers, lateral branch connections and connecting lateral sewers shall be assigned on site.

ANNEX 1

P.T = Max 10%

مرسوم رقم ١٣٤٩٥

تحديد دقائق تطبيق وتنفيذ المرسوم الاشتراعي رقم ٦٨ تاريخ ٨٣/٩/٩ (تنظيم أشغال الحفر لمد خطوط الخدمات العامة في الطرق وبراحاتها)

ان رئيس الجمهورية،
بناء على الدستور،
بناء على أحكام المادة الثامنة من المرسوم الاشتراعي رقم ٦٨ تاريخ ٨٣/٩/٩ (تنظيم أشغال الحفر لمد خطوط الخدمات العامة في الطرق وبراحاتها)،
بناء على اقتراح وزير الأشغال العامة ووزير الشؤون البلدية والقروية،
وبعد استشارة مجلس شورى الدولة (الرأي رقم ٩٨/٢٤-٩٩ تاريخ ١٩٩٨/١٠/٢٢)،
وبعد موافقة مجلس الوزراء بتاريخ ١٩٩٨/١٠/١،

يرسم ما يأتي:

المادة الأولى – مع مراعاة أحكام المادتين الرابعة والخامسة من المرسوم الاشتراعي رقم ٦٨ تاريخ ٨٣/٩/٩ (تنظيم أشغال الحفر لمد خط الخدمات العامة في الطرق وبراحاتها) تطبق عند ردم أشغال الحفر المواصفات والشروط التالية:

أولا: في طبقة الأساس

granular base coarse (T.V) :

تردم بسماكة ٣٠ سم على طبقتين تحت طبقة الإسفلت على أن تتكون كل طبقة من مواد صلبة مكسرة خالية من المواد الدلغانية (clay) وتتضمن المواصفات التالية:

- معادل رملي لا يقل عن ٥٠%
- التآكل (A.L) لا يقل عن ٤٠%
- تدرج ضمن حدود المواصفات المطلوبة في دفتر الشروط.

ثانيا: المواد الصالحة للردم:

تعتبر مواد صالحة للردم Suitable material المواد ذات المواصفات التالية:

L.L = Max 40%

على ألا تحتوي على حجارة او مواد صلبة يزيد حجمها عن ٥ سم.

- تردم هذه المواد على طبقات بسماكة ٢٠ سم وحتى عمق ٦٠ سم ابتداء من طبقة الأساس وحتى الوصول الى كثافة ٩٥% بروكتور معدل.
- من ٦٠ سم وما دون ذلك تردم المواد الصالحة بسماكة ٣٠ سم وحتى الوصول الى كثافة ٩٠% بروكتور معدل.

ثالثا: فلش الطبقة الاسفلتية:

تفلش الطبقة الاسفلتية فوق طبقة الأساس على الشكل التالي:

نفس سماكة الزفت الموجود على الطرق على الا يقل عن سماكة ٩ سم للطرق (الدولية والرئيسية والثانوية) وعلى ألا يقل عن سماكة ٤,٥ سم للطرق المحلية والداخلية.

رابعا: في حال عدم توفر الردميات المنصوص عنها في البند ثانيا يتم الردم بواسطة ردميات (sraoc esab buS) على ان يتضمن المواصفات التالية:

- معادل رملي لا يقل عن ٤٠%
- التآكل (A.L) لا يقل عن ٤٠%
- حد اللدونة (P.I) ٦ % xaM P.I
- لا يزيد حجم الحجارة او المواد الصلبة عن ٥ سم.
- يتم الردم بسماكة ٢٠ سم حتى عمق ٦٠ سم ابتداء من طبقة الأساس حتى الوصول الى كثافة ٩٥% بروكتور معدل.
- من عمق ٦٠ سم وما دون ذلك يتم الردم بسماكة ٣٠ سم وحتى الوصول الى كثافة ٩٠% بروكتور معدل.
- تدرج ضمن حدود المواصفات المطلوبة في دفتر الشروط.

المادة ٢ ـ يبلغ هذا المرسوم من يلزم ويعمل به فور نشره في الجريدة الرسمية.

بعبدا في ٥ تشرين الثاني ١٩٩٨

الإمضاء: الياس الهراوي

صدر عن رئيس الجمهورية

رئيس مجلس الوزراء

الإمضاء: رفيق الحريري

وزير الأشغال العامة

الإمضاء: علي حراجلي

وزير الشؤون البلدية والقروية بالوكالة

الإمضاء: باسم السبع

مرسوم اشتراعي رقم ٦٨

صادر في ٩ ايلول سنة ١٩٨٣

تنظيم اشغال الحفر لمد خطوط الخدمات العامة في الطرق وبراحاتها

ان رئيس الجمهورية
بناء على الدستـــور
بناء على القـــانون رقم ٨٢/٣٦ تاريخ ١٩٨٢/١١/١٧ (منح الحكومة حق اصدار مراسيم اشتراعية) ،
بناء على القانون رقم ٨٣/١٠ تاريخ ١٩٨٣/٥/٢١ (تمديد العمل باحكام القانون رقم ٨٢/٣٦ تاريخ ١٩٨٢/١١/١٧) ،
بناء على اقتراح وزير الداخلية ووزير الاشغال العامة والنقل ،
وبعد استشارة مجلس شورى الدولة ،
وبعد موافقة مجلس الوزراء بتاريخ ١٩٨٣/٨/١١ ،

يرسم ما ياتي :

المادة الاولى ـ يحظر القيام باشغـــال الحفر ضمن حدود الاستملاك للطرق لمـــد خطوط الخدمـــات العامة على اختـــلاف انواعها او تقويتها او صيانتها مـــا لم تراع الاحكام المنصوص عنها في هذا المرســـوم الاشتراعي .

المادة الثانية ـ تؤمن مواقع تمديدات خطوط الخدمات العامة كالمياه والكهربـــاء والهاتف والمجارير وغيرها ضمن سطـــح الطرق وبراحاتها على الوجه التالي :

١ ـ ضمـــن جوانب وارصفة الطـــرق المنوى تخطيطهـــا او توسيعهـــا ويمكن المباشرة باشغال التمديدات فور الانتهـــاء من معاملات الاستملاك ؛

٢ ـ ضمن حدود الاملاك العموميـــة التابعة للطرق المنفذة خارج القسم المزفت .

٣ ـ اذا تعـــذر تطبيق الفقـــرة (٢) السابقة لا سيما في حال عدم توفر المساحة اللازمة لتامين التمديدات المذكورة يلجـــا الى استعمال حق الارتفاق المنصوص عنـــه في المادة التالية .

المادة الثالثة ـ ١ ـ [redacted] الاشتراعي [redacted] .

٢ ـ يطبق حق الارتفاق المنصـــوص عنه في الفقرة السابقة من هذه المـــادة فـي [redacted] ولقـــاء تعويض عـــادل عن الضرر اللاحق بالعقار من جراء تنفيذ الاشغال .

٣ ـ يحدد التعويض بقرار يصدر عـــن

لجنة الاستملاك ويخضع للاصول المنصوص عنها في قانون الاستملاك ٠

يتخذ اساسا لتحديد التعويض قيمة الاشجار والمزروعات التي يستدعي تنفيذ الاشغال ازالتها ، وتكاليف اعادة الانشاءات والتجهيزات الى ما كانت عليه ٠

٤ ـ لا يستعمل حق الارتفاق المنصوص عنه في الفقرة (١) اعلاه ولا يسجل على الصحائف العينية للعقارات المشمولة به ما لم ينظم محضر كشف ويصدر قرار من لجنة الاستملاك ولو في حال عدم وجود اضرار او تعويض ٠

المادة الرابعة ـ لا يرخص باشغال حفر الطرق المنفذة الا في حال وضع برنامج عمل للمشروع يلحظ تفاصيل اشغال الحفر كتحديد اقسام الطرق المنوى حفرها والعمق الملحوظ وحجم التمديدات وتبليغه الى مديرية الطرق او البلدية المختصة قبل المباشرة بالاشغال بسنة واحدة في المرحلة الانتقالية التي تستغرق ثلاث سنوات اعتبارا من تاريخ نفاذ هذا المرسوم الاشتراعي وبثلاث سنوات على الاقل بعد المرحلة المذكورة ، الا انه يمكن الترخيص باشغال الحفر هذه في اي وقت كان دون برنامج عمل على ان يتم اعلام مديرية الطرق او البلدية المختصة عن العمل المراد القيام به وموقعه ومدة تنفيذه وذلك في الحالات الاستثنائية التالية :

١ ـ اذا تعذر استعمال حق الارتفاق المنصوص عنه في المادة السابقة في مواقع الابنية الملاصقة للطريق ، على ان لا يتعدى الترخيص بالحفر المواقع المجاورة للابنية المذكورة ٠

٢ ـ اذا اضطرت الادارة او المؤسسة العامة او البلدية المختصة الى اصلاح او صيانة الخطوط التابعة لها والمارة تحت الطريق ٠

٣ ـ في حال الاضطرار الى حفر الطريق عرضيا ، او بسبب وجود اعطال طارئة تستلزم اصلاحات فورية تبادر الدائرة المختصة لدى الادارة او المؤسسة طالبة الترخيص الى القيام بها بالتعاون مع الادارة المرخصة ٠

المادة الخامسة ـ يصدر الترخيص بالحفر عن مدير الطرق فيما يتعلق بالطرق المصنفة التي ترعى شؤونها وزارة الاشغال العامة والنقل وعن رئيس السلطة التنفيذية في البلدية المختصة فيما يتعلق بالطرق الداخلية الواقعة في نطاقها لصلحة الجهة طالبة الترخيص مع مراعاة الشروط التالية :

١ ـ ان يقدم طلب الترخيص الى مديرية الطرق او البلدية المختصة يبين فيه الاشغال المطلوبة مع الخرائط والصورات من مسطحات ومقاطع طولية وعرضية وتصاميم تفصيلية عائدة للتمديدات والاشغال ويتضمن تعهدا بالتقيد بالشروط اللازمة للمحافظة على سلامة السير والسلامة العامة اثناء التنفيذ ٠

٢ ـ فور تسلمها الطلب تقوم الادارة الصالحة للترخيص بوضع دراسة تتضمن الشروط الفنية اللازمة وتعيده الى الجهة طالبة تنفيذ الاشغال مع قرار الترخيص والمدة التي يستلزمها التنفيذ وتاريخ العمل به ٠

٣ ـ مع مراعاة احكام المادة ٧٤ من المرسوم الاشتراعي رقم ١١٨ تاريخ ١٩٧٧/٦/٣٠ (قانون البلديات) تتحمل الجهة طالبة الترخيص تكاليف اعادة الطريق الى حالتها الاصلية وفقا لشروط فنية تضعها الادارة المرخصة ٠

٤ ـ يجب ان يكون المتعهدون المكلفون باعادة الطريق الى حالتها الاصلية مؤهلين

لهذه الاشغال وفقا لنظام التصنيف المعمول به في الادارات العامة .

٥ ـ لا يصرف اي مبلغ للمتعهد عن الاشغال موضوع الترخيص المتعلقة باعادة الطريق الى حالتها الاصلية ما لم يقترن بموافقة الادارة المرخصة .

المادة السادسة ـ يجري الاشراف على التنفيذ بواسطة فرع الصيانة في المديرية الاقليمية المختصة او بواسطة الوحدة التي يكلفها بهذه المهمة المدير العام للطرق والمباني فيما يتعلق بالطرق التي ترعى شؤونها وزارة الاشغال العامة والنقل ، وبواسطة الجهاز الفني البلدي بالنسبة لبلديتي بيروت وطرابلس والجهاز الفني في اتحاد البلديات بالنسبة للبلديات التابعة للاتحاد او احدى الوحدات التابعة للمديرية العامة للتنظيم المدني بالنسبة لباقي البلديات .

المادة السابعة ـ لا تطبق احكام هذا المرسوم الاشتراعي على الاشغال الجاري تنفيذها وكذلك المشاريع الملحوظة في برامج العمل المصدقة بتاريخ نفاذه على ان يجرى التنسيق مسبقا بالنسبة لهذه البرامج مع الادارة المختصة .

المادة الثامنة ـ تحدد عند الاقتضاء دقائق تطبيق وتنفيذ هذا المرسوم الاشتراعي بمراسيم تتخذ في مجلس الوزراء بناء على اقتراح وزير الاشغال العامة والنقل او وزير الداخلية .

المادة التاسعة ـ تلغى جميع النصوص المخالفة لاحكام هذا المرسوم الاشتراعي او غير المتفقة ومضمونه .

المادة العاشرة ـ يعمل بهذا المرسوم الاشتراعي فور نشره في الجريدة الرسمية .

بعبدا في ٩ ايلول سنة ١٩٨٣

الامضاء : امين الجميل

صدر عن رئيس الجمهورية
رئيس مجلس الوزراء
الامضاء : شفيق الوزان

وزير الداخلية
الامضاء : شفيق الوزان

وزير الاشغال العامة والنقل
الامضاء : بيار الخوري

نشر هذا المرسوم الاشتراعي في عدد الجريدة الرسمية رقم ٣٨ تاريخ ١٩٨٣/٩/٢٢

الجمهورية اللبنانية
وزارة الأشغال العامة والنقل

الوزير

مصلحة الصيانة
الرقم ٧٦٣/
تاريخ الورود ٢٠١٠ آذار
تاريخ الصدور

مذكرة إدارية رقم ٢١/ف

تكليف رئيس مصلحة الصيانة في مديرية الطرق
إصدار تراخيص الحفر .

١ آذار ٢٠١٠

عطفاً على مضمون إحالتنا عدد ٧٥٠٠ تاريخ ٢٠٠٩/١٢/١٦ المُتضمنة التأكيد على عدم توقيع مدير الطرق والمدير العام للطرق والمباني على المعاملات تحت طائلة المسؤولية ،
وعطفاً على المذكرة الإدارية رقم ٧/ف تاريخ ٢٠١٠/١/٩ (التعميم على كافة الوحدات التقيد بالإحالة عدد ٢٠٠٩/٧٥٠٠) ،
تُحدد بصورة إستثنائية ومؤقتة آلية إصدار تراخيص الحفر للطرق المُصنفة التي ترعى شؤونها وزارة الأشغال العامة والنقل وفقاً للآتي :

١- يُقدم طلب الترخيص الى مصلحة الصيانة في مديرية الطرق .
٢- يُحول الطلب الى المهندس حسين شبقجي المُكلف إعداد إجازات الحفر وذلك وفقاً للأصول الواردة في المرسوم الإشتراعي رقم ١٩٨٣/٦٨ .
٣- يصدر ترخيص الحفر عن رئيس مصلحة الصيانة في مديرية الطرق .
٤- تُبلغ إجازة الحفر الى المديرية الإقليمية المُختصة للمُتابعة والإشراف وفقاً للأصول والأنظمة المرعية الإجراء ولا سيما المرسوم الإشتراعي رقم ١٩٨٣/٦٨ .
٥- تُبلغ إجازة الحفر أيضاً الى كُل من الجهة الطالبة للترخيص ومفرزة السير المُختصة وإدارة التفتيش المركزي للمُتابعة .

العنوان – تلفون: ٠٥/٤٥٩٦٧٠ – ٠٥/٤٥٨٩٧٥ – ٠٥/٤٥٨٩٨٠ – فاكس: ٠٥/٤٥٩٤٣٤

الجمهورية اللبنانية
وزارة الأشغال العامة والنقل

الوزير

٦- يتم الإستلام المؤقت للأشغال المطلوب الترخيص لها بعد موافقة المديرية الإقليمية المُختصة ، أما الإستلام النهائي فيتم بعد مرور سنة من تاريخ الإستلام المؤقت وبعد موافقة مصلحة الصيانة في مديرية الطرق وعلى أن تُعاد الكفالة المصرفية بعد إجراء الإستلام النهائي وفقاً لما ورد أعلاه .

٧- يُطلب الى المديريات الإقليمية التشدد في المُراقبة والإشراف على أعمال تنفيذ الحفر وفقاً للشروط والمواصفات المعمول بها في وزارة الأشغال العامة والنقل ولأحكام المرسوم الإشتراعي رقم ١٩٨٣/٦٨ .

يُعمل بهذه المذكرة فور صدورها .

وزير الأشغال العامة والنقل

١ آذار ٢٠١٠

غازي العريضي

تبلغ الى :
- مصلحة الصيانة
- المديريات الإقليمية
- مصلحة الإنشاءات

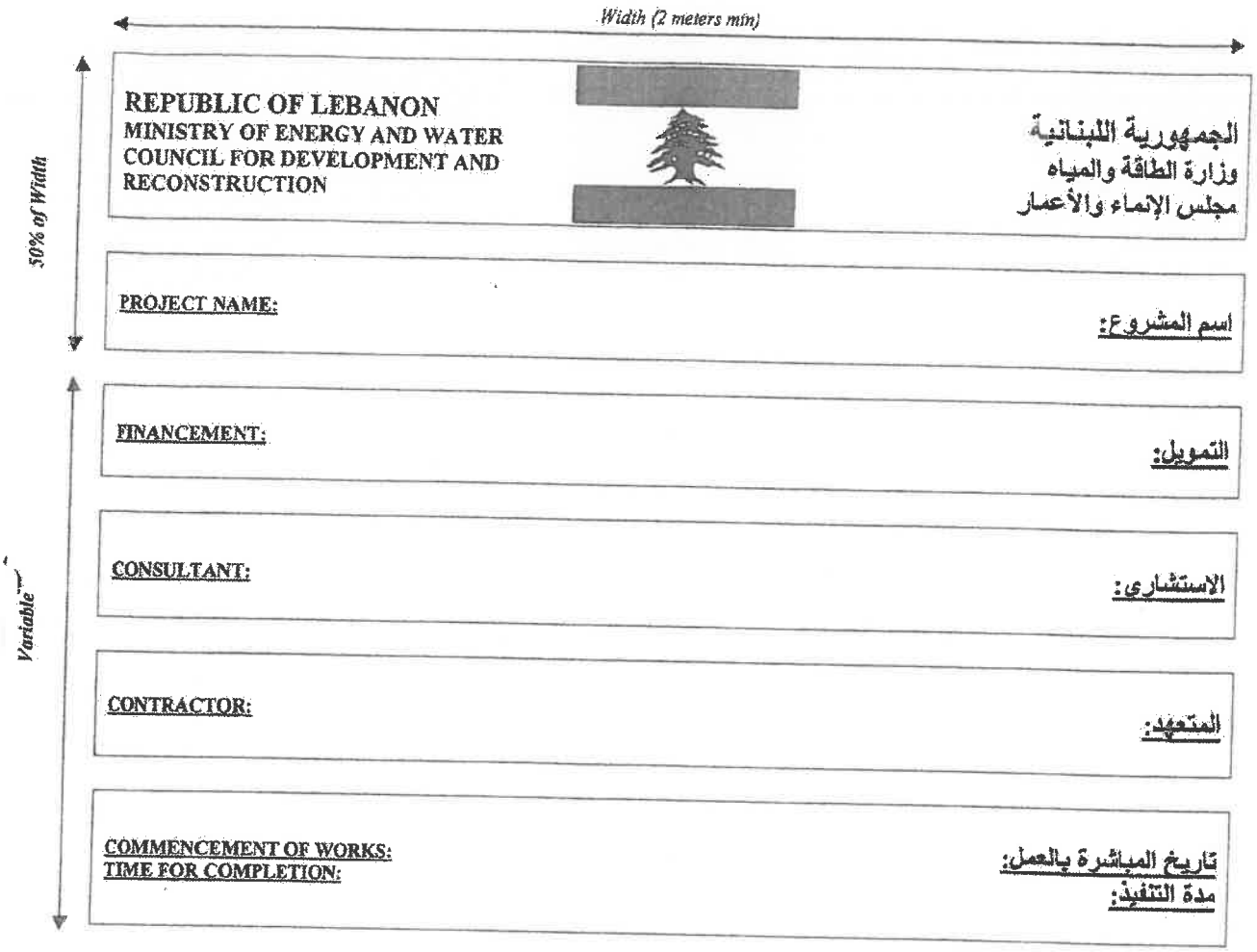
الجمهورية اللبنانية
وزارة الأشغال العامة والنقل
الإدارة المشتركة

طبق الأصل
رمونا يزبك

القلم
التبليغ

رئيس مصلحة الصيانة بالإنابة
المهندس سامر درجوج

الفياضية, لبنان - تلفون: ٠٥/٤٥٩٦٧٠ - ٠٥/٤٥٨٩٧٥ - ٠٥/٤٥٨٩٨٠ - فاكس: ٠٥/٤٥٩٤٣٤



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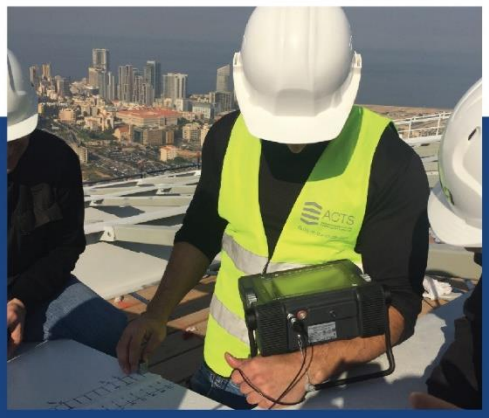
ANNEX 2

DEWATERING WORKS



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BTD

El Mina Coastal Wastewater Project

Dewatering Design Report

Q27015/Rev.01

02/05/2024

ACTS
ADVANCED CONSTRUCTION TECHNOLOGY SERVICES

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Document Control

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Project Name: El Mina Coastal Wastewater Project

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1. INTRODUCTION

1.1. General

Based on the request of M/s **BTD**, Advanced Construction Technology Services (ACTS) has prepared a dewatering design report for the **El Mina Coastal Wastewater Project** which comprises the installation of wastewater conveyors. The project is located in El Mina, North Lebanon. The site is bounded by existing structures from the north, south, east and west. The project location is provided in **Figure 1**

Based on elevations taken during the site investigation, elevations ranged between +1.50m MSL to +3.37m MSL were observed within the site. The construction of the remaining coastal sewer collectors will require excavations varying from 1.0m bEGL to 7.0m bEGL. Given the proximity to the sea and the excavation levels required, a suitable dewatering system should be installed.

Figure 1: Project Location Extracted from Google Earth

1.2. Scope of Report

This report will address the dewatering design for the coastal wastewater project. The following will be presented in the report:

- Summary of the available geotechnical investigation campaigns.
- Assessment of the subsurface conditions including strata types, strata development and groundwater.
- Assessment of the permeability coefficients of different layers based on site findings, in-situ tests, lab testing and general engineering correlations.
- Assessment and design of the dewatering system.

Calculation of seepage induced settlements or anything similar are outside the scope of this report.

1.3. List of Abbreviations

ACI : American Concrete Institute
ASCE : American Society of Civil Engineers
ASTM : American Society for Testing and Materials
bEGL : below Existing Ground Level
BH : Borehole
BS : British Standards
DGPS : Differential Global Positioning Systems
DP : Design Profile
EGL : Existing Ground Level
FGL : Finish Ground Level
FHWA : Federal Highway Administration
FoS : Factor of Safety
GSI : Geological Strength Index
GWT : Ground Water Table
IBC : International Building Code
LL : Liquid Limit
Max. : Maximum
Min. : Minimum
PI : Plasticity Index
PL : Plastic Limit
PLI / I_S : Point Load Index
PSD : Particle Size Distribution
RQD : Rock Quality Designation
RMR : Rock Mass Rating
SCR : Solid Core Recovery
SLS : Service Limit State
SPT : Standard Penetration Test
StDev. : Standard Deviation
TCR : Total Core Recovery
UCS : Unconfined (or Uniaxial) Compressive Strength
ULS : Ultimate Limit State
Undet. : Undetermined

1.4. Report Limitations

This geotechnical analysis report has been prepared with generally accepted geotechnical and foundation practices. No other warranty, expressed or implied, is made. Moreover, the below findings and recommendations are applicable only for the said project – **El Mina Coastal Wastewater Project.**

Any significant change to the layout, size, location or formation levels – may require changes to the recommendations depicted in this report. Furthermore, the findings and recommendations provided in this engineering report are based on the results of the field investigations, borehole drilling/in-situ testing, laboratory testing and data delivered at the time of preparation of the report. It should be noted that findings of the ground investigation campaign depict subsurface conditions only at the specific locations and times of sampling. The designated boundaries between strata, are approximate and may vary across the site.

ACTS holds no responsibility for possible variations in the subsurface conditions not revealed by the factual report and thus, not accounted for in this interpretive report. Should any variation or undesirable conditions be encountered during construction works or later stages, **ACTS** should be notified in order to review the findings mentioned herein.

2. FIELD WORKS

The field works completed on the project site are summarized as follows:

A. Drilling three (03) Nos. of boreholes using rotary coring techniques down to a depth ranging between 7.0m and 10.0m below the existing ground level with soil and rock sampling.
B. Soil and rock sampling in boreholes to obtain core samples having a diameter of 63mm
C. Carrying out standard penetration tests (SPT) in drilled boreholes when applicable.
D. Performing three (03) Nos. of Falling Head Permeability tests in the drilled boreholes.
E. Backfilling the boreholes with material arising from the drilling operations.

2.1. Summary of Field Works

The list of completed exploratory holes along with their respective depths and as-built coordinates and elevations are presented in **Table 1**.

Table 1: Borehole Details

BH No.	Easting [m UTM]	Northing [m UTM]	Elevation [m MSL]	Depth [m]
BH-01	759,114.36	3,815,514.59	+1.50	10.00
BH-02	758,738.27	3,815,341.29	+3.37	7.00
BH-03	758,872.98	3,815,843.31	+2.15	7.00

The figure below shows an aerial view of the borehole locations extracted from Google Earth.

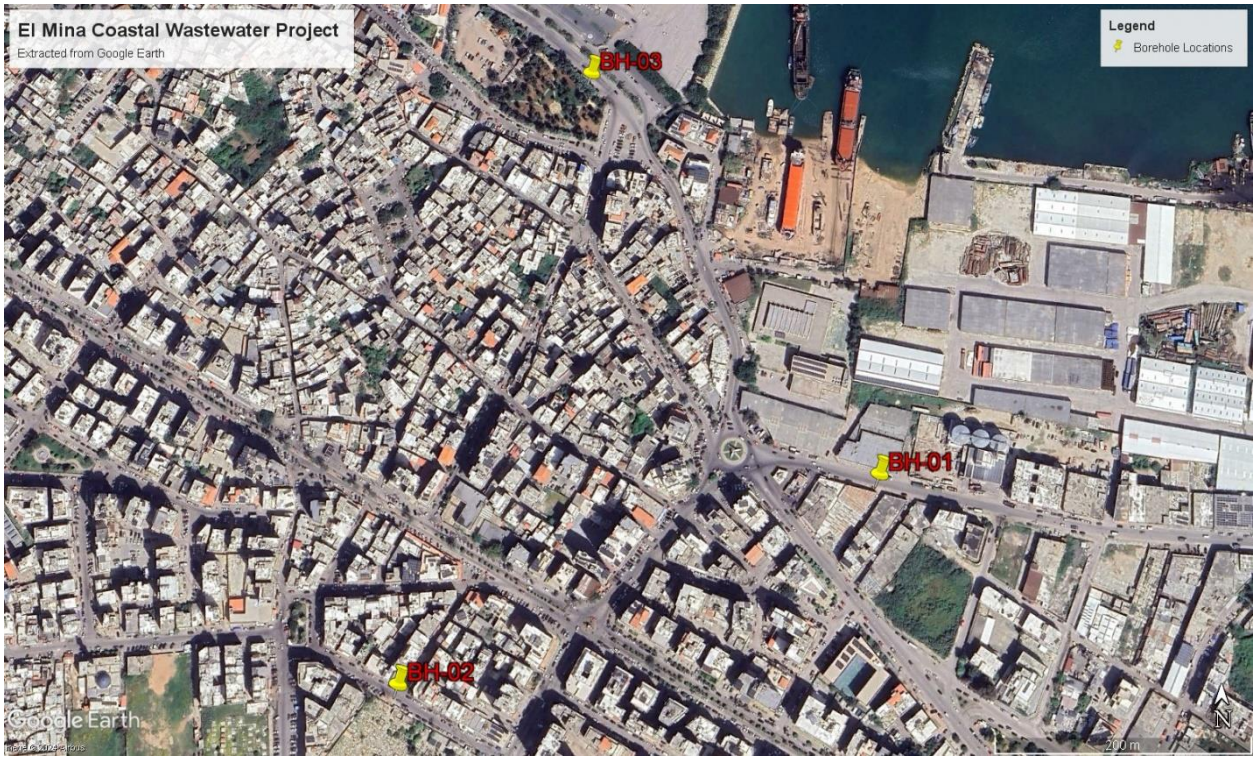

Figure 2: Aerial View of the Borehole Locations from Google Earth

2.2. Project Resources and Organization

In order to complete the above scope, **ACTS** mobilized one (01) drilling rig to the project site along with the necessary tools and competent personnel in order to supervise, coordinate the site activities and to carry out the required in-situ tests, if any. The rig selected for this operation was the drilling rig CME equipped with an automatic SPT hammer and a wire-line system for soil samples retrieval.

2.3. Surveying – Setting Out

The coordinates of the exploratory holes were provided and specified by **BTD**. Setting out was carried out by ACTS in accordance with BS 5930:2015 using a DGPS system connected to UTM with an accuracy less than 30 cm did setting out at each location.

The above survey is in accordance with the Universal Transversal Mercator coordinate system (UTM) for the reported horizontal coordinates and for the reported elevations m MSL (Mean Sea Level).

2.4. Drilling of Boreholes

Regular sampling using Standard penetration test (SPT) was carried out in soil and continuous coring in the rock was carried out using HQ type double barrel (with the use of appropriate bits to prevent the washing of erodible material during coring and maintaining best recovery possible). The retrieval of the samples was done using a wireline system. Fresh non-saline water was used as a flushing medium. The casing was used to support the borehole sides to prevent any collapse.

The final borehole depth, as well as the groundwater table level, were measured and verified during and at the end of each boring using a dip meter. It is important to highlight that no groundwater table is encountered.

2.5. Sampling

Sampling of soil and rock was carried out in accordance with BS 5930: 2015. The project number, borehole number, depth of sample, and the date of sampling labeled the retrieved samples. The retrieved samples were transferred to ACTS Warehouse upon completion of each borehole.

2.5.1. SPT Samples

Standard penetration test (SPT) was carried out in accordance with BS EN ISO 22476-3. The disturbed soil samples retrieved from the split spoon were placed immediately in airtight plastic bags for classification purposes. The weight of these samples was varying depending on the length penetrated and the quantity retrieved from the split spoon.

2.5.2. Rock Core Samples

Upon removal of the inner split barrel the core was placed in a core box such that the cores are retained in position. The retrieved cores were wrapped with thick layers of plastic cling film. The core depths (Top and Base) were marked on the core box. Wooden spacers were placed at the top and base of each core run. The cores were examined and logged in accordance with BS 5930:2015 (Code of practice for site investigation), and BS EN ISO 14689-1. In addition, Total Core Recovery (TCR), Solid Core Recovery (SCR) and Rock Quality Designation (RQD) were measured on site.

Upon receipt of the client's approval, the core boxes were transported to ACTS Warehouse for storage purposes and to protect them against sunlight, drying and vibration. Afterwards then the core boxes were photographed using a digital camera. The photographs were taken with legible identification labels, scale and a standard color reference chart clearly visible.

2.6. Logging Procedure

The logging and description of soil samples was carried out in accordance with BS 5930:2015 (Code of practice for site investigation) & BS EN ISO 14688 for soil. The borehole logs, core box photos and geological cross section are presented in **Appendix A, B, & C.**

2.7. Backfilling of the Boreholes

Upon completion of the field works, the boreholes were backfilled with the arisings.

3. REGIONAL GEOLOGY

Lebanon extends along the eastern coast of the Mediterranean Sea ("Levantine margin") and covers a surface area of 10,450 sq. km. The Lebanon area has been divided since antiquity into three NNE-SSW aligned zones. From west to east these are:

- Mount Lebanon
- The elevated upland basin of the Bekaa
- The Anti-Lebanon Range, which includes Mount Hermon at its southern end

These mountain ranges are major uplifts, with Late Cretaceous rocks forming the highest point of Mount Lebanon at 3,088 m, and Middle Jurassic rocks forming the summit of Mount Hermon at 2,814 m. These three meso-structural features correspond, in essence, to two Jurassic cored anticlinoria, separated by a Neogene-infilled Bekaa synclinorium. Regional-scale tectonic elements in Lebanon include the Palmyride Basin, Levant Fault System, Levantine Margin, and the Syrian Arc fold belt. These elements have played an important role in defining the present-day structural and stratigraphic setting of the country.

A general geologic survey of the site and its surrounding area was conducted, coupled with a review of the geological maps. The site is located in El Mina, North Lebanon. A review of the available geological maps indicates that the subsurface will mainly comprise of Alluvial deposits (alluvions actuelles) refer to sediment or materials deposited by flowing water with alternation of fixed dunes (Sand) "q_d" &"a". The location of the site superimposed over the geological map produced by Dubertret is presented in **Figure 3** below.

Lebanon is cut by several major and minor faults with different scales as shown in **Figure 4**. The longest and main fault in Lebanon is the Yammouneh Fault that runs SSW-NNE along the western margin of the Bekaa and links the major fault of the Jordan Valley to the Ghab Valley Fault of Northern Syria. This is a lateral, or strike slip fault and it represents the Lebanese segment of the Dead Sea Transform Fault. It originated around 12 to 10 million years ago as the boundary between the Arabia Plate and the Levantine part of the African Plate due to the opening of the Red Sea. Another major fault system is the Mount Lebanon Thrust fault which is mainly offshore and runs under the entire western flank and coast of Mount Lebanon. It is an active, east dipping fault that runs just off the coast of Lebanon and goes all the way inland towards Tripoli and is around 100 to 150 kms long. Because it is in large parts underwater, the earthquakes produced by this fault line can generate tsunamis.

The area of investigation is located close to the Mount-Lebanon Thrust fault and close to Yammouneh Fault. Therefore, the site is considered relatively close from the seismic activity. Minor inactive faults also exist around the site. In fact, the violent shaking that would result from any earthquake would affect not only the structures immediately adjacent to the epicenter, but also those within distances of several kilometers from it. Minor earthquakes events are indeed very frequent in Lebanon on the seabed between Cyprus and Lebanon and along the Lebanese coast due to the Mount-Lebanon Thrust Fault, the Roum Fault and the Yammouneh Fault.

It is, therefore, recommended that seismic considerations be taken in the analysis and design of the foundations and structure systems.

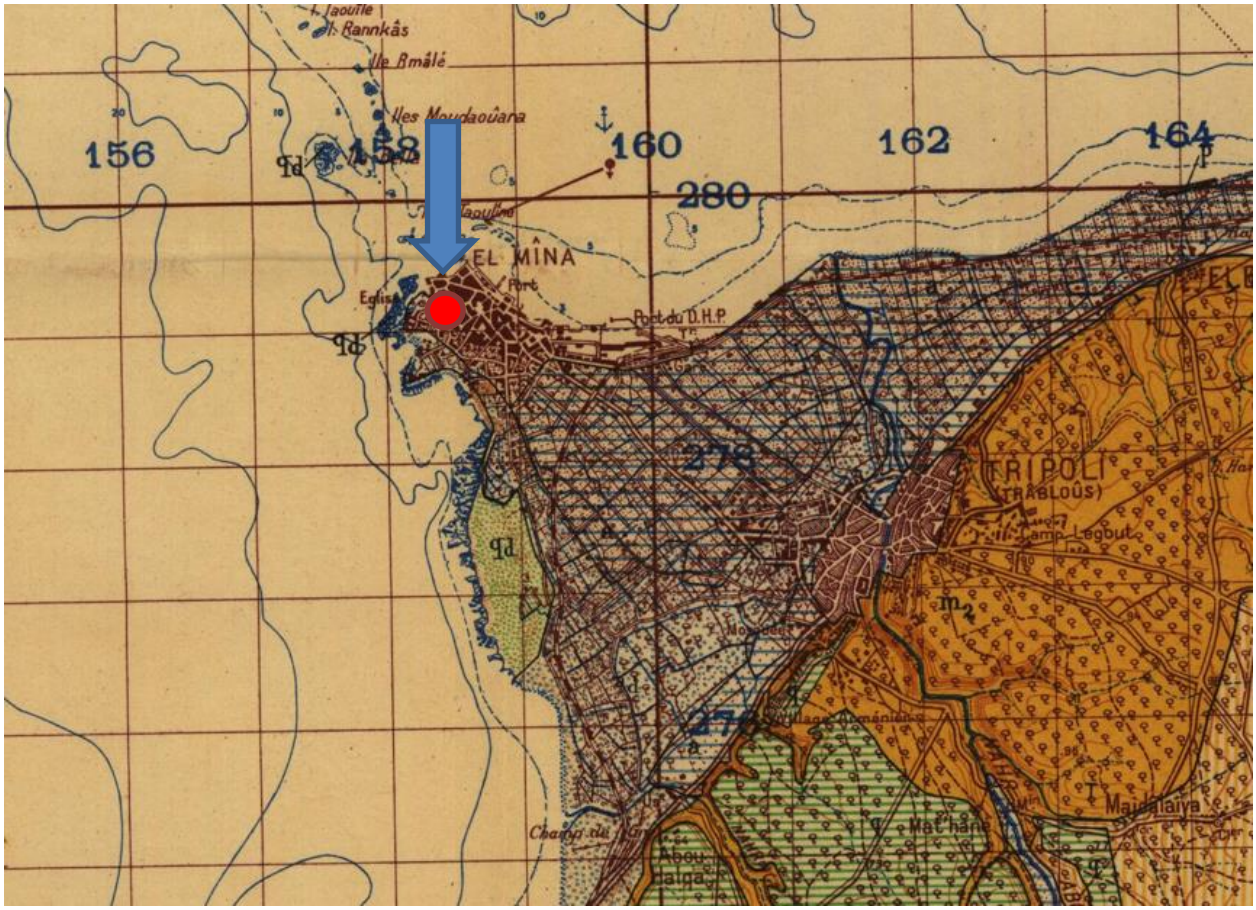

Figure 3: Geological Map by Dubertret (1945)

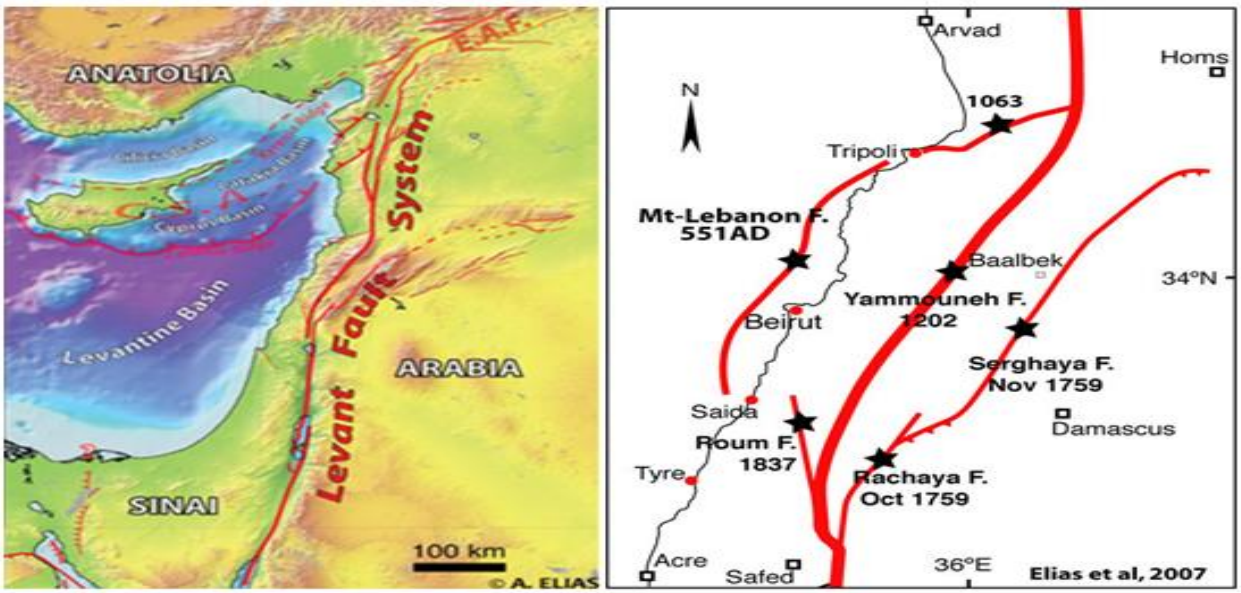

Figure 4: Structural Map of Lebanon.

4. LABORATORY TESTING

Upon completion of the site works, laboratory testing programs were prepared in accordance with the project specifications and the approved Bill of Quantities. Afterwards, the testing programs were provided to the laboratory along with the selected samples. All necessary geotechnical laboratory testing was carried out on selected soil samples recovered from the boreholes in order to determine the physical, chemical and strength properties of the ground materials. The scope of the completed laboratory testing with the used standard test methods are summarized in **Table 2** below.

Table 2: List of Laboratory Tests

Type	Test	Standard Test Method	Completed Quantity
Soil	Sieve Analysis	ASTM D422 & ASTM D1140	06
	Atterberg Limits	ASTM D4318	06
Chemical	pH of Soil	BS EN 1377 P3	01
	Water Soluble Chloride Content in Soil	BS EN 1377 P3	01
	Water Soluble Sulfate Content in Soil	BS EN 1377 P3	01

The completed laboratory test results along with their summaries are presented in **Appendix F**.

Table 3: Summary of Completed Soil Laboratory Tests

Test	Unit	No. of Tests	Min.	Max.	Average	Standard Deviation
PSD – Gravel	%	06	0.80	41.30	13.00	15.53
PSD – Sand	%	06	19.30	77.10	45.95	25.39
PSD – Fines	%	06	10.80	75.40	41.05	24.34
LL	%	06	31.00	43.00	37.33	4.76
PL	%	06	17.00	20.00	18.50	1.05
PI	%	06	13.00	24.00	18.83	4.26

Table 4: Summary of Core Recoveries

Test	Unit	No. of Tests	Min.	Max.	Average	Standard Deviation
TCR	%	02	75.00	82.00	78.50	4.95
SCR	%	02	55.00	60.00	57.50	3.54
RQD	%	02	45.00	55.00	50.00	7.07

Table 5: Summary of Completed Soil Chemical Laboratory Tests

Test	Unit	No. of Tests	Min.	Max.	Average	Standard Deviation
pH for Soil	-	01	7.80	7.80	-	-
Water Soluble Chloride Content in Soil	%	01	<0.002	<0.002	-	-
Water Soluble Sulphate Content in Soil	mg/L	01	345.0	345.0	-	-

5. IN-SITU TESTS

5.1. Standard Penetration Test

Standard Penetration Test (SPT) was carried out mostly in the superficial deposits when encountered as well as on rock strata, where low core recovery and very poor RQD's were encountered. The test was carried out in accordance with BS EN ISO 22476-3 to assess the relative densities of the ground materials. The SPT hammers used were of the type incorporating an automatic trip mechanism to ensure free fall. When the test was performed in gravelly material or highly to completely weathered rock, a 60° cone replaced the driving shoe of the split spoon sampler and the N-values extended up to 100 blows.

The SPT's were corrected for the hammer efficiency based on the equation below:

$$N_{60} = \frac{N.\eta_H.\eta_B.\eta_S.\eta_R}{60} \qquad \text{(Equation 1)}$$

Where:

N	SPT blows for the 300mm, N field.
η_H	Hammer Efficiency, equals to 60%.
η_B	Correction for Borehole Diameter, equals to 1.
η_S	Sampler Correction, equals to 1.
η_R	Correction for Rod length, varies with depth.

The standard penetration tests along with the corrected values are presented in **Appendix D.**

5.2. Falling Head Permeability Test

Three (03) Nos. of Falling Head Permeability tests were performed in the drilled boreholes. The tests were in accordance to BS 5930:1999+A2:2010, Section 25.4. The results were analyzed using the time lag method after Hvorslev as detailed below. A summary of the results of the falling head water test are presented in **Table 6** below and provided in **Appendix E.**

Table 6: Falling Head Permeability Test Results

Borehole No	Test Depth [m bEGL]	Test Elevation [m MSL]	Test Stratum	K_1 [m/s]	K_2 [m/s]
BH-01	7.00	-5.50	Clay	1.18E-05	9.34E-06
BH-02	7.00	-3.64	Clay	8.57E-05	3.49E-05
BH-03	7.00	-4.85	Clay	1.03E-04	2.03E-05

K_1: time lag method
K_2: general approach

A permeability value of **1.00E-04 m/s** will be taken in the design for the Clay layer encountered at shallow depth. And an estimated permeability value of **1.00E-07 m/s, 1.00E-05 m/s and 5.00E-04 m/s** will be taken for Clay (at deep depth), Sandstone and Gravelly Cobbles layers respectively.

6. LOCAL GEOLOGY AND GROUND STRATIGRAPHY

The information obtained from field works and laboratory testing indicates that the subsurface stratigraphy generally consists of three (03) geologic units. It should be noted that the connotation provided in **Table 7** was used. Each unit might have a sub-set depending on the type of material encountered. It should be noted that unit 4 below was not encountered in the boreholes.

Table 7: Connotation for Lithological Units

Unit #	General Behavior
1	Fill Materials /Cohesionless Soils
2	Cohesive Soils
3	Highly Weathered Rock – Low Core Recoveries
4	Highly to Slightly Weathered Rock – High Recoveries *(not encountered in current investigation*

The detailed descriptions of the lithological units are provided below.

GRAVELLY COBBLES: The top layer encountered in all exploratory boreholes consists of man-made ground going down to a depth of 1.50m bEGL and can be described as light brownish white, gravelly cobbles of mainly Limestone. Moreover, a layer of gravelly cobbles was then encountered in BH-01 extending down from 6.50m bEGL to a depth of 8.00m bEGL.

CLAY: Underlying the made ground a layer of Clay was encountered in BH-01 extending down to a depth of 6.50m bEGL and in BH-02 and BH-03 extending down to a depth 3.00m bEGL. It can be described as light to dark brown, Clay. This layer was then encountered in the drilled boreholes extending down from 8.00m bEGL in BH-01 and from 6.00m bEGL in BH-02 and BH-03 to the bottom of the investigatory depths.

SANDSTONE: Below the Clay layer was encountered in BH-02 and BH-03 extending down from 3.00m bEGL to a depth 6.00m bEGL. This layer can be described as extremely weak to medium strong, light grey to light brown, Sandstone, highly weathered and fractures are closely spaced.

7. GROUND MODEL

7.1. General

Referring to **Section 6**, one (01) idealized subsurface profile will be used to model the ground conditions. The idealized subsurface profile was based on the changes in material composition, behavior, relative strength and density. The same along with the corresponding permeability coefficients are provided in **Table 8** below.

Table 8: Idealized Subsurface Profile

Layer No.	Soil Description	Depth [m bEGL]		Thickness [m]	Permeability Coefficient, k [m/s]
		Top	Bottom		
1	Gravelly Cobbles	0.00	2.00	2.00	5.0E-04
2	Clay	2.00	4.00	2.00	1.0E-04
3	Gravelly Cobbles	4.00	6.50	2.50	5.0E-04
4	Clay	6.50	EoID*	-	1.0E-07

** End of Influence Depth*

It should be noted that although the groundwater table was encountered at an approximate depth of 1.09m bEGL to 3.25m bEGL, the design groundwater table will be taken at a depth of 0.5m bEGL.

7.2. Groundwater Table

Table 9 shows the design water depths and elevations in each borehole that shall be incorporated in the design calculations. The most critical water depth was adopted considering ±1 meter to account for seasonal fluctuations.

The design groundwater table was computed as follows:

- Design Groundwater Value = Highest recorded ground water table depth - 1.0m (to account for possible fluctuations from seasonal and tidal variations).

Table 9: Design Ground Water Depths and Elevations

Borehole No.	Water Depth [m bEGL]	Water Elevation [m MSL]	Design Water Depth [m bEGL]	Design Water Elevation [m MSL]
BH-01	1.09	+0.41	0.09	+1.41
BH-02	1.93	+1.44	0.93	+2.44
BH-03	3.25	-1.10	2.25	-0.10

It should be noted that the water table depths and elevations provided above correspond to water strike depths and elevations which are influenced by the drilling water etc…

7.3. Karst Features / Cavities

Open karst features/ cavities were not encountered within the drilled depths at the time of the investigation. Nevertheless, it should be noted that cavities could be encountered within the

project site since the boreholes logs and related information represent the subsurface conditions only at the specified borehole's locations and the time at which the investigation was carried out

8. DEWATERING ANALYSIS

8.1. General

The analysis will be carried out for three excavation sections having the following dimensions:

➢ **Section 1**

- Excavation Width = 4.62m
- Excavation Length = 100.00m
- Excavation Depth = 7.00m bEGL

➢ **Section 2**

- Excavation Width = 3.87m
- Excavation Length = 100.00m
- Excavation Depth = 6.00m bEGL

➢ **Section 3**

- Excavation Width = 3.47m
- Excavation Length = 100.00m
- Excavation Depth = 5.00m bEGL

➢ **Section 4**

- Excavation Width = 3.07m
- Excavation Length = 100.00m
- Excavation Depth = 4.00m bEGL

➢ **Section 5**

- Excavation Width = 2.77m
- Excavation Length = 100.00m
- Excavation Depth = 3.00m bEGL

➢ **Section 6**

- Excavation Width = 2.47m
- Excavation Length = 100.00m
- Excavation Depth = 2.00m bEGL

8.2. Dewatering System Analysis Assumptions

The following assumptions were adopted in the design and analysis of dewatering system:

- Ground Conditions: As presented in **Section 7**.
- Design Excavation Depth: ≈ 7.00m bEGL for Excavation Section 1.
  ≈ 6.00m bEGL for Excavation Section 2.
  ≈ 5.00m bEGL for Excavation Section 3.
  ≈ 4.00m bEGL for Excavation Section 4.
  ≈ 3.00m bEGL for Excavation Section 5.

≈ 2.00m bEGL for Excavation Section 6.

- Required Drawdown: 0.5m below the 20.0mm single size aggregate layer
- Design Ground Water: 0.5m bEGL.
- Isotropic Ground Conditions: (i.e $k_v = k_h$) ~ Conservative
- Ground Water Flow Conditions: Steady State Seepage
- Software: Slide v6.0
- Boundary Conditions: A constant total head of 0.5m was considered, as presented in **Figure 5** to **Figure 10**.

Seepage analysis was performed using the software *Slide v6.0*, a 2D Finite element software. A steady state seepage analysis was carried out in order to determine the required pump flow to achieve dry conditions inside the excavation. It should be noted that the calculation of seepage induced settlements is outside the scope of this report.

In the analysis conducted, a passive dewatering method was employed to manage groundwater in the excavation site. This was achieved by positioning each pump at 0.5 meters below the bottom of the excavation, with a layer of gravel of 20.0cm thickness placed on the top of the pump to act as a filter. The purpose of this method is to prevent the direct entrance of groundwater into the trench, while the pump worked to passively remove any accumulated water. This approach effectively maintained a dry working environment, enhancing safety and efficiency during excavation operations.

8.3. Analysis Results

Based on the above, the groundwater ingress volumes from the bottom of the excavation and drawdowns on the backside of the excavation wall (from crest of slope) are presented below. The detailed analysis is presented in **Appendix G**.

Table 10: Recommendations for Number of Required Pump with the Corresponding Flow

Excavation No.	Width [m]	Length [m]	Depth [m]	Drawdown [m]	$Q_{t/m\ length}$ [m^3/day/m]	$Q_{t,\ excavation}$ [m^3/d]	Nos of pumps	Q_p [m^3/d]	Q_p [m^3/h]
1	4.62	100.0	7.0	7.5	80	8,000	16	500	21
2	3.87	100.0	6.0	6.5	33	3,300	7	472	20
3	3.47	100.0	5.0	5.5	30	3,000	7	428	18
4	3.07	100.0	4.0	4.5	23	2,300	5	460	20
5	2.77	100.0	3.0	3.5	27	2,700	6	450	19
6	2.47	100.0	2.0	2.5	18	1,800	4	450	19

$Q_{t/m\ Length}$ = Flow per Linear Meter

$Q_{t,\ excavation}$ = Total Flow Across Trench = $Q_{t/m\ Length}$ x Length

Q_p = Flow per Pump = $Q_{t,\ excavation}$ / Nos of pumps

The above represents the required capacities for each pump installed at 0.5m below the bottom of each excavation.

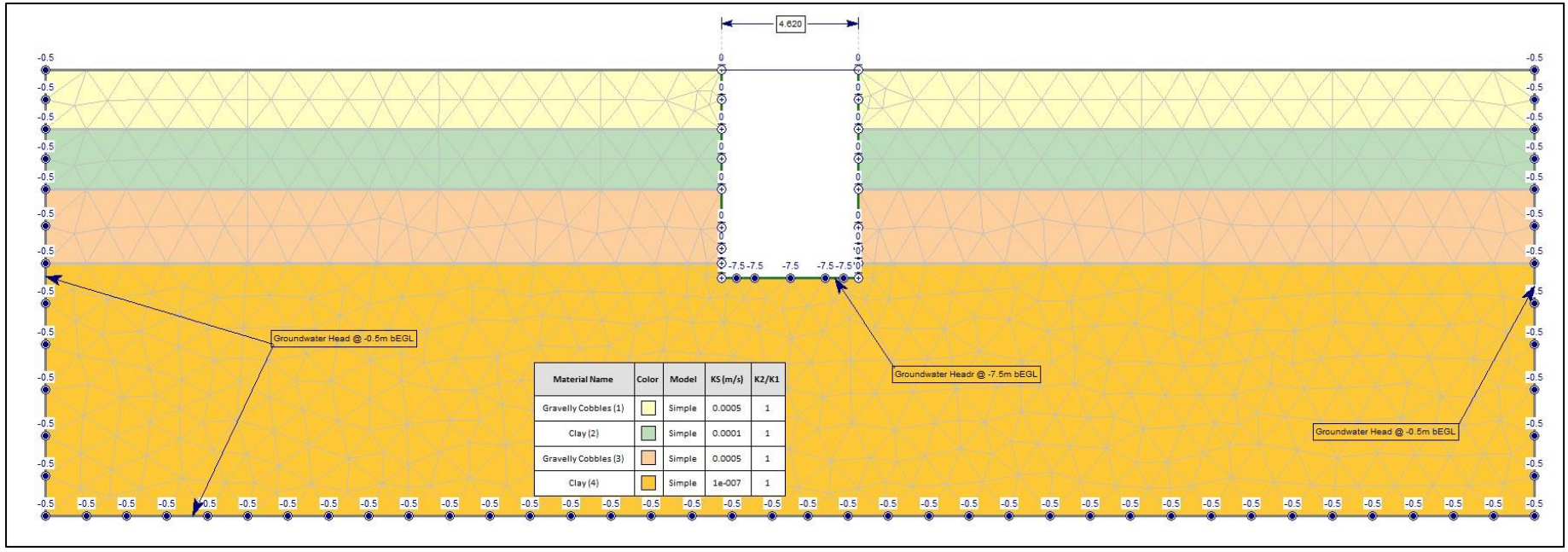

Figure 5: Section Geometry & Boundary Conditions – Excavation Section 1

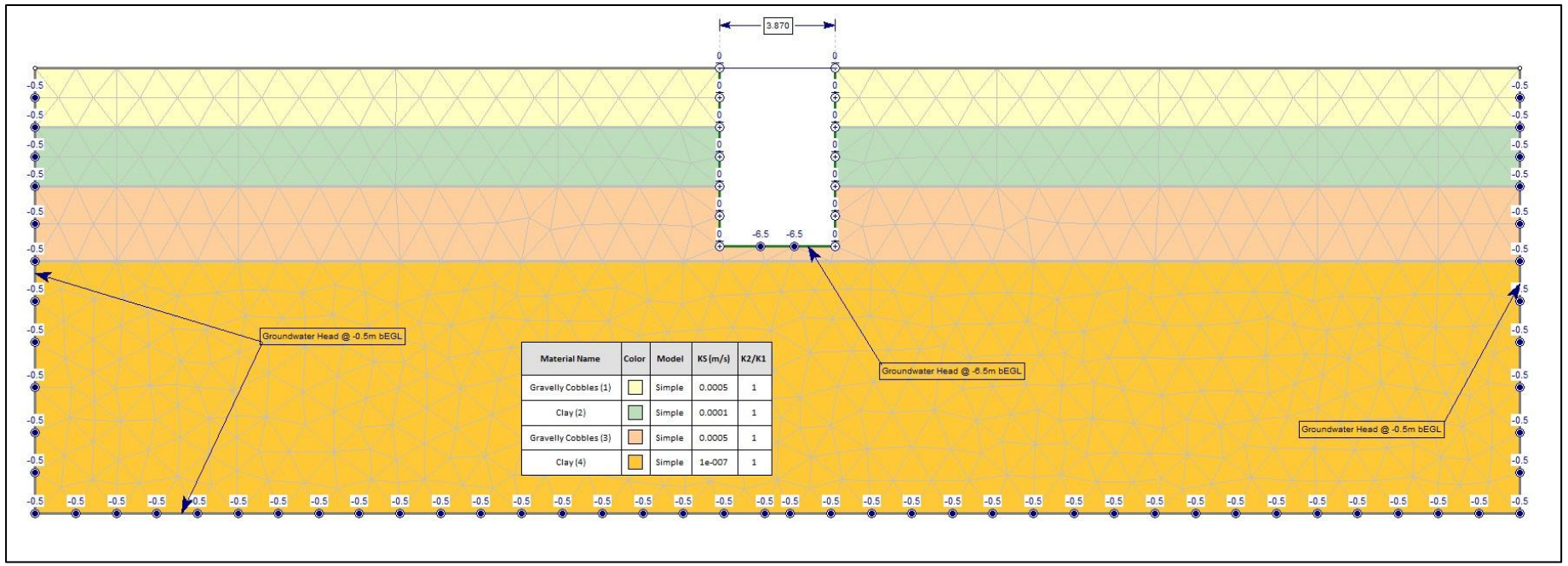

Figure 6: Section Geometry & Boundary Conditions – Excavation Section 2

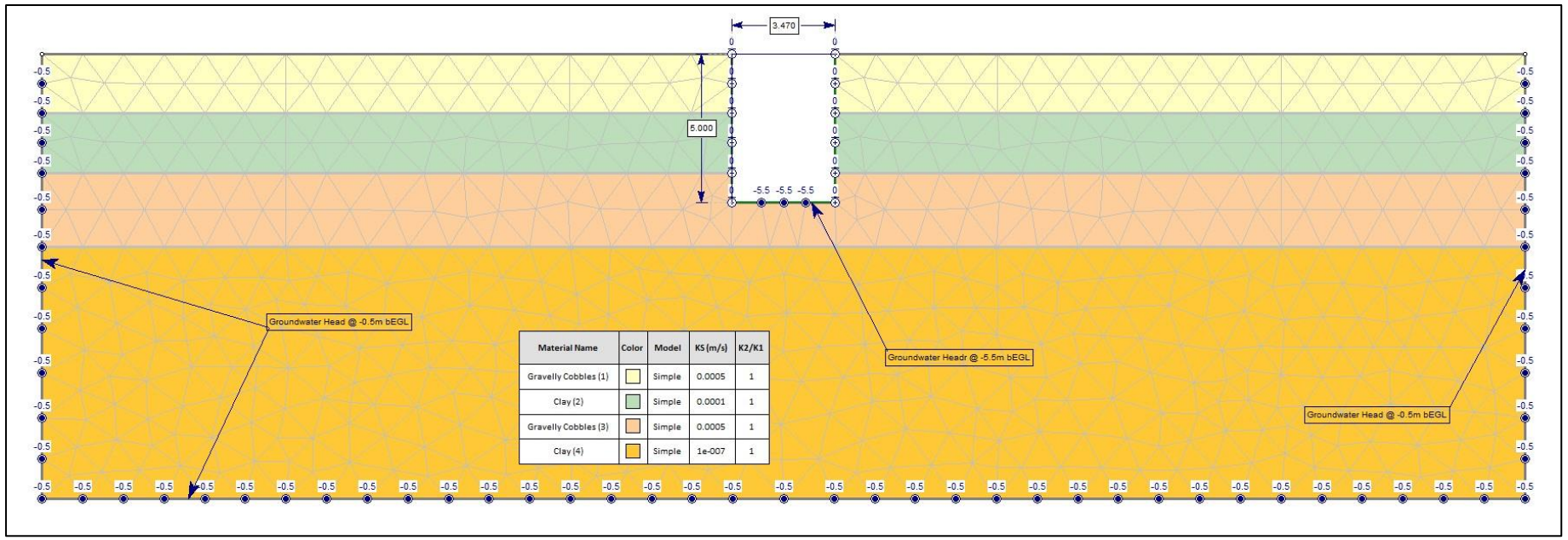

Figure 7: Section Geometry & Boundary Conditions – Excavation Section 3

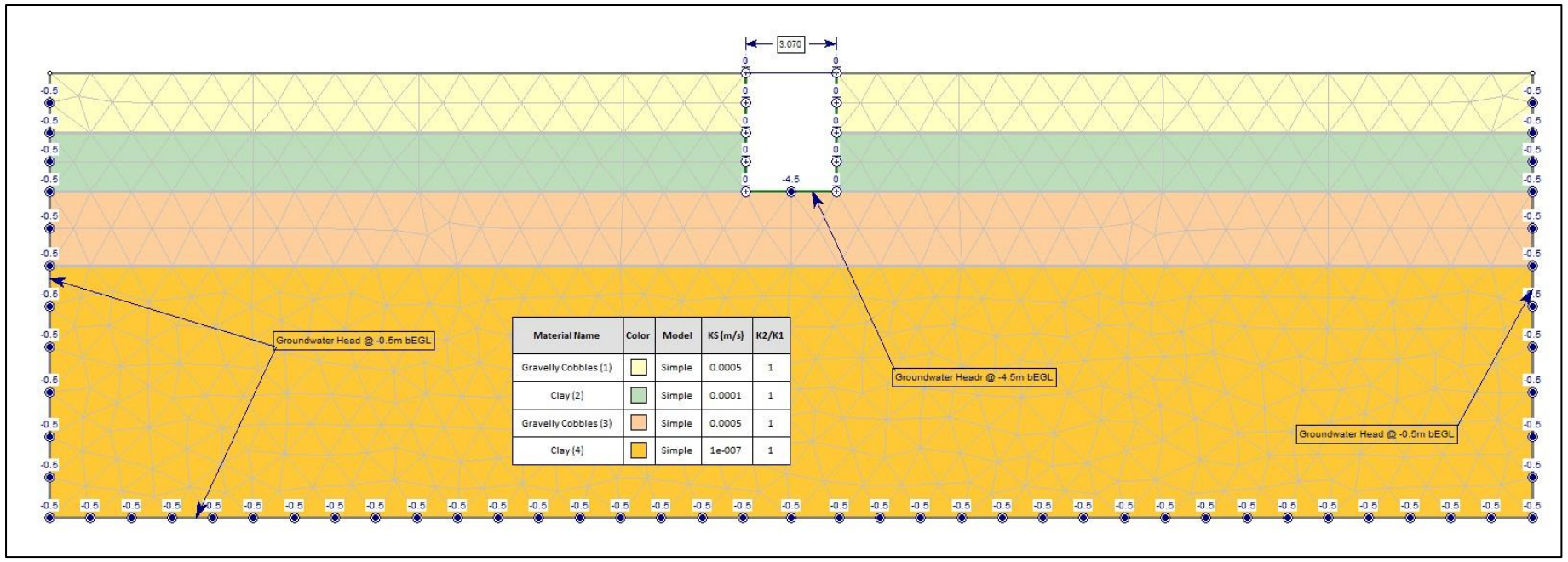

Figure 8: Section Geometry & Boundary Conditions – Excavation Section 4

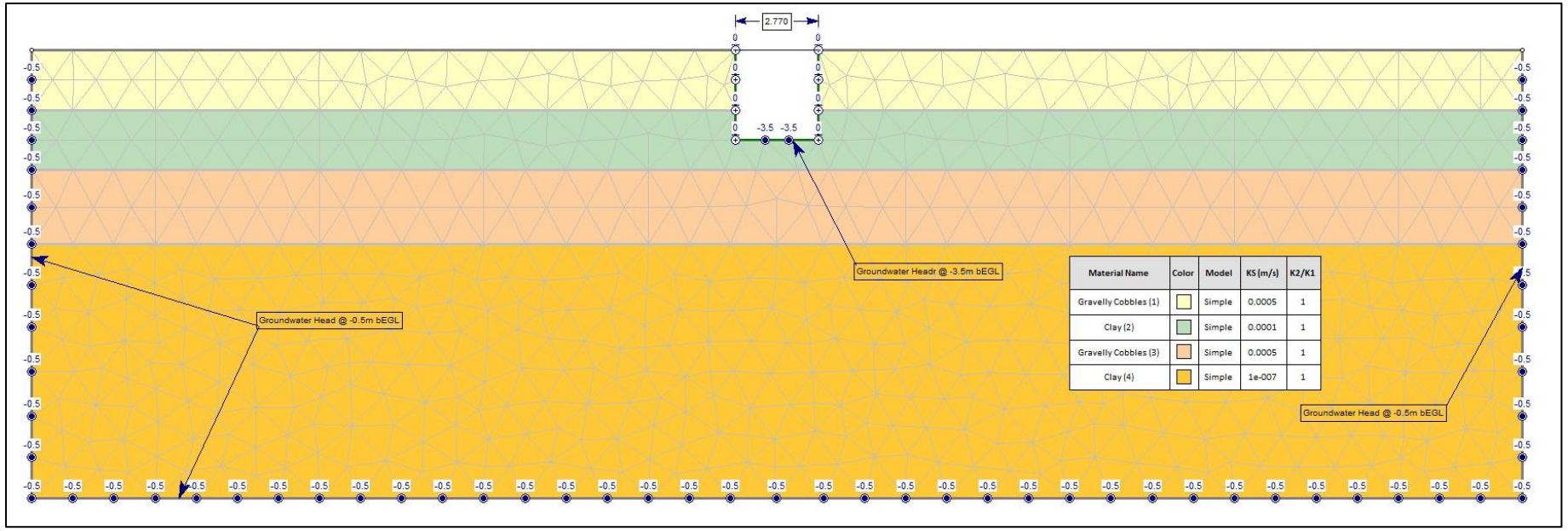

Figure 9: Section Geometry & Boundary Conditions – Excavation Section 5

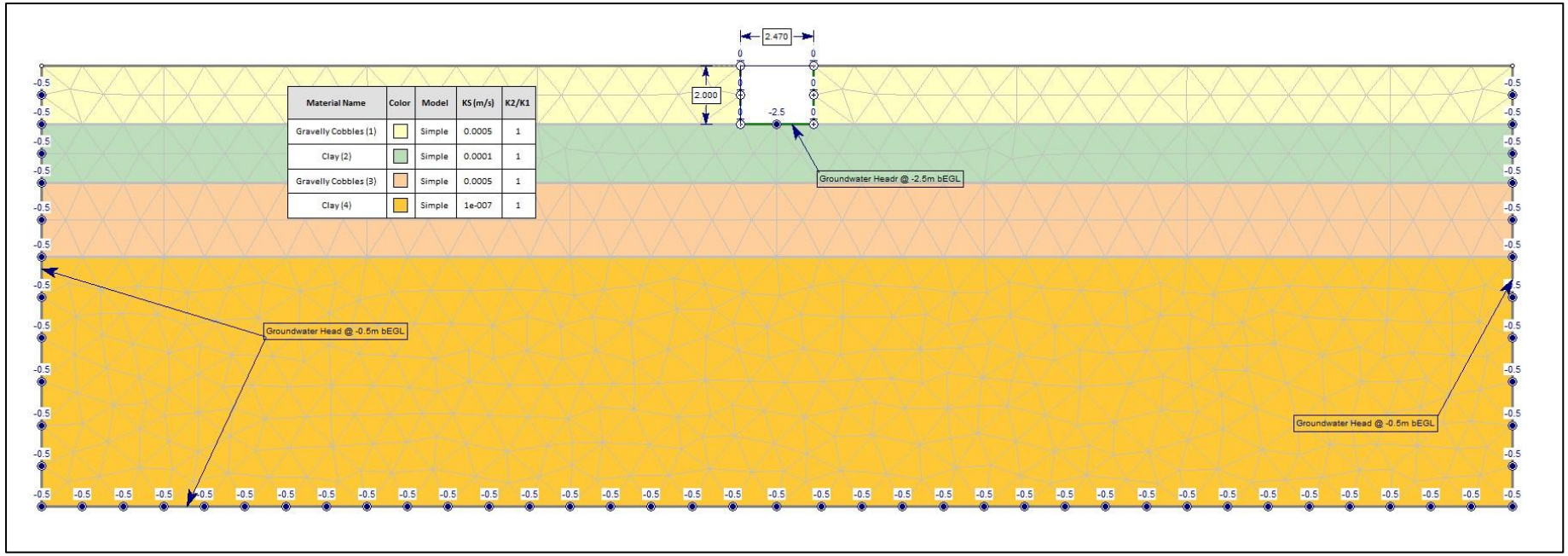

Figure 10: Section Geometry & Boundary Conditions – Excavation Section 6

9. CONCLUSION AND RECOMMENDATIONS

Based on the request of **BTD**, ACTS have carried out a dewatering assessment for the temporary works required for the construction of the **El Mina Coastal Wastewater Project**. The dewatering assessment was based on the ground investigation campaign carried out on March 25, 2024.

Using the above a steady state seepage analysis was carried out using the software Slide v6.0. The analysis indicates that the groundwater ingress to the excavation will be in the order to:

- 8,000 m^3/day in Excavation Section 1.
- 3,300 m^3/day in Excavation Section 2.
- 3,000 m^3/day in Excavation Section 3.
- 2,300 m^3/day in Excavation Section 4.
- 2,700 m^3/day in Excavation Section 5.
- 1,800 m^3/day in Excavation Section 6.

As outlined in **Section 8**, a passive dewatering approach is recommended by placing each pump at 0.5m below the bottom of the excavation with a layer gravel of 20.0cm thickness on the top of the pump.

As such, it is proposed to install:

- Sixteen (16) Nos. of pumps at 0.5m below the bottom of the Excavation Section 1.
- Seven (07) Nos. of pumps at 0.5m below the bottom of the Excavation Section 2.
- Seven (07) Nos. of pumps at 0.5m below the bottom of the Excavation Section 3.
- Five (05) Nos. of pumps at 0.5m below the bottom of the Excavation Section 4.
- Six (06) Nos. of pumps at 0.5m below the bottom of the Excavation Section 5.
- Four (04) Nos. of pumps at 0.5m below the bottom of the Excavation Section 6.

Moreover, the flow of each pump will be in the order of:

- 5.8 l/sec in Excavation Section 1.
- 5.5 l/sec in Excavation Section 2.
- 5.0 l/sec in Excavation Section 3.
- 5.4 l/sec in Excavation Section 4.
- 5.2 l/sec in Excavation Section 5.
- 5.2 l/sec in Excavation Section 6.

Appendix A – Borehole Logs

BOREHOLE LOG

Borehole No: BH-01	**Date Started:** 27-03-24	**Depth of Casing:** NIL
Borehole Depth: 10m	**Date Finished:** 27-03-24	**ID Dia. of Casing:** NIL
Project Name: El Mina Costal Wastewater Project		**Borehole Log Scale** 1:50
Sheet 1 of 1	**Project No:** Q27015	**Location:** Mina - North Lebanon	**Client Name:** BTD

Logged by/date: G.R- 30/03/24	**Type of Boring:** Rotary Cored	**Positioning:** GPS	**Coordinates**	**North (Y-m):**	3815514.59
Checked by/date: M.M- 15/04/24	**Dia. of Boring:** 96mm	**Drilling Fluid:** water		**East (X-m):**	759114.36
Drilled by: A.H	**Core Barrel Type:** HQ	**Piezometer:** N/A		**Level (m):**	1.50
Rig Type: CME	**Core Diameter:** 63mm	**GWT (mbGL):** 1.09	**Grid:** UTM	**Datum:** MSL	

Scale (m)	Sample Type & Ref	UDS	TCR (%)	SCR (%)	RQD (%)	FI	SPT Blows/75mm	SPT N Value	N60	Depth of GWT (m)	Description & Remarks	Level (m)	Depth (m)	Legend
0.5	RC-1										A layer of Asphalt with thikness of 10 cm. [Asphalt]	1.40	0.10	
											light brownish white Gravelly Cobbles off mainly Limestone. [Gravelly Cobbles]			
1.0										1.09 m 30/03/24		0.50	1.00	
1.5	SPT-1						5,0/8,0,11,0	19			Dark brown, Clay, cohesive. [Clay]			
2.0	RC-2													
2.5														
3.0	SPT-2						2,0/2,0,3,0	5						
3.5	RC-3													
4.0														
4.5	SPT-3						1,0/2,0,4,0	6						
5.0	RC-4													
5.5														
6.0	SPT-4						8,0/14,0,19,0	33				-5.00	6.50	
6.5	RC-5										light brownish white Gravels off mainly Limestone. [Gravel]	-5.50	7.00	
7.0											light brownish white Gravelly Cobbles off mainly Sandstone. [Gravelly Cobbles]			
7.5												-6.50	8.00	
8.0	SPT-5										Light brown, Clay, cohesive. [Clay]			
8.5														
9.0	RC-6						5,0/2,0,2,0	4						
9.5	SPT-6											-8.50	10.00	

Remarks:

END OF BOREHOLE @ 10.00m

Legend:

SPT: Standard Penetration Test
C : Core Sample
SPT(C) : SPT(Cone)
B : Bulk Disturbed Sample
U : Undisturbed Sample
NI : Non Intact Core
TCR: Total Core Recovery
SCR: Solid Core Recovery
RQD: Rock Quality Designation
GWT: Ground Water Table
FI : Fracture Index
FR : Flush Return

BOREHOLE LOG

ACTS Build on our credentials	**Borehole No:** BH-02	**Date Started:** 28-03-24	**Depth of Casing:** NIL
	Borehole Depth: 7m	**Date Finished:** 28-03-24	**ID Dia. of Casing:** NIL
	Project Name: El Mina Costal Wastewater Project		**Borehole Log Scale** 1:50
Sheet 1 of 1	**Project No:** Q27015	**Location:** Mina - North Lebanon	**Client Name:** BTD

Logged by/date: G.R- 30/03/24	**Type of Boring:** Rotary Cored	**Positioning:** GPS	**Coordinates**	**North (Y-m):**	3815341.29
Checked by/date: M.M- 15/04/24	**Dia. of Boring:** 96mm	**Drilling Fluid:** water		**East (X-m):**	758738.27
Drilled by: A.H	**Core Barrel Type:** HQ	**Piezometer:** N/A		**Level (m):**	3.37
Rig Type: CME	**Core Diameter:** 63mm	**GWT (mbGL):** 1.93	**Grid:** UTM	**Datum:** MSL	

Scale (m)	Sample Type & Ref	UDS	TCR (%)	SCR (%)	RQD (%)	FI	SPT Blows/75mm	SPT N Value	N60	Depth of GWT (m)	Description & Remarks	Level (m)	Depth (m)	Legend
0.5	RC-1										light brownish white Gravelly Cobbles off mainly Limestone. [Gravelly Cobbles]	2.17	1.20	
1.0											Dark brown, Clay, cohesive. [Clay]	1.87	1.50	
1.5	SPT-1						3,0/5,0,5,0	10		1.93 m 28/03/24	light brownish white Gravelly Cobbles off mainly Limestone. [Gravelly Cobbles]			
2.0	RC-2											0.57	2.80	
2.5											Light brown, Clay, cohesive. [Clay]	0.37	3.00	
3.0	SPT-2						6,0/9,0,7,0	16			Extremely weak, light grey, Sandstone, highly weathered and fractures are closely spaced. [Sandstone]			
3.5	RC-3											-1.13	4.50	
4.0														
4.5	SPT-3						>50,*/*,*,*,*	>50			Very weak, light brownish grey, Sandstone, highly weathered and fractures are closely spaced. [Sandstone]	-2.43	5.80	
5.0	RC-4													
5.5											Light brown, Clay, cohesive. [Clay]	-3.63	7.00	
6.0	SPT-4						4,0/7,0,10,0	17						
6.5	RC-5													
7.0											END OF BOREHOLE @ 7.00m			
7.5														
8.0														
8.5														
9.0														
9.5														

Remarks:

Legend:

SPT: Standard Penetration Test
C : Core Sample
SPT(C) : SPT(Cone)
B : Bulk Disturbed Sample
U : Undisturbed Sample
NI : Non Intact Core
TCR: Total Core Recovery
SCR: Solid Core Recovery
RQD: Rock Quality Designation
GWT: Ground Water Table
FI : Fracture Index
FR : Flush Return

BOREHOLE LOG EL MINA COSTAL WASTEWATER PROJECT.GPJ SAMIR.GDT 4/30/24

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BOREHOLE LOG

Borehole No: BH-03	**Date Started:** 25-03-24	**Depth of Casing:** NIL	
Borehole Depth: 7m	**Date Finished:** 25-03-24	**ID Dia. of Casing:** NIL	
Project Name: El Mina Costal Wastewater Project		**Borehole Log Scale** 1:50	
Sheet 1 of 1	**Project No:** Q27015	**Location:** Mina - North Lebanon	**Client Name:** BTD

Logged by/date: G.R- 30/03/24	**Type of Boring:** Rotary Cored	**Positioning:** GPS	**Coordinates**	**North (Y-m):**	3815843.31
Checked by/date: M.M- 15/04/24	**Dia. of Boring:** 96mm	**Drilling Fluid:** water		**East (X-m):**	758872.98
Drilled by: A.H	**Core Barrel Type:** HQ	**Piezometer:** N/A		**Level (m):**	2.15
Rig Type: CME	**Core Diameter:** 63mm	**GWT (mbGL):** 3.25	**Grid:** UTM	**Datum:** MSL	

Scale (m)	Sample Type & Ref	UDS	TCR (%)	SCR (%)	RQD (%)	FI	SPT Blows/75mm	SPT N Value	N60	Depth of GWT (m)	Description & Remarks	Level (m)	Depth (m)	Legend
0.5	RC-1										A layer of Asphalt with thikness of 10 cm. [Asphalt]	2.00	0.15	
1.0											light brownish white Gravels off mainly Limestone. [Gravel]			
1.5	SPT-1						4,0/5,0,5,0	10				0.65	1.50	
											Very weak, light brown, Sandstone, highly weathered and fractures are closely spaced. [Sandstone]			
2.0												0.15	2.00	
2.5	RC-2										Dark brown, Clay, cohesive. [Clay]			
3.0	SPT-2						1,0/1,0,2,0	3		3.25 m 28/03/24		-0.85	3.00	
3.5			75	60	55						Medium strong becoming very weak, light brown, Sandstone,porous, highly weathered and fractures are closely spaced. [Sandstone]			
4.0	RC-3													
4.5	SPT-3						>50,*/*,*,*,*	>50						
5.0			82	55	45									
5.5	RC-4													
6.0												-3.85	6.00	
6.5	RC-5										Light brown, Clay, cohesive. [Clay]			
7.0												-4.85	7.00	
7.5											END OF BOREHOLE @ 7.00m			
8.0														
8.5														
9.0														
9.5														

Remarks:

Legend:

SPT: Standard Penetration Test
C : Core Sample
SPT(C) : SPT(Cone)
B : Bulk Disturbed Sample
U : Undisturbed Sample
NI : Non Intact Core
TCR: Total Core Recovery
SCR: Solid Core Recovery
RQD: Rock Quality Designation
GWT: Ground Water Table
FI : Fracture Index
FR : Flush Return

BOREHOLE LOG EL MINA COSTAL WASTEWATER PROJECT.GPJ SAMIR.GDT 4/30/24

Appendix B – Corebox Photos

El Mina Costal Wastewater Project		
ACTS	**Date: 25/03/2024**	
BH-01	**Box 1 (0.00-7.00m)**	**Total Depth: 10.0m**
Client: BTD		

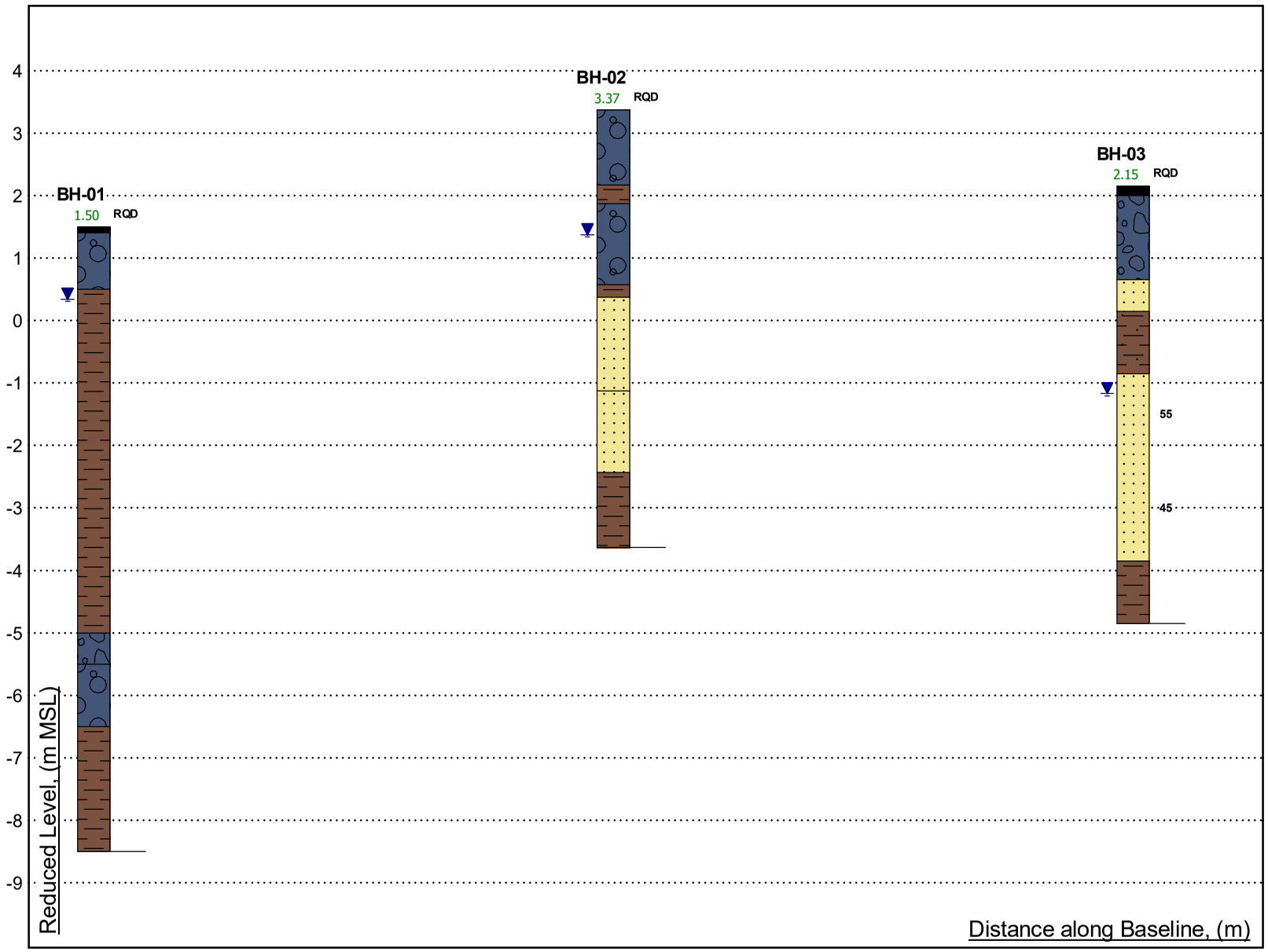
El Mina Costal Wastewater Project		
ACTS	**Date: 27/03/2024**	
BH-01	**Box 1 (6.50-7.00m)**	**Total Depth: 7.0m**
Client: BTD		

El Mina Costal Wastewater Project		
ACTS	**Date: 25/03/2024**	
BH-01	**Box 2 (7.50-8.00m)**	**Total Depth: 10.0m**
Client: BTD		

El Mina Costal Wastewater Project		
ACTS	**Date: 27/03/2024**	
BH-02	**Box 1 (0.00-7.00m)**	**Total Depth: 7.0m**
Client: BTD		

El Mina Costal Wastewater Project		
ACTS	**Date: 27/03/2024**	
BH-03	**Box 1 (0.00-6.50m)**	**Total Depth: 7.0m**
Client: BTD		

Appendix C – Geological Section



LEGEND

- ASPHALT
- Gravelly COBBLES
- CLAY
- GRAVEL
- SANDSTONE
- Sandy CLAY

PLAN VIEW

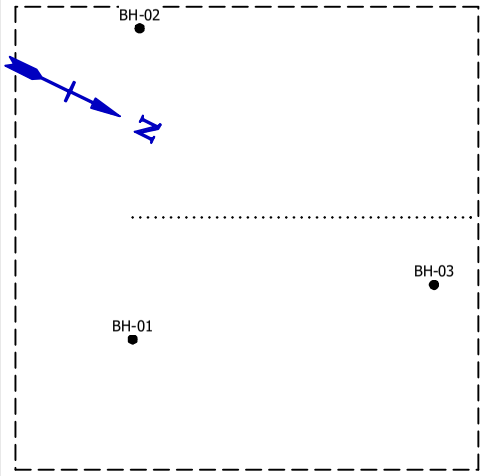


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Figure : LITHOLOGY SECTION		**Client Name:**	BTD
Project Name:	El Mina Costal Wastewater Project	**Project No:**	Q27015
Project Location:	Mina - North Lebanon	**Project Grid:**	UTM **Datum:**

Appendix D – Laboratory Test Results

ACTS ADVANCED CONSTRUCTION TECHNOLOGY SERVICES Build on our credentials	**Project:**	El Mina Coastal Wastewater Project	**Form #:**	GR#00
	ACTS Project # :	Q27015	**Made by:**	ED
	Client:	BTD	**Checked by:**	MS
	Subject:	Soil Lab Testing Results Summary	**Date:**	5/17/2024

BH No.	Depth (m)	Water Content (%)	Sieve Analysis			Hydrometer		Atterberg Limits			Unit Weight [kN/m3]	Specific Gravity	Compaction		CBR [%]	Field Density			UCS-S [kPa]	Consolidation			Direct Shear Test		Triaxial Testing	
			Gravel (%)	Sand (%)	Fines (%)	Silt [%]	Clay [%]	LL (%)	PL (%)	PI (%)			MDD [kN/m^3]	O.M.C [%]		M.C [%]	FDD [kN/m^3]	RC [%]		Cv	P'$_c$ [kPa]	e_0	c [kPa]	ϕ [deg]	c [kPa]	ϕ [deg]
BH-01	3.00-4.00		0.80	54.30	45.00			40.00	20.00	20.00																
BH-01	8.50-9.00		3.30	21.30	75.40			43.00	19.00	24.00																
BH-02	1.00-1.50		1.70	71.80	26.40			33.00	17.00	16.00																
BH-02	5.50-6.00		41.30	31.90	26.80			36.00	19.00	17.00																
BH-03	1.50-3.00		12.10	77.10	10.80			31.00	18.00	13.00																
BH-03	6.00-6.50		18.80	19.30	61.90			41.00	18.00	23.00																

ACTS ADVANCED CONSTRUCTION TECHNOLOGY SERVICES Build on our credentials	**Project:**	El Mina Coastal Wastewater Project	**Form #:**	GR#00
	ACTS Project # :	Q27015	**Made by:**	MAS
	Client:	BTD	**Checked by:**	MS
	Subject:	Chemical Lab Testing Results Summary	**Date:**	5/17/2024

BHNo.	Depth [m]	pH	Organic Content (%)	Sulfite Content (SO3)		Sulfate Content (SO4)		Chloride Content		Carbonate Content (%)	Magnesium Content (%)	Sulfate Content of Water (ppm)	Chloride Content of Water (ppm)	TDS of Water	PH of Water
				Acid soluble SO3 (%)	Water soluble SO3 (mg/L)	Acid soluble SO4 (%)	Water soluble SO4 (mg/L)	Acid soluble Chloride (%)	Water soluble Chloride (%)						
BH-01	3.00-4.00	7.8					345		<0.002						

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Date : 16-Apr-24
Serial No. : 101644
Page 1 of 1

TEST REPORT

Tested at : "ACTS Central Laboratory, Beirut, Sanayeh area, George Assy st. P.O.Box: 14/5918-Code:1105-2080 Tel: 01-737400; Fax: 01-737222"

Client : ACTS GEOTECHNICAL Sanayeh 01-753100

DETERMINATION OF WATER SOLUBLE CHLORIDE & SULFATE (BS EN 1377 P3)

Contractor : ------
Consultant : ------
Project : El Mina Costal Wastewater Project
Sample Type : Soil

Work Order No. : ACTS-2400999
Sample Received on : 8-Apr-24
Sample Tested on : 16-Apr-24
Sampled by : ACTS

Sample Ref.	Source	CHLORIDE (Cl^-)	SULFATE (SO_4^{2-})
		%	mg/l
BH-01 [3.00-4.00m]	BH-01 [3.00-4.00m]	<0.002	345
------	------	------	------
------	------	------	------
------	------	------	------
------	------	------	------
------	------	------	------

Tested by : Rana Karsifi
Chemist

ACTS
ADVANCED CONSTRUCTION TECHNOLOGY SERVICES
P.O.BOX 14/5918 Beirut - Lebanon

Reviewed by : Kassem Salemeh
Chief Chemist

Samples will be disposed after one week from the delivery date of report.

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Date : 16-Apr-24
Serial No. : 101645

TEST REPORT

Tested at : "ACTS Central Laboratory, Beirut,
Sanayeh area, George Assy st.
P.O.Box: 14/5918-Code:1105-2080
Tel: 01-737400; Fax: 01-737222"

Client : ACTS GEOTECHNICAL
Sanayeh
01-753100

DETERMINATION OF pH
(BS 1377-P3)

Contractor : ------
Consultant : ------
Project : El Mina Costal Wastewater Project
Sample Type : Soil

Work Order No. : ACTS-2400999
Sample Received on : 8-Apr-24
Sample Tested on : 15-Apr-24
Sampled by : ACTS

Sample Ref.	pH in Distilled Water at 23.5 °C
BH-01 [3.00-4.00m]	7.8
------	------
------	------
------	------
------	------
------	------

Tested by : Rana Karsifi
Chemist

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Reviewed by : Kassem Salemeh
Chief Chemist

Samples will be disposed after one week from the delivery date of report.

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Date : 22-Apr-24
Serial No. : 101833

TEST REPORT

Tested at : "ACTS Central Laboratory
Beirut, Sanayeh area, George Assy st.
P.O.Box: 14/5918-Code:1105-2080
Tel: 01-737400; Fax: 01-737222"

Customer : Bureau Technique pour le Développement

Sanayeh
03-766944

AMOUNT OF MATERIAL IN SOILS FINER THAN No. 200 (75-µm) SIEVE AND PARTICLE-SIZE ANALYSIS OF SOILS

(ASTM D422 & D1140)

Contractor : ------
Consultant : ------
Project : El Mina Costal Wastewater Project

Work Order No. : ACTS-2400999
Sample received on : 8-Apr-24
Sample tested on : 16-Apr-24

Sampling Details
Sample type : Soil
Location of sampling : ------
Standard sampling method : ASTM D75
Sample Ref. : BH-01 [3.00-4.00m]

Date of sampling : 8/Apr/24
Sampled by : ACTS
Any deviation : ------
Weight of sample (g) : 593.32
ACTS Ref. : APR2408080102

	Sieve Openings (mm)	Retained weight (g)	Retained weight (%)	Cumulative retained (%)	Percent passing (%)
GRAVEL	75.0	0.0	0.0	0.0	100.0
	50.0	0.0	0.0	0.0	100.0
	37.5	0.0	0.0	0.0	100.0
	25.0	0.0	0.0	0.0	100.0
	19.0	0.0	0.0	0.0	100.0
	9.5	1.2	0.2	0.2	99.8
	4.75	3.3	0.6	0.8	99.2
SAND	2.00	11.2	1.9	2.6	97.4
	0.850	31.3	5.3	7.9	92.1
	0.425	31.0	5.2	13.1	86.9
	0.250	26.1	4.4	17.5	82.5
	0.106	170.8	28.8	46.3	53.7
	0.075	51.7	8.7	55.0	45.0
FINE	Pan	266.7	45.0	100.0	0.0

Gravel	Sand	Fine Content
0.8	54.3	45.0

Classification : ASTM D2487 Clayey Sand
AASHTO M145 A-6 Clayey Soils

ACTS
ADVANCED CONSTRUCTION TECHNOLOGY SERVICES
P.O.BOX 14/5918 Beirut - Lebanon

Reviewed by
Lab Engineer : Shaher Mehieddine Cheikh El Balad

Approved by
Department Head : Mohammad El Masri

ACTS
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Date : 22-Apr-24
Serial No. : 101834

TEST REPORT

Tested at : "ACTS Central Laboratory
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P.O.Box: 14/5918-Code:1105-2080
Tel: 01-737400; Fax: 01-737222"

Customer: Bureau Technique pour le
0
03-766944

LIQUID LIMIT, PLASTIC LIMIT & PLASTICITY INDEX OF SOILS (ASTM D4318)

Contractor : ------
Consultant : ------
Project : El Mina Costal Wastewater Project
Sample Type : Soil
Sample Ref. : BH-01 [3.00-4.00m]
ACTS Ref. : APR2408080102
Date of Sampling : 8-Apr-24
Location of Sampling : ------
Specimen Preparation : Wet Preparation

Work Order No. : ACTS-2400999
Sample Received on : 8-Apr-24
Sample Tested on : 18-Apr-24
Sampled by : ACTS

Test		Liquid Limit			Plastic Limit		
Testing Equipments Used		Mechanical Device & Metal Grooving Tool			Hand Rolled		
No. of Blows		15	23	34	-------	-------	-------
Container Ref.		1	2	3	A	B	-------
(A) Mass of Container (g)		21.98	23.27	21.85	24.69	25.42	-------
(B) Mass of wet soil + Container (g)		40.71	44.25	46.49	32.31	32.67	-------
(C) Mass of dry soil + Container (g)		35.22	38.21	39.56	31.05	31.49	-------
Moisture content (%)	$\left(\frac{B-C}{C-A}\right)\times 100$	41.5	40.4	39.1	19.8	19.4	-------
Limits		Liquid (LL) =		**40**	Plastic (PL) =		**20**
Plasticity Index (PI)		PI (LL - PL) =		**20**			

Remarks : The specimen was prepared by washing it on 425 µm (No.40) sieve.
The specimen contained 13.1 % retained on the sieve 425 µm (No.40) sieve.

Reviewed by: Shaher Mehieddine Cheikh El Balad
Lab Engineer

Approved by: Mohammad El Masri
Department Head

This test is under the scope of ISO 17025 accreditation.

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Date : 22-Apr-24
Serial No. : 101835

TEST REPORT

Tested at : "ACTS Central Laboratory
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P.O.Box: 14/5918-Code:1105-2080
Tel: 01-737400; Fax: 01-737222"

Customer: Bureau Technique pour le
0
03-766944

LIQUID LIMIT, PLASTIC LIMIT & PLASTICITY INDEX OF SOILS (ASTM D4318)

Contractor : ------
Consultant : ------
Project : El Mina Costal Wastewater Project
Sample Type : Soil
Sample Ref. : BH-01 [8.50-9.00m]
ACTS Ref. : APR2408080103
Date of Sampling : 8-Apr-24
Location of Sampling : ------
Specimen Preparation : Wet Preparation

Work Order No. : ACTS-2400999
Sample Received on : 8-Apr-24
Sample Tested on : 18-Apr-24
Sampled by : ACTS

Test		Liquid Limit			Plastic Limit		
Testing Equipments Used		Mechanical Device & Metal Grooving Tool			Hand Rolled		
No. of Blows		17	26	35	-------	-------	-------
Container Ref.		1	2	3	A	B	-------
(A) Mass of Container (g)		22.52	23.65	22.39	21.89	24.69	-------
(B) Mass of wet soil + Container (g)		41.88	38.98	38.69	30.08	31.86	-------
(C) Mass of dry soil + Container (g)		35.94	34.38	33.87	28.78	30.71	-------
Moisture content (%)	$\left(\frac{B-C}{C-A}\right)\times 100$	44.3	42.9	42.0	18.9	19.1	-------
Limits		Liquid (LL) =		**43**	Plastic (PL) =		**19**
Plasticity Index (PI)		PI (LL - PL) =		**24**			

Remarks : The specimen was prepared by washing it on 425 µm (No.40) sieve.
The specimen contained 9.3 % retained on the sieve 425 µm (No.40) sieve.

Reviewed by: Shaher Mehieddine Cheikh El Balad
Lab Engineer

Approved by: Mohammad El Masri
Department Head

This test is under the scope of ISO 17025 accreditation.

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Date : 22-Apr-24
Serial No. : 101836

TEST REPORT

Tested at : "ACTS Central Laboratory
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Tel: 01-737400; Fax: 01-737222"

Customer : Bureau Technique pour le Développement

Sanayeh
03-766944

AMOUNT OF MATERIAL IN SOILS FINER THAN No. 200 (75-µm) SIEVE AND PARTICLE-SIZE ANALYSIS OF SOILS

(ASTM D422 & D1140)

Contractor : ------
Consultant : ------
Project : El Mina Costal Wastewater Project

Work Order No. : ACTS-2400999
Sample received on : 8-Apr-24
Sample tested on : 16-Apr-24

Sampling Details
Sample type : Soil
Location of sampling : ------
Standard sampling method : ASTM D75
Sample Ref. : BH-01 [8.50-9.00m]

Date of sampling : 8/Apr/24
Sampled by : ACTS
Any deviation : ------
Weight of sample (g) : 611.42
ACTS Ref. : APR2408080103

	Sieve Openings (mm)	Retained weight (g)	Retained weight (%)	Cumulative retained (%)	Percent passing (%)
GRAVEL	75.0	0.0	0.0	0.0	100.0
	50.0	0.0	0.0	0.0	100.0
	37.5	0.0	0.0	0.0	100.0
	25.0	0.0	0.0	0.0	100.0
	19.0	0.0	0.0	0.0	100.0
	9.5	1.7	0.3	0.3	99.7
	4.75	18.5	3.0	3.3	96.7
SAND	2.00	20.0	3.3	6.6	93.4
	0.850	10.6	1.7	8.3	91.7
	0.425	6.0	1.0	9.3	90.7
	0.250	12.7	2.1	11.4	88.6
	0.106	58.9	9.6	21.0	79.0
	0.075	21.8	3.6	24.6	75.4
FINE	Pan	461.2	75.4	100.0	0.0

Gravel	Sand	Fine Content
3.3	21.3	75.4

Classification : ASTM D2487 Lean Clay with Sand
AASHTO M145 A-7-6 Clayey Soils

Reviewed by
Lab Engineer : Shaher Mehieddine Cheikh El Balad

ACTS
ADVANCED CONSTRUCTION TECHNOLOGY SERVICES
P.O.BOX 14/5918 Beirut-Lebanon

Approved by
Department Head : Mohammad El Masri

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Date : 22-Apr-24
Serial No. : 101837

TEST REPORT

Tested at : "ACTS Central Laboratory
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P.O.Box: 14/5918-Code:1105-2080
Tel: 01-737400; Fax: 01-737222"

Customer : Bureau Technique pour le Développement

Sanayeh
03-766944

AMOUNT OF MATERIAL IN SOILS FINER THAN No. 200 (75-µm) SIEVE AND PARTICLE-SIZE ANALYSIS OF SOILS

(ASTM D422 & D1140)

Contractor : ------
Consultant : ------
Project : El Mina Costal Wastewater Project

Work Order No. : ACTS-2400999
Sample received on : 8-Apr-24
Sample tested on : 16-Apr-24

Sampling Details
Sample type : Soil
Location of sampling : ------
Standard sampling method : ASTM D75
Sample Ref. : BH-02 [1.00-1.50m]

Date of sampling : 8/Apr/24
Sampled by : ACTS
Any deviation : ------
Weight of sample (g) : 281.84
ACTS Ref. : APR2408080104

	Sieve Openings (mm)	Retained weight (g)	Retained weight (%)	Cumulative retained (%)	Percent passing (%)
GRAVEL	75.0	0.0	0.0	0.0	100.0
	50.0	0.0	0.0	0.0	100.0
	37.5	0.0	0.0	0.0	100.0
	25.0	0.0	0.0	0.0	100.0
	19.0	0.0	0.0	0.0	100.0
	9.5	0.0	0.0	0.0	100.0
	4.75	4.9	1.7	1.7	98.3
SAND	2.00	11.6	4.1	5.9	94.1
	0.850	16.6	5.9	11.7	88.3
	0.425	11.9	4.2	16.0	84.0
	0.250	71.6	25.4	41.4	58.6
	0.106	77.4	27.5	68.8	31.2
	0.075	13.3	4.7	73.6	26.4
FINE	Pan	74.5	26.4	100.0	0.0

Gravel	Sand	Fine Content
1.7	71.8	26.4

Classification : ASTM D2487 Clayey Sand
AASHTO M145 A-2-6 Silty or Clayey Gravel Sand

Reviewed by
Lab Engineer : Shaher Mehieddine Cheikh El Balad

ACTS
ADVANCED CONSTRUCTION TECHNOLOGY SERVICES
P.O.BOX 14/5918 Beirut - Lebanon

Approved by
Department Head : Mohammad El Masri

Certified ISO 9001

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Date : 22-Apr-24
Serial No. : 101838

TEST REPORT

Tested at : "ACTS Central Laboratory
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Customer: Bureau Technique pour le
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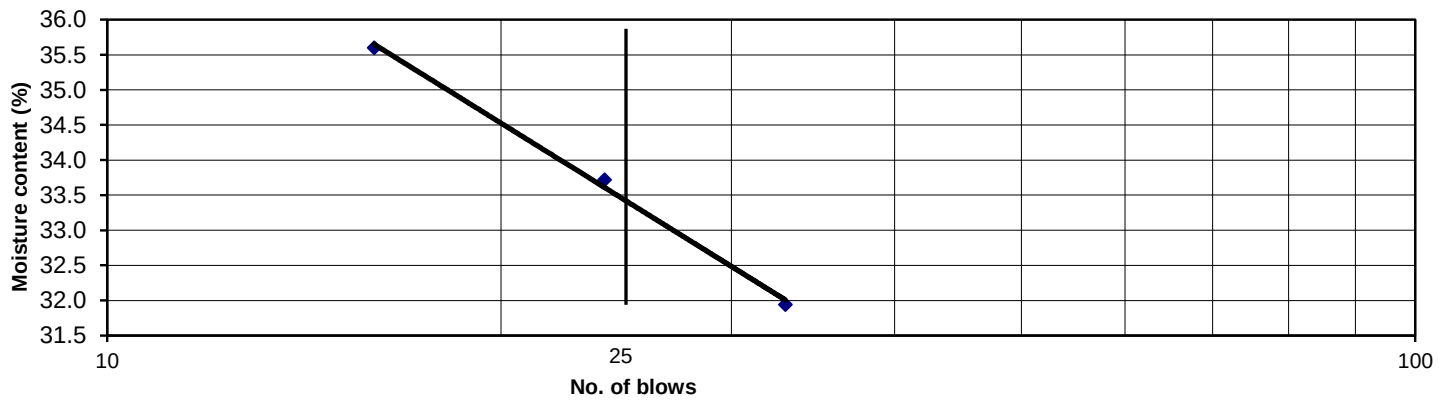
03-766944

LIQUID LIMIT, PLASTIC LIMIT & PLASTICITY INDEX OF SOILS (ASTM D4318)

Contractor : ------
Consultant : ------
Project : El Mina Costal Wastewater Project
Sample Type : Soil
Sample Ref. : BH-02 [1.00-1.50m]
ACTS Ref. : APR2408080104
Date of Sampling : 8-Apr-24
Location of Sampling : ------
Specimen Preparation : Wet Preparation

Work Order No. : ACTS-2400999
Sample Received on : 8-Apr-24
Sample Tested on : 18-Apr-24
Sampled by : ACTS

Test		Liquid Limit			Plastic Limit		
Testing Equipments Used		Mechanical Device & Metal Grooving Tool			Hand Rolled		
No. of Blows		16	24	33	-------	-------	-------
Container Ref.		1	2	3	A	B	-------
(A) Mass of Container (g)		24.28	24.33	22.67	24.07	24.5	-------
(B) Mass of wet soil + Container (g)		52.39	51.93	52.41	32.67	31.97	-------
(C) Mass of dry soil + Container (g)		45.01	44.97	45.21	31.39	30.88	-------
Moisture content (%)	$\left(\frac{B-C}{C-A}\right)\times 100$	35.6	33.7	31.9	17.5	17.1	-------
Limits		Liquid (LL) =		**33**	Plastic (PL) =		**17**
Plasticity Index (PI)		PI (LL - PL) =		**16**			



Remarks : The specimen was prepared by washing it on 425 µm (No.40) sieve.
The specimen contained 16.0 % retained on the sieve 425 µm (No.40) sieve.

Reviewed by: Shaher Mehieddine Cheikh El Balad
Lab Engineer

Approved by: Mohammad El Masri
Department Head

This test is under the scope of ISO 17025 accreditation.

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Date : 22-Apr-24
Serial No. : 101839

TEST REPORT

Tested at : "ACTS Central Laboratory
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Tel: 01-737400; Fax: 01-737222"

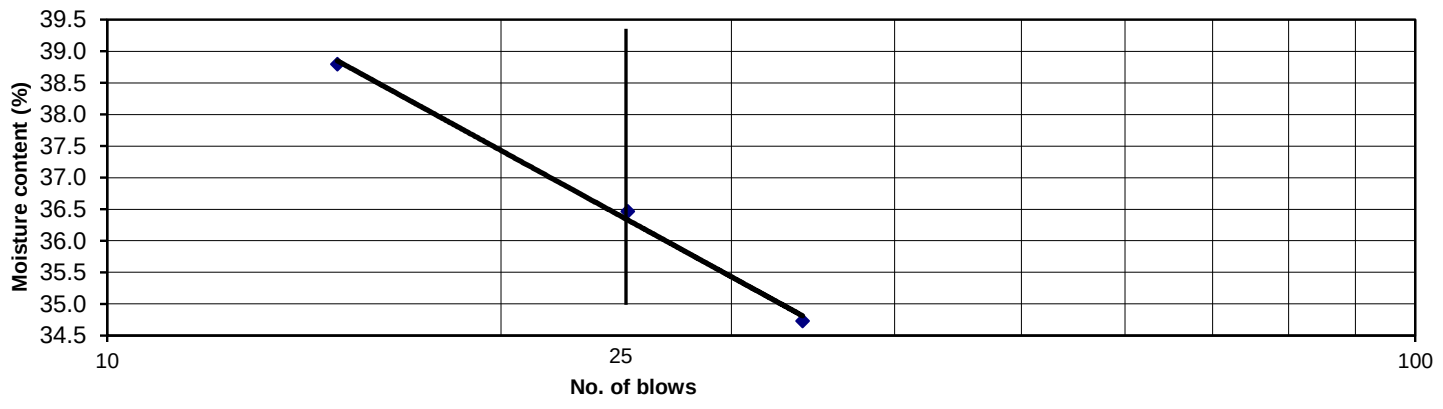
Customer: Bureau Technique pour le
0
03-766944

LIQUID LIMIT, PLASTIC LIMIT & PLASTICITY INDEX OF SOILS (ASTM D4318)

Contractor : ------
Consultant : ------
Project : El Mina Costal Wastewater Project
Sample Type : Soil
Sample Ref. : BH-02 [5.50-6.00m]
ACTS Ref. : APR2408080105
Date of Sampling : 8-Apr-24
Location of Sampling : ------
Specimen Preparation : Wet Preparation

Work Order No. : ACTS-2400999
Sample Received on : 8-Apr-24
Sample Tested on : 18-Apr-24
Sampled by : ACTS

Test		Liquid Limit			Plastic Limit		
Testing Equipments Used		Mechanical Device & Metal Grooving Tool			Hand Rolled		
No. of Blows		15	25	34	-------	-------	-------
Container Ref.		1	2	3	A	B	-------
(A) Mass of Container (g)		23.77	24.32	21.39	21.89	23.19	-------
(B) Mass of wet soil + Container (g)		51.03	49.32	50.33	30.61	30.74	-------
(C) Mass of dry soil + Container (g)		43.41	42.64	42.87	29.18	29.52	-------
Moisture content (%)	$\left(\frac{B-C}{C-A}\right)\times 100$	38.8	36.5	34.7	19.6	19.3	-------
Limits		Liquid (LL) =		**36**	Plastic (PL) =		**19**
Plasticity Index (PI)		PI (LL - PL) =		**17**			



Remarks : The specimen was prepared by washing it on 425 µm (No.40) sieve.
The specimen contained 58.6 % retained on the sieve 425 µm (No.40) sieve.

Reviewed by: Shaher Mehieddine Cheikh El Balad
Lab Engineer

Approved by: Mohammad El Masri
Department Head

This test is under the scope of ISO 17025 accreditation.

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Date : 22-Apr-24
Serial No. : 101840

TEST REPORT

Tested at : "ACTS Central Laboratory
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Tel: 01-737400; Fax: 01-737222"

Customer : Bureau Technique pour le Développement

Sanayeh
03-766944

AMOUNT OF MATERIAL IN SOILS FINER THAN No. 200 (75-µm) SIEVE AND PARTICLE-SIZE ANALYSIS OF SOILS

(ASTM D422 & D1140)

Contractor : ------
Consultant : ------
Project : El Mina Costal Wastewater Project

Work Order No. : ACTS-2400999
Sample received on : 8-Apr-24
Sample tested on : 16-Apr-24

Sampling Details
Sample type : Soil
Location of sampling : ------
Standard sampling method : ASTM D75
Sample Ref. : BH-02 [5.50-6.00m]

Date of sampling : 8/Apr/24
Sampled by : ACTS
Any deviation : ------
Weight of sample (g) : 531.97
ACTS Ref. : APR2408080105

	Sieve Openings (mm)	Retained weight (g)	Retained weight (%)	Cumulative retained (%)	Percent passing (%)
GRAVEL	75.0	0.0	0.0	0.0	100.0
	50.0	0.0	0.0	0.0	100.0
	37.5	0.0	0.0	0.0	100.0
	25.0	36.7	6.9	6.9	93.1
	19.0	66.6	12.5	19.4	80.6
	9.5	85.8	16.1	35.5	64.5
	4.75	30.4	5.7	41.3	58.7
SAND	2.00	34.5	6.5	47.7	52.3
	0.850	34.3	6.4	54.2	45.8
	0.425	23.6	4.4	58.6	41.4
	0.250	33.5	6.3	64.9	35.1
	0.106	36.7	6.9	71.8	28.2
	0.075	7.2	1.4	73.2	26.8
FINE	Pan	142.7	26.8	100.0	0.0

Gravel	Sand	Fine Content
41.3	31.9	26.8

Classification : ASTM D2487 Clayey Gravel with Sand
AASHTO M145 A-2-6 Silty or Clayey Gravel Sand

Reviewed by
Lab Engineer : Shaher Mehieddine Cheikh El Balad

ACTS
ADVANCED CONSTRUCTION TECHNOLOGY SERVICES
P.O.BOX 14/5918 Beirut-lebanon

Approved by
Department Head : Mohammad El Masri

Certified ISO 9001

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Date : 22-Apr-24
Serial No. : 101841

TEST REPORT

Tested at : "ACTS Central Laboratory
Beirut, Sanayeh area, George Assy st.
P.O.Box: 14/5918-Code:1105-2080
Tel: 01-737400; Fax: 01-737222"

Customer : Bureau Technique pour le Développement
Sanayeh
03-766944

AMOUNT OF MATERIAL IN SOILS FINER THAN No. 200 (75-µm) SIEVE AND PARTICLE-SIZE ANALYSIS OF SOILS

(ASTM D422 & D1140)

Contractor : ------
Consultant : ------
Project : El Mina Costal Wastewater Project

Work Order No. : ACTS-2400999
Sample received on : 8-Apr-24
Sample tested on : 16-Apr-24

Sampling Details
Sample type : Soil
Location of sampling : ------
Standard sampling method : ASTM D75
Sample Ref. : BH-03 [1.50-3.00m]

Date of sampling : 8/Apr/24
Sampled by : ACTS
Any deviation : ------
Weight of sample (g) : 963.92
ACTS Ref. : APR2408080106

	Sieve Openings (mm)	Retained weight (g)	Retained weight (%)	Cumulative retained (%)	Percent passing (%)
GRAVEL	75.0	0.0	0.0	0.0	100.0
	50.0	0.0	0.0	0.0	100.0
	37.5	0.0	0.0	0.0	100.0
	25.0	16.6	1.7	1.7	98.3
	19.0	0.0	0.0	1.7	98.3
	9.5	44.2	4.6	6.3	93.7
	4.75	55.8	5.8	12.1	87.9
SAND	2.00	120.2	12.5	24.6	75.4
	0.850	169.9	17.6	42.2	57.8
	0.425	188.4	19.5	61.7	38.3
	0.250	150.9	15.7	77.4	22.6
	0.106	103.0	10.7	88.1	11.9
	0.075	10.5	1.1	89.2	10.8
FINE	Pan	104.4	10.8	100.0	0.0

Gravel	Sand	Fine Content
12.1	**77.1**	**10.8**

Classification : ASTM D2487 Well-Graded Sand with Clay
AASHTO M145 A-2-6 Silty or Clayey Gravel Sand

Reviewed by Lab Engineer : Shaher Mehieddine Cheikh El Balad

Approved by Department Head : Mohammad El Masri

ACTS ADVANCED CONSTRUCTION TECHNOLOGY SERVICES
P.O.BOX 14/5918 Beirut - Lebanon

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ACTS
ADVANCED CONSTRUCTION TECHNOLOGY SERVICES
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Date : 22-Apr-24
Serial No. : 101842

TEST REPORT

Tested at : "ACTS Central Laboratory
Beirut, Sanayeh area, George Assy st.
P.O.Box: 14/5918-Code:1105-2080
Tel: 01-737400; Fax: 01-737222"

Customer: Bureau Technique pour le
0
03-766944

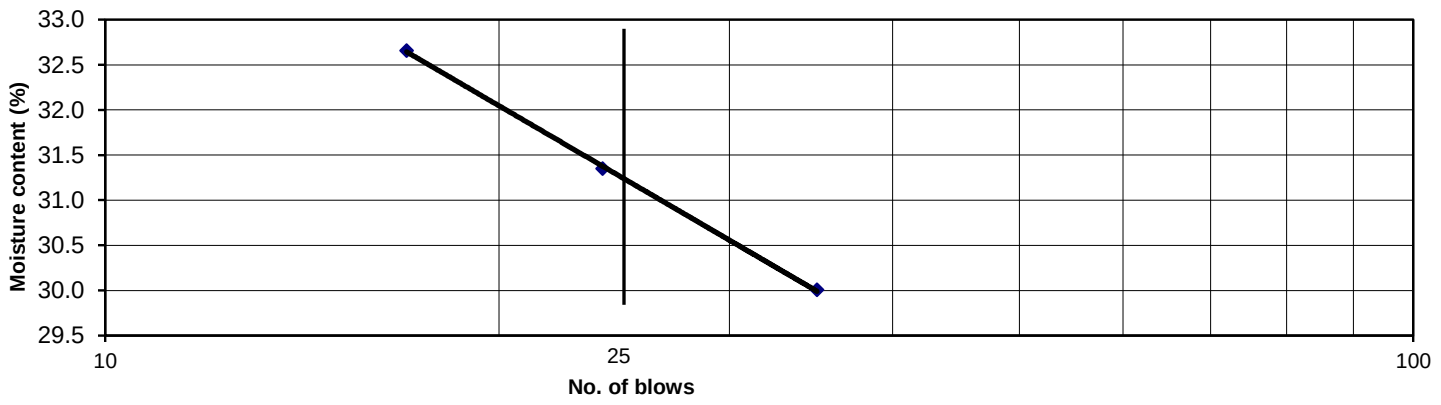
LIQUID LIMIT, PLASTIC LIMIT & PLASTICITY INDEX OF SOILS (ASTM D4318)

Contractor : ------
Consultant : ------
Project : El Mina Costal Wastewater Project
Sample Type : Soil
Sample Ref. : BH-03 [1.50-3.00m]
ACTS Ref. : APR2408080106

Work Order No. : ACTS-2400999
Sample Received on : 8-Apr-24
Sample Tested on : 18-Apr-24
Sampled by : ACTS

Date of Sampling : 8-Apr-24
Location of Sampling : ------
Specimen Preparation : Wet Preparation

Test		Liquid Limit			Plastic Limit		
Testing Equipments Used		Mechanical Device & Metal Grooving Tool			Hand Rolled		
No. of Blows		17	24	35	-------	-------	-------
Container Ref.		1	2	3	A	B	-------
(A) Mass of Container (g)		22.78	22.37	23.45	22.62	22.19	-------
(B) Mass of wet soil + Container (g)		50.97	48.39	49.62	31.32	30.41	-------
(C) Mass of dry soil + Container (g)		44.03	42.18	43.58	30.02	29.18	-------
Moisture content (%)	$\left(\frac{B-C}{C-A}\right)\times 100$	32.7	31.3	30.0	17.6	17.6	-------
Limits		Liquid (LL) =		**31**	Plastic (PL) =		**18**
Plasticity Index (PI)		PI (LL - PL) =		**13**			



Remarks : The specimen was prepared by washing it on 425 µm (No.40) sieve.
The specimen contained 61.7 % retained on the sieve 425 µm (No.40) sieve.

Reviewed by: Shaher Mehieddine Cheikh El Balad
Lab Engineer

Approved by: Mohammad El Masri
Department Head

This test is under the scope of ISO 17025 accreditation.

ACTS
ADVANCED CONSTRUCTION TECHNOLOGY SERVICES
P.O.BOX 14/5918 Beirut - Lebanon

IAS ACCREDITED Testing Laboratory

ACTS
ADVANCED CONSTRUCTION TECHNOLOGY SERVICES
Build on our credentials

Date : 22-Apr-24
Serial No. : 101843

TEST REPORT

Tested at : "ACTS Central Laboratory
Beirut, Sanayeh area, George Assy st.
P.O.Box: 14/5918-Code:1105-2080
Tel: 01-737400; Fax: 01-737222"

Customer: Bureau Technique pour le
0
03-766944

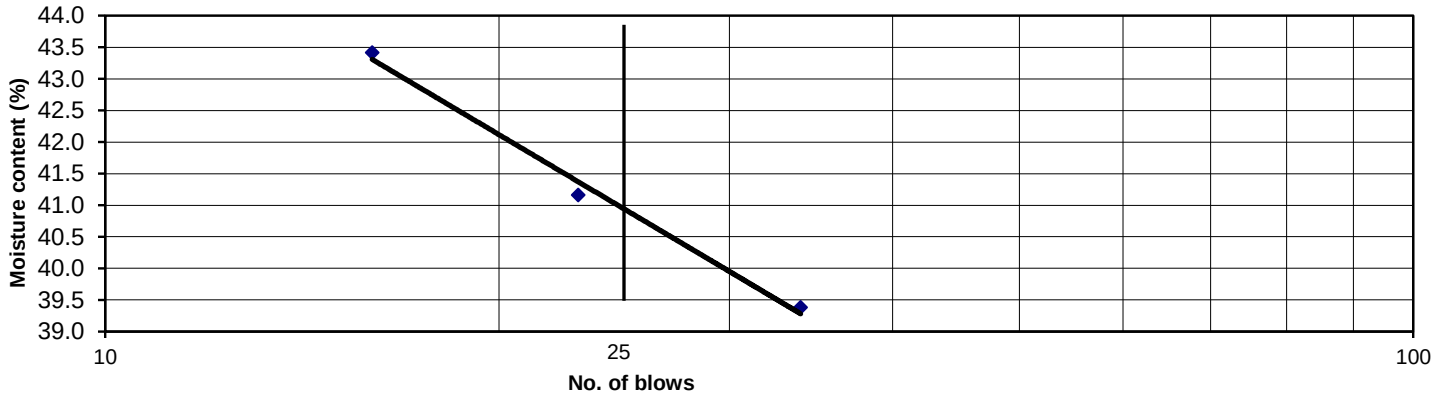
LIQUID LIMIT, PLASTIC LIMIT & PLASTICITY INDEX OF SOILS (ASTM D4318)

Contractor : ------
Consultant : ------
Project : El Mina Costal Wastewater Project
Sample Type : Soil
Sample Ref. : BH-03 [6.00-6.50m]
ACTS Ref. : APR2408080107

Work Order No. : ACTS-2400999
Sample Received on : 8-Apr-24
Sample Tested on : 18-Apr-24
Sampled by : ACTS

Date of Sampling : 8-Apr-24
Location of Sampling : ------
Specimen Preparation : Wet Preparation

Test		Liquid Limit			Plastic Limit		
Testing Equipments Used		Mechanical Device & Metal Grooving Tool			Hand Rolled		
No. of Blows		16	23	34	-------	-------	-------
Container Ref.		1	2	3	A	B	-------
(A) Mass of Container (g)		21.18	22.29	22.37	21.19	22.19	-------
(B) Mass of wet soil + Container (g)		45.69	43.69	45.02	30.48	30.79	-------
(C) Mass of dry soil + Container (g)		38.27	37.45	38.62	29.06	29.48	-------
Moisture content (%)	$\left(\frac{B-C}{C-A}\right)\times 100$	43.4	41.2	39.4	18.0	18.0	-------
Limits		Liquid (LL) =		**41**	Plastic (PL) =		**18**
Plasticity Index (PI)		PI (LL - PL) =		**23**			



Remarks : The specimen was prepared by washing it on 425 µm (No.40) sieve.
The specimen contained 28.5 % retained on the sieve 425 µm (No.40) sieve.

Reviewed by: Shaher Mehieddine Cheikh El Balad
Lab Engineer

Approved by: Mohammad El Masri
Department Head

This test is under the scope of ISO 17025 accreditation.

ACTS
ADVANCED CONSTRUCTION TECHNOLOGY SERVICES
P.O.BOX 14/5918 Beirut - Lebanon

IAS ACCREDITED Testing Laboratory

ACTS
ADVANCED CONSTRUCTION TECHNOLOGY SERVICES
Build on our credentials

Date : 22-Apr-24
Serial No. : 101844

TEST REPORT

Tested at : "ACTS Central Laboratory
Beirut, Sanayeh area, George Assy st.
P.O.Box: 14/5918-Code:1105-2080
Tel: 01-737400; Fax: 01-737222"

Customer : Bureau Technique pour le Développement

Sanayeh
03-766944

AMOUNT OF MATERIAL IN SOILS FINER THAN No. 200 (75-µm) SIEVE AND PARTICLE-SIZE ANALYSIS OF SOILS

(ASTM D422 & D1140)

Contractor : ------
Consultant : ------
Project : El Mina Costal Wastewater Project

Work Order No. : ACTS-2400999
Sample received on : 8-Apr-24
Sample tested on : 16-Apr-24

Sampling Details
Sample type : Soil
Location of sampling : ------
Standard sampling method : ASTM D75
Sample Ref. : BH-03 [6.00-6.50m]

Date of sampling : 8/Apr/24
Sampled by : ACTS
Any deviation : ------
Weight of sample (g) : 1005.01
ACTS Ref. : APR2408080107

	Sieve Openings (mm)	Retained weight (g)	Retained weight (%)	Cumulative retained (%)	Percent passing (%)
GRAVEL	75.0	0.0	0.0	0.0	100.0
	50.0	0.0	0.0	0.0	100.0
	37.5	0.0	0.0	0.0	100.0
	25.0	86.3	8.6	8.6	91.4
	19.0	22.1	2.2	10.8	89.2
	9.5	56.5	5.6	16.4	83.6
	4.75	24.4	2.4	18.8	81.2
SAND	2.00	35.4	3.5	22.4	77.6
	0.850	47.6	4.7	27.1	72.9
	0.425	14.5	1.4	28.5	71.5
	0.250	36.3	3.6	32.1	67.9
	0.106	50.6	5.0	37.2	62.8
	0.075	9.3	0.9	38.1	61.9
FINE	Pan	622.0	61.9	100.0	0.0

Gravel	Sand	Fine Content
18.8	19.3	61.9

Classification : ASTM D2487 Sandy Lean Clay with Gravel
AASHTO M145 A-7-6 Clayey Soils

Reviewed by
Lab Engineer : Shaher Mehieddine Cheikh El Balad

ACTS
ADVANCED CONSTRUCTION TECHNOLOGY SERVICES
P.O.Box 14/5918 Beirut-Lebanon

Approved by
Department Head : Mohammad El Masri

Certified ISO 9001

Appendix E – SPT Corrections

ACTS ADVANCED CONSTRUCTION TECHNOLOGY SERVICES Build on our credentials	Project Name	El Mina Coastal Wastewater Project	Calc. Ref.#	GEO/GIR/SPT_Rev.00
	Project No.	Q27015	Rev.	Rev.00
	Client	BTD	Made by:	E.D
	Calculation:	SPT Correction	Date:	22-Apr-24

SPT CORRECTIONS:

Borehole Diameter:	**96**
SamplerType:	**Standard**
Min. Rod Length:	**3.5**

ηH	VAR
ηB	1.00
ηS	1.00
ηR	1.00

Test No.	BH No.	Hammer Efficiency	Depth (m bEGL)	Elevation (m MSL)	ηR	N	N_{60}
1	BH-01	60.0%	1.50	0.00	0.75	19	14
2	BH-01	60.0%	3.00	-1.50	0.85	5	4
3	BH-01	60.0%	4.50	-3.00	0.95	6	6
4	BH-01	60.0%	6.00	-4.50	0.95	33	31
5	BH-01	60.0%	9.00	-7.50	1.00	4	4
6	BH-02	60.0%	1.50	1.87	0.75	10	8
7	BH-02	60.0%	3.00	0.37	0.85	16	14
8	BH-02	60.0%	4.50	-1.14	0.95	>50	50
9	BH-02	60.0%	6.00	-2.64	0.95	17	16
10	BH-03	60.0%	1.50	0.65	0.75	10	8
11	BH-03	60.0%	3.00	-0.85	0.85	3	3
12	BH-03	60.0%	4.50	-2.35	0.95	>50	50

Appendix F – Falling Head Permeability Test Results

ACTS ADVANCED CONSTRUCTION TECHNOLOGY SERVICES — Build on our credentials	**Project Name**	El Mina Costal Wastewater Project		**Calc. Ref.#**	GEO/FHT_Rev.00
	Project No.	ACTS - Q27015		**Rev.**	0
	Client	Ms. Lena Abou Rached		**Tested by:**	R.O
	Type of Calc.	Borehole permeability test - BS 5930:1999+A2:2010, Section 25.4		**Checked by:**	M.M
	Borehole No.	BH 01	**Test No.** 1	**Testing Date:**	8-Apr-24

BOREHOLE AND TEST DATA

a) Top of BH	1.50	m MSL	
b) Bottom of Test	7.00	m begl	-5.50 m MSL
c) Bottom of Casing (steel)	5.00	m begl	-3.50 m MSL
d) Initial Ground Water Level from Top of BH	1.09	m begl	0.41 m MSL
e) Height of Riser Pipe above GL	0.00	m	
f) Borehole Diameter	76.0	mm	
g) Head at Commencement of Test from Riser Pipe, H_0	1.1	m	
i) Tested Layer	Clay		

Test Record

Time elapsed, t sec	Time elapsed, t (Min)	Water Level below Top of Riser Pipe (m)	Head, H_t (m)	H_t/H_o
0	0.0	0.00	1.09	1.00
18	0.3	0.30	0.79	0.72
60	1.0	0.55	0.54	0.50
120	2.0	0.75	0.34	0.31
180	3.0	0.88	0.21	0.19
240	4.0	0.97	0.12	0.11
300	5.0	1.04	0.05	0.05
600	10.0	1.08	0.01	0.01

Calculations and Comments

A =	0.0045	m^2	
L/D =	26.32		
F =	3.80		Intake Factor
T =	101	secs	Basic Time

Calculated Permeability (Time Lag Method)

$$k = \frac{A}{FT}$$

k = 1.18E-05 m/sec

Permeability (General Approach):

$$k = \frac{A}{F(t_2 - t_1)} \log_e \frac{H_1}{H_2} \text{ (general approach)}$$

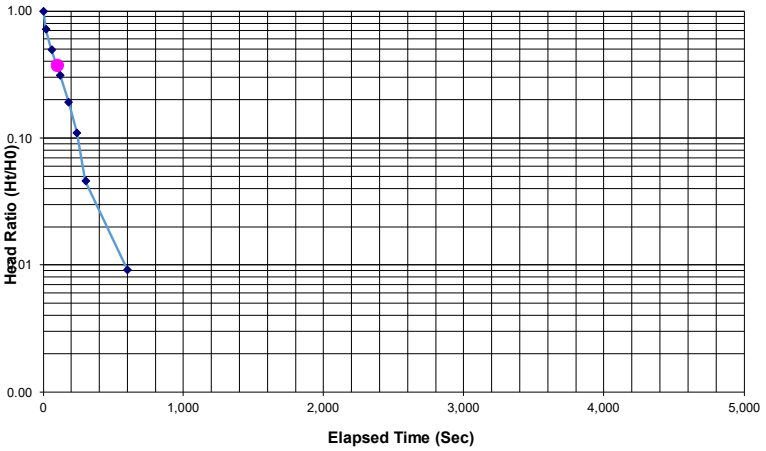
k = 9.34E-06 m/sec

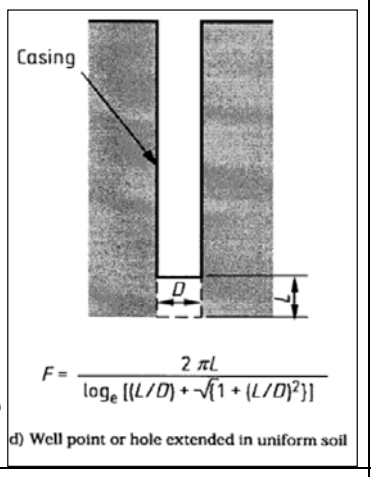
Notes:

1) The intake factor "F" was calculated in accordance with BS5930 Section 25.4.6 - Figure 6 - Case D

2) The basic Time "T" was calculated as the time at which H/H_0 reaches a value of 0.37, in accordance with BS5930 Section 25.4.6- Figure 8.

3) For the general approach, the permeability coefficient was calculated using time of start and time of end.





Project Name	El Mina Costal Wastewater Project			Calc. Ref.#	GEO/FHT_Rev.00
Project No.	ACTS - Q27015			Rev.	0
Client	Ms. Lena Abou Rached			Tested by:	R.O
Type of Calc.	Borehole permeability test - BS 5930:1999+A2:2010, Section 25.4			Checked by:	M.M
Borehole No.	BH 02	Test No.	1	Testing Date:	28-Mar-24

BOREHOLE AND TEST DATA

a) Top of BH	3.37	m MSL	
b) Bottom of Test	7.00	m begl	-3.63 m MSL
c) Bottom of Casing (steel)	5.00	m begl	-1.63 m MSL
d) Initial Ground Water Level from Top of BH	1.93	m begl	1.44 m MSL
e) Height of Riser Pipe above GL	0.00	m	
f) Borehole Diameter	76.0	mm	
g) Head at Commencement of Test from Riser Pipe, H_0	1.9	m	
i) Tested Layer	Clay		

Test Record

Time elapsed, t sec	Time elapsed, t (Min)	Water Level below Top of Riser Pipe (m)	Head, H_t (m)	H_t/H_o
0	0.0	0.00	1.93	1.00
18	0.3	1.57	0.36	0.19
60	1.0	1.80	0.13	0.07
120	2.0	1.90	0.03	0.02
180	3.0	1.92	0.01	0.01
240	4.0	1.93	0.00	0.00

Calculations and Comments

A =	0.0045	m^2	
L/D =	26.32		
F =	3.80		Intake Factor
T =	14	secs	Basic Time

Calculated Permeability (Time Lag Method)

$$k = \frac{A}{FT}$$

k = 8.57E-05 m/sec

Permeability (General Approach):

$$k = \frac{A}{F(t_2 - t_1)} \log_e \frac{H_1}{H_2} \text{ (general approach)}$$

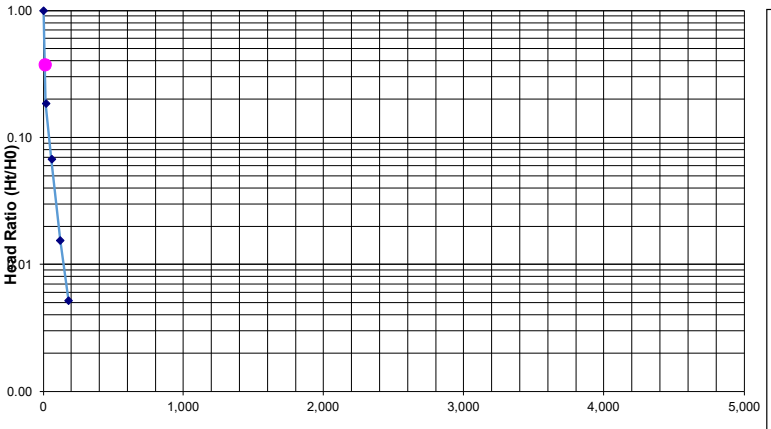
k = 3.49E-05 m/sec

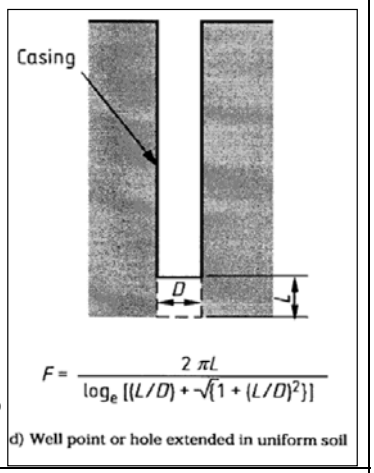
Notes:

1) The intake factor "F" was calculated in accordance with BS5930 Section 25.4.6 - Figure 6 - Case D

2) The basic Time "T" was calculated as the time at which H/H_0 reaches a value of 0.37, in accordance with BS5930 Section 25.4.6- Figure 8.

3) For the general approach, the permeability coefficient was calculated using time of start and time of end.





d) Well point or hole extended in uniform soil

ACTS ADVANCED CONSTRUCTION TECHNOLOGY SERVICES — Build on our credentials	**Project Name**	El Mina Costal Wastewater Project		**Calc. Ref.#**	GEO/FHT_Rev.00
	Project No.	ACTS - Q27015		**Rev.**	0
	Client	Ms. Lena Abou Rached		**Tested by:**	R.O
	Type of Calc.	Borehole permeability test - BS 5930:1999+A2:2010, Section 25.4		**Checked by:**	M.M
	Borehole No.	BH 03	**Test No.** 1	**Testing Date:**	8-Apr-24

BOREHOLE AND TEST DATA

a) Top of BH	2.15	m MSL	
b) Bottom of Test	7.00	m begl	-4.85 m MSL
c) Bottom of Casing (steel)	5.00	m begl	-2.85 m MSL
d) Initial Ground Water Level from Top of BH	3.25	m begl	-1.10 m MSL
e) Height of Riser Pipe above GL	0.00	m	
f) Borehole Diameter	76.0	mm	
g) Head at Commencement of Test from Riser Pipe, H_0	3.3	m	
i) Tested Layer	Clay		

Test Record

Time elapsed, *t* sec	Time elapsed, *t* (Min)	Water Level below Top of Riser Pipe (m)	Head, H_t (m)	H_t/H_o
0	0.0	0.00	3.25	1.00
18	0.3	3.17	0.08	0.02
60	1.0	3.19	0.06	0.02
120	2.0	3.19	0.06	0.02
180	3.0	3.20	0.05	0.02
240	4.0	3.20	0.05	0.02
300	5.0	3.23	0.02	0.01
600	10.0	3.24	0.01	0.00

Calculations and Comments

A =	0.0045	m^2	
L/D =	26.32		
F =	3.80		Intake Factor
T =	12	secs	Basic Time

Calculated Permeability (Time Lag Method)

$$k = \frac{A}{FT}$$

k = 1.03E-04 m/sec

Permeability (General Approach):

$$k = \frac{A}{F(t_2 - t_1)} \log_e \frac{H_1}{H_2} \text{ (general approach)}$$

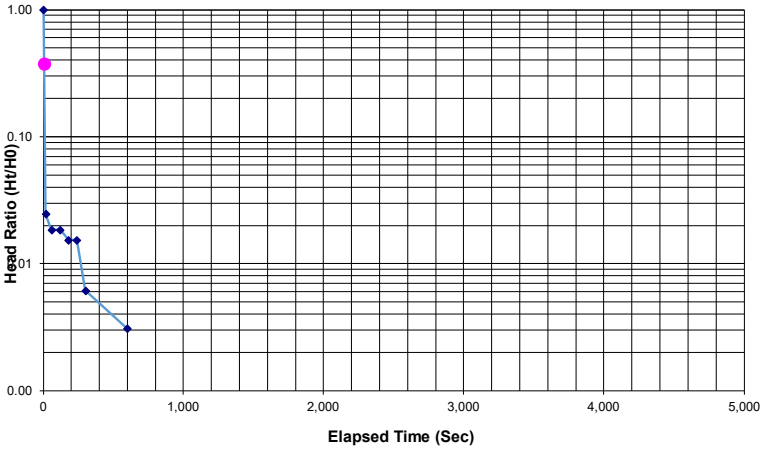
k = 2.03E-05 m/sec

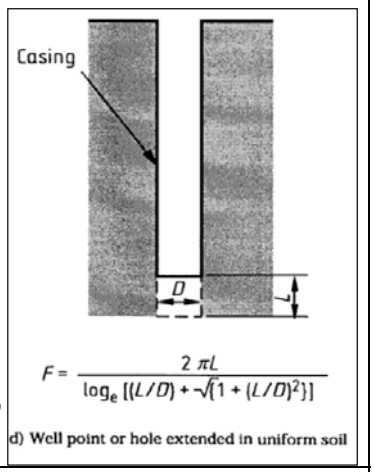
Notes:

1) The intake factor "F" was calculated in accordance with BS5930 Section 25.4.6 - Figure 6 - Case D

2) The basic Time "T" was calculated as the time at which H/H_0 reaches a value of 0.37, in accordance with BS5930 Section 25.4.6- Figure 8.

3) For the general approach, the permeability coefficient was calculated using time of start and time of end.





Appendix G – Slide v6.0 Dewatering Analysis Reports

Slide Analysis Information

El Mina Coastal Wastewater

Project Summary

File Name: Excavation 1
Last saved with Slide version: 6.025
Project Title: El Mina Coastal Wastewater
Analysis: Trench (7.0m depth) - Dewatering Design - Section 1
Author: E.D
Company: ACTS
Date Created: 23/04/2024

General Settings

Units of Measurement: Metric Units
Time Units: days
Permeability Units: meters/second
Failure Direction: Right to Left
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

Bishop simplified
Janbu simplified

Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Steady State FEA
Pore Fluid Unit Weight: 9.81 kN/m3
Tolerance: 1e-006
Maximum number of iterations: 500
Advanced Groundwater Method: None
Mesh Element Type: 3 noded triangles
Number of Elements: 1205
Number of Nodes: 662

Random Numbers

Pseudo-random Seed: 10116
Random Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Circular
Search Method: Slope Search
Number of Surfaces: 5000
Upper Angle: Not Defined
Lower Angle: Not Defined

Composite Surfaces: Disabled
Reverse Curvature: Invalid Surfaces
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Property	Gravelly Cobbles (1)	Clay (2)	Gravelly Cobbles (3)	Clay (4)
Color				
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [kN/m3]	17	16.5	17.5	16.5
Cohesion [kPa]	0	24.3	0	24.3
Friction Angle [deg]	29	28	32	28
Unsaturated Shear Strength Angle [deg]	0	0	0	0
Air Entry Value [kPa]	0	0	0	0
Ks [meters/second]	0.0005	0.0001	0.0005	1e-007
K2/K1	1	1	1	1
K Angle [deg]	0	0	0	0
Groundwater Model	Simple	Simple	Simple	Simple
GW Model Properties	Soil Type: General	Soil Type: General	Soil Type: General	Soil Type: General

List Of Coordinates

Discharge section

X	Y
22.69	-7
27.31	-7

Discharge section

X	Y
22.69	0
22.69	-7

Discharge section

X	Y
27.31	0
27.31	-7

External Boundary

X	Y
0	-15
50	-15
50	-6.5
50	-4
50	-2
50	0
27.31	0
27.31	-2
27.31	-4
27.31	-6.5
27.31	-7
22.69	-7
22.69	-6.5
22.69	-4
22.69	-2
22.69	0

0	0
0	-2
0	-4
0	-6.5

Material Boundary

X	Y
27.31	-6.5
50	-6.5

Material Boundary

X	Y
27.31	-4
50	-4

Material Boundary

X	Y
27.31	-2
50	-2

Material Boundary

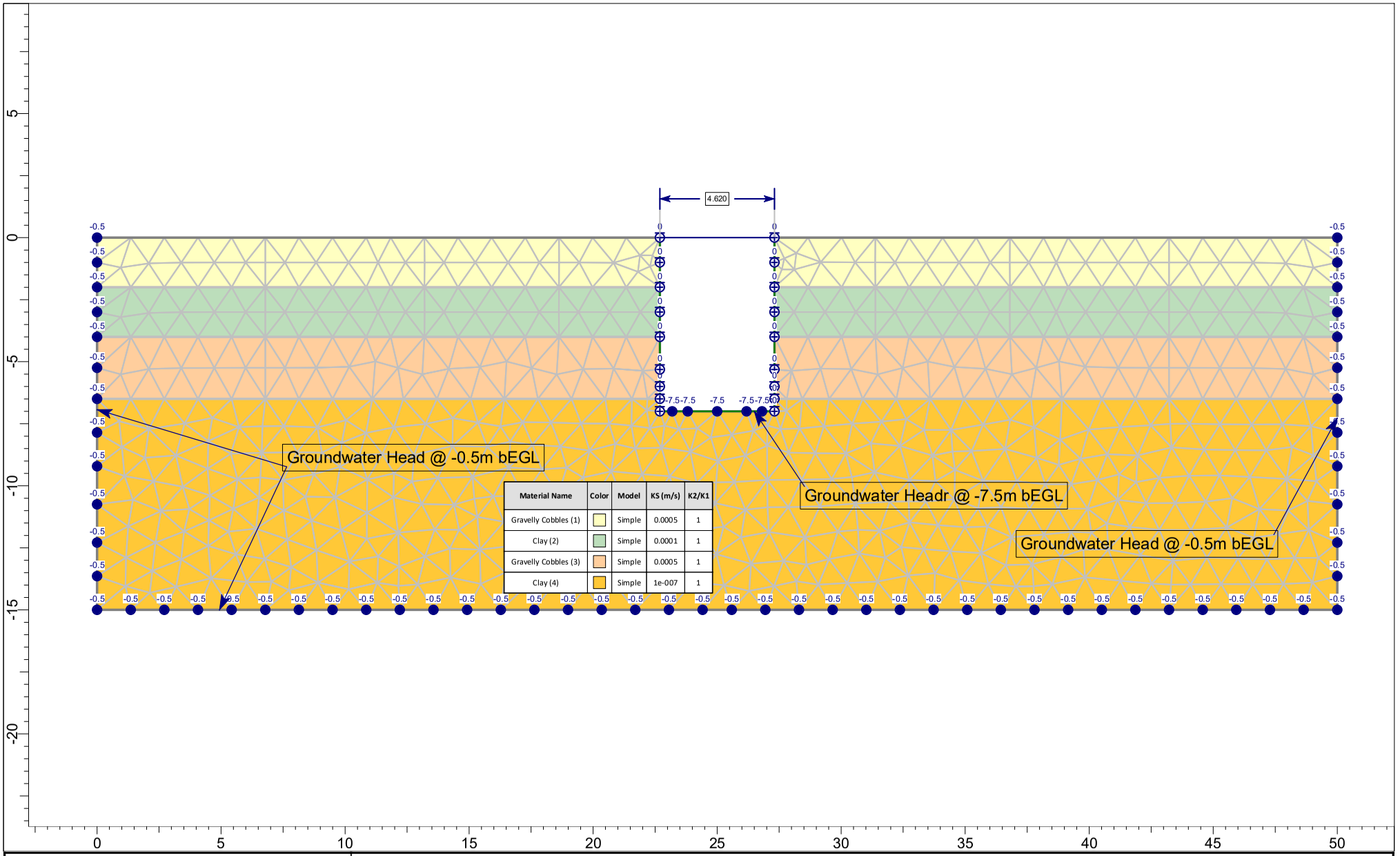
X	Y
0	-6.5
22.69	-6.5

Material Boundary

X	Y
0	-4
22.69	-4

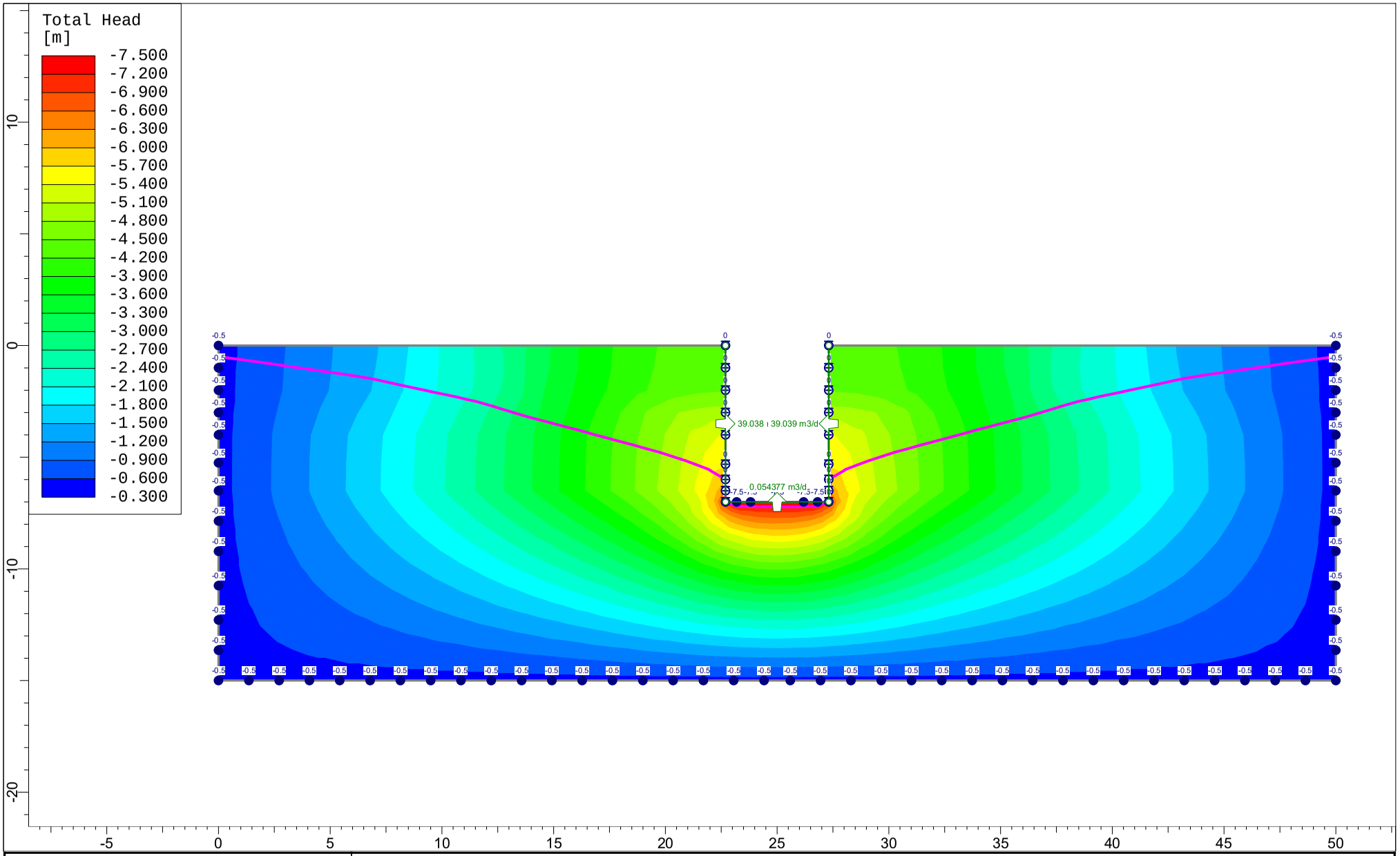
Material Boundary

X	Y
0	-2
22.69	-2



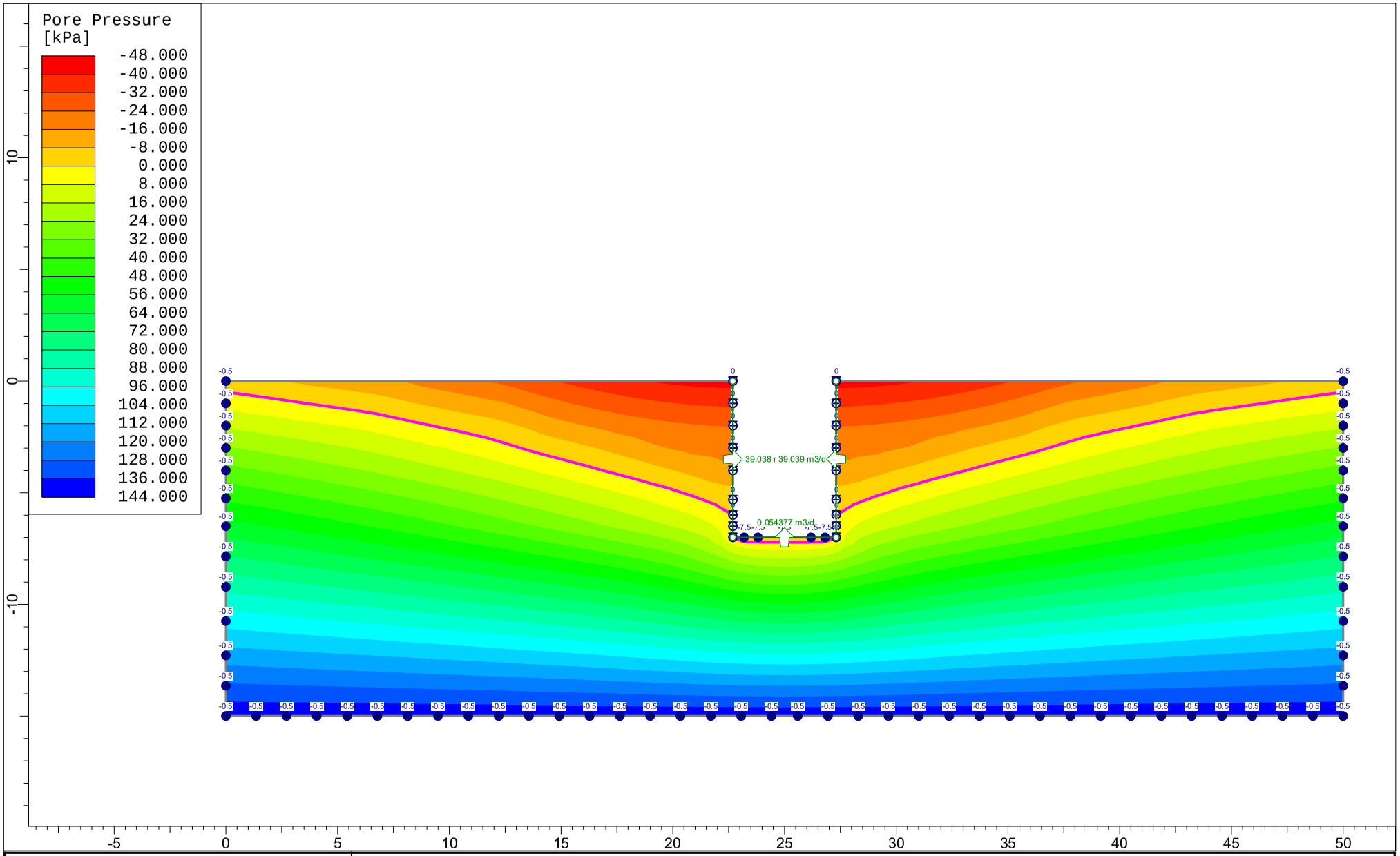
Project	El Mina Coastal Wastewater		
Analysis Description	Trench (7.0m depth) - Dewatering Design - Section 1		
Drawn By: ED	Scale: 1:210	Company: ACTS	
Date: 23/04/2024		File Name: Excavation 1.slim	

SLIDE 6.025



Project	El Mina Coastal Wastewater		
Analysis Description	Trench (7.0m depth) - Dewatering Design - Section 1		
Drawn By: E.D	Scale: 1:234	Company: ACTS	
Date: 23/04/2024		File Name: Excavation 1.slim	

SLIDEINTERPRET 6.025



	Project	El Mina Coastal Wastewater		
	Analysis Description	Trench (7.0m depth) - Dewatering Design - Section 1		
	Drawn By	E.D	Scale 1:234	Company ACTS
SLIDEINTERPRET 6.025	Date	23/04/2024		File Name Excavation 1.slim

Slide Analysis Information

El Mina Coastal Wastewater

Project Summary

File Name: Excavation 2
Last saved with Slide version: 6.025
Project Title: El Mina Coastal Wastewater
Analysis: Trench (6.0m depth) - Dewatering Design - Section 2
Author: E.D
Company: ACTS
Date Created: 30/04/2024

General Settings

Units of Measurement: Metric Units
Time Units: days
Permeability Units: meters/second
Failure Direction: Right to Left
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

Bishop simplified
Janbu simplified

Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Steady State FEA
Pore Fluid Unit Weight: 9.81 kN/m3
Tolerance: 1e-006
Maximum number of iterations: 500
Advanced Groundwater Method: None
Mesh Element Type: 3 noded triangles
Number of Elements: 1218
Number of Nodes: 665

Random Numbers

Pseudo-random Seed: 10116
Random Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Circular
Search Method: Slope Search
Number of Surfaces: 5000
Upper Angle: Not Defined
Lower Angle: Not Defined

Composite Surfaces: Disabled
Reverse Curvature: Invalid Surfaces
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Property	Gravelly Cobbles (1)	Clay (2)	Gravelly Cobbles (3)	Clay (4)
Color				
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [kN/m3]	17	16.5	17.5	16.5
Cohesion [kPa]	0	24.3	0	24.3
Friction Angle [deg]	29	28	32	28
Unsaturated Shear Strength Angle [deg]	0	0	0	0
Air Entry Value [kPa]	0	0	0	0
Ks [meters/second]	0.0005	0.0001	0.0005	1e-007
K2/K1	1	1	1	1
K Angle [deg]	0	0	0	0
Groundwater Model	Simple	Simple	Simple	Simple
GW Model Properties	Soil Type: General	Soil Type: General	Soil Type: General	Soil Type: General

List Of Coordinates

Discharge section

X	Y
23.065	-6
26.935	-6

Discharge section

X	Y
23.065	0
23.065	-6

Discharge section

X	Y
26.935	0
26.935	-6

External Boundary

X	Y
0	-15
50	-15
50	-6.5
50	-4
50	-2
50	0
26.935	0
26.935	-2
26.935	-4
26.935	-6
23.065	-6
23.065	-4
23.065	-2
23.065	0
0	0
0	-2

0	-4
0	-6.5

Material Boundary

X	Y
26.935	-4
50	-4

Material Boundary

X	Y
26.935	-2
50	-2

Material Boundary

X	Y
0	-6.5
50	-6.5

Material Boundary

X	Y
0	-4
23.065	-4

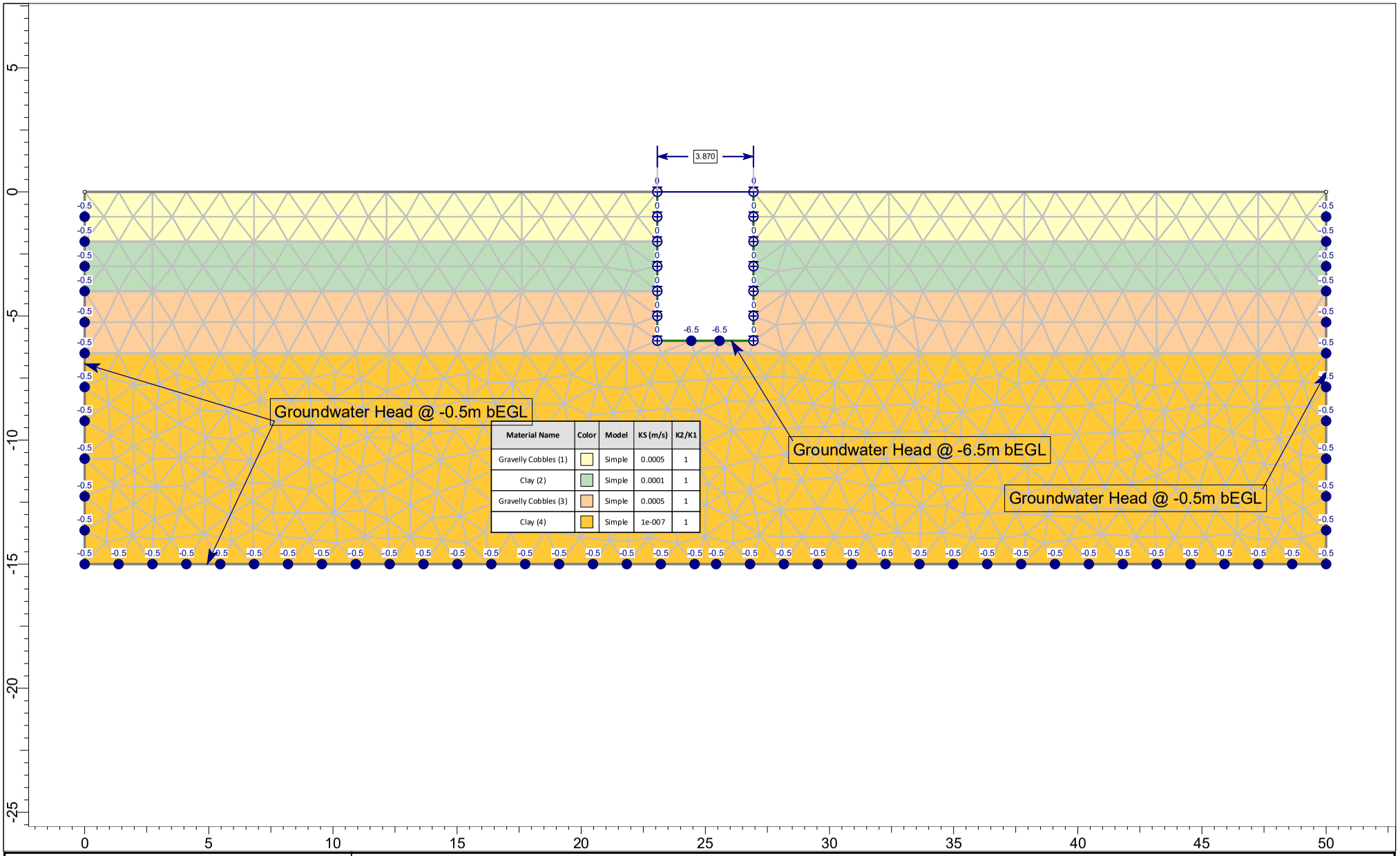
Material Boundary

X	Y
0	-2

23.065 -2

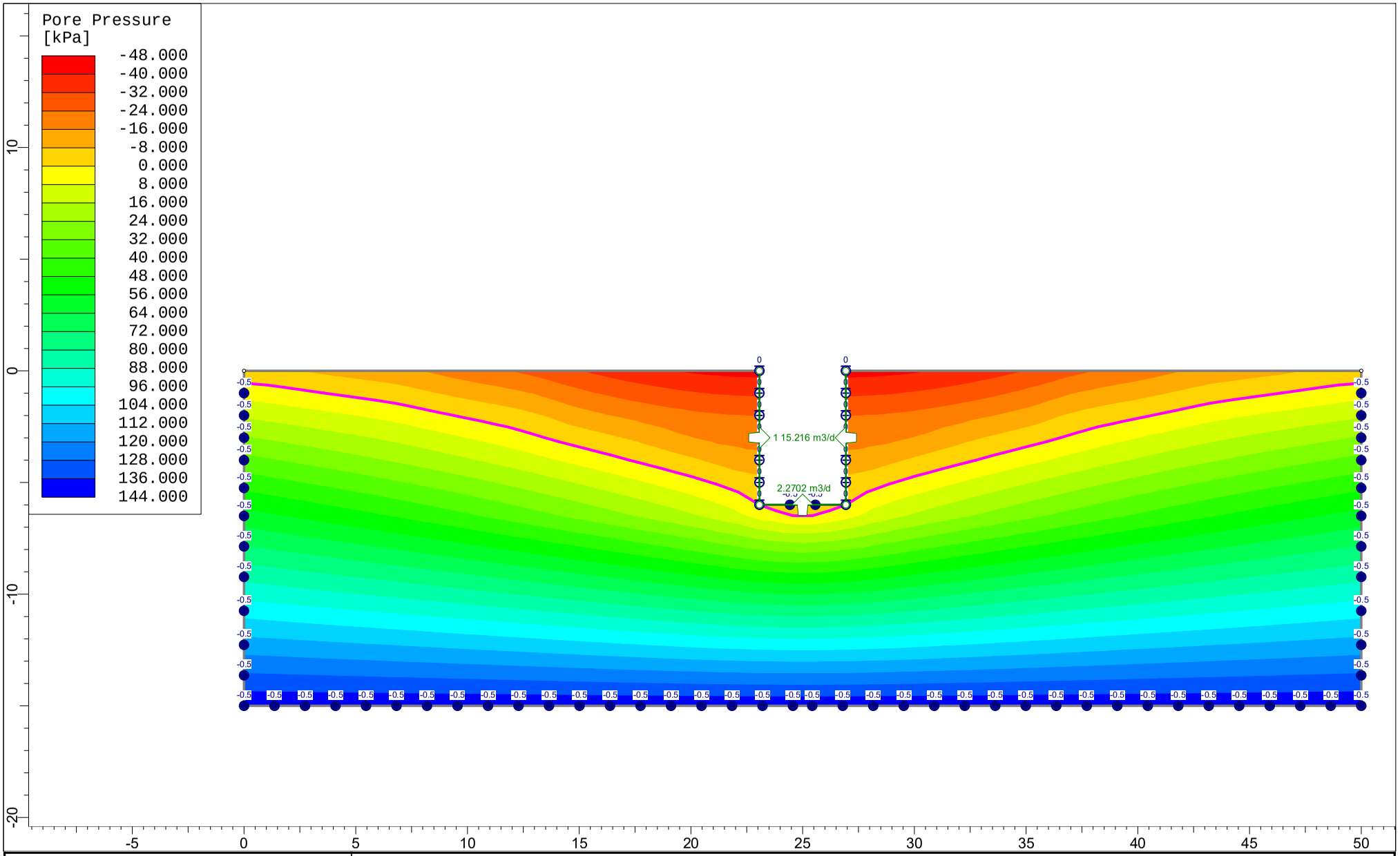
rocscience	Project: El Mina Coastal Wastewater		
	Analysis Description: Trench (6.0m depth) - Dewatering Design - Section 2		
	Drawn By: ED	Scale:	Company: ACTS
	Date: 30/04/2024		File Name: Excavation 2.slim

SLIDE 6.025



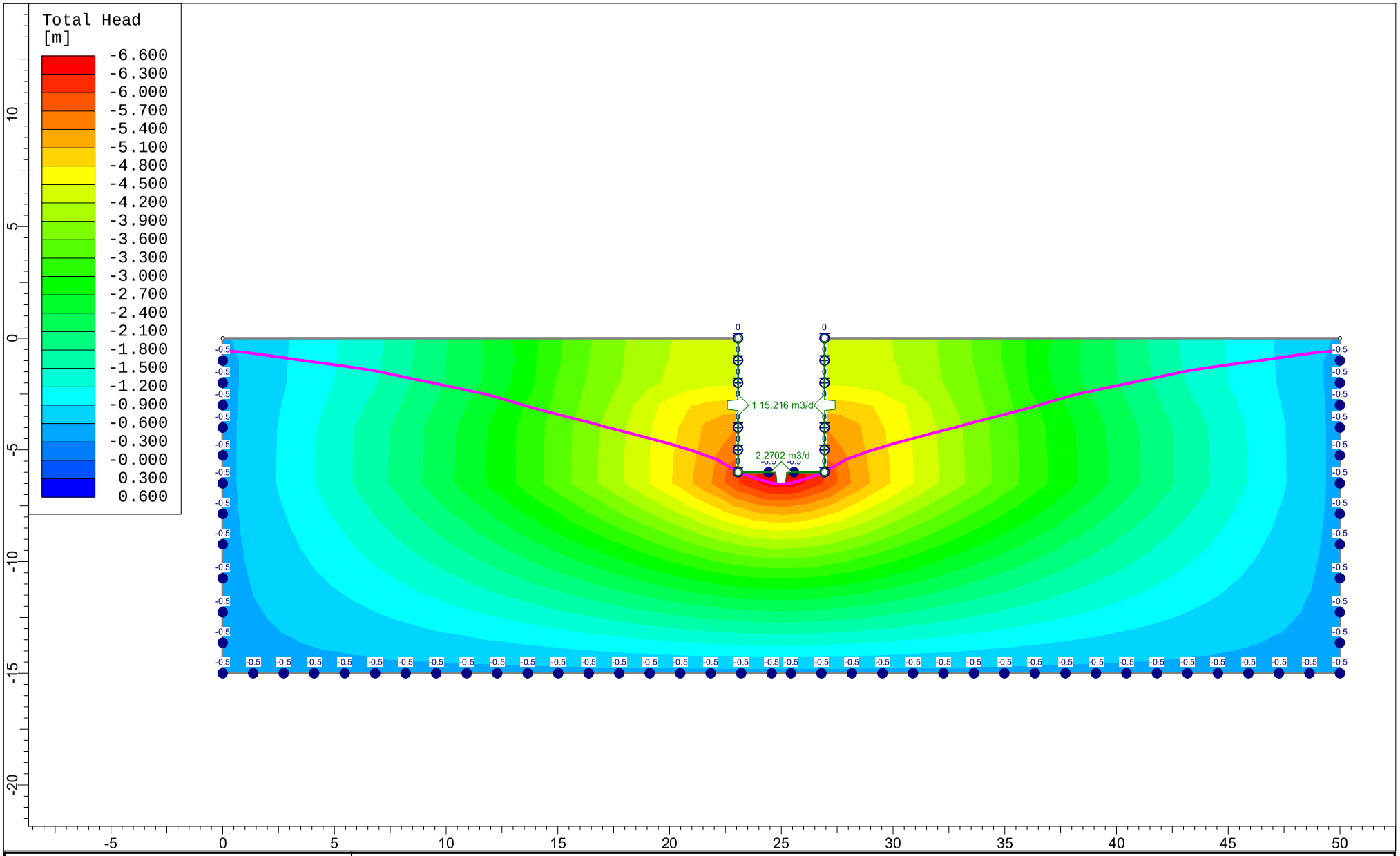
Project	El Mina Coastal Wastewater		
Analysis Description	Trench (6.0m depth) - Dewatering Design - Section 2		
Drawn By: ED	Scale: 1:210	Company: ACTS	
Date: 30/04/2024		File Name: Excavation 2.slim	

SLIDE 6.025



Project	El Mina Coastal Wastewater		
Analysis Description	Trench (6.0m depth) - Dewatering Design - Section 2		
Drawn By	E.D	Scale 1:234	Company ACTS
Date	30/04/2024		File Name Excavation 2.slim

SLIDEINTERPRET 6.025



SLIDEINTERPRET 6.025	*Project*	El Mina Coastal Wastewater		
	Analysis Description	Trench (6.0m depth) - Dewatering Design - Section 2		
	Drawn By	E.D	*Scale* 1:234	*Company* ACTS
	Date	30/04/2024		*File Name* Excavation 2.slim

Slide Analysis Information

El Mina Coastal Wastewater

Project Summary

File Name: Excavation 3
Last saved with Slide version: 6.025
Project Title: El Mina Coastal Wastewater
Analysis: Trench (5.0m depth) - Dewatering Design - Section 3
Author: E.D
Company: ACTS
Date Created: 30/04/2024

General Settings

Units of Measurement: Metric Units
Time Units: days
Permeability Units: meters/second
Failure Direction: Right to Left
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

Bishop simplified
Janbu simplified

Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Steady State FEA
Pore Fluid Unit Weight: 9.81 kN/m3
Tolerance: 1e-006
Maximum number of iterations: 500
Advanced Groundwater Method: None
Mesh Element Type: 3 noded triangles
Number of Elements: 1106
Number of Nodes: 608

Random Numbers

Pseudo-random Seed: 10116
Random Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Circular
Search Method: Slope Search
Number of Surfaces: 5000
Upper Angle: Not Defined
Lower Angle: Not Defined

Composite Surfaces: Disabled
Reverse Curvature: Invalid Surfaces
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Property	Gravelly Cobbles (1)	Clay (2)	Gravelly Cobbles (3)	Clay (4)
Color				
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [kN/m3]	17	16.5	17.5	16.5
Cohesion [kPa]	0	24.3	0	24.3
Friction Angle [deg]	29	28	32	28
Unsaturated Shear Strength Angle [deg]	0	0	0	0
Air Entry Value [kPa]	0	0	0	0
Ks [meters/second]	0.0005	0.0001	0.0005	1e-007
K2/K1	1	1	1	1
K Angle [deg]	0	0	0	0
Groundwater Model	Simple	Simple	Simple	Simple
GW Model Properties	Soil Type: General	Soil Type: General	Soil Type: General	Soil Type: General

List Of Coordinates

Discharge section

X	Y
23.265	-5
26.735	-5

Discharge section

X	Y
23.265	0
23.265	-5

Discharge section

X	Y
26.735	0
26.735	-5

External Boundary

X	Y
0	-15
50	-15
50	-6.5
50	-4
50	-2
50	0
26.735	0
26.735	-2
26.735	-4
26.735	-5
23.265	-5
23.265	-4
23.265	-2
23.265	0
0	0
0	-2

0	-4
0	-6.5

Material Boundary

X	Y
26.735	-4
50	-4

Material Boundary

X	Y
26.735	-2
50	-2

Material Boundary

X	Y
0	-6.5
50	-6.5

Material Boundary

X	Y
0	-4
23.265	-4

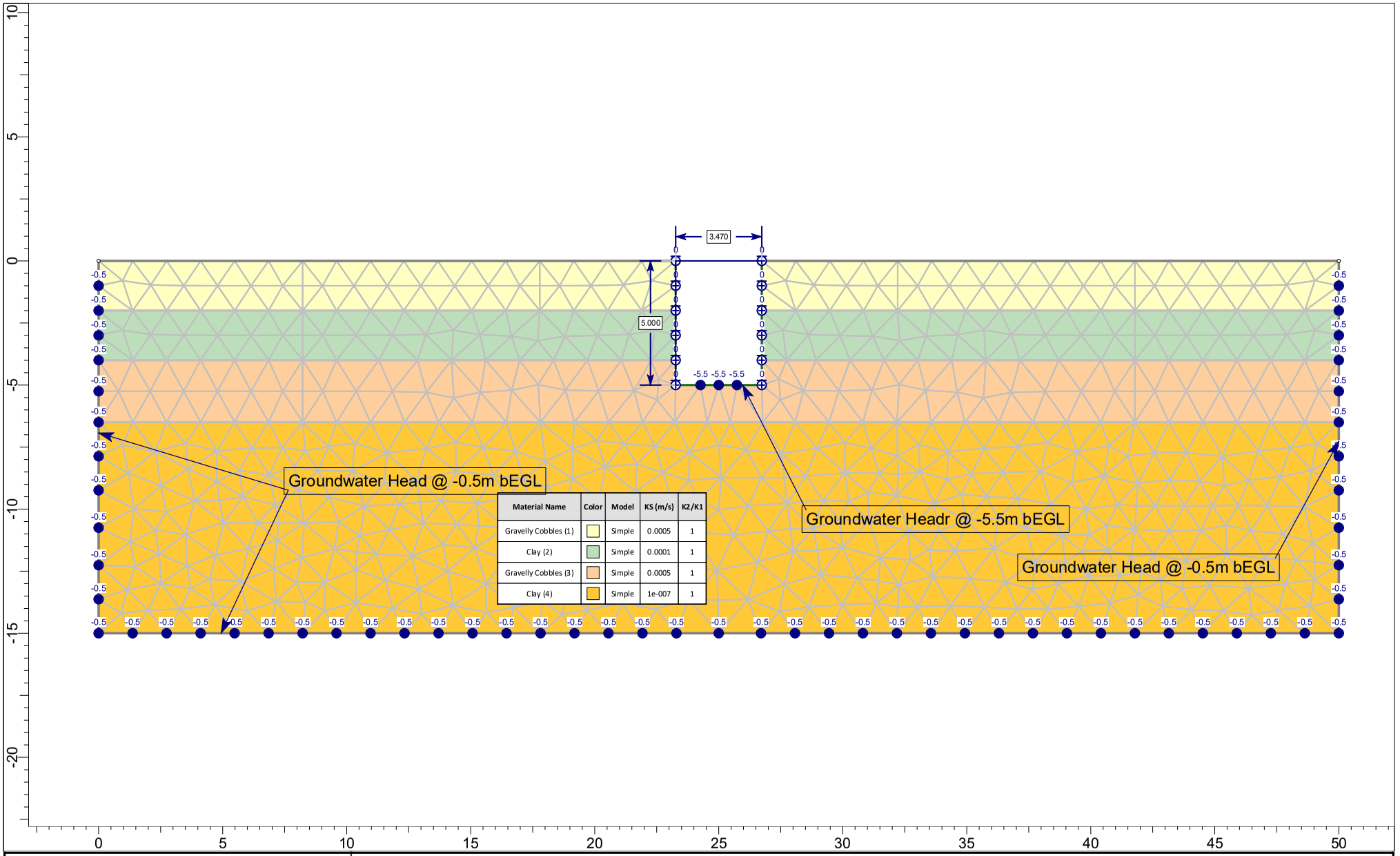
Material Boundary

X	Y
0	-2

23.265 -2

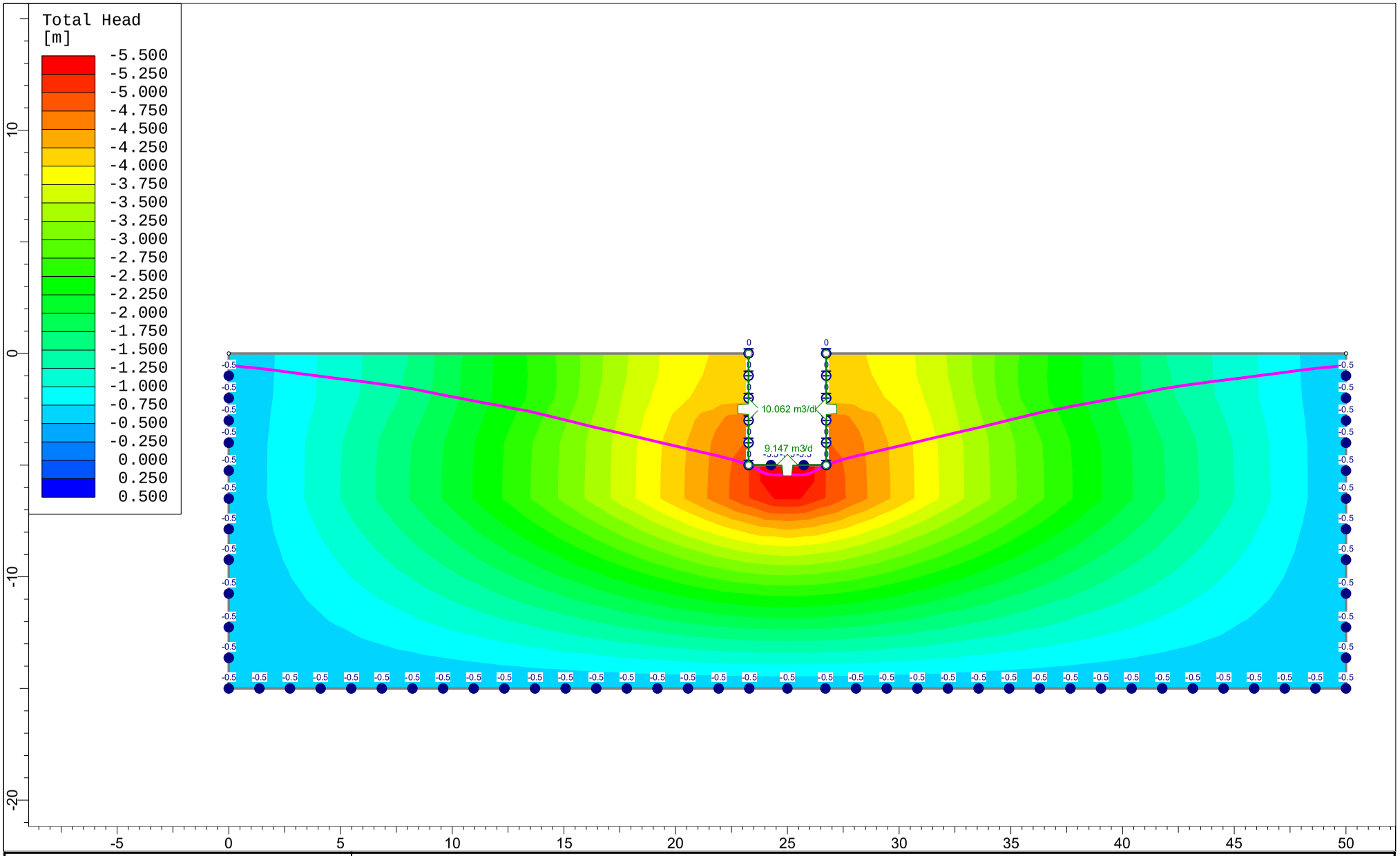
Project	El Mina Coastal Wastewater		
Analysis Description	Trench (5.0m depth) - Dewatering Design - Section 3		
Drawn By: ED		Scale:	Company: ACTS
Date: 30/04/2024			File Name: Excavation 3.slim

SLIDE 6.025



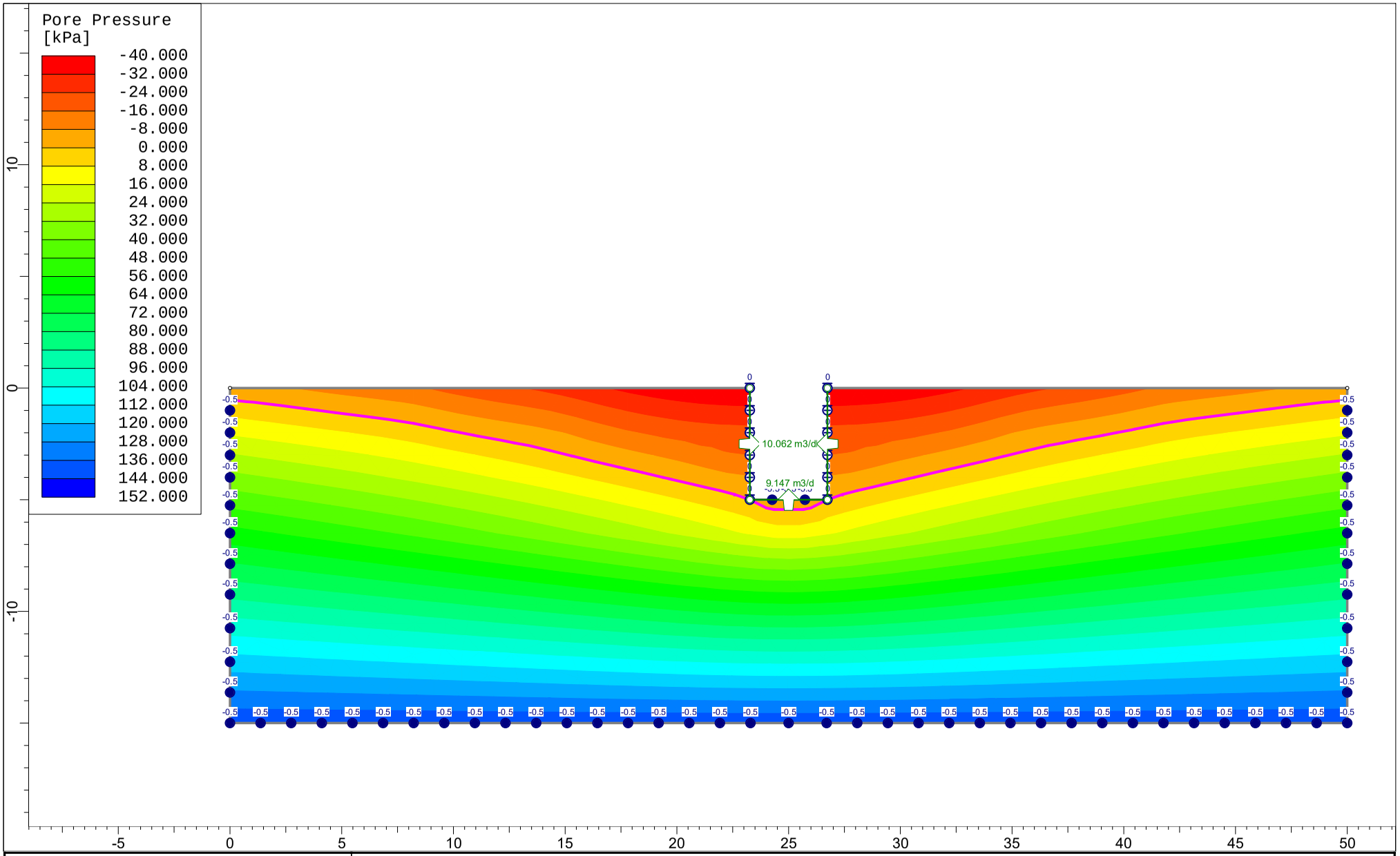
Project	El Mina Coastal Wastewater		
Analysis Description	Trench (5.0m depth) - Dewatering Design - Section 3		
Drawn By: ED	Scale: 1:210	Company: ACTS	
Date: 30/04/2024		File Name: Excavation 3.slim	

SLIDE 6.025



rocscience	Project	El Mina Coastal Wastewater		
	Analysis Description	Trench (5.0m depth) - Dewatering Design - Section 3		
	Drawn By	E.D	Scale 1:234	Company ACTS
	Date	30/04/2024		File Name Excavation 3.slim

SLIDEINTERPRET 6.025



Project	El Mina Coastal Wastewater		
Analysis Description	Trench (5.0m depth) - Dewatering Design - Section 3		
Drawn By: E.D	Scale: 1:234	Company: ACTS	
Date: 30/04/2024		File Name: Excavation 3.slim	

SLIDEINTERPRET 6.025

Slide Analysis Information

El Mina Coastal Wastewater

Project Summary

File Name: Excavation 4
Last saved with Slide version: 6.025
Project Title: El Mina Coastal Wastewater
Analysis: Trench (4.0m depth) - Dewatering Design - Section 4
Author: E.D
Company: ACTS
Date Created: 30/04/2024

General Settings

Units of Measurement: Metric Units
Time Units: days
Permeability Units: meters/second
Failure Direction: Right to Left
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

Bishop simplified
Janbu simplified

Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Steady State FEA
Pore Fluid Unit Weight: 9.81 kN/m3
Tolerance: 1e-006
Maximum number of iterations: 500
Advanced Groundwater Method: None
Mesh Element Type: 3 noded triangles
Number of Elements: 1148
Number of Nodes: 627

Random Numbers

Pseudo-random Seed: 10116
Random Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Circular
Search Method: Slope Search
Number of Surfaces: 5000
Upper Angle: Not Defined
Lower Angle: Not Defined

Composite Surfaces: Disabled
Reverse Curvature: Invalid Surfaces
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Property	Gravelly Cobbles (1)	Clay (2)	Gravelly Cobbles (3)	Clay (4)
Color				
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [kN/m3]	17	16.5	17.5	16.5
Cohesion [kPa]	0	24.3	0	24.3
Friction Angle [deg]	29	28	32	28
Unsaturated Shear Strength Angle [deg]	0	0	0	0
Air Entry Value [kPa]	0	0	0	0
Ks [meters/second]	0.0005	0.0001	0.0005	1e-007
K2/K1	1	1	1	1
K Angle [deg]	0	0	0	0
Groundwater Model	Simple	Simple	Simple	Simple
GW Model Properties	Soil Type: General	Soil Type: General	Soil Type: General	Soil Type: General

List Of Coordinates

Discharge section

X	Y
23.465	-4
26.535	-4

Discharge section

X	Y
23.465	0
23.465	-4

Discharge section

X	Y
26.535	0
26.535	-4

External Boundary

X	Y
0	-15
50	-15
50	-6.5
50	-4
50	-2
50	0
26.535	0
26.535	-2
26.535	-4
23.465	-4
23.465	-2
23.465	0
0	0
0	-2
0	-4
0	-6.5

Material Boundary

X	Y
26.535	-4
50	-4

Material Boundary

X	Y
26.535	-2
50	-2

Material Boundary

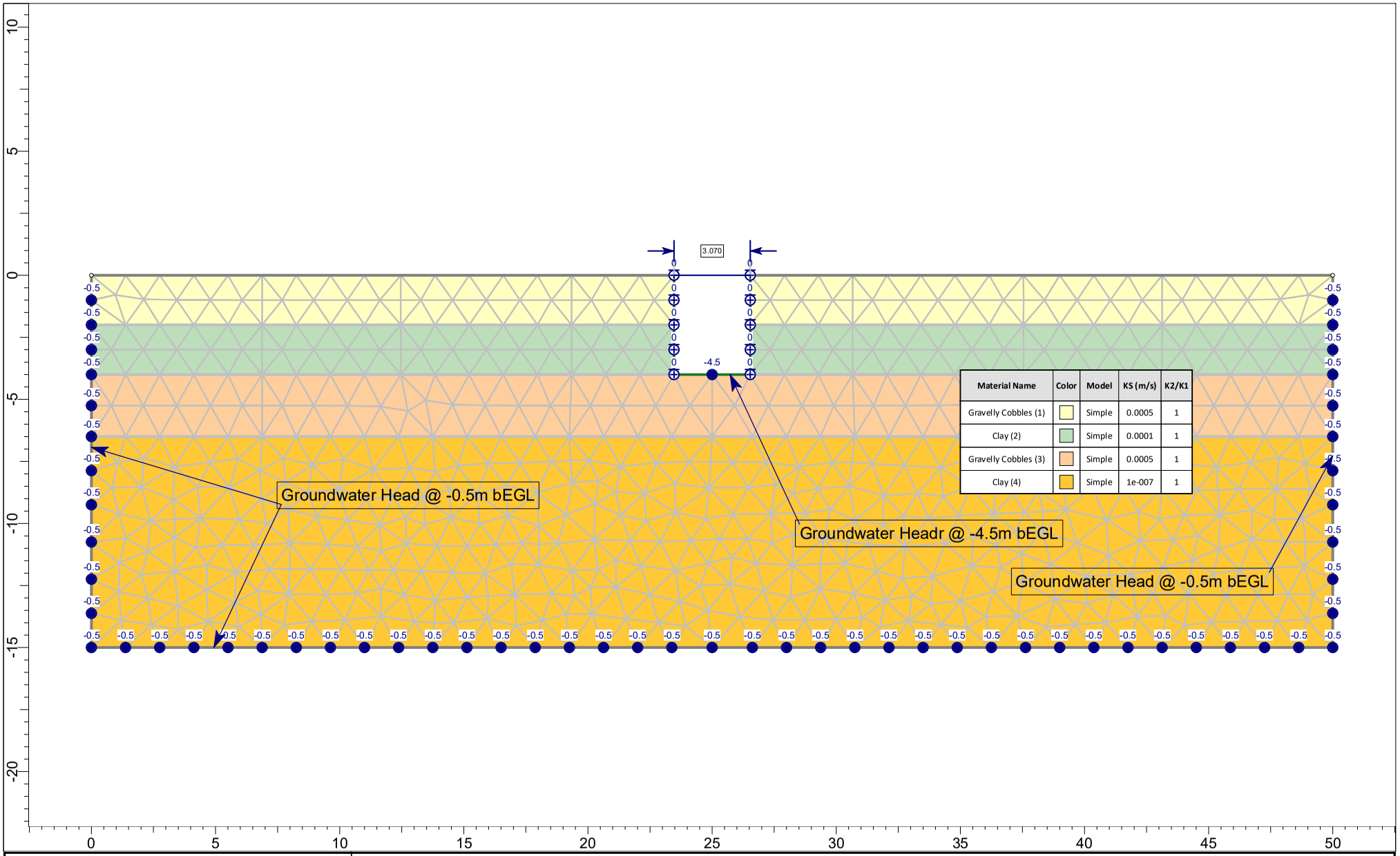
X	Y
0	-6.5
50	-6.5

Material Boundary

X	Y
0	-4
23.465	-4

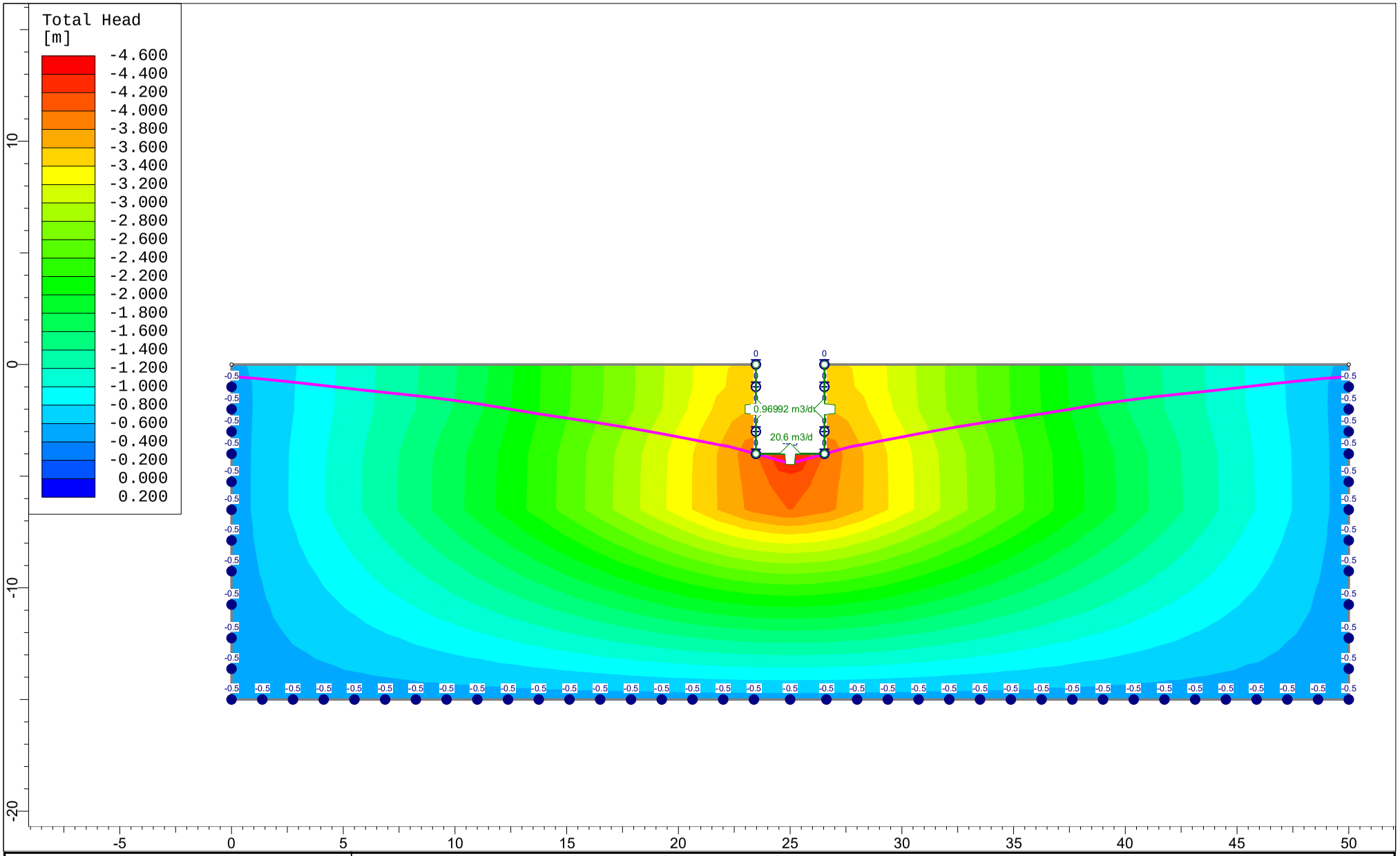
Material Boundary

X	Y
0	-2
23.465	-2



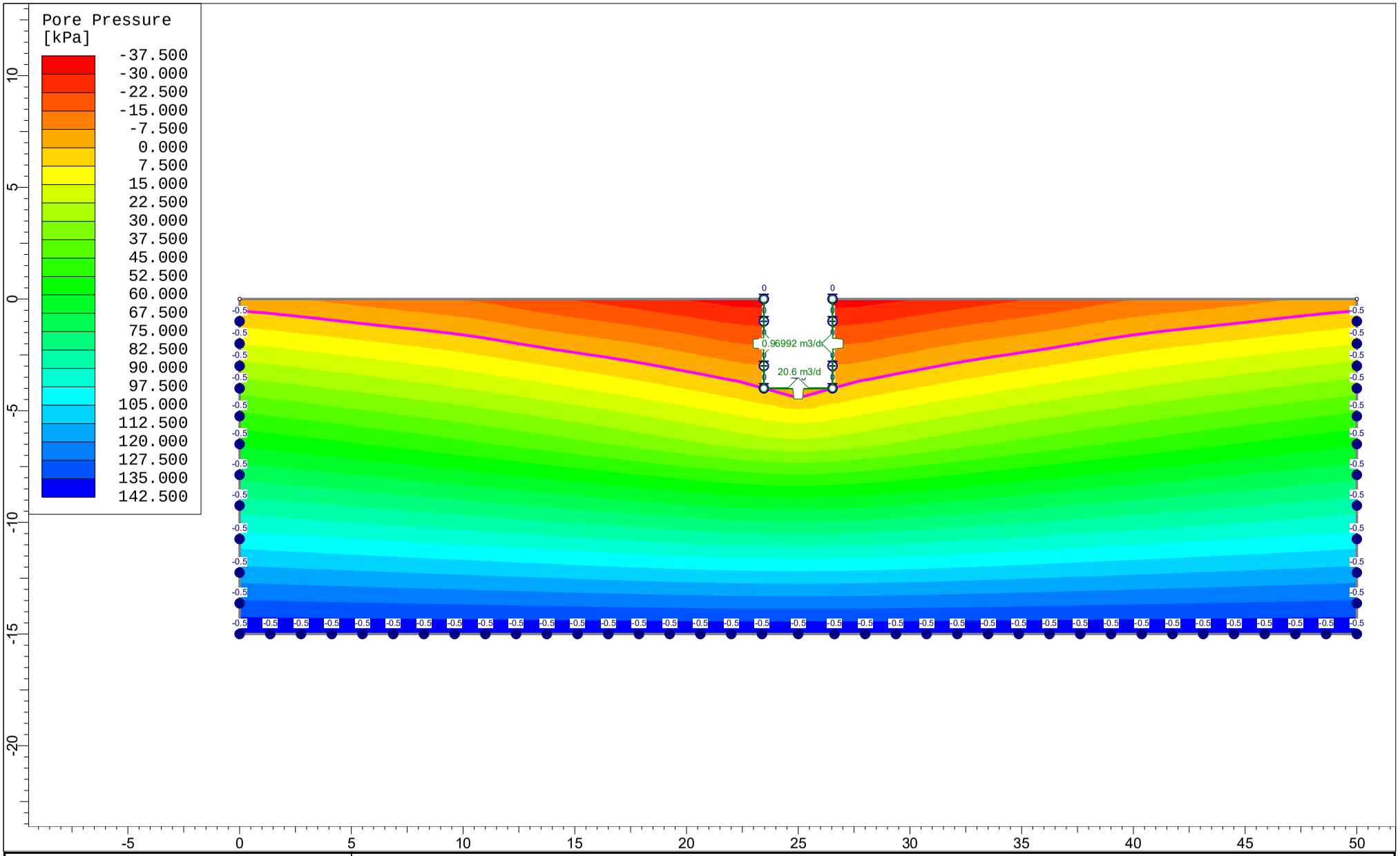
rocscience	Project	El Mina Coastal Wastewater		
	Analysis Description	Trench (4.0m depth) - Dewatering Design - Section 4		
	Drawn By	ED	Scale 1:210	Company ACTS
	Date	30/04/2024		File Name Excavation 4.slim

SLIDE 6.025



rocscience	Project	El Mina Coastal Wastewater		
	Analysis Description	Trench (4.0m depth) - Dewatering Design - Section 4		
	Drawn By	E.D	Scale 1:234	Company ACTS
	Date	30/04/2024		File Name Excavation 4.slim

SLIDEINTERPRET 6.025



Project	El Mina Coastal Wastewater		
Analysis Description	Trench (4.0m depth) - Dewatering Design - Section 4		
Drawn By	E.D	Scale 1:234	Company ACTS
Date	30/04/2024		File Name Excavation 4.slim

SLIDEINTERPRET 6.025

Slide Analysis Information

El Mina Coastal Wastewater

Project Summary

File Name: Excavation 5
Last saved with Slide version: 6.025
Project Title: El Mina Coastal Wastewater
Analysis: Trench (3.0m depth) - Dewatering Design - Section 5
Author: E.D
Company: ACTS
Date Created: 30/04/2024

General Settings

Units of Measurement: Metric Units
Time Units: days
Permeability Units: meters/second
Failure Direction: Right to Left
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

Bishop simplified
Janbu simplified

Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Steady State FEA
Pore Fluid Unit Weight: 9.81 kN/m3
Tolerance: 1e-006
Maximum number of iterations: 500
Advanced Groundwater Method: None
Mesh Element Type: 3 noded triangles
Number of Elements: 1211
Number of Nodes: 658

Random Numbers

Pseudo-random Seed: 10116
Random Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Circular
Search Method: Slope Search
Number of Surfaces: 5000
Upper Angle: Not Defined
Lower Angle: Not Defined

Composite Surfaces: Disabled
Reverse Curvature: Invalid Surfaces
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Property	Gravelly Cobbles (1)	Clay (2)	Gravelly Cobbles (3)	Clay (4)
Color				
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [kN/m3]	17	16.5	17.5	16.5
Cohesion [kPa]	0	24.3	0	24.3
Friction Angle [deg]	29	28	32	28
Unsaturated Shear Strength Angle [deg]	0	0	0	0
Air Entry Value [kPa]	0	0	0	0
Ks [meters/second]	0.0005	0.0001	0.0005	1e-007
K2/K1	1	1	1	1
K Angle [deg]	0	0	0	0
Groundwater Model	Simple	Simple	Simple	Simple
GW Model Properties	Soil Type: General	Soil Type: General	Soil Type: General	Soil Type: General

List Of Coordinates

Discharge section

X	Y
23.615	-3
26.385	-3

Discharge section

X	Y
23.615	0
23.615	-3

Discharge section

X	Y
26.385	0
26.385	-3

External Boundary

X	Y
0	-15
50	-15
50	-6.5
50	-4
50	-2
50	0
26.385	0
26.385	-2
26.385	-3
23.615	-3
23.615	-2
23.615	0
0	0
0	-2
0	-4
0	-6.5

Material Boundary

X	Y
26.385	-2
50	-2

Material Boundary

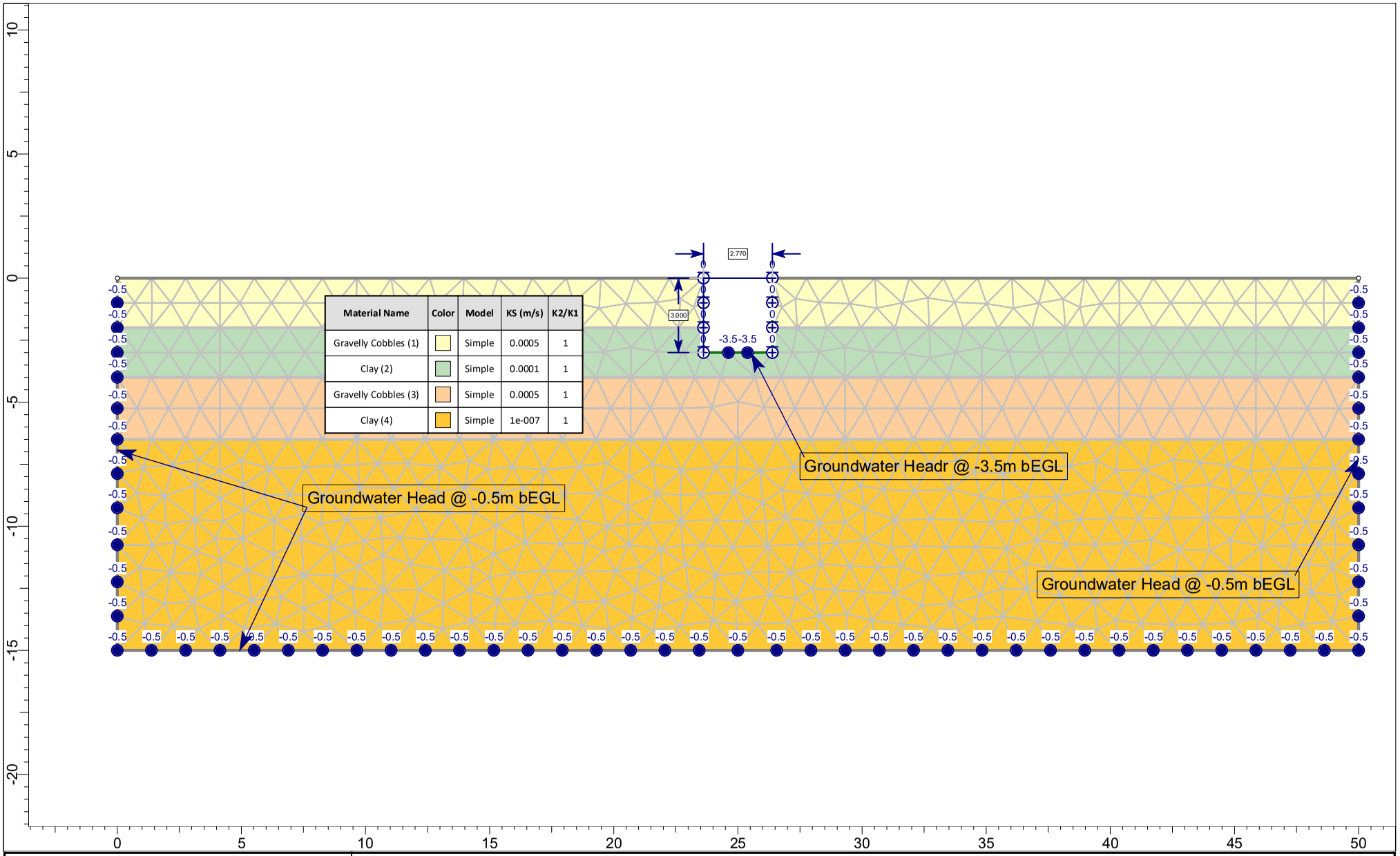
X	Y
0	-6.5
50	-6.5

Material Boundary

X	Y
0	-4
50	-4

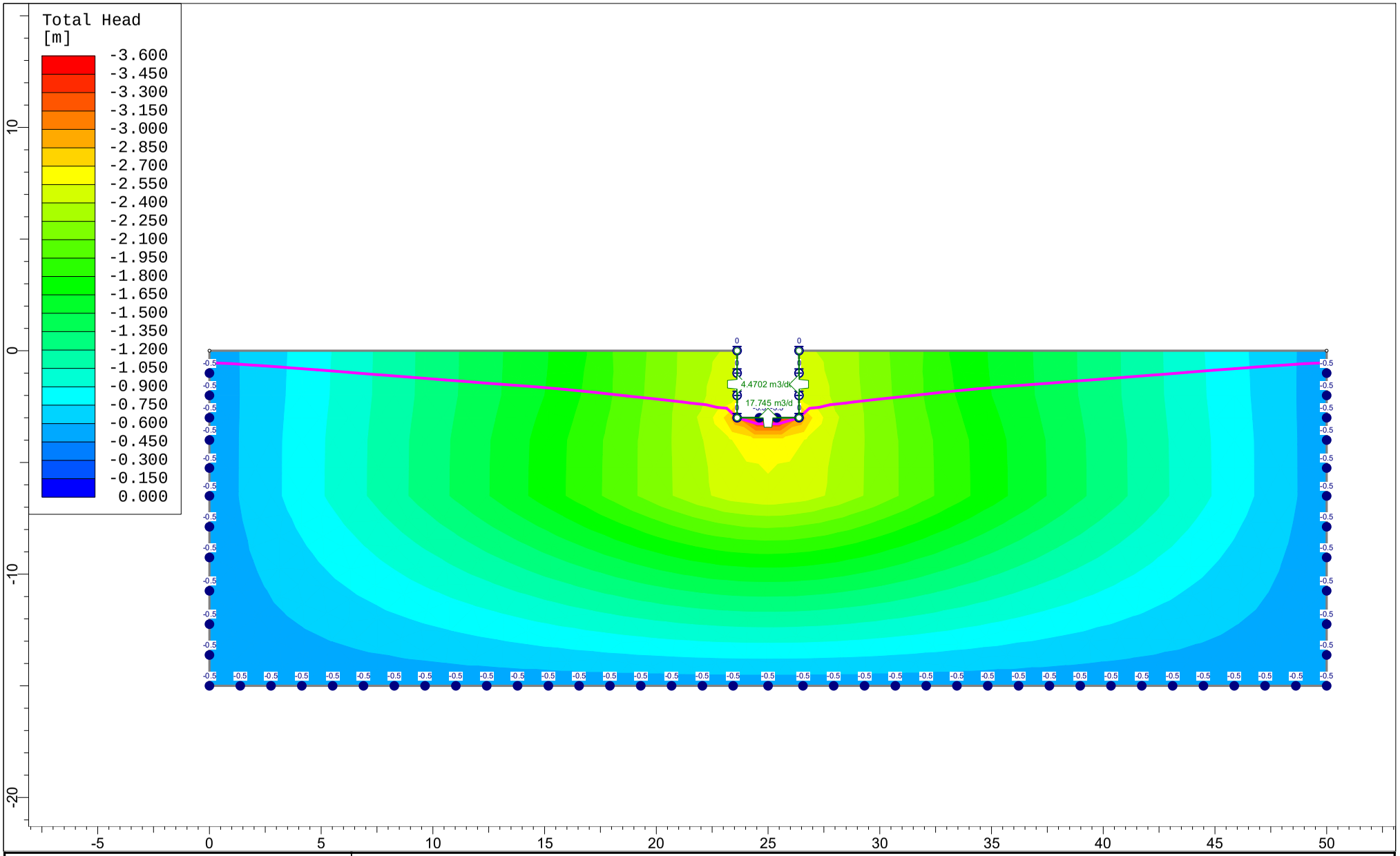
Material Boundary

X	Y
0	-2
23.615	-2



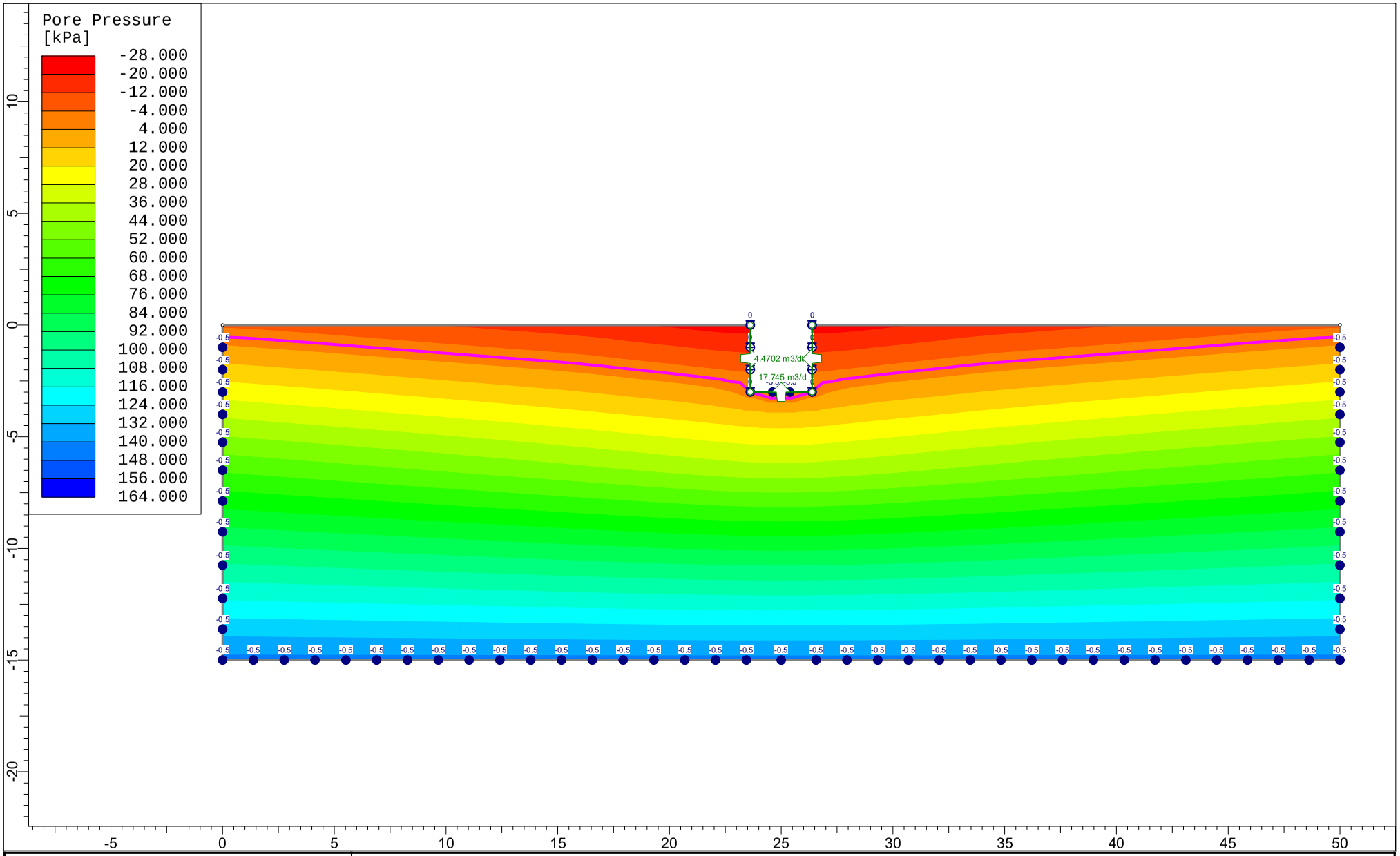
Project	El Mina Coastal Wastewater		
Analysis Description	Trench (3.0m depth) - Dewatering Design - Section 5		
Drawn By	ED	Scale 1:210	Company ACTS
Date	30/04/2024		File Name Excavation 5.slim

SLIDE 6.025



rocscience	Project	El Mina Coastal Wastewater		
	Analysis Description	Trench (3.0m depth) - Dewatering Design - Section 5		
	Drawn By	E.D	Scale 1:234	Company ACTS
	Date	30/04/2024		File Name Excavation 5.slim

SLIDEINTERPRET 6.025



Project	El Mina Coastal Wastewater		
Analysis Description	Trench (3.0m depth) - Dewatering Design - Section 5		
Drawn By	E.D	Scale 1:234	Company ACTS
Date	30/04/2024		File Name Excavation 5.slim

SLIDEINTERPRET 6.025

Slide Analysis Information

El Mina Coastal Wastewater

Project Summary

File Name: Excavation 6
Last saved with Slide version: 6.025
Project Title: El Mina Coastal Wastewater
Analysis: Trench (2.0m depth) - Dewatering Design - Section 6
Author: E.D
Company: ACTS
Date Created: 02/05/2024

General Settings

Units of Measurement: Metric Units
Time Units: days
Permeability Units: meters/second
Failure Direction: Right to Left
Data Output: Standard
Maximum Material Properties: 20
Maximum Support Properties: 20

Analysis Options

Analysis Methods Used

Bishop simplified
Janbu simplified

Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50
Check malpha < 0.2: Yes
Initial trial value of FS: 1
Steffensen Iteration: Yes

Groundwater Analysis

Groundwater Method: Steady State FEA
Pore Fluid Unit Weight: 9.81 kN/m3
Tolerance: 1e-006
Maximum number of iterations: 500
Advanced Groundwater Method: None
Mesh Element Type: 3 noded triangles
Number of Elements: 1156
Number of Nodes: 629

Random Numbers

Pseudo-random Seed: 10116
Random Number Generation Method: Park and Miller v.3

Surface Options

Surface Type: Circular
Search Method: Slope Search
Number of Surfaces: 5000
Upper Angle: Not Defined
Lower Angle: Not Defined

Composite Surfaces: Disabled
Reverse Curvature: Invalid Surfaces
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Property	Gravelly Cobbles (1)	Clay (2)	Gravelly Cobbles (3)	Clay (4)
Color				
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [kN/m3]	17	16.5	17.5	16.5
Cohesion [kPa]	0	24.3	0	24.3
Friction Angle [deg]	29	28	32	28
Unsaturated Shear Strength Angle [deg]	0	0	0	0
Air Entry Value [kPa]	0	0	0	0
Ks [meters/second]	0.0005	0.0001	0.0005	1e-007
K2/K1	1	1	1	1
K Angle [deg]	0	0	0	0
Groundwater Model	Simple	Simple	Simple	Simple
GW Model Properties	Soil Type: General	Soil Type: General	Soil Type: General	Soil Type: General

List Of Coordinates

Discharge section

X	Y
23.765	-2
26.235	-2

Discharge section

X	Y
23.765	0
23.765	-2

Discharge section

X	Y
26.235	0
26.235	-2

External Boundary

X	Y
0	-15
50	-15
50	-6.5
50	-4
50	-2
50	0
26.235	0
26.235	-2
23.765	-2
23.765	0
0	0
0	-2
0	-4
0	-6.5

Material Boundary

X	Y
26.235	-2
50	-2

Material Boundary

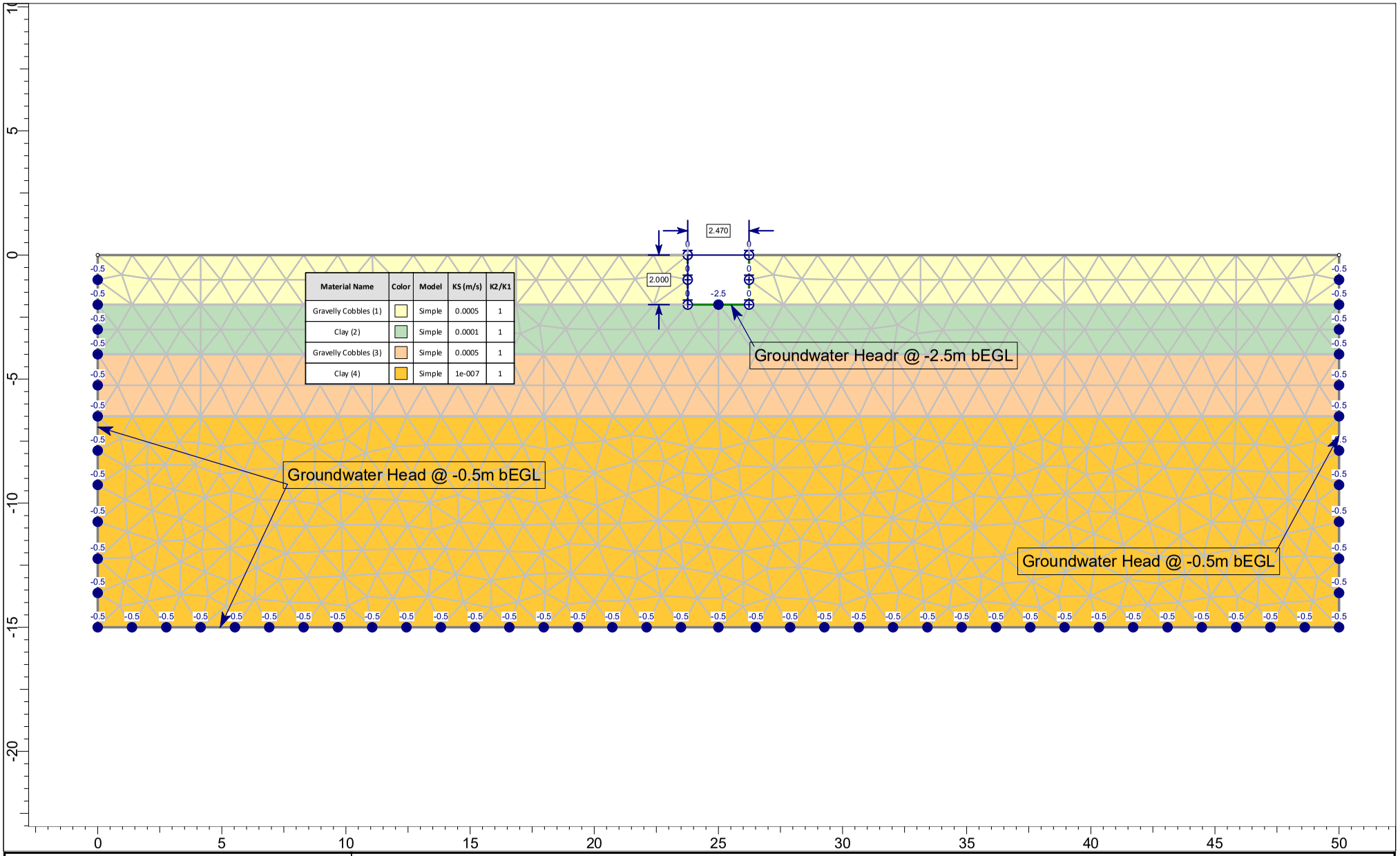
X	Y
0	-6.5
50	-6.5

Material Boundary

X	Y
0	-4
50	-4

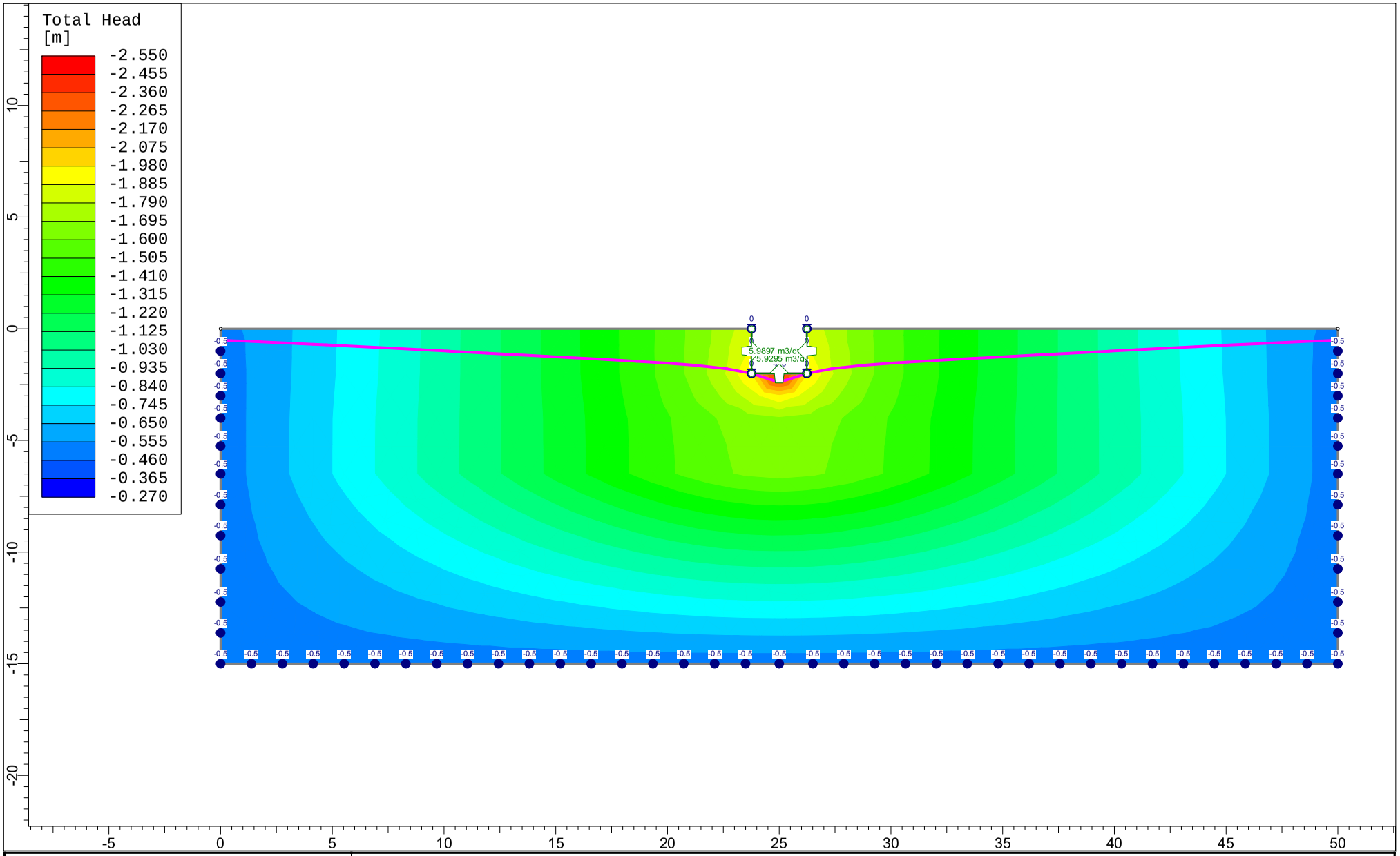
Material Boundary

X	Y
0	-2
23.765	-2



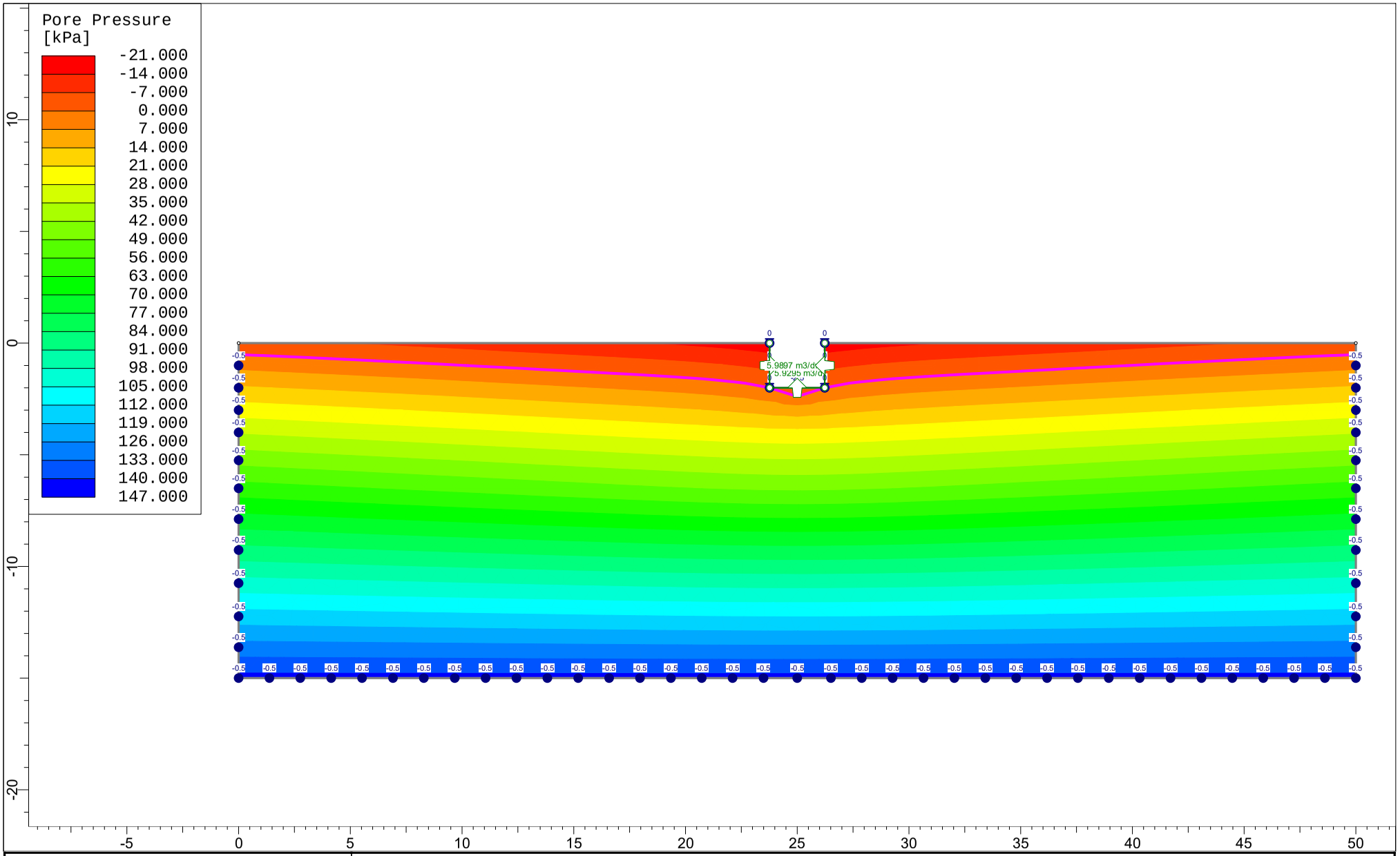
rocscience	*Project*	El Mina Coastal Wastewater	
	Analysis Description	Trench (2.0m depth) - Dewatering Design - Section 6	
	Drawn By ED	*Scale* 1:210	*Company* ACTS
	Date 02/05/2024		*File Name* Excavation 6.slim

SLIDE 6.025



rocscience	Project	El Mina Coastal Wastewater		
	Analysis Description	Trench (2.0m depth) - Dewatering Design - Section 6		
	Drawn By	E.D	Scale 1:234	Company ACTS
	Date	02/05/2024		File Name Excavation 6.slim

SLIDEINTERPRET 6.025



rocscience	Project: El Mina Coastal Wastewater		
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	Date: 02/05/2024		File Name: Excavation 6.slim

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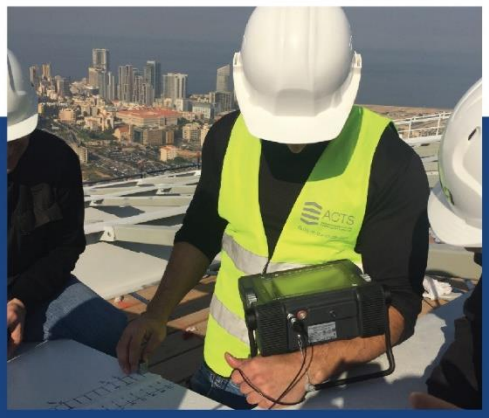
Appendix H – Specification for Dewatering



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BTD

El Mina Coastal Wastewater Project

Specification for Dewatering

02/05/2024

ACTS
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Document Control

Client Name: BTD

Project Name: El Mina Coastal Wastewater Project

Report Title: Specification for Dewatering

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00	02.05.2024	Elias Deaibess	Michel Saad	Elie Khairallah

Contents

1. GENERAL

1.1. Description of Work

This section covers the performance requirements for the lowering and control of groundwater table, hydrostatic pressures and surface water to permit excavation, backfilling and construction works to be carried out safely and to be performed in the dry.

The Contractor shall design, install and maintain dewatering and surface water control measures to achieve the following objectives:

a. To install and operate dewatering systems to facilitate the installation of shoring, undertake excavations, form cut slopes, excavate for foundations and below ground structures and to allow construction and subsequent backfilling works.
b. To prevent surface water run-off from entering excavations or leaving the work areas, including prevention of run-off onto adjacent properties, or to allow water to enter controlled waterways.
c. To contain groundwater and surface run-off prior to discharge, ensuring water complies with prescribed water quality and contamination limits.
d. Dewater and maintain excavations free of water to permit safe operation of plant and equipment, placement of geotextiles, drainage blankets, structural fill, concreting and other works that rely on a stable and dry working surface.
e. To maintain groundwater a minimum of 500mm below the subgrade, or as indicated in the Contract Drawings to meet the requirements of the particular project.
f. Prevent potential destabilizing effects from hydrostatic pressures and gradients, including piping, basal heave and shear failure and erosion of slopes.
g. To prevent the adverse impact on services and structures from groundwater drawdown and hydrostatic pressures.
h. To maintain groundwater a minimum of 500mm below the subgrade, until the structure and backfilling is complete and the structure can resist buoyancy effects.
i. To provide a dewatering system that is effective under likely site and construction conditions, making immediate and effective repairs, or replacement of the dewatering system in the event of breakdown or schedule maintenance.

The Contractor shall maintain the quality of the dewatering and surface waters by implementing measures, such as:

a. Providing well screens to wellpoints to minimize loss of fines and migration of soil, and erosion and sedimentation controls to mitigate loss of materials from surface run-off.
b. Provision of siltation traps, ponds or mechanical filtration systems, such as ‘Silt Busters, cyclones, to reduce suspended solids to such that water meets regulatory requirements.
c. To maintain the siltation traps, ponds or mechanical filtration systems such that are effective throughout the construction period, removing the build-up of retained materials, replacing parts as required, and providing backup systems.
d. Undertaking sampling and chemical analysis of water to establish and confirm throughout the construction period that water meets with regulatory limits to allow discharge, or if required, to implement additional treatment methods prior to discharge.

e. To only discharge the water via approved routes.

1.2. References

The referred codes and standards are intended to provide an acceptable level of quality for materials, products and workmanship. In case of conflict between these standards and the text of this Specification, the Specification text shall govern.

a. Seepage Control in Earth Foundations, Engineering Manual EM 11110-2-1901 (1986), United States Corps of Engineers.
b. Dewatering and Groundwater Control, UFC 3-220-05 (2004), United Facilities Criteria (UFC).
c. Groundwater Control Design and Practice (Second Edition), Construction Industry Research and Information Association, CIRIA Publication 750, (2016).
d. Groundwater Lowering in Construction: A Practical Guide to Dewatering (Second Edition) by P.M. Cashman and M. Preene, Published by CRC Press.

1.3. Definitions

Artificial Recharge: Replenishment of extracted groundwater artificially (via trenches, ponds, pits or wells) to reduce the extent of drawdown surrounding a dewatering system or to dispose of discharged groundwater.
Basal Heave: Upward movement of the floor of an excavation caused by unrelieved pore water pressures.
Cofferdam: A temporary retaining structure which may also be used to exclude lateral flows and under-seepage of groundwater and surface water from entering an excavation.
Confined Aquifer: An aquifer overlain by a significantly lower permeability confining stratum resulting in a piezometric level which is above the base of the confining stratum.
Consolidation Settlement: Settlements resulting from a reduction in groundwater levels or piezometric level with a resulting increase in vertical effective stress.
Construction Dewatering: Means to control groundwater.
Discharge: The flowrate pumped by a groundwater control system or flowing along a natural or manmade channel.
Discharge Consent: Permit from the regulatory authority to allow the discharges of construction dewatering to a controlled channel.
Drawdown: The vertical and lateral extent of lowering the water table in an unconfined aquifer or the piezometric level in a confined aquifer from operation of the groundwater control system.
Ejector: A water jet pump which creates a vacuum by circulating clean water at high pressure through a nozzle and venturi arrangement located in a well.
Falling Head Test: An in-situ permeability test carried out in pits, boreholes or piezometers where water is added to raise the water level in the borehole, and permeability determined by the rate at which the water level falls.
Groundwater: Water contained within, and flowing through the pores and fabric of soil and fissures in rock.
Groundwater Control System: A means to control the groundwater, typically inflows into excavations.

Hydraulic Gradient: The difference in hydraulic head between two points, divided by flow path length.
Loss of Fines: The removal of soil particles by excess flow velocity and poorly designed filter pack, particularly associated with wellpoints.
Numerical Model: Modelling of groundwater flow model which defines the boundary conditions, soil and rock parameters using finite difference or finite element models, typically solved by computers.
Observation Well: A well (or piezometer) used for monitoring groundwater levels or piezometric head.
Permeability Test: An in-situ or laboratory test to measure the permeability of the soil.
Pumping Rate: The rate at which water is abstracted from the ground by the dewatering system.
Phreatic Level: The level at which the pore water pressure is zero (i.e. atmospheric).
Piezometer: An instrument, typically consisting of a ceramic filter installed into the ground over an isolated and specific length for monitoring groundwater levels.
Pumping Test: A test to confirm the hydraulic parameters or pumping and wellpointing requirements to effect drawdown and groundwater control.
Radial Flow: Flow which converges on an axis of radial symmetry.
Radius of Influence: The limits of the effects of dewatering.
Recharge: A means to artificially allow inflow or inject surface and groundwater into the ground.
Recharge Well: A well that is used to recharge or inject water into the ground.
Standpipe: An instrument, typically consisting of a slotted or perforated tube installed into the ground for monitoring groundwater levels.
Submersible Pump: Electric pump commonly used for sump pumping, or slim-line ejector or multistage pumps for use in deep wells.
Sump Pump: A pump capable of handling sediment and chemical-laden water, used to pump from sumps.
Surface Water: Water from precipitation, leakage or from lakes, rivers, conveyed in man- made channels etc. which has not soaked into the ground.
Unconfined Aquifer: An aquifer, not overlain by a relatively impermeable confining layer, where a water table exists and is exposed to the atmosphere.
Watercourse: Natural or man-made surface drainage features such as a stream, river or channel conveying run-off, discharges and the like.
Wellpoint: Small diameter shallow well normally installed at close centers by jetting techniques
Yield: The flowrate from an individual well.

1.4. Submittals

1.5. Quality Assurance

1.5.1. General

The Contractor shall be responsible for the quality of the work and shall develop and propose programs and methods of construction and testing such as to achieve the specified quality to the approval of the consultant/client.

The Contractor shall appoint a specialist dewatering Contractor who has a minimum of 10 years of experience in the design, installation and operation of dewatering systems for projects of similar size and complexity.

The Contractor shall appoint a licensed Engineer who has a minimum of 10 years of experience where the dewatering system requires the installation and operation of dewatering wells.

1.5.2. Field Quality Control

The Contractor shall take samples and perform water quality testing to demonstrate compliance with the Requirements and the Specifications.

2. PRODUCTS

2.1. General

All goods and products covered by these Specifications shall be procured, when available, from an in-Lebanon manufacturer. Procurement of all goods and products manufactured out-of-Lebanon must be approved by the consultant/client.

2.2. Dewatering Equipment

Discharge pipes/lines well screens, header pipes, pumps, generators and other equipment shall comply with minimum material grades, diameters, sizes, pump capacities and outputs to meet the required performance requirements.

Pumps and generators, including standby equipment shall have effective muffling devices, sound insulation, or temporary noise enclosure walls, bunds or housing to maintain noise levels.

3. EXECUTION

3.1. Preparation

- Before commencing any dewatering works the Contractor shall have obtained the necessary Regulatory Permits and approvals.

- The Contractor shall protect all structures, utilities, pavement, and other facilities from damage caused by settlement, lateral movement, undermining, wash-out and other hazards created by the installation and operation of the dewatering system.

- Unless otherwise agreed with the consultant/client the Contractor shall undertake a pre-condition, survey and prepare a Pre-Condition Survey Report of all the utilities, pavement, buildings and other facilities which may be impacted by the dewatering measures.

- The Contractor shall undertake an 'as-built' topographic survey as part of the above, to establish the exact elevations at fixed points on structures, and to establish benchmarks and reference points for subsequent monitoring during the dewatering.

- Unless otherwise agreed with the consultant/client the Contractor shall install instrumentation and groundwater monitoring systems to assess the impact of the dewatering system on adjacent utilities, pavement, buildings and other facilities.

- Surface settlement points shall be no more than 5m apart and positioned on at least four (4) points of each structure. The minimum perpendicular distance surface and structural monitoring points shall extend from the boundary of the works is five (5) times the depth pf the excavation.

- The Contractor's surveys and instrumentation shall be monitored in advance of the works and readings shall form the baseline against which subsequent ground and structural movements shall be assessed.

- Undertake necessary preparatory works, including grading of site and building of protection bunds and trenches to prevent run-off from and onto the site.

- Set out elements of the dewatering system in accordance with the approved drawings, including location of drainage trenches, well-pointing systems, discharge pipes/lines, generators and pumps to confirm there are no conflict with existing utilities and the planned constructions works.

3.2. Installation and Operation

- Install dewatering control system to lower and control surface and groundwater levels; utilizing berms, trenches, wellpoints, or other approved methods, complete with pumping equipment, standby power and pumps, filter materials, valves, collector ditches, piping and

discharging to an approved disposal route.

- Prior to excavation below the phreatic surface switch on the dewatering control system to lower the water to the specified levels. Ensure system is operated continuously to permit excavation, construction of structures, placement of drainage layers and structural fill on a 'dry' stable subgrade, with the water table maintained at 500mm below the surface of the excavation, or as otherwise directed on the Drawings and in the Specifications.

- Ensure system is not switched off until completion of the structures, services and backfilling, having demonstrated and obtained approval from the consultant/client that dewatering is no longer required.

- Dispose of water removed by dewatering in an approved manner that avoids endangering public health, property, and portions of the completed work, or work still under construction.

- Provide standby equipment on-site, installed and available for immediate operation, to maintain continuous dewatering, in the event any part of system is ineffective, fails or requires maintenance. If dewatering system is inadequate or fails and results in damage to the works then the Contractor shall repair damaged works, structures, services, etc, including third party.

3.3. Field Quality and Monitoring

- Take survey readings from benchmarks and reference points at required intervals and report these values in daily, weekly and monthly reports, or until the dewatering control system has been removed.

- The Contractor shall assess survey and settlement readings and notify the consultant/client of an exceedance condition relative to the 'Alert', 'Action' or 'Alarm' Values, as stated on the Contract drawings. The Contractor shall implement required mitigation and control measures and obtain approval from the consultant/client prior to increasing excavation extents, depths or rates of discharge.

- Install piezometers and/or observation and monitoring wells around the site to assess the drawdown and fluctuations in the groundwater levels.

- The Contractor shall monitor the groundwater control system, including assessing the performance of the wells, recording discharge rates, monitoring groundwater levels and fluctuations with time.

3.4. Decommissioning

- Remove dewatering system from site upon completion of dewatering. Unless agreed with the consultant/client all well-points shall be removed. Where well-points are left in place, they shall be backfilled with either sand or cement grout (1:1 mix) and cut-off a minimum of

900mm below finished grade level

- Upon completion of dewatering works, undertake a post-condition survey and report findings in the Post-Condition Survey Report, which shall include monitoring results for all the surface and structural settlement points, the dewatering control system records and an assessment of ground and structural settlements.

- The report shall note any exceedance of limiting values and impacts on roads and services, together with planned remedial actions or actions taken, including repairs, demolition, strengthening, etc. to mitigate the effects from dewatering.