	JOB No.	DOC. No.	Rev.
TABEER ENERGY	0-7918-20	S-000-13M0-101	1
	DATE 15 - Jun - 2018	SHEET 1 OF 4	
	PREP'D	Y. Ishida	
	CHK'D	K. Uchino	
	APP'D	K. Uchino	

BATHYMETRIC SURVEY REPORT

Pakistan LNG Receiving Facilities/Site Selection Follow-up Activities

FOR FEED

REV.	Date	Page	DESCRIPTION	PRE'D	CHK'D	APP'D
0	15 June 2018	All	For Review (Preliminary)	Y. Ishida	K. Uchino	K. Uchino
1	24-Aug-18	2, Att-2	For FEED	N. Inoue	K. Uchino	K. Uchino

JGC JGC CORPORATION

HOLD LIST

None

Contents

1 INTRODUCTION

1.1 Background

JGC Corporation is responsible for the Pre-FEED of the proposed LNG Terminal at Pakistan using Floating Storage Regasification Unit (FSRU) technology (hereinafter referred as "the Project") owned by Mitsubishi Corporation.

1.2 Objectives of Study

The main objectives of the Bathymetric Survey were identification of:

- Surveying the accurate existing seabed level where encompass the area to be dredged, to calculate dredge volume;

1.3 Scope

The scope of work of the Bathymetric Survey includes the following facilities:

- Bathymetric Survey shall be carried out within the area specified in figure-1;
- The survey shall be carried out by narrow multi beam echo sounder;
- Single beam echo sounder allows to use the inshore sounder;
- Manual survey (topographic / levelling) allows to apply where water depth is shallow and survey boat is not accessible;

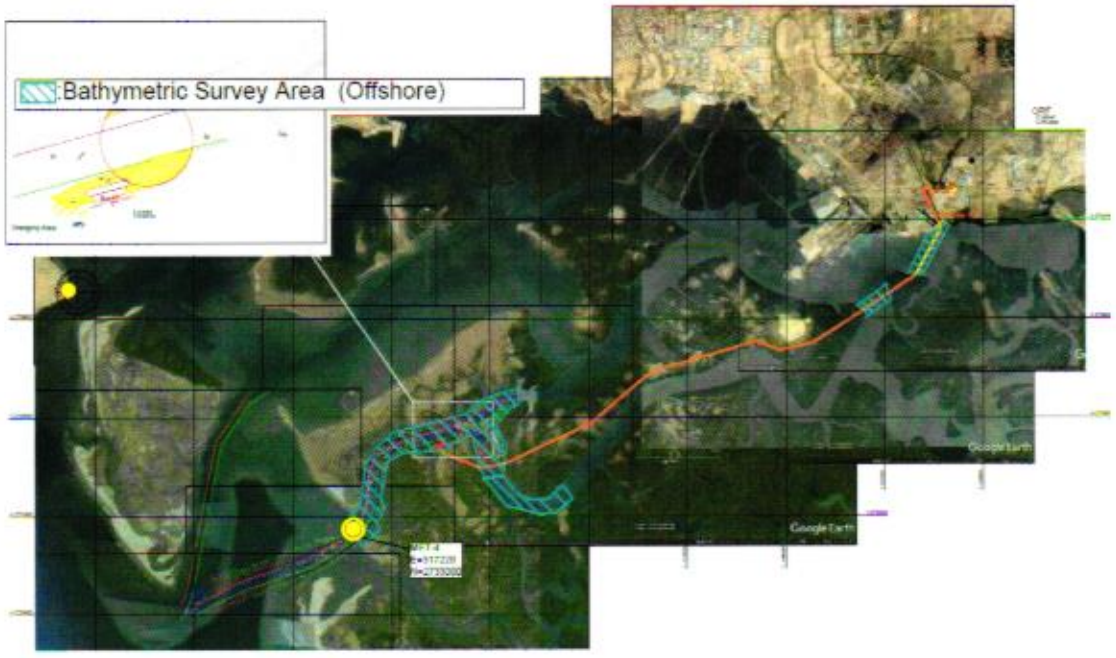


Figure-1 Bathymetric Survey Area

1.4 Survey Period

From May-2018 to June-2018

1.5 Bathymetric Survey

- The depths are in meters and are reduced to Chart Datum, obtained at Tango-5 weather station.

Figure-2 Tango-5 Wether Station

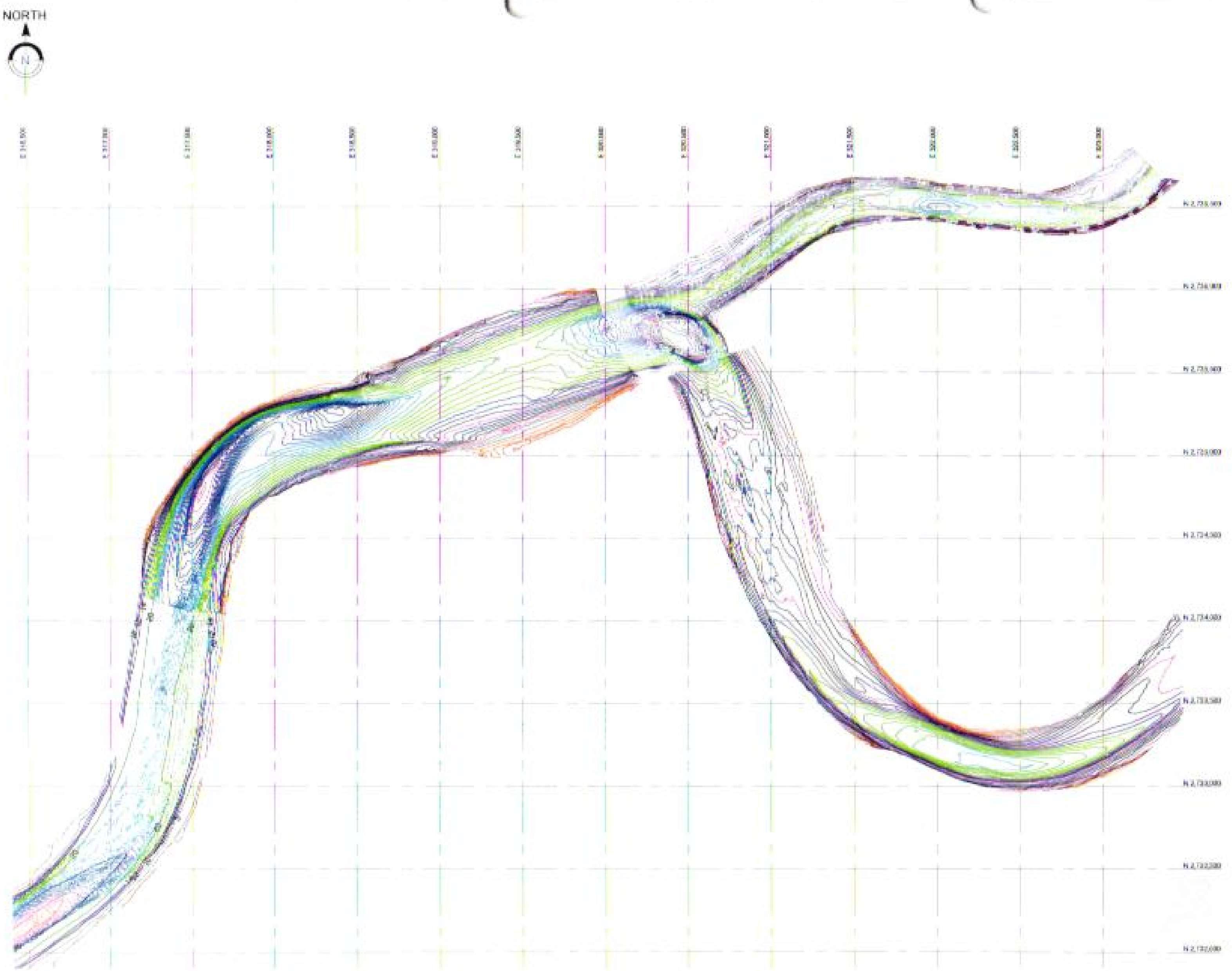
1.6 Applicable Specification

S-000-1311-001 Specification for Site Survey

2 ATTACHMENTS

Attachment -1 Bathymetric Survey Around Jetty Area
Attachment -2 Bathymetric Survey at Graro Creek Crossing

NOTES.
1. ALL DIMENSIONS ARE INDICATED IN METERS.



TOPOGRAPHICAL NOTES

Rev.	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
1	21-AUG-18	FOR TECB			
0	10-JUL-18	FOR REVIEW			

REVISIONS

JGC CORPORATION

BATHYMETRIC SURVEY

DATE 10 _ JUL _ 18 SCALE 1:12000

K. UCHINO K. UCHINO

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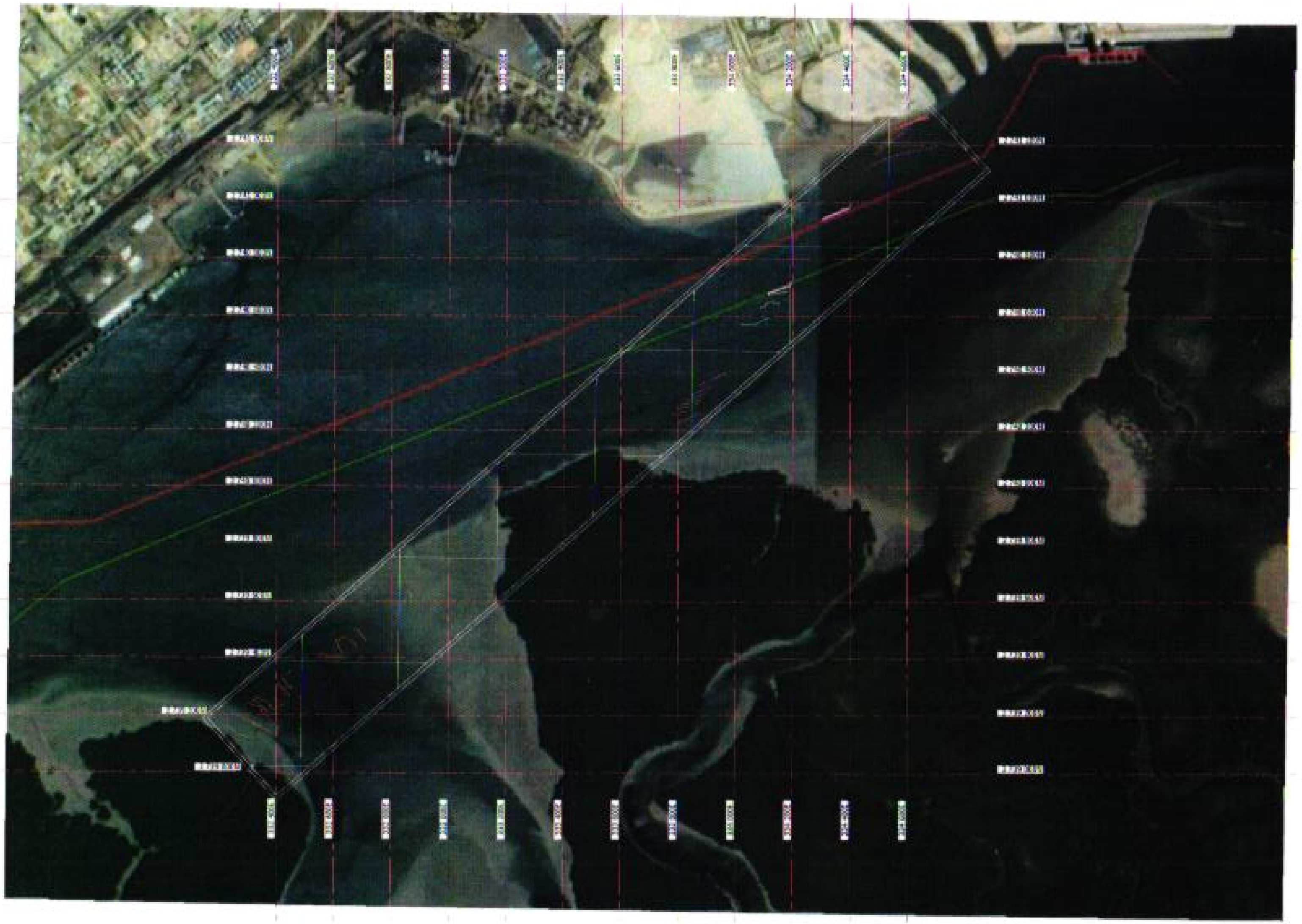
NORTH



NOTES:
1. ALL DIMENSIONS ARE INDICATED IN METERS.

TOPOGRAPHICAL NOTES

NO.	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	29-AUG-13	FOR FEED			

REVISIONS

JGC CORPORATION

BATHYMETRIC SURVEY

DATE 29 _ AUG _ 13 SCALE 1:7500

Y. ASAHIYAMA K. DOHINO K. DOHINO

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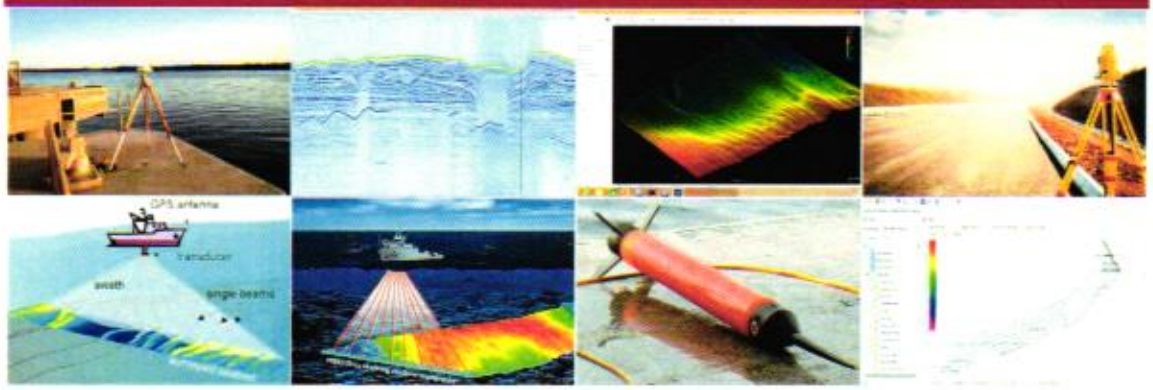
TABEERENERGY

JGC

Pakistan FSRU Project Chann Wadoo Creek Port Qasim



Geophysical Survey Report

incorporating:

(i) Sub-Bottom Profile Survey
(ii) Bathymetric (Single / Multi Beam) Survey
(iii) Topographic & Metal Detecter Survey

Final Report
December 2018

Techno-Consult International (Pvt) Ltd.
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Electronic Mail: email@techno-consult.com Web site: www.techno-consult.com

CLIENT: JGC Corporation, Japan

PROJECT: Pakistan FSRU Project Chann Wadoo Creek Port Qasim

REPORT: GEO-PHYSICAL SURVEY REPORT

		Signature	Dated
Prepared By TCI: (Project Engineer)	M Ali / S Shahid/ A Ahmed		
Reviewed By TCI: (Director)	Waseem Ahmed		
Approved by JGC Client: (FSRU Project Manager)	Keita Uchino		
Approved by JGC PM:			

Issue / Revision Index

Issue Code	Revision					Revision Details
	No.	By	Rev'd	App	Date	
RR	00	MA/SS/AA	WA		25 Oct 2018	Rev. 01
RF	01	MA/SS/AA	WA		28 Dec 2018	Rev. 02

Issue Codes: RC =Released for Construction, RD = Released for Design, RI = Released for Information, RP = Released for Purchase, RQ = Released for Quotation, RR = Released for Review & Comments, RF=Final Document

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1.0 INTRODUCTION

1.1 Project Description

Pakistan's growing energy needs requires reliable maritime infrastructure facilities for import of fuel in form of Oil and Gas. In this connection Tabeer Energy (Private) Limited as TEPL has taken on a commitment to provide additional maritime infrastructure at Port Qasim to facilitate the import of natural gas in form of LNG.

TEPL, an SPV created by Mitsubishi Corporation for the project, is actively engaged in sponsoring and developing an FSRU based LNG terminal at Port Qasim namely Tabeer LNG Project at Chann Waddo Creek. The Terminal is proposed to be constructed at Chann Waddo creek in close vicinity of the confluence of Chann Waddo, Rakkhal and Jharri Creeks close to the entrance to Port Qasim. Chann Waddo creek is located east of Phitti Creek.

Figure 1 Showing Project Location Plan

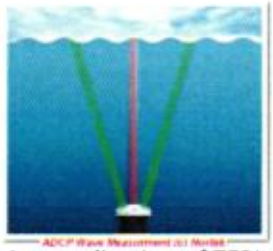
An application for NOC has been applied and in consonance with PQA requirements certain essential site investigations and geophysical surveys studies are required to be undertaken. M/s JGC Corporation of Japan are appointed engineers for Pre FEED work and M/S. Techno-Consult International (Pvt.) Ltd. (TCI) has been commissioned as consultants to carry out field studies and investigative works for the proposed LNG terminal.

Tentatively, the terminal will be designed to host **one liquid bulk pier** suitable for QMax type LNG Carriers. The berth will consist of Mooring and Breasting dolphins and a Jetty Head built on a suitable platform with pile foundations. The storage vessel FSRU will be permanently moored to the berth & the supply vessel (LNGC) will be moored alongside FSRU to carry out Ship to Ship transfer (STS). The supply line to the SSGC designated shore point will follow an alignment along the creek banks, delivering gas to on-shore installations for customer distribution.

In connection with hydraulic studies, M/s JGC Corporation of Japan commissioned Techno-Consult International (TCI) to undertake geophysical surveys of creek waters where terminal and pipeline components are likely to be located.

The project is located in the vicinity of Port Qasim at the confluence of Chann Waddo, Rakhel, and Jharri Creek. It is bound by the Arabian sea at 24°43'09.85"N latitude and 67°12'50.40"E Longitude as shown in the figure.

1.2 Investigative Campaign



In support of Pre-FEED and FEED studies, Geo Physical surveys consisting of geotechnical investigations and sub bottom profiling has been commissioned by JGC. In addition to geo physical surveys a campaign of metocean data collection has already been completed and report finalized. These investigative works will serve as a basic platform for the technical proposal, to be submitted to Port Qasim. This proposal will support the BOT concession application of TEPL.

1.3 Site Description

The site is located in Chann Wadoo Creek where the width varies between 400 to 500 m. This creek also presents with naturally deep waters (20-25 m) at select locations which are favorable for deep sea vessels. However, dredging may be required to maintain a smooth turning radius for large vessels.

1.4 Salient Features of Marine Facility

Terminal

Tabeer Energy is SPV for implementation of LNG terminal. JGC Corporation of Japan is in process of Pre-FEED study for development Terminal for imported LNG regasification project. This project consists of an FSRU based terminal at the Chann Wadoo Creek site, taking an easterly route to Port Muhammad Bin Qasim (Port Qasim). After having reached Port Qasim, the re-gasified liquid natural gas (RLNG) will make its way into the existing pipeline grid at the SSGC connection to reach end users.

The proposed location for the LNG Terminal is at the confluence of Chann Waddo, Rakhel & Jharri Creek. It leads into Port Qasim following a 16 kilometer easterly route on which twin Tenaga class storage vessels will be permanently moored at the jetty. The storage will be supplied by conventional LNG carriers (QFlex and QMax type).

Main Jetty:

- Open Piled structure
- Working platform fitted with loading arms
- Control room
- Security room
- Twin berthing dolphins
- Three mooring dolphins on each side
- Quick release capstans
- Heavy duty fenders
- Firefighting equipment
- Electric generators
- Re gasification facility on platform or floating utilizing Air Vaporizer Banks technology

1.5 Pipeline Connection to Shore

A route for pipeline has been identified which is also in the process of being surveyed. This will serve as FSRU HP transfer system to the Tabeer Energy / SSGC connecting point on shore. The route has been adapted after careful consideration of technical feasibility, pipe length, mangrove impact, constructability and cost considerations.

2.0 OUTLINE SCOPE

A survey plan and specification were provided by JGC. After careful analysis and planning the geo physical surveys was initiated on 22nd May 2018.

In brief the scope of the geophysical survey work can be divided into the following 03 components:

A. Sub-Bottom Profiling Survey

B. Bathymetric Surveys

C. Land Topographic & Metal Detector Surveys

Scope under these individual items are described below:

A. Sub-Bottom Profiling Survey

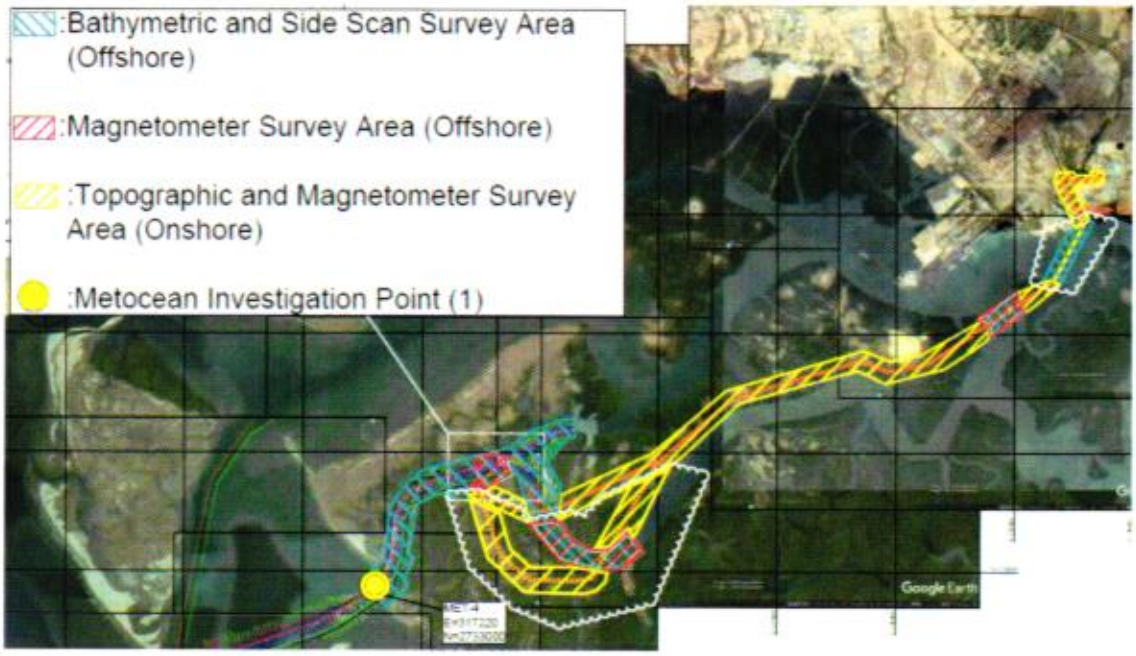
The basic scope and purpose of Sub-Bottom profiling survey is to supplement and reinforce the results and finding of the geotechnical investigations. M/s Soil Testing Services (STS) have partnered with TCI to perform this task which consists of a series of boreholes and CPTs to be executed for Terminal and Pipe lines locations. They are responsible for all field works and present findings of the geotechnical drilling and results. These are submitted under a separate cover to JGC as a report by M/s STS. This report provides test location plan drawing, boring logs, un-disturbed samples and photographs, details of drilling rig employed, CPT's performed together with method statement and equipment used and laboratory test results.

TCI's scope to conduct sub-bottom profiling surveys would allow JGC to have a Geophysical map and profiles of the area surveyed. The scope requires that the map shall serve to display the seabed depth profile of at least top 10 meters of strata below the seabed, with a resolution of better than 0.3 meters. Generally the sub bottom survey extent should match with survey limits of the bathymetric survey.

B. Bathymetric Surveys

A Bathymetric survey map with 1m contour line is essentially required under the scope. Digital data of bathymetric survey coordinate data (x, y, z) are presented in a sounding chart of the survey areas. Bathymetric survey area is shown in figure 2 below:

Figure 2 Showing Bathymetric Survey Area



JGC

The longitudinal and transverse survey grid intervals shall be 25m*25m. Accurate positioning of survey vessel should be by RTK GPS positioning system with motion sensor adjustments

Bathy survey results to be presented in AutoCAD format drawings with 1/500, 1/1000, 1/2500 and 1/5000

C. Metal Detector and Topographic Surveys

Magnetic anomalies in project areas are to be derived using two methods. One for the sea based pipeline crossing and the other for the 50 m land strip leading form shore to RLNG tie in points.

For the sea part the separate report on UXO Factual study is to be referred whereas for land part the metal detector and topographic survey is covered under this report.

Topographic survey is required along the pipeline route. However for mangrove laden areas where the site presents with harmful and un-breathable conditions and which might affect

the health of the survey personnel alternative methods such as use of aerial drones has been agreed during the course of investigative campaign.

However for the land side the existing facilities including underground, TCI was required to search the 50m banded area of pipeline route as center by means of metal detector.

See Figure-3 for reference.

The survey results are required to be presented in AutoCAD format drawings

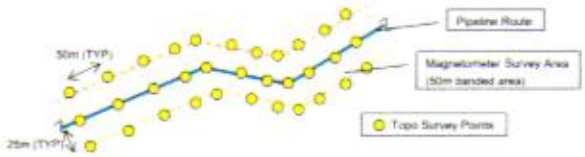


Figure 3 Magnetometer and Topographic Survey for Onshore

Equipment Employed

TCI employed following equipment which fully meets the technical requirements given in the specifications from M/s JG Corporation. Further details of each equipment are given in the method statement sections in later parts of this report.

Innomar SES-2000 Narrow beam Parametric Sub Bottom Profiler (SBP)

1. Sub Bottom Profiler
2. Single Beam Echo Sounder
3. Multi Beam Sounder
4. Magnetometer (for sea)
5. Metal Detector for land strip survey
6. Total Station for Topography
7. GPS Receivers for control points

All land and marine survey equipment and survey boats are owned by TCI with the exception of a magnetometer. As such there was no need to outsource the equipment for this campaign.

3.0 SURVEY METHODOLOGIES

A. Sub-Bottom Profiling Survey

3.1 General

The objective of this component of the geophysical investigation campaign was to perform acoustic sub-bottom profiling through the JGC specified survey areas. These areas covered essentially the route of the pipe line which traverses through creeks and patches of mangrove

laden inter-tidal lands. A separate campaign for Geotechnical Investigations comprising of Boreholes, CPT measurements and Laboratory testing is also being executed in parallel. The sub bottom profiling surveys were particularly useful in those stretches of project areas where boreholes were also being executed as part of the Geotechnical Investigations.

The sub-bottom profiler distinguishes between sub-surface soil layers firmness and helps to classify and correlate drilling information received from geotechnical bore holes in an efficient manner. At the times sub-bottom profiling operations if taken in advance, the information is used to optimize the borehole investigation process.

3.2 TCI Scope for Sub-bottom Profile survey

Essentially the key requirements for the execution of sub-bottom profiling survey is to produce a continuous clear profile of at least the top 10 meters of the strata below the seabed, with a resolution of better than 0.3 meters.

The area to be surveyed and outline scope has been described in Figure 2 and foregoing sections of this report.

3.3 Details of Equipment Employed

For this project, the following sub bottom profiler, owned and operated by TCI was employed:

Innomar SES-2000 Narrow beam Parametric Sub-Bottom Profiler

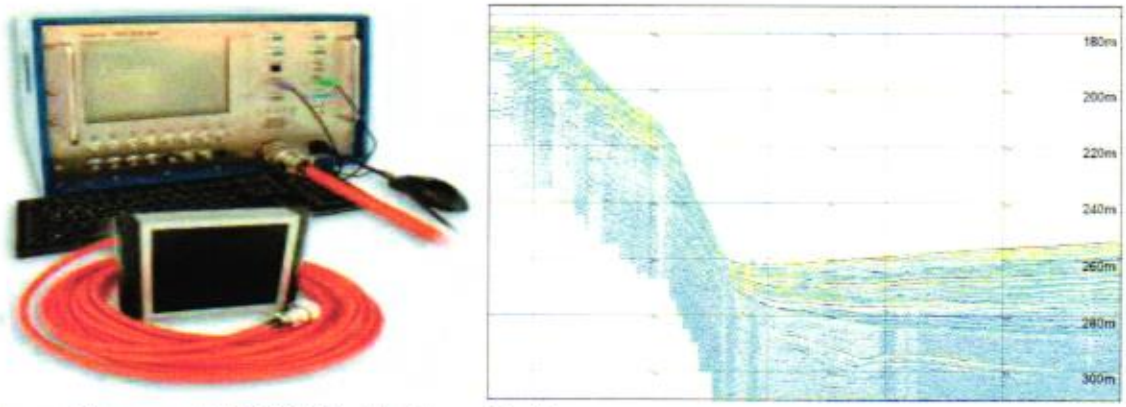


Figure 4 Innomar SES-2000 Sub-bottom Profiler

SES-2000 Parametric Sub-bottom Profiler, SESWIN 2.2.0.9 by Innomar Technologie GmbH 2016-02 sub-bottom profilers exploit parametric sound generation to achieve narrow low-frequent sound beams without side lobes and to transmit wide-band pulses to get high-resolution data.

Technical Specification

Water Depth Range	0.5 – 400m
Sediment Penetration	up to 40m (depending on sediment type and noise)
Range / Layer Resolution	approx. 1cm / up to 5cm
Transmit Beam Width (-3dB)	approx. ±2° / footprint <7% of water depth

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Primary Frequencies (PF)	approx. 100kHz (frequency band 85 – 115 kHz)
PF Source Level / Acoustic Power	>236 dB//µPa re 1m
Secondary Low Frequency (SLF)	centre freq. user selectable: 4, 5, 6, 8, 10, 12, 15 kHz (total frequency band 2 – 22 kHz)
Pulse Width	user selectable 0.07 – 1.0 ms
Pulse Type	Ricker, CW
Ping Rate	up to 50 pings/s
Topside Unit (Transceiver)	W 0.52m × D 0.40m × H 0.38m (19"/7U) / 35kg
Transducer (20m cable)	W 0.30m × D 0.26m × H 0.07m / 22kg incl. cable
Heave / Roll / Pitch Compensation	heave (depending on external sensor data)
Data Acquisition	digital 24bit @ 96kHz sample rate; PF 100kHz envelope echo-sounder data / bottom track; SLF full-waveform sub-bottom data
Auxiliary Input	GNSS, HRP sensor, trigger
Auxiliary Output	trigger, bottom track, analogue SLF
Power Supply	100–240V AC / 50-60 Hz (fuse 16A / slow)

3.4 Trimble NMEA 0183 Global Positioning System (GPS) receiver

For sub-meter horizontal positioning utilizing Ominstar satellite differential corrections (RTX).

3.5 Hypack – 2017 Hydrographic Survey Software

For survey line planning and real-time navigation management.

3.6 Innomar ISE Post Processing Software

a. For generation of plan and profile
b. Profiling on both high & low frequencies
c. High frequency for bottom detection and low frequency for sub bottom strata

3.7 ESRI ArcGIS 9.2

For generation of deliverable drawings.

3.8 Reconnaissance of the Area

To help plan the SBP survey, it was imperative to undertake a reconnaissance survey for given location of sub-bottom profile scope by JGC. This include the creek areas from service jetty (Port Qasim), Mitsubishi, Jhari Creek and Chand Waddo. This reconnaissance was carried out

on 15th May to 1st June 2018 by the following representative of (TCI) Techno Consult International.

1. Cdr(r) Arif Hussain (Senior Hydrographer)
2. Muhammad Ali (Engineer)
3. Sheikh Shahid Hussain (Engineer)

The project area is presented bellow

Figure 5 Project Area

3.9 General Climate & Limitations thereof

PQA falls within a sub-tropical region. The area is generally hot in summer and cold in winter, temperature at times rises above 40 degree centigrade between May and August. The minimum average temperature of less than 10 degree centigrade occur during December to January. The annual rainfall average about 5 to 6 inches, falling mainly during July & August. The south-westerly monsoon wind begins to blow in mid-February and continues until the end of September, whereas the cool northerly wind blows during the winter, from October to January.

The wind speed in this area is higher from May to August and which is not ideal for performing surveys in the open seas and those part of creeks which are close to entrance to Arabian Sea. These stretches included the SW part of the Chann Waddo Creek. During the SBP surveys, there were spells in weather where average wind speed encountered exceeded beyond 15 knots. This posed with choppy conditions as the survey boat took impact of wave actions creating heaving and rolling of boat. As such weather windows suitable for surveys as well as for safe HSE conditions were awaited causing frequent disruptions to the SBP survey schedule. However, whenever the wind speed was found suitable, the survey was planned and conducted, refer Fig -4 which presents weather window.

Figure 6 ***Weather window***

4.0 SURVEY METHODOLOGY

After completion of planned survey lines and their entry into the navigational software Hypak, the system was initialized on the survey boat. Prior to surveys the Innomar's initialization and its sensors were calibrated onboard the TCI survey vessel Dolphin.

Before the survey starts, some test lines were done to ensure all sensors are working and to find best SBP settings (e.g. frequency, pulse width) for the current application, vessel, survey are and its surroundings (Port Qasim) environmental conditions.

During data acquisition, all sub-bottom profile data was collected with geographic positioning relative to the World Geodetic System of 1984 (WGS-1984). As mentioned earlier, the sub-bottom profile data were recorded in the time domain so that the vertical profile data was referenced to milliseconds of travel-time.

To perform this survey, TCI planned a series of survey profiles to provide broad coverage of each of the four survey footprints in the project area while incorporating existing geological borehole locations, for later ground-truth during interpretation.

Data acquisition after checking of the SBP at site, was carried out using Hypack and ISE software. The survey SBP data logged was processed by using Innomar Post Processing Software. The bottom detection/XYZ data from HF and Penetration from LF with appropriate adjustment were gained, as required. The processed survey data was converted into tst / xyz format from HF data and sub bottom from LF is exported to GIF/TIF/PDF.

The overall project area has been divided into four survey footprints: Chand Waddo, Rakhel, Jhari and Gharo Creek in Port Qasim. In general, survey profiles in the projected area were set at 30meter of line spacing parallel to the Banks/contours in each of the creek as per project scope. During the survey all pre-planned lines were sailed. Data recording was started and stopped at each survey line start and end, respectively. This generates two data files (*.raw / *.ses) for every survey line. The main parameters for the operator to think about and to look at are:

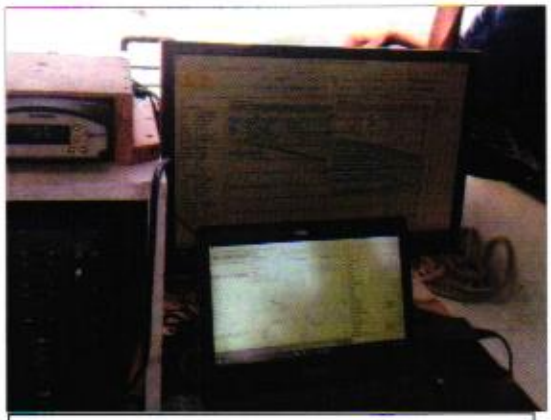


Figure 7 Equipment on Boat

- Frequency
- Pulse length
- Range
- Gain

These parameters affect the achievable resolution (i.e. vertical layer to layer resolution), the penetration (i.e. how deep can we look into the sediments), the ping rate (i.e. how many pings are generated per time unit and distance travelled) and the signal to noise ratio of the received echo signals (i.e. what is the weakest detectable reflector).

Figure 8 Equipment set-up Boat

Innomar SES-2000 Narrow Beam Parametric Sub-Bottom Profiler and Hypack 2017 along with GPS (Global Positioning System) were used together for navigation guidance and data acquiring. Innomar for sub-bottom profiling draws upon the use of both high and low frequency echo sounders that operate between 100 kHz and 4 to 15 kHz respectively to penetrate into bottom sediments with the goal of developing high resolution subsurface imagery and Hypack for navigation the planned lines. At the start of survey, the GPS was turned "On" because it takes about 45 minutes to stabilize its vertical datum properly, the GPS Antenna offset/height was calculated 2.05m from top to water surface level. With all these hardware setup, and previously Known K-N (Height of ellipsoid above the chart datum) for each area, Real time tide was calculated by taking recorded ellipsoidal height from GPS(RTX mode), and the antenna offset. The transducer offset / draft was 0.43m from water surface

level and then put this value in Innomar software, (refer Fig: 9). The planned lines were navigated / surveyed accordingly one by one in the survey area.

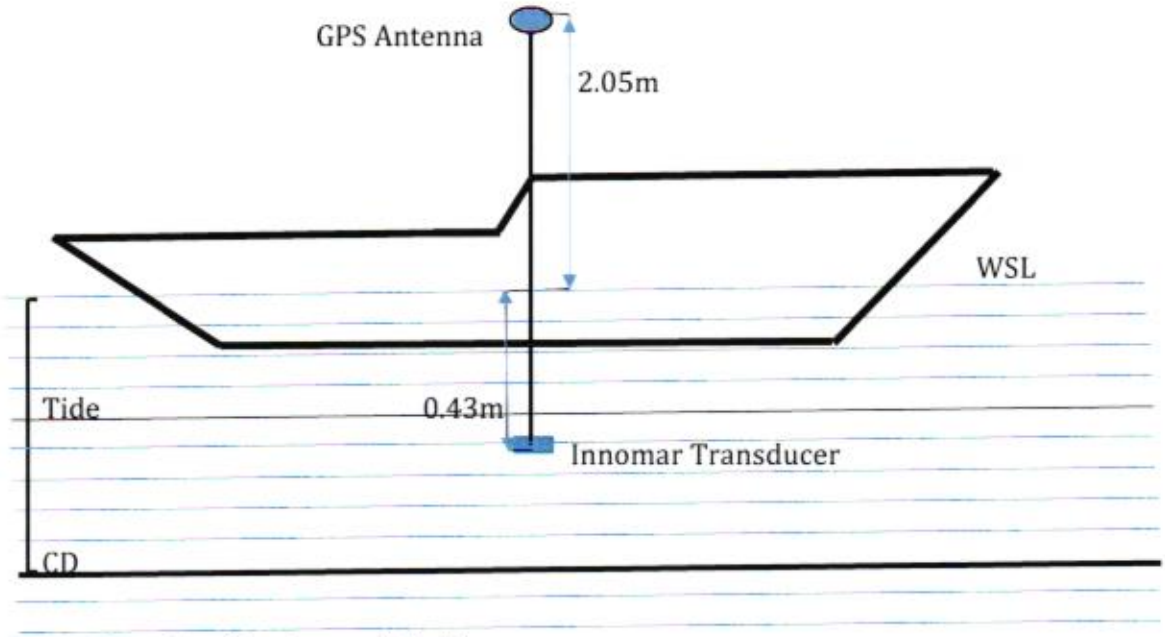


Figure 9 Boat Profile along with offsets.

During data acquisition, the speed of sound traveling through the media (water, silt, sand, etc.) was about 1545m/s as calculated through SVP of AML Mos X. Surveyed profile data were post-processed and interpreted within a properly scaled geographic context, simultaneous geographic positioning is collected using a survey-grade global positioning satellite (GPS) operating in RTX mode.

4.1 Problems Encountered

While surveying in an active Port Area such as Port Qasim, it is not un-common to encounter situations which present to survey team with hindrances and impediments. Some of the difficulties faced by survey team worth mentioning are given below:

- Tug Boats operated by Port Qasim or its terminal operators / marine contractors crossed the survey planned line impacting the planned boat path which had to be deviated. Moreover the wake and bow waves produced by crossing vessels, often resulted in heaving and rolling of survey vessels.
- Sudden encountering of shallow patches and sudden loss of depth along the survey lines, halted or altered the planned survey line navigation
- At times at starboard side, Dredging craft "Indus Dolphin" crossed the survey planned lines un expectedly

- Air resistance encountered opposite to the direction of the boat impacted straight line navigation.
- Soft materials like loose dredged material and gravel present on surface of the water is picked up an anomaly or false echo, on the profiler
- At times during survey, the sea state became rough and exceeded the tolerable limits of survey
- At times buoys and fishing nets used by fishermen, interrupted the survey.

4.2 Survey Findings

4.2.1 Data Quality Check (Innomar ISE Software)

The recorded INNOMAR SES-2000 data files immediately after acquisition, were opened with the INNOMAR ISE software from the operator's workstation. Partly this served as a quick check measure was one of the measures on quality control on data. Procedure entailed copying the field acquired large sized data files to hard disk folder and starting "ISE" suite with help of USB dongle.

4.2.2 Borehole Layers Isolated

A review of the geological borings in the project area by another STS (Soil Testing Services) subcontractor BH-5,BH-6, BH-7, BH-8, BH-31 &BH-32 data was used to correlate SBP data Different types of material like sand, clay, silt etc. are scattered throughout the project area in isolated pockets, but a general scarcity of borings could be a likely cause of any isolation in sediment type from sample to sample.

Annexure-B contains the selected borehole data that indicated potentially desirable sand in the project area. During the processing and interpretation of acoustic sub-bottom profile data, it helped to simplify the geologic units by characterizing the sediments as Silt, Sand, Silty or Clayey Silt, and Clay.

4.3 Post Processing

The Data have been stored during the survey in two different data formats (*.raw / *.ses). Both file formats can be used for the processing, but for high-resolution results the RAW data was used which is recommended. Coordinate transformation and UTM projection zone was used automatically and most important steps is interpolation for metric coordinate system was done before start of post processing the surveyed lines.

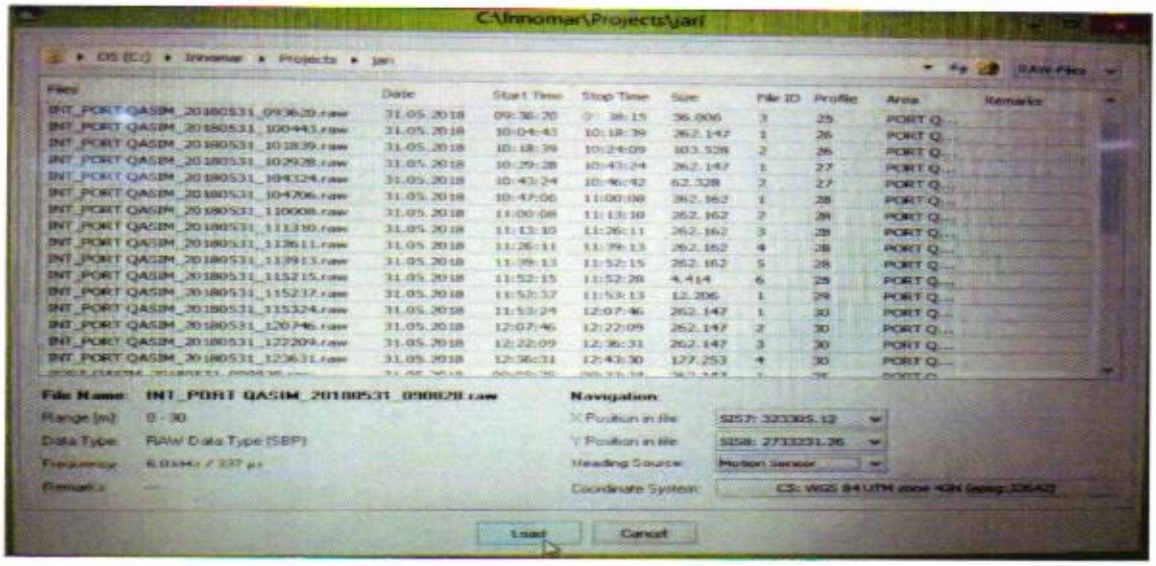


Figure 10 Loading Raw files

Single data files to be processed are loaded with the "File Load" dialogue, see picture on next page. It was make sure to select the correct SIS-IDs for position data and to apply tide correction if appropriate.

After loading the files from GIS Track, the plan view of the line has been displayed then the line was selected to which want to see the profile.

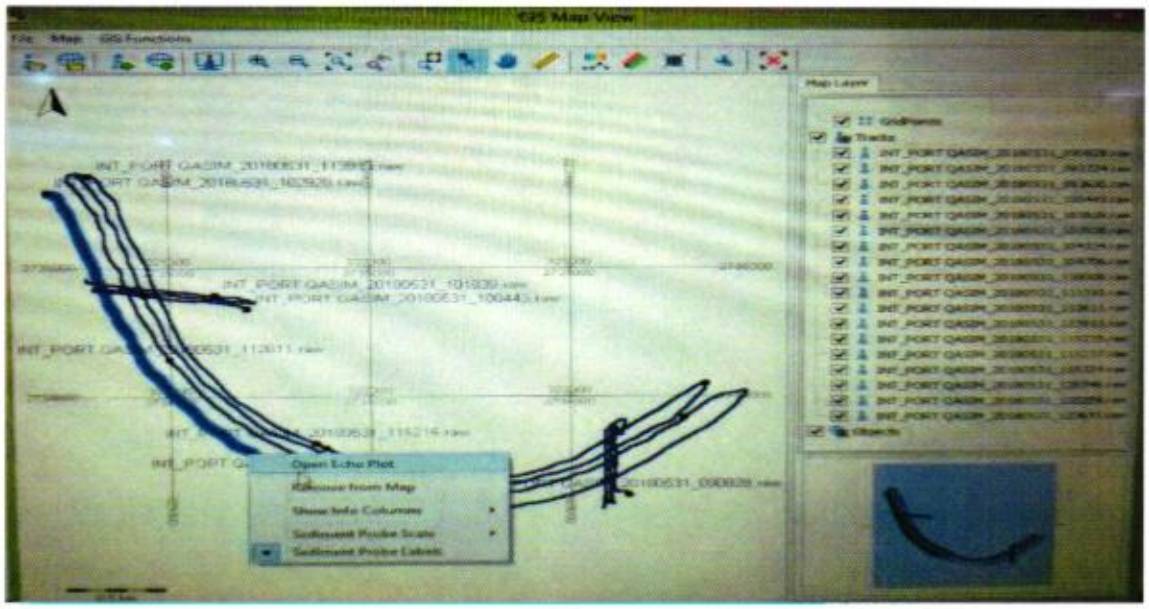


Figure 11 Export GIS Map View

It has already discussed earlier that the HF was used for bottom detection and LF for strata of the seabed and it was make sure that SIS-ID were selected correctly.

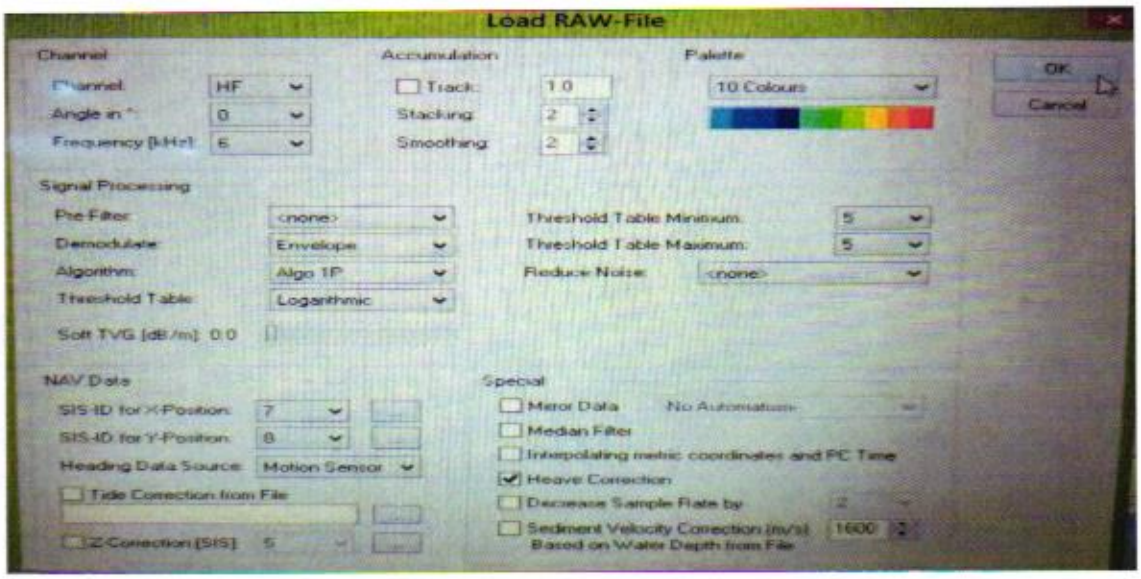


Figure 12 Open Echo Plot.

It was very important to check either the seabed bottom was detected correct or not, if find any discrepancy like spikes in data as a consequence of false echoes etc. Hence, at times the spikes were removed and bottom was detected manually.

During the processing, the bottom detected file window displayed a color (or grey scale) coded picture which was used to digitized the sediment layer or position of targets like buried pipe lines or cables and other materials

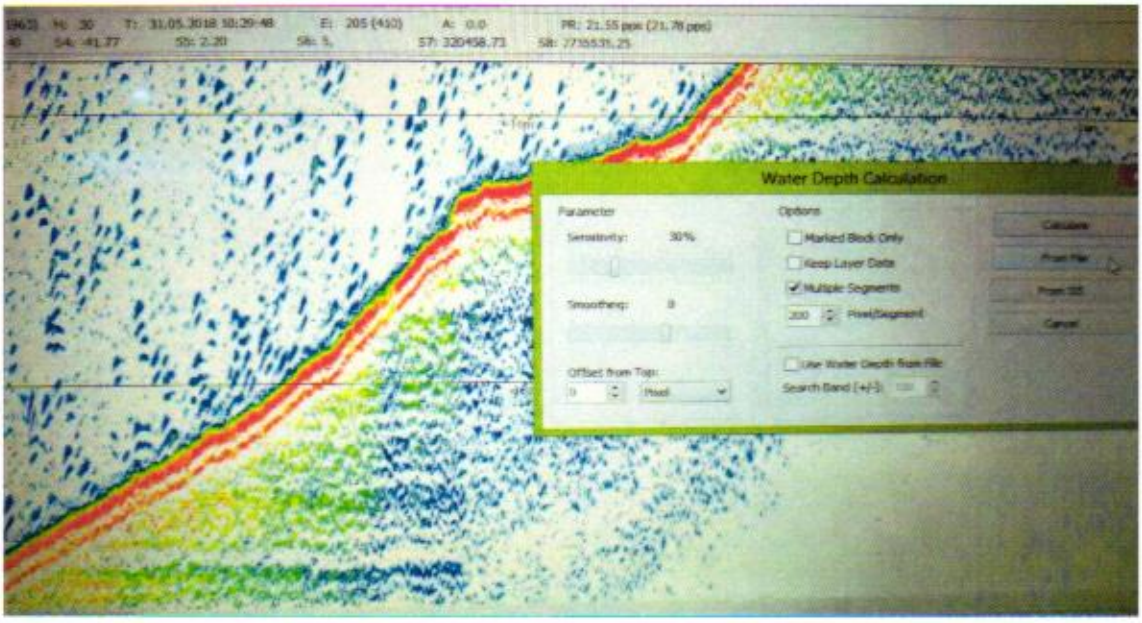


Figure 13 Calculate Water depth.

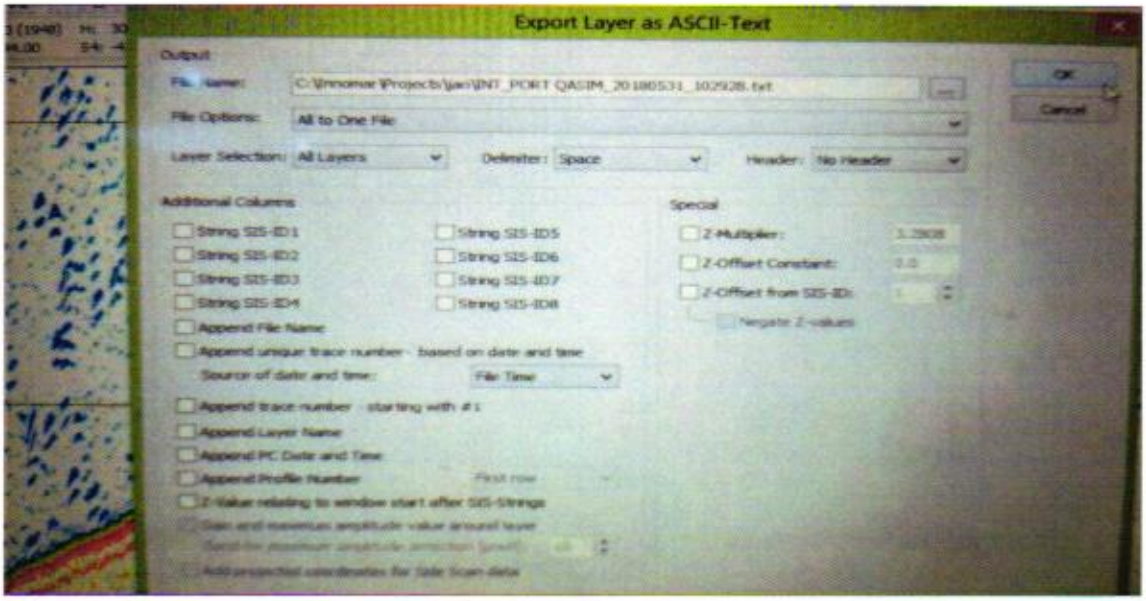


Figure 14 Export layer as Txt format.

In the end these all profiles were exported layer as text.

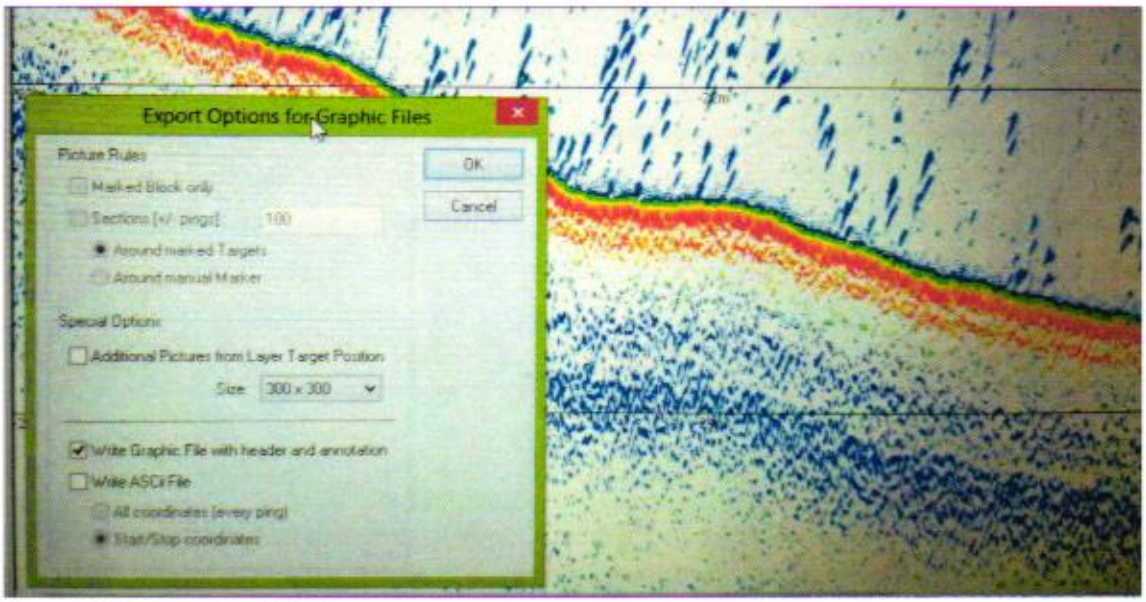


Figure 15 Export Graphic layers

Finally, all the information was exported out for all these layers to obtain a graphic output, such that any end user can display the profile without the need of software dongle USB. Sediment layers were subsequently digitized in the low-frequency data. To digitize sub-seafloor sediment layers ISE provides a semi-automatic capture tool, see figure below.

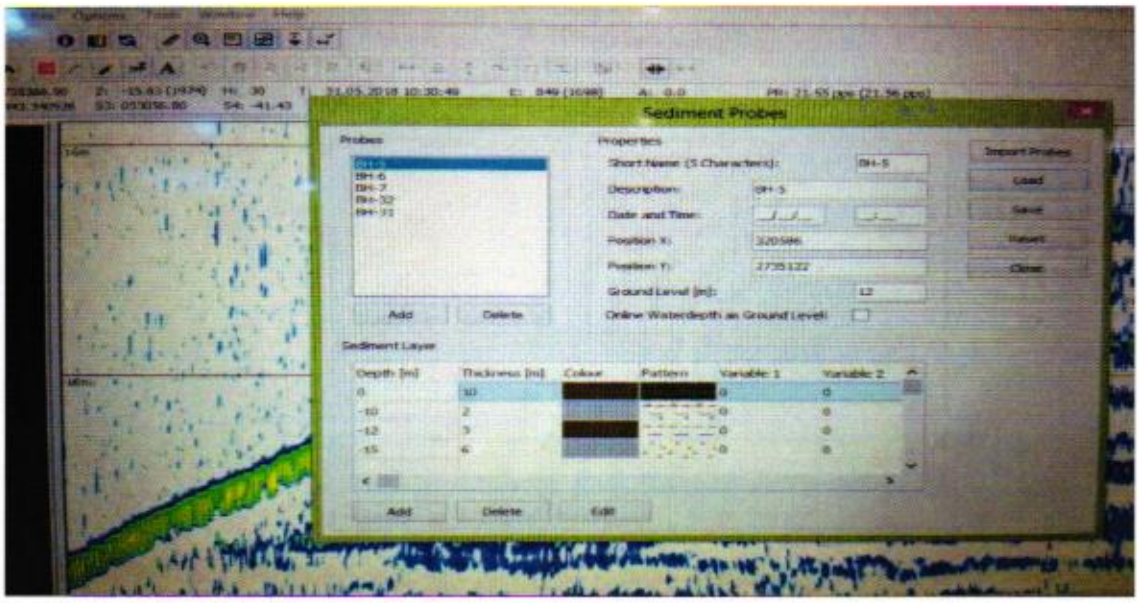


Figure 16 Digitize Sediment layers

In accordance with standard practice, different layers and colors for different geological interfaces were employed. Names and line properties (color, thickness) were defined in ISE Post Processing Software window. The planned and surveyed lines in Hypack and plans & profiles of sub-bottom of the survey area are presented in **Annexure-A**. The borehole logs are provided in **Annexure-B**

The digitized layer interfaces were exported in combination with interpolated position data to separated ASCII files ("File -> Export Layer Data"). ASCII files in xyz format. Layer data was also exported as Graphic, SVG or AutoCAD DXF files. The calculated echo prints were saved in different graphics formats, including Geo Tiff & Giff.

5.0 BATHYMETRIC SURVEYS

5.1 General

First and foremost, in undertaking bathymetric survey is to setup a horizontal control network of few points for the survey positioning purposes. This control network is surveyed using GPS high precision observations and the coordinates are established on permanent reference points or fixtures on ground which remains un-inundated. Thereafter, the vertical datum computed for the area being surveyed is transferred to these control point locations. These points are later used to reduce the sounding heights observed by the echo sounder during data processing. It should be noted that in Port Qasim creek waters, the tides at Service Jetty in Phitti Creek (located some 50 km inshore from main seas) arrives about 20 to 25 minutes later than tide at the entrance to Port Qasim creeks i.e. a location near the Bundal Island. This

is due to fact that local tidal datum's of Phitti Creek and Service Jetty are geographically apart and distinct in nature.

Hence the locally determined tidal datum at Service Jetty at Phitti Creek is different than the datum computed at Tango 5 station (i.e. Met 1 station of JGC survey). As such, in reduction of sounding data for the two surveys which are located approximately 45 to 50 km apart, the respective datum's are applied to the sounding data of each survey.

5.2 Establishment of Horizontal and Vertical Control (GPS Network Observation)

A set of primary ground control points were established and triangulated with the Port Qasim and Survey of Pakistan known data point. A list of control points with their values were obtained from above departments for the transfer of control while maintaining the triangulation geometry.

04 Nos. geodetic accuracy GPS units were setup on the controls survey points to take observations in Static modes for more than 04 hours to establish GPS Control Survey Points for permanent bench marks (PBMs).

This Network was connected to the PQA grid for transfer of horizontal control and chart datum was transferred by GPS methods as double levelling was not possible due to wide width of the Chann Wadoo Creek (400 to 600 m).

Network closure errors were carefully checked and evaluated for tolerances. RTX subscription was obtained and GPS control network was checked using an alternate method.

The vertical control was transferred from Tango-5 Station in Chann Wadoo Creek to the twin bench marks using GPS RTX systems.

5.3 Bathymetric Survey with Single / Multi Beam

5.3.1 Equipment

Depending on work scope bathymetric survey was carried out by a combination of equipment consisting of single or multi beam equipment.

For Multibeam hydrographic survey, TCI used its own survey vessel name "Breakwater". It is a Fiber Glass Hull boat equipped with YAMAHA 270 HP Diesel Engine with Stern Drive.

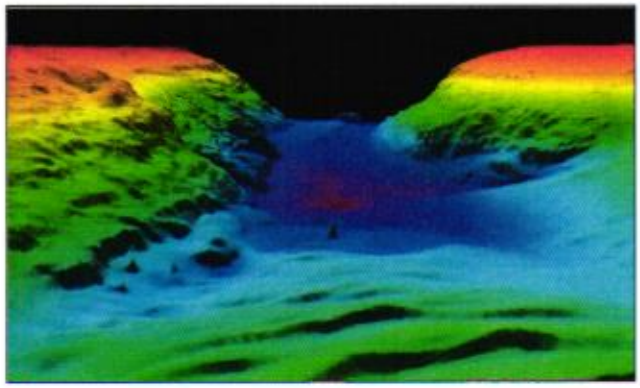
The draft of the boat is 0.5m and has a free board of approx. 1m.

This boat is fitted with the following equipment.

1) Humming bird 9700 side scan sonar / echo sounder
2) GPS
3) Compass Gyro (Magnetic
4) ODOM Hydrotrack single beam echo sounder (200 khz)
5) Survey Grade duel frequency Trimble MS 750 RTK GPS.
6) Multibeam Survey System comprising of
   (i) R2Sonic 2022 System (100 meter depth capable)
   (ii) DMS – Motion Sensor (IMU)
   (iii) Valeport Mini SUS (Sound velocity probe at Transducer)
   (iv) Valeport CTD probe (for velocity profile vs. depth)
7) High Speed PC with Hypack / Hysweep Data Capturing Hydrographic software
8) High speed Ethernet port with 8 Serial Port (RS 232) Bus

5.3.2 Multi Beam Bathymetry

The Multi Beam survey was executed using an ultra-high resolution focused multi beam echo sounder. Utilizing dynamically focused receive beams (0.5° x 1.0°), the system detects the seafloor morphology with a very high detail. The transducer was deployed with an over-side pole.



The multi beam acquisition system is equipped with Hypack 2018 hydrographic software, which is interfaced in real time with some external sensors (positioning system, gyro compass, motion reference unit, sound velocity probe).

Once a day (or more if necessary) a sound velocity profile was determined using a sound velocity probe. All the data acquired was stored in Hypack 2018 (multi beam data) formats.

As safety of the personnel and equipment is paramount in any marine job, it is mandatory to carry out reconnaissance survey for familiarization and avoid any mishaps due to hidden/submerged obstacle / shallow rubble areas. This information was ported to the project in Hypack software with well-defined geodesy as per project area and plotted grid. A series of rigorous calibration / patch test were performed before the actual start of any day, survey work. The test are as follows:

(i) Horizontal position test
(ii) Vertical position test (RTK tide)
(iii) Sound velocity test (1-PPS system generated)
(iv) Sound velocity test (by sound velocity profile)
(v) Depth calibration test (by adjusting parameters)
(vi) Latency, Roll, Pitch and Yaw test

Once the tests performed to the satisfaction only then the survey lines were navigated and logged. The number of survey lines/ line spacing depends on beam angle and depth of the water column of the area under consideration. It was exercised to keep the survey density consistent for different depths. Any Gap area due to beamed angle / shallow water was covered by additional survey line. All the depth recorded were processed the same day for any errors. If errors or high noise were noticed in the data, then it was resurveyed the following day.

Daily logs were maintained for sea state (Douglas Sea Scale, or Beaufort scale), wind, temp etc. before the start of the survey at the end of the day survey. No Night survey was planned/ done. Tide recording at T5 was ensured on each day as redundant for comparison and accuracy of the RTK tide. Although any loss of RTK data on board stop the survey logging but a false reading would go undetected, therefore with redundant tide we can be assured to avoid such situation. Velocity cast was performed as per standards that is twice daily minimum and records are well maintained.

Multibeam bathymetry in the approaches to Chann Wadoo & Rakhel creek have been done, for Approached and turning basin of the proposed terminal site through Hysweep survey module of Hypack meant for Multibeam data acquisition.

Data processing of Multibeam survey is a tedious job and requires high skill, all calibrations of devices setup through Patch, latency and yaw test carried out prior to data acquisition are rechecked for fine-tuned.

Hysweep module of the Hypack is used for the editing of raw recorded data and false echoes are removed. In the absence of any analog recording of seabed, through experience is required to remove false echoes.

Tin module of Hypack is used to export edited data to a desired bin size depending on the scale of the plot and the contours of the desired interval.

Track lines of Multibeam survey are shown in the fallowing figures.

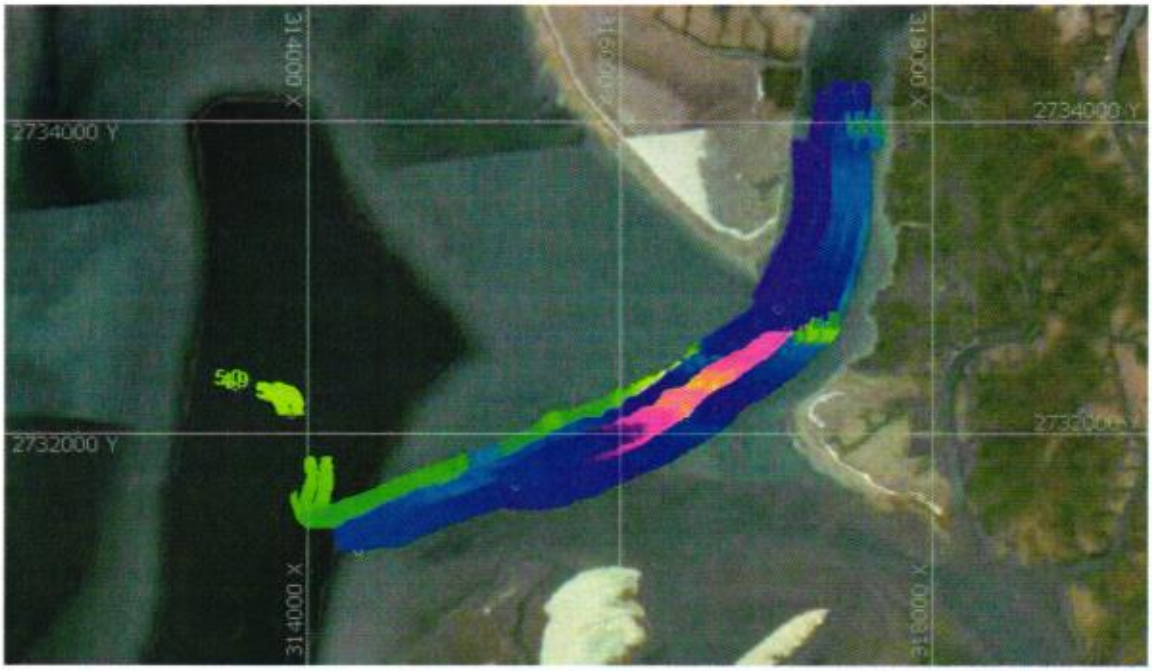


Figure 17 Chann waddo & its approaches

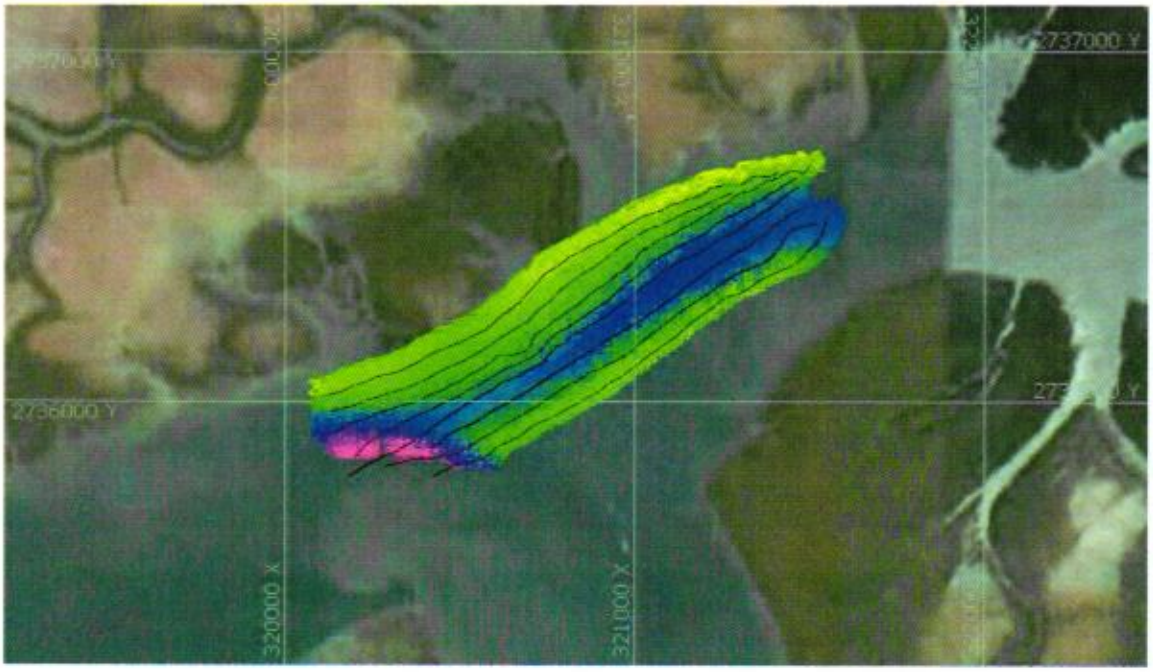


Figure 18 Rakhel Creek

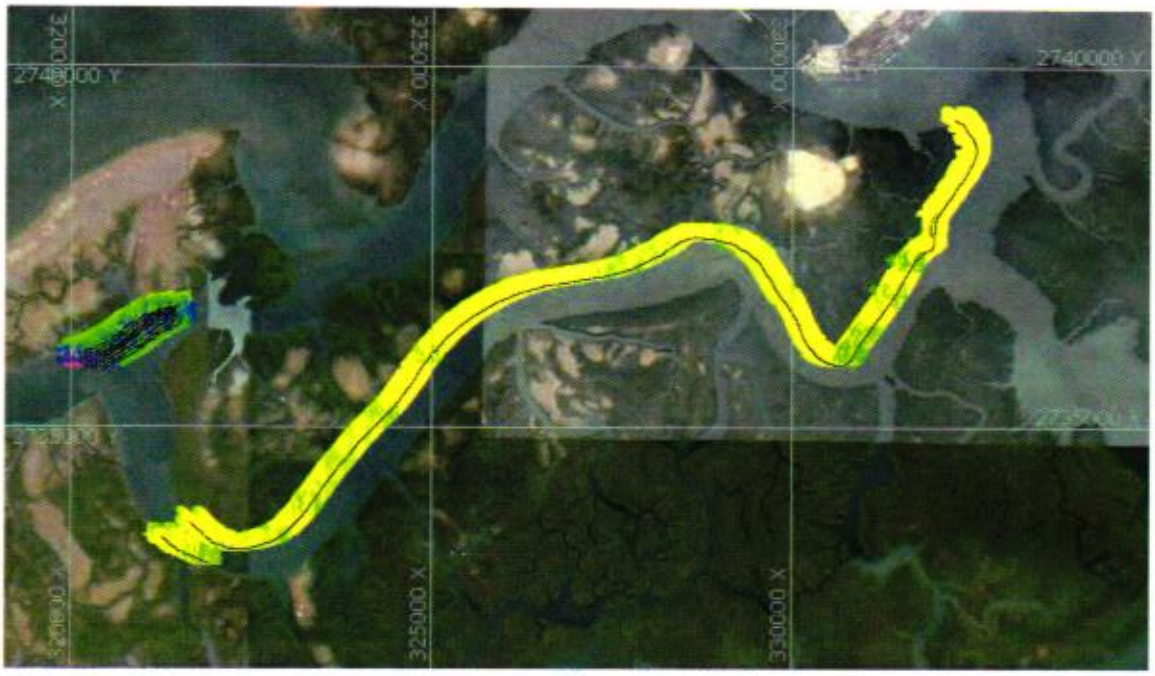


Figure 19 Pipe Line Route Jhari & Isaro Creek

Data was plotted through HYPLOT module of Hypack for which 5X5m bin processed data and 1meter contour file were used.

5.3.3 Single Beam Bathymetry

All the single beam surveys were carried out by using Odom high-precision hydrographic echo-sounder with high frequency transducer, installed on TCI shallow/deep draft survey vessels. The objective was to determine low water lines and tidal flat area for the areas of interest.

A high-resolution bathymetric survey with a spatial resolution of approximately 10 m to 20 m was carried out at the berthing basin site in Channwaddo creek for engineering purposes. A low-resolution single beam bathymetric survey with a spatial resolution of approximately 50 m was carried out in Jhari creek for the two proposed pipe line routes crossing the Jhari creek. Single beam bathymetry was also carried out on the northern bank of Jhari creek to cover tidal flat area for topographic survey of proposed pipe line route.

Hydrotrac Echo Sounder

Trimble GNSS R2 & SPS 855 was used in RTX mode for precise positioning and elevation of the survey boat. High frequency 200Khz single beam transducer installed over the side of TCI boat breakwater with GPS antenna on the top of the transducer for zero offset.

Measured draft of the transducer is further calibrated with a disk under it before start of each day work. Sound velocity is always checked and recorded with velocity profile of AML MINOS SVP. The casted SVP of each day is applied in data editing module of Hypack

Bar check procedure was also adopted on first day of data acquisition, pre & post survey to confirm the SVP data for sound velocity.

Planned lines at right angle to the banks was generated for the desired line spacing in office which were navigated by a trained helmsman under the guidance of Survey module of Hypack, to capture seabed topography after calibrations of horizontal and vertical control.

The tracked lines of single beam surveys are shown in the fallowing figure:

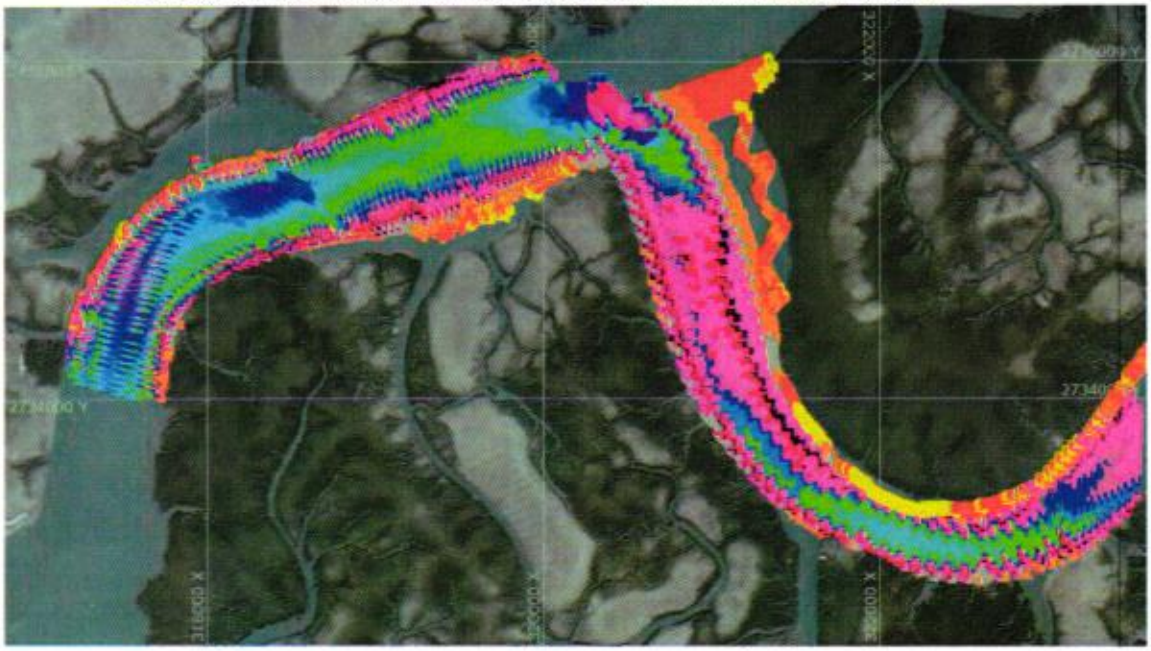


Figure 20 Chann waddo - Terminal Site & Jhari Creek – Pipe crossing

End of each day data was downloaded for processing in office. Data processed through Edit module of Hypack, where digitally recorded profiles are compared with analog record, recorded on echo trace of the echosounder. The false echoes are removed to match the analog record with digital profile. RTK tide generated by GPS is compared with the tide recorded by Tide gauge at T5 for any gross error.

Processed data is sorted for the desired scale of plot through Sort module of Hypack, for seabed contours Tin module of Hypack is used to generate seabed profile and export contours for desired spacing.

The sorted data and contours files along with the other recorded features of the area are used for plotting sheet through Plot module of Hypack.

The completed sounding charts are enclosed as Annexure C.

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6.0 TOPOGRAPHIC & MAGNETOMETER SURVEYS

6.1 Topographic survey

Owing to complexity of terrain which includes inter tidal zones, mangrove swamps, muddy and lose ground conditions, a combination of survey methods has been considered.

LNG Terminal Area survey was carried by a combination of Total Station and Aerial Drone by RTX GPS methods.

Furthermore, the pipeline route survey however presented with some difficulty. Main concern was health of surveyor while surveying in or around mangroves as breathing becomes difficult in such environment.

TCI also applied for permission for flying drone with Pak Navy which could not be reviewed by time of writing of this report. The methodology given here is for purposes of factual report on field surveys using multiple methods.

6.2 Total Station Surveys

The total station method is straight forward and involves use of Electronic total station with combined infrared distance meter and theodolite. Two known control points are used to level up and set up equipment. Topographic features are captured taking reading from a prism installed on a survey rod which is used by a survey assistance in taking tachometric details covering the visible topographic features. The precision survey baseline is then extended using high resolution APS system to progressively transfer instrument stations. Topographic features are directly recorded on data collectors which are connected to total stations via cable, thereby minimizing human errors of manually recording transit angle and distances.

The above process is repeated till entire band of survey is covered. The data from data recorder is downloaded on daily basis and processed in AutoCAD revealing any inconsistencies or misread points. Any missing data or points to be re-surveyed are covered in the next day of survey progression.

6.3 GPS RTX Surveys

RTX is a service by Trimble Navigation of USA which eliminates the need for Real Time Kinematic (RTK) corrections of the Ephemeris GPS data. The RTK corrections are normally transmitted between base and rover GPS equipment stations using a powerful radio transmitter and data modems. Due to intermittent presence of mangroves forests in Chann Wadoo and Jharri creeks, the line of sight was not available and radio signals transmissions was not found to be efficient for real time data processing of GPS data between base and rover units. As such use of innovative technology was used.

TCI purchased subscription and employed the Trimble USA based RTX system. When subscribed to this service the need for a base GPS receiver with radio transmission of satellite Ephemeris signal is eliminated and the satellite GPS corrections are received directly from the satellites, while maintaining the RTK level accuracies.

6.4 Maps:

The maps were prepared using GPS and total station resolved data duly converted into the UTM-zone 42 grid system. The GPS system employs the WGS-84 system with geoidal values.

The total station data together with GPS observed data was used to plot the base maps.

6.5 Drone based mapping:

The DJI Phantom 4 Professional drone was employed to survey the dry patches of land behind the proposed LNG terminal site in Chann Wadoo Creek. Flight of drone was achieved from the survey vessel moored near the island. There was no boat fixing or alongside jetty facility at terminal site.

Prior to drone mapping the planning of the area to be mapped was undertaken in the office and the parcel of land was defined in the software package for drone mapping namely "Pixel 4D" by Imaginit Software company. Using google satellite imagery the limits of parcel of land to be surveyed by aerial means was drawn in the software package interface.

The software package efficiently determines a flight plan and the height of flight as well as number of sorties required for the drone survey flights to cover mapping for area of interest. It must be kept in mind that drone flights is limited by battery time which is typically 20 minutes on the DJI drone.

Prior to drone flight, a series of fiducial 'X' markers were required to be placed on the area to be surveys in a fashion that it would allow the triangulation of a network of these markers within software with large angles. High resolution coordinates values were then observed at these X markers using RTX based high precision GPS observations.

Once the values of the coordinates of X markers were obtained the Pixel 4D issued command to DJI drone to automatically fly out. The Pixel 4D would then control the flight of the drone in a manner that besides the topography of the land parcel, the X markers are also captured in the flight.

Use of spare charged batteries was made so that multi drone flights could be achieved and the targeted area is captured in the sea voyage of a given day. Daylight hours with sun at zenith position is important to capture fully lit images and reduced casting of any shadows.

Later once all the flight imagery is captured, the data is then passed on to the Pixel 4D software installed back in the workstation in the office. Later when aerial triangulation of the X marker is made internally through Bundle Block Adjustment (aerial triangulation) procedure, the individual stereo images captured by the DJI drone are then stretched, pulled and compressed to suit the GPS geometry. Subsequent to this operation, the program proceeds to rasterize the features found on the land and using fiducial markers data, elevations and accurate positions are assigned internally within the software. Millions of points are processed depending on the area surveyed. It typically takes few hours to determine and compute the digitized image of the area surveyed. Later the program assigns contours to the elevations thereby yielding a contoured topographic map.

Not all area under the topographic survey campaign could be mapped with Pix4D mapper due to un-availability of drone flying permission for the Port Qasim areas.

The drone based survey maps are provided in Annexure - D

6.6 About Pix4D

Pix4Dmapper used at Tabeer energy site was for the mapping and modelling solution to convert thousands of images into geo-referenced 2D mosaics and 3D models created using images captured by DJI drone. It has both accuracy and efficiency in mapping. Pix4Dmapper automatically processes terrestrial and aerial imagery acquired by light-weight UAV aircraft using its innovative technology based purely on image content. For survey of Chann Wadoo island side, it converted the images into map able information. It has the ability to customize index maps at any resolution, classify terrain and objects automatically, create objects and animations directly in the software.

7.0 MAGNETOMETER (MAGNETIC) SURVEY

The magnetometer data was carried out in two parts.

1. Seawater based Magnetometer Survey

2. Land based metal detector survey

Details on S. No. 1 Sea water magnetometer is provided in a separate report referred to a UXO Objects Factual data report which is one of the deliverable of the Tabeer Energy investigative program instigated by JGC Corporation.

Whereas in this report, the details and modalities of the land based metal detector survey have been provided as this survey relates closely to the 50 m wide topographic survey of a strip of land which is proposed to serve as corridor for the conveyance RLNG gas line to the SSGC tie in point at Port Qasim. This tie in station of SSGC is located approx. 3.7 km east of the Marginal Wharf area.

The metal detector aims to serve the identification and geo-referencing of any metallic object underlying in the 50 m corridor. Any magnetic anomaly detected in this corridor will be shown on a surveyed plan giving its X and Y coordinates in the UTM Zone 42 grid system commonly in use at Port Qasim.

The objects that may be encountered / detected include buried metal objects, crossing pipelines & communication cables, UXO (UneXploded Ordnances) and notable debris detected by sensor of the metal detector.

7.1 Metal Detection Equipment Employed

The TCI owned equipment used in the survey was a professional grade metal detector portable unit by Garrett Corporation of USA. The model of equipment is Sea Hunter Mark II™

Metal Detector.

TCI has used this equipment not only on land but also underwater. It Ideal for oceans, beaches, lakes and all types of waterways. It includes underwater headphones as well.

This is an all-purpose instrument to find all types of metal, including brass, lead, cartridge shells and foil. It is further equipped with a discrete 'Trash Elimination mode' which eliminates un-necessary detection of small insignificant metal objects such as pull tabs and other small metal trash. Using this technology the metal detector can focus on locating the major metallic targets with time-saving precision. The equipment can be configured in various modes for use over ground, in the mud, in the surf or underwater down to 200 feet.

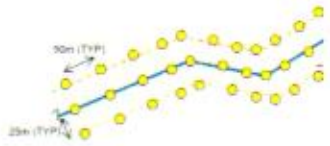
Broad Specifications for the Sea Hunter Mark II model are as under:

- Length: 28" to 52" (.71m - 1.32m), Weight: 6 lbs. (2.7kgs)
- 8" PRO submersible search coil
- Underwater headphones
- All-Metal deep seeking mode for maximum depth on all targets
- Audio Threshold: adjustable
- Discrimination, Full Range (PI)

7.2 50 m Corridor Survey Methodology

7.2.1 Topographic Survey Team

As first step, the strip of 50 m to serve as corridor for the RLNG pipeline was earmarked for survey in AutoCAD. This was in accordance with JGC specifications showing probable sea-to land interface of the pipeline.



Based on this plan, the Total Station data collectors were programmed to obtain heights and coordinates to develop topography using an appropriate survey interval.

To serve as starting out points within the survey corridor, two fixed locations to serve as back sight and foresight for Electronic Total Station were also identified. These two fixed positions were separately assigned a GPS coordinate and elevation using RTX GPS survey procedure. All the coordinates obtained by Total Station were reduced on these two reference points.

The survey crew started from the Creek side and continued the survey land wards picking up the physical object by the tachometric methods. These included above features such as road corners, building corners, fence corners, culverts and bridges, above ground pipelines. No services or utilities passing underground were neither excavated nor surveyed. This excludes

the metallic objects detectable by Metal detecting devices which is surveyed using another procedure.

The electronic total station team collected all the topographic survey data during two days of survey i.e On 17th and 18th October 2018.

The completed topographic map of the (50 m) strip survey which is the route of pipeline from creek shore to the SSGC tie in point is provided in Annexure E.

7.2.2 Metal Object Detection Team

This team marked the boundaries of the 50 m strip of corridor on a hand held GPS device.

The team employed GPS positioning methods which had Trimble RTX technology. The team programmed the GPS equipment for way points of survey lines at 5m center to center line spacing's.

The detector team started the metal detection survey by walking along the programmed survey lines. In case a detection of an object is made, the team would issue a "fix" point in the GPS system data controller. This fix point will primarily have attributes of Object number, X coordinate and Y Coordinate.

On completion of both the surveys, the points captured by metal detecting team were overlaid on the Topographic survey team AutoCAD map to provide a combined map of Topography duly delineating any metallic objects detected.

Both surveys were carried out on same grid system i.e. UTM Zone 42 in use common use by Port Qasim Authority. No on-site excavation of pits for nonmetallic buried lines was undertaken to prove the alignment of utility services.

The survey results are presented in AutoCAD format drawings separately as part of deliverable under this section of the JGC investigative campaign.

The detected metal anomalies found during the metal detector survey have been plotted on the 50 m topographic strip survey chart. This is provided under Annexure F.

7.2.3 Conclusion

The sub-bottom profiling systems were used to identify and characterize layers of sediment under the seafloor. Implementing a sub-bottom system inevitably involves a trade-off between penetration into the seabed and resolution as well.

The topographic and metal detector surveys helped map the topography of the 50 m wide land strip for conveying incoming RLNG pipeline from sea to the SSGC tie in points. The topographic survey was also complemented by metallic anomalies picked by the hand held metal detector.

The bathymetric survey helped map the sea bed contours in the areas of interest identified in the specifications at the desired contour intervals.

ANNEXURE – A

CHANN WADOO, RAKHEL CREEK

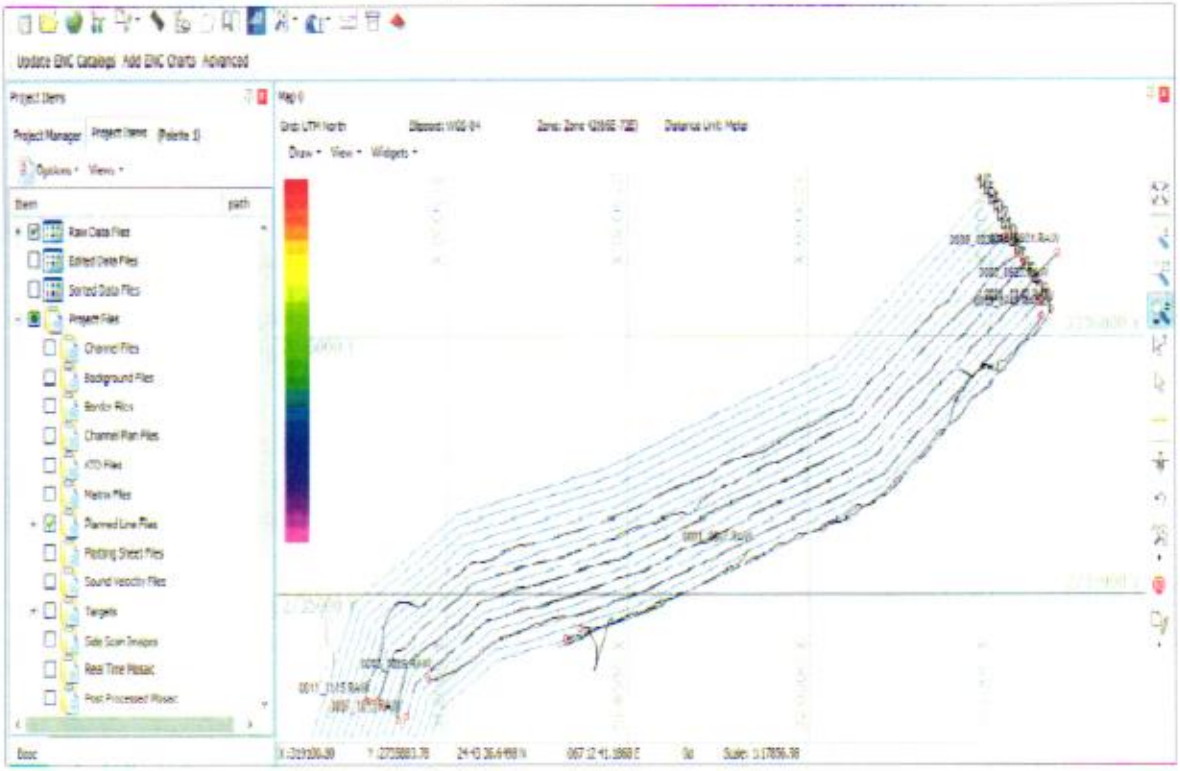


Figure 1 Planned and surveyed lines in Hypack.

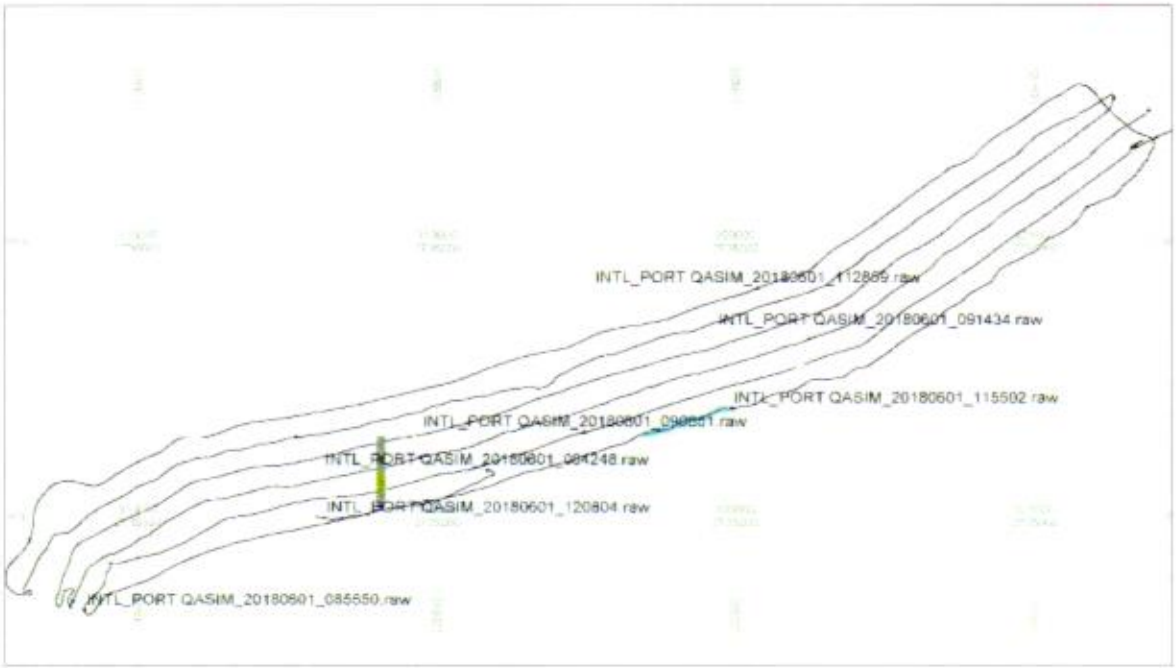


Figure 2 Plan view of surveyed lines in ISE Post Processing Software.

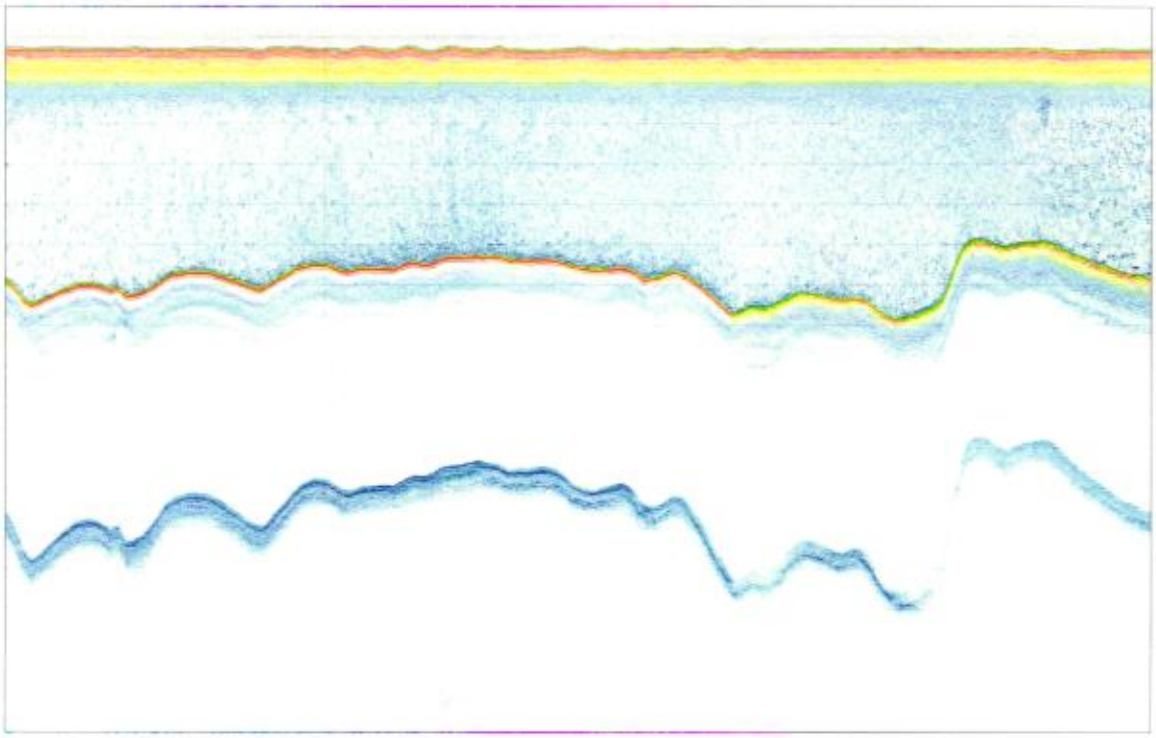


Figure 3 Profile of surveyed lines in ISE Post Processing Software.

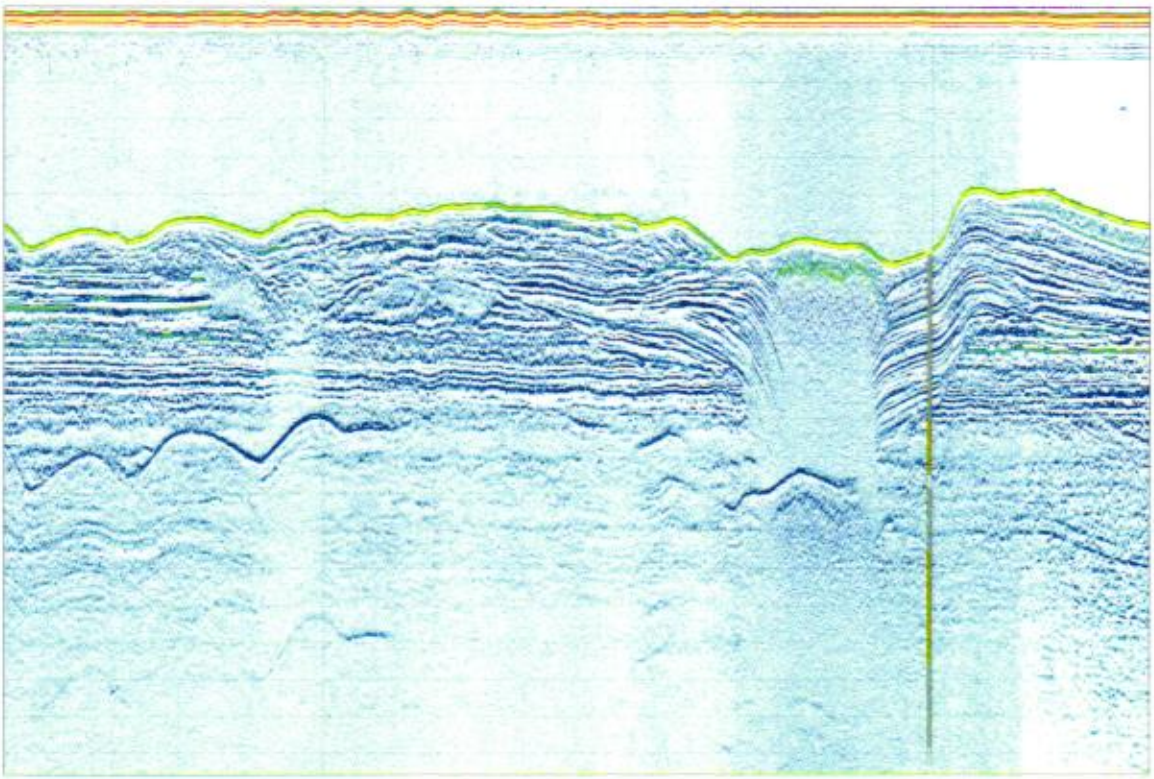


Figure 4 Profile of sediments layers in low frequency with borehole.

JHARI CREEK

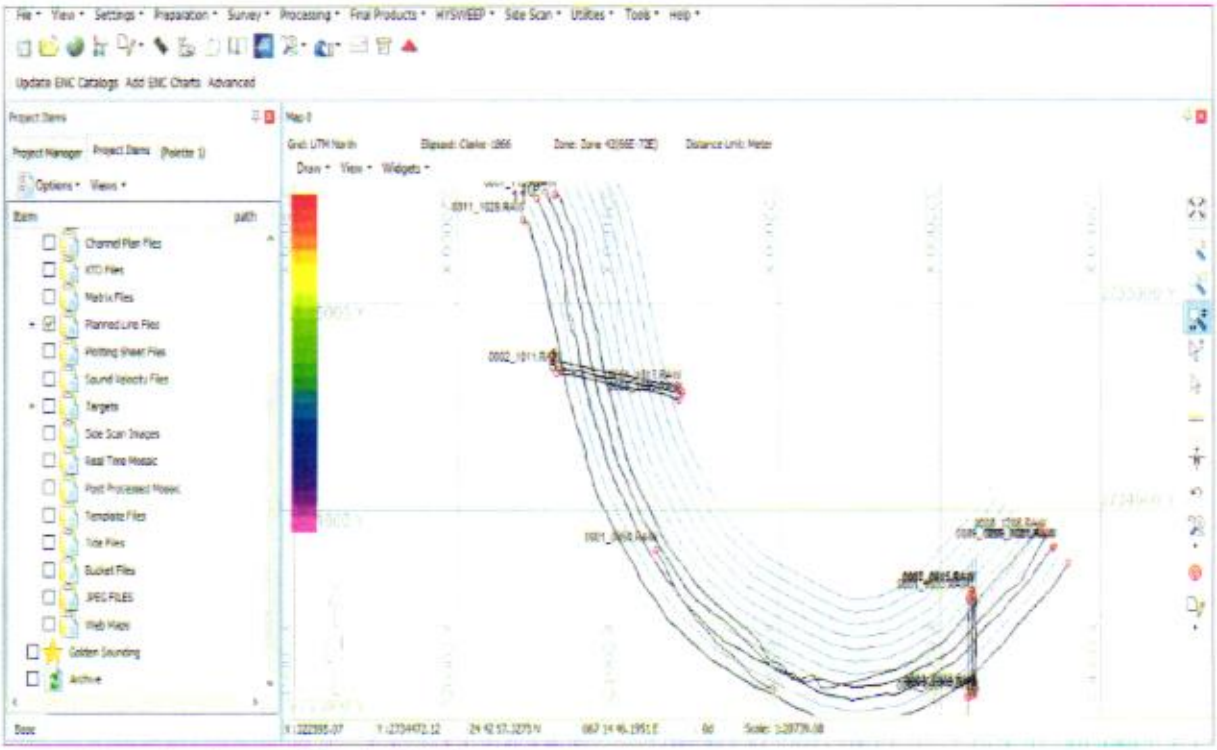


Figure 5 Planned and surveyed lines in Hypack.

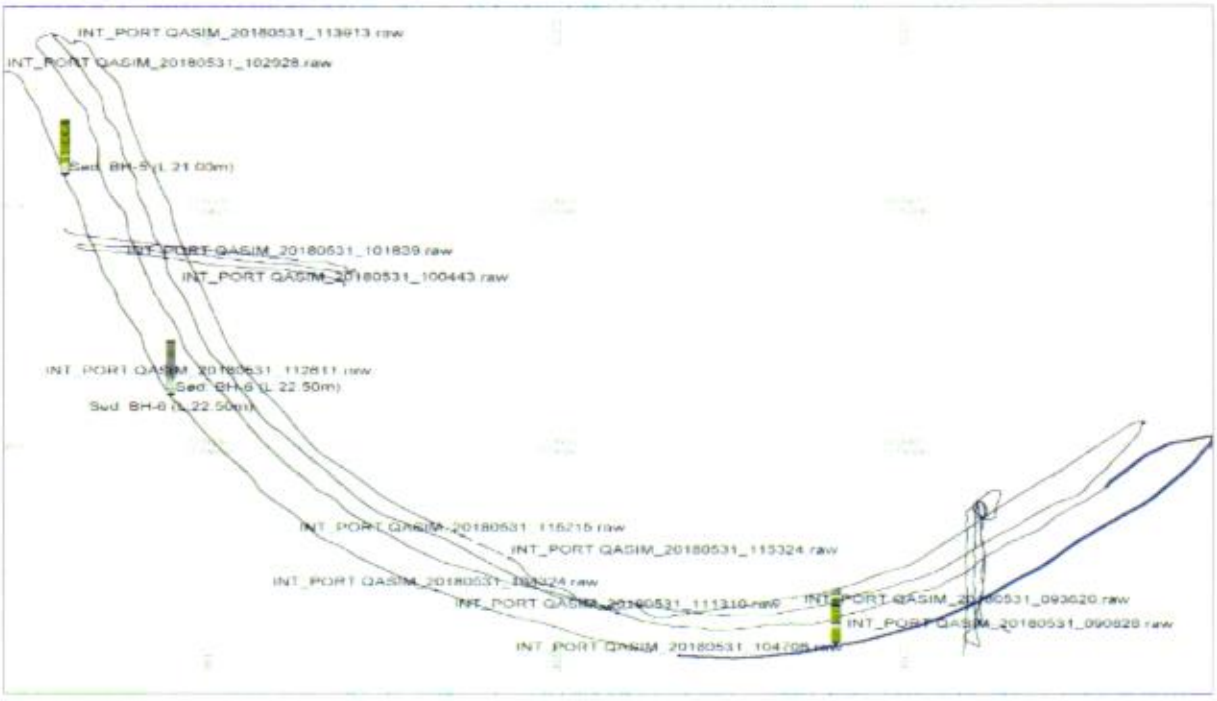


Figure 6 Plan view of surveyed lines in ISE Post Processing Software.

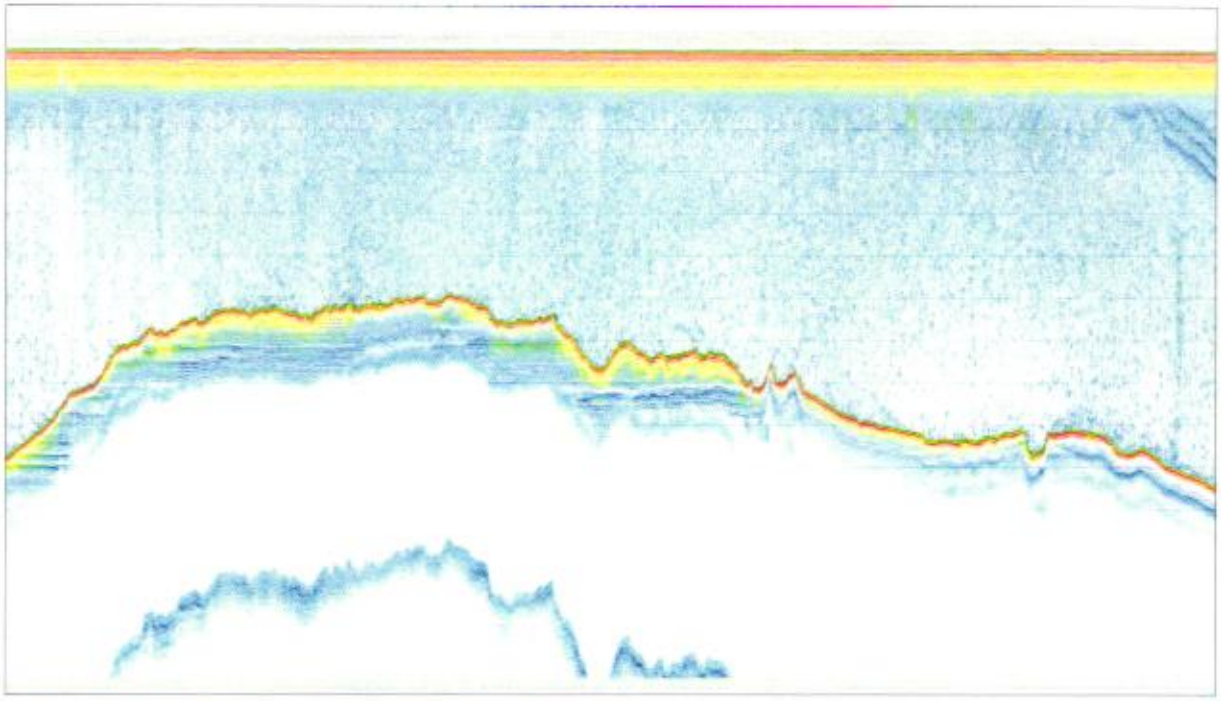


Figure 7 Profile of surveyed lines in ISE Post Processing Software.

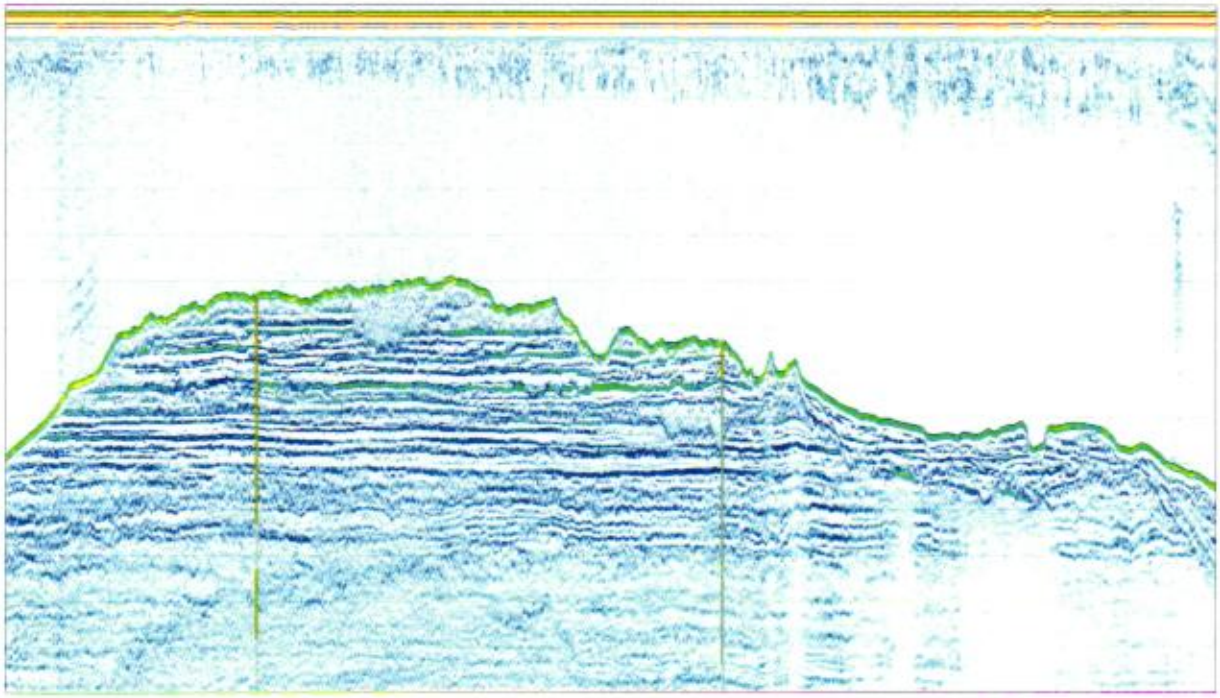


Figure 8 Profile of sediments layers in low frequency with borehole.

GHARO CREEK

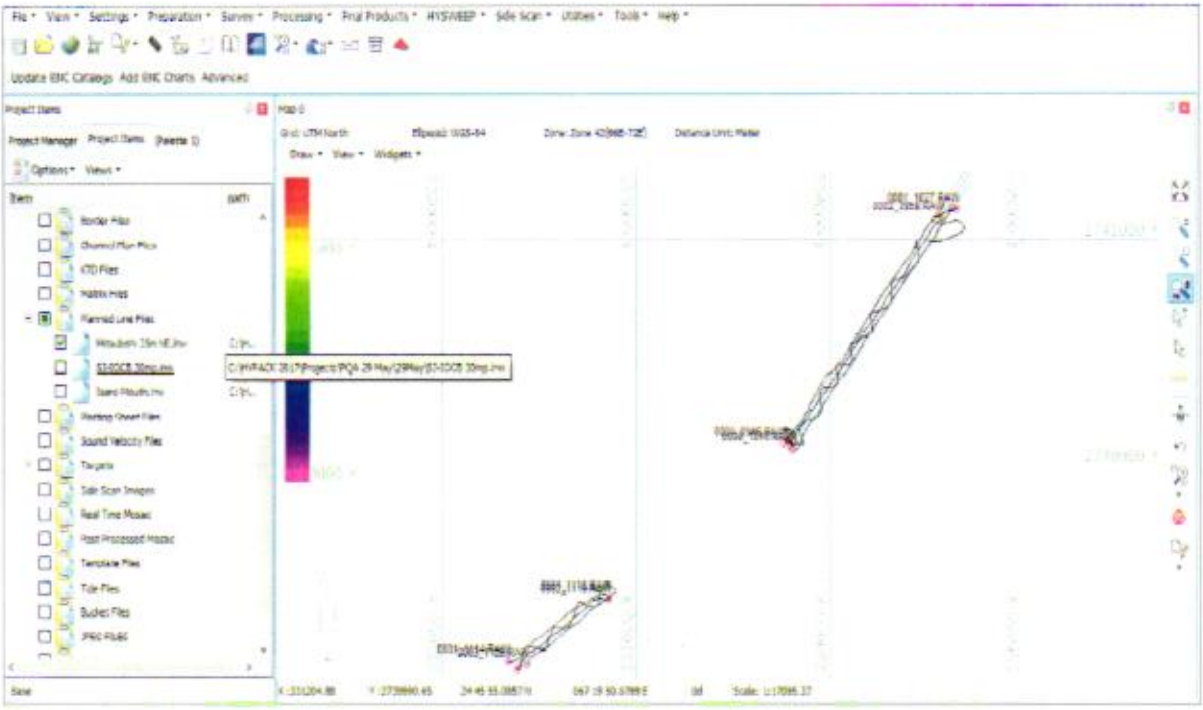


Figure 9 Planned and surveyed lines in Hypack

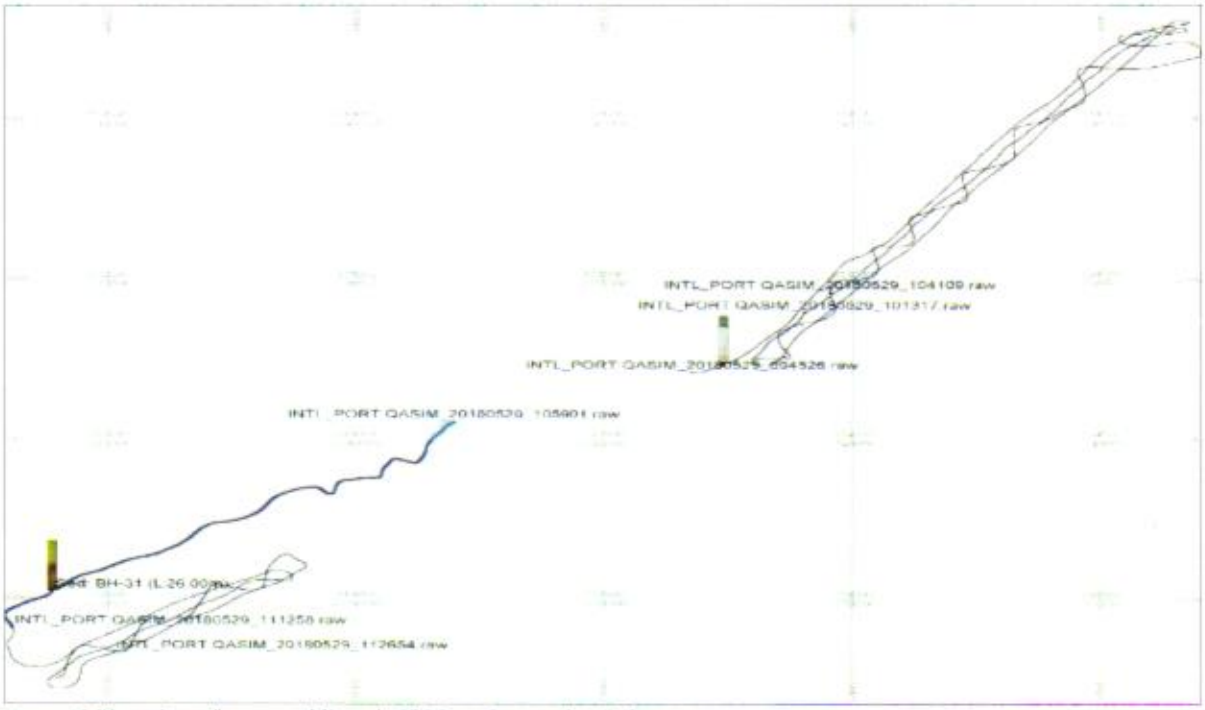


Figure 10 Plan view of surveyed lines in ISE Post Processing Software.

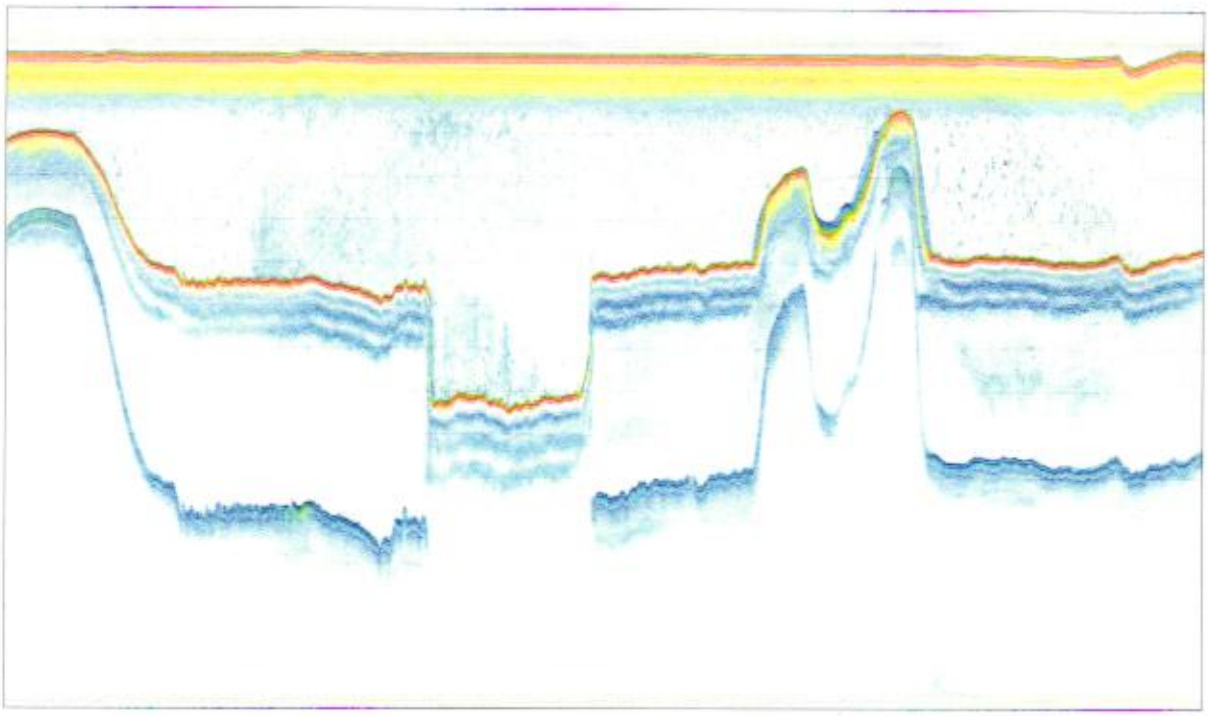


Figure 11 Profile of surveyed lines in ISE Post Processing Software.

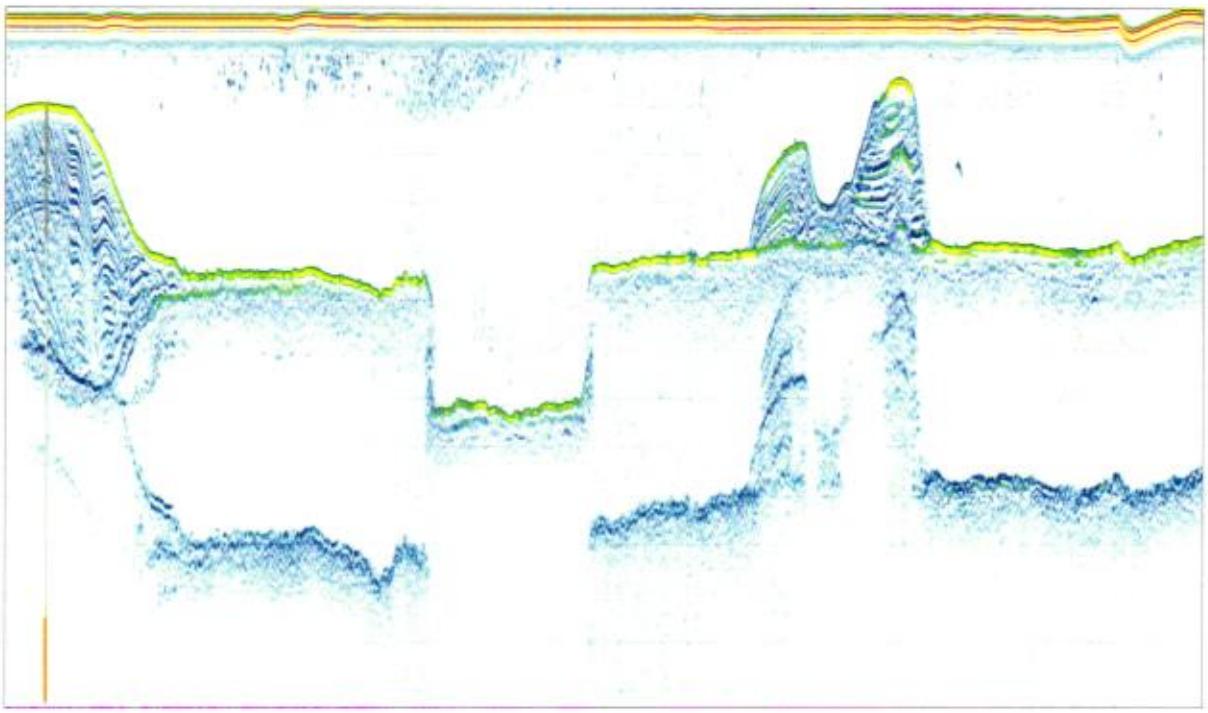
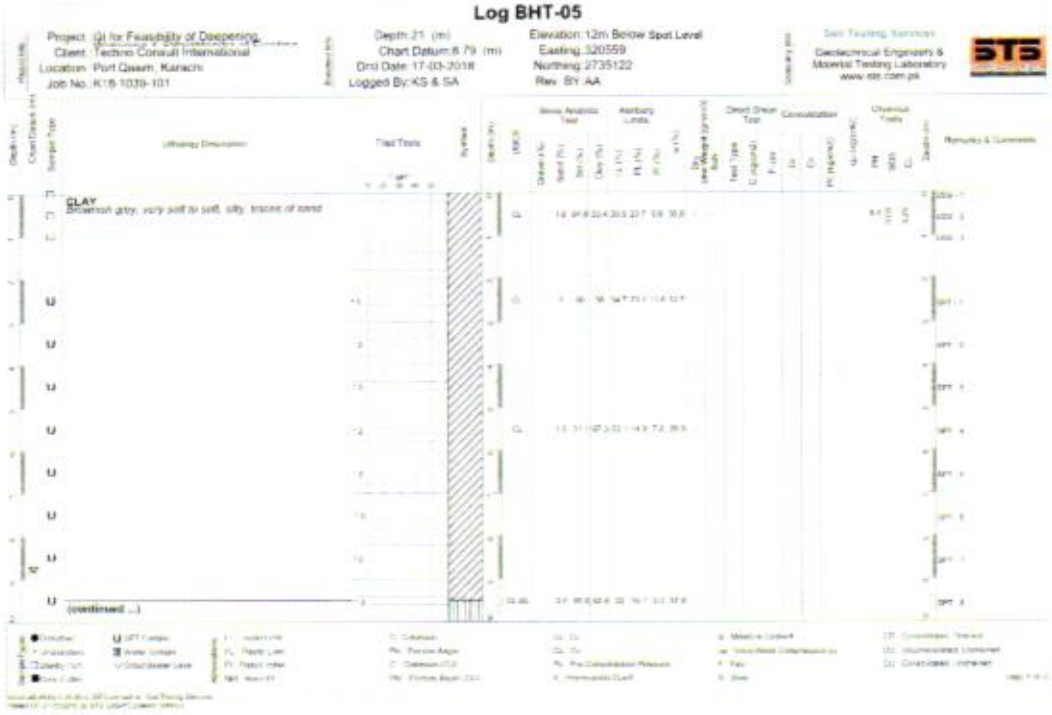
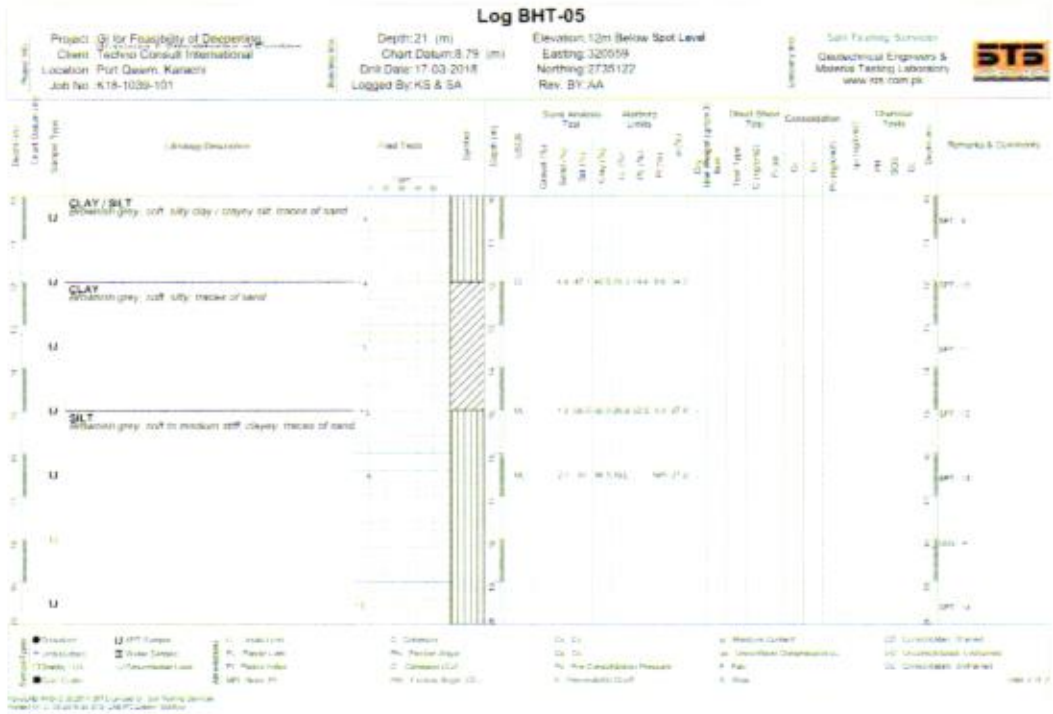
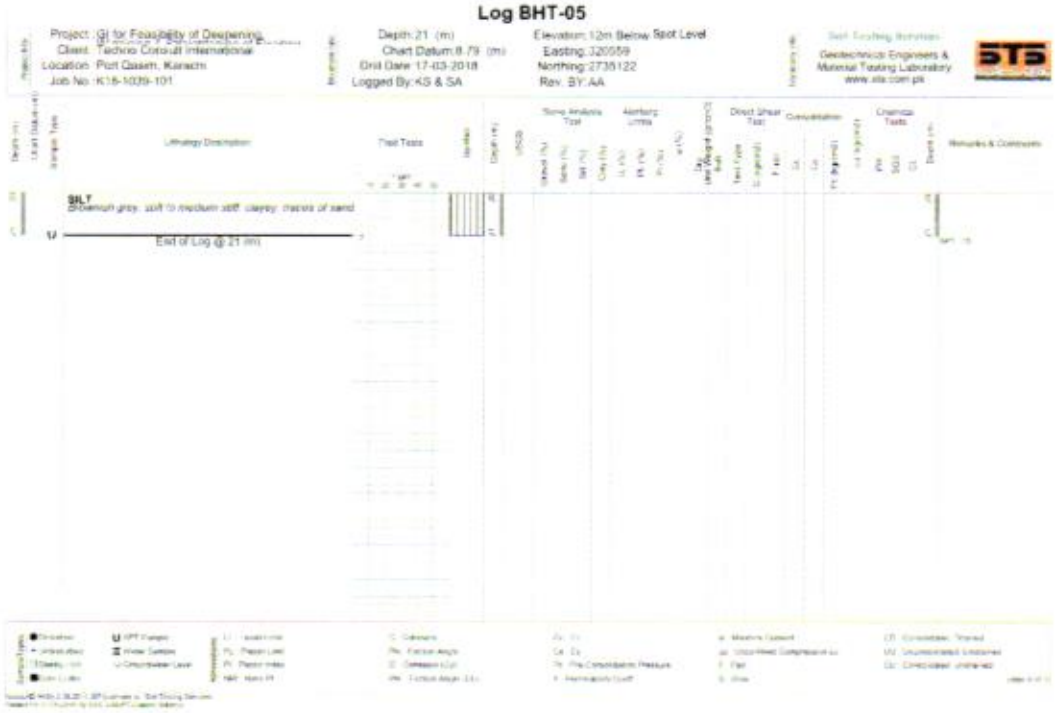


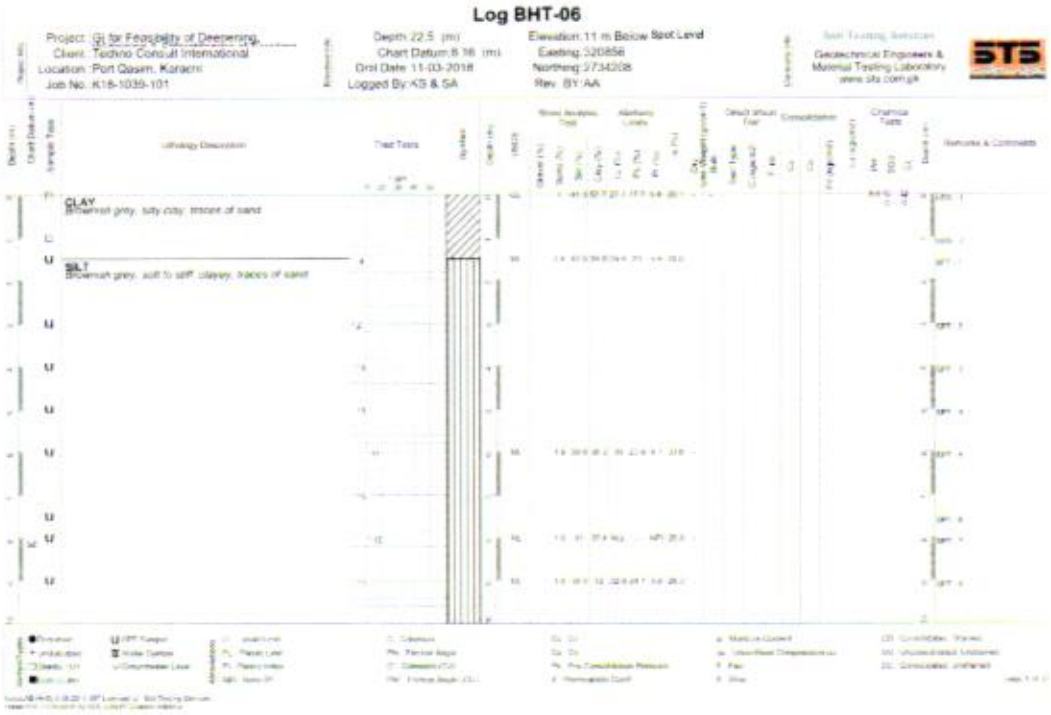
Figure 12 Profile of sediments layers in low frequency with borehole.

ANNEXURE: B


Log BHT-05
Project: GI for Feasibility of Deepening
Client: Techno Consult International
Location: Port Qasim, Karachi
Job No.: K18-1039-101
Depth: 21 (m)
Chart Datum: 8.79 (m)
Drill Date: 17-03-2018
Logged By: KS & SA
Elevation: 12m Below Spot Level
Easting: 320559
Northing: 2735122
Rev: BY: AA
CLAY
Brownish grey, very soft to soft, silty, traces of sand
(continued ...)


Log BHT-05
Project: GI for Feasibility of Deepening
Client: Techno Consult International
Location: Port Qasim, Karachi
Job No.: K18-1039-101
Depth: 21 (m)
Chart Datum: 8.79 (m)
Drill Date: 17-03-2018
Logged By: KS & SA
Elevation: 12m Below Spot Level
Easting: 320559
Northing: 2735122
Rev: BY: AA
CLAY / SILT
Brownish grey, soft, silty clay / clayey silt, traces of sand
CLAY
Brownish grey, soft, silty, traces of sand
SILT
Brownish grey, soft to medium stiff, clayey, traces of sand


Log BHT-05
Project : GI for Feasibility of Deepening
Client : Techno Consult International
Location : Port Qasim, Karachi
Job No : K18-1039-101
Depth: 21 (m)
Chart Datum: 8.79 (m)
Drill Date: 17-03-2018
Logged By: KS & SA
Elevation: 12m Below Spot Level
Easting: 320559
Northing: 2735122
Rev: SY: AA
Geotechnical Engineers & Material Testing Laboratory
www.stb.com.pk
SILT
End of Log @ 21 (m)


Log BHT-06
Project: GI for Feasibility of Deepening
Client: Techno Consult International
Location: Port Qasim, Karachi
Job No.: K18-1039-101
Depth: 22.5 (m)
Chart Datum: 8.16 (m)
Drill Date: 11-03-2018
Logged By: KS & SA
Elevation: 11 m Below Spot Level
Easting: 320856
Northing: 2734208
Rev: BY: AA
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk
CLAY
SILT

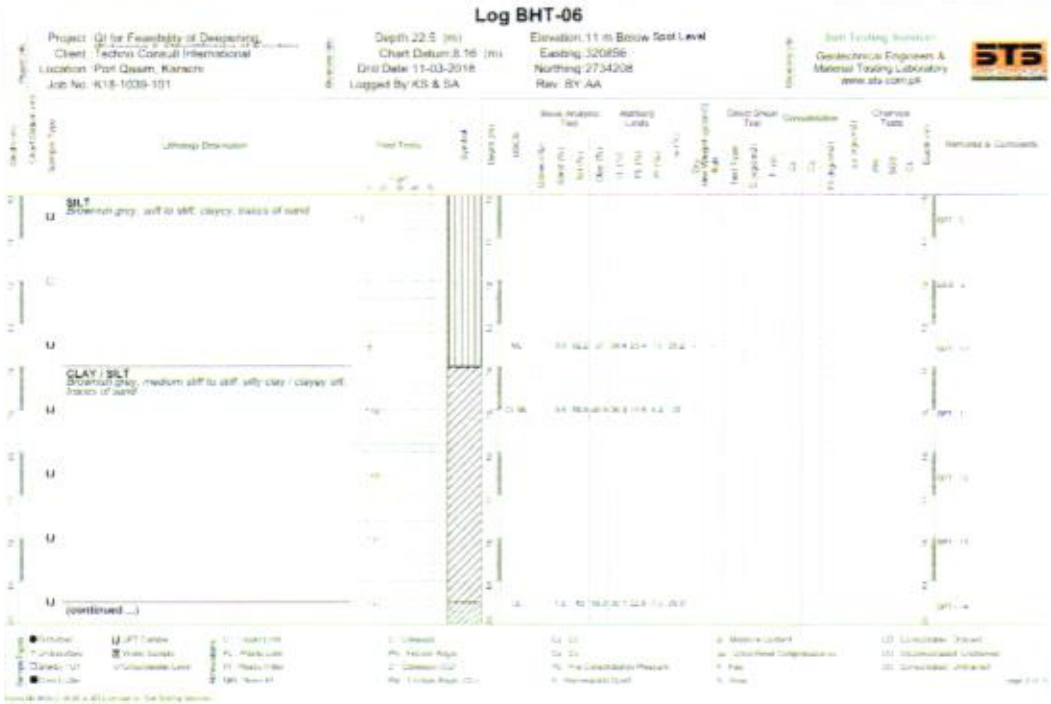
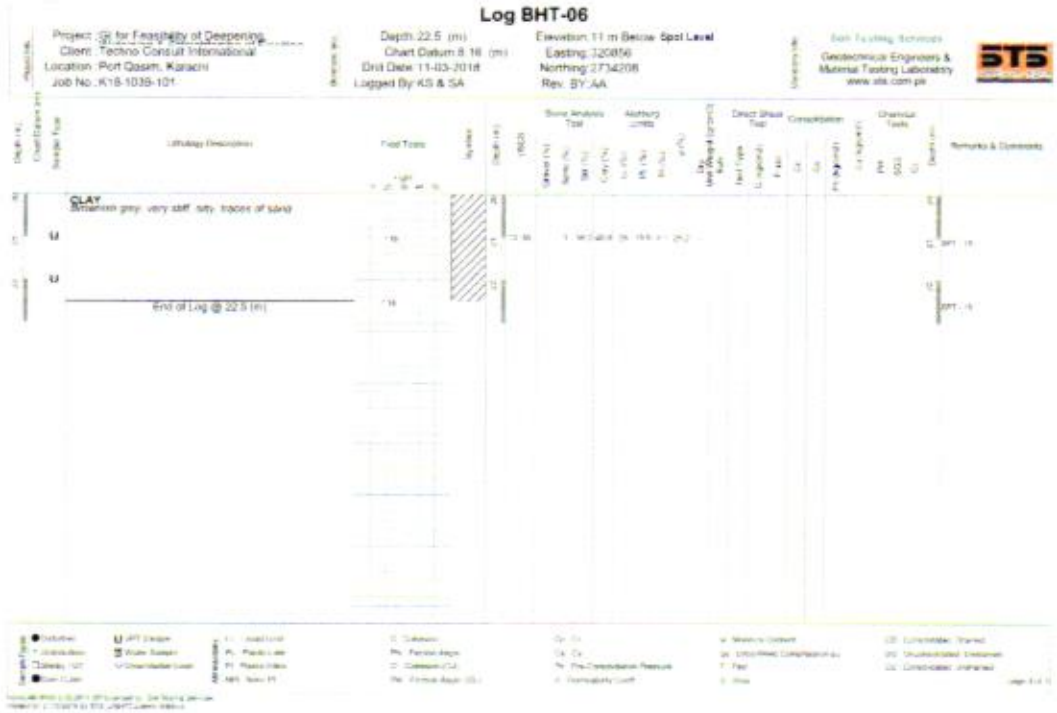

Log BHT-06
Project: GI for Feasibility of Deepening
Client: Techno Consult International
Location: Port Qasim, Karachi
Job No.: K18-1039-101
Depth: 22.5 (m)
Chart Datum: 8.16 (m)
Drill Date: 11-03-2018
Logged By: KS & SA
Elevation: 11 m Below Spot Level
Easting: 320856
Northing: 2734208
Rev: BY: AA
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk
SILT
CLAY / SILT
(continued ...)

Fig 07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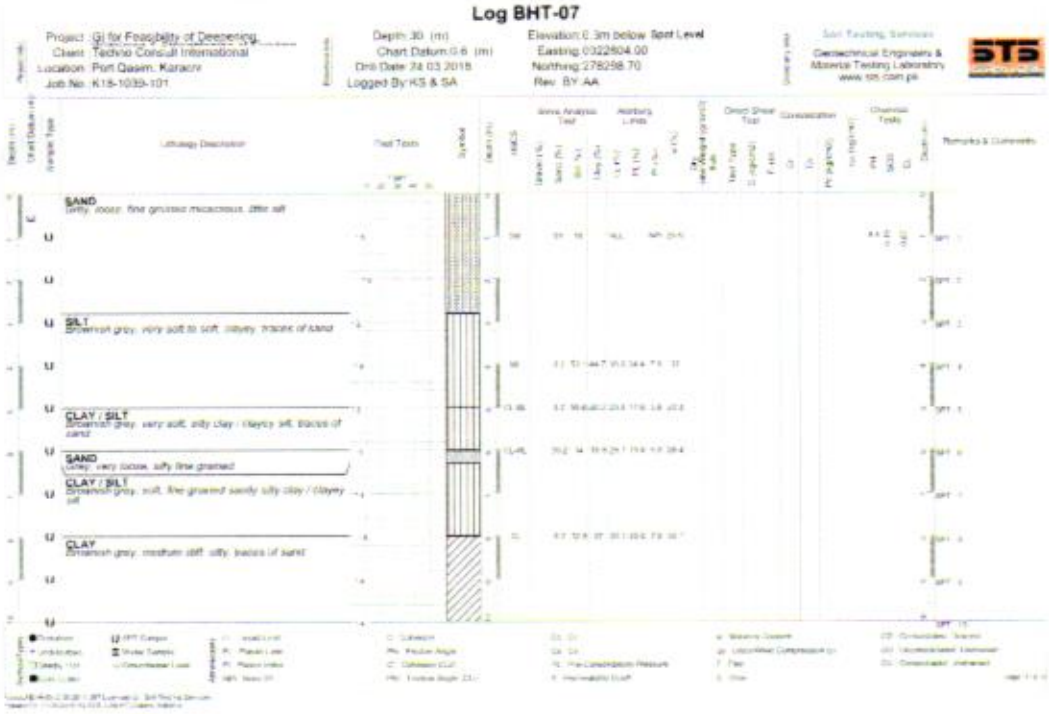
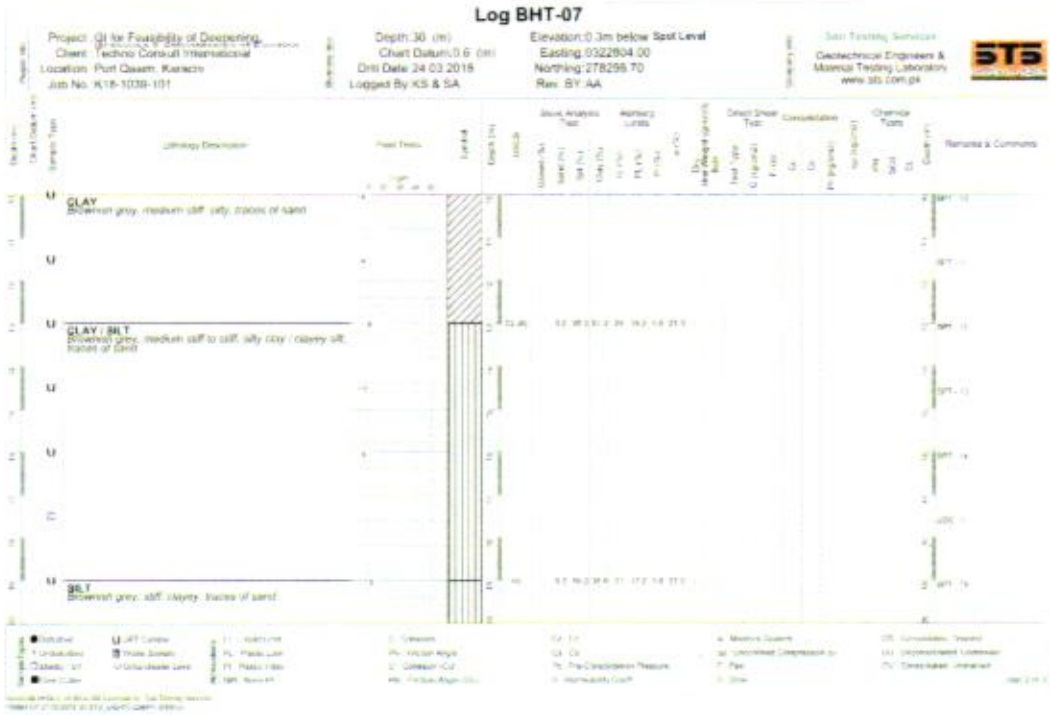
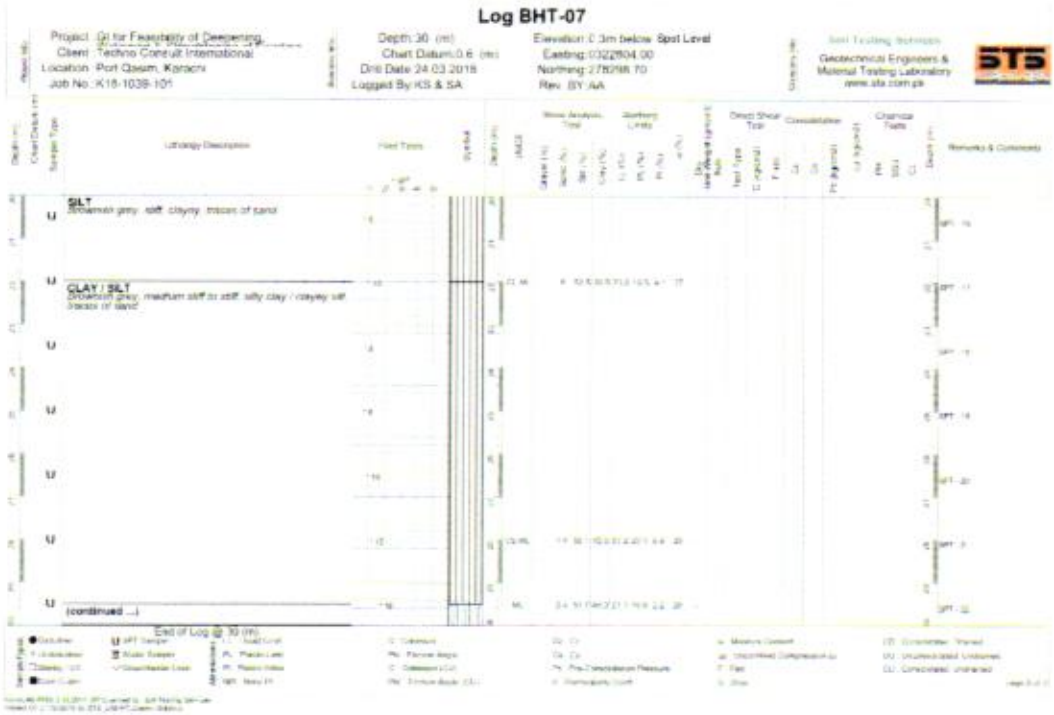
Project: for Feasibility of Deepening
Client: Techno Consult International
Location: Port Qasim, Karachi
Job No.: K18-1039-101
Depth: 22.5 (m)
Chart Datum: 8.16 (m)
Drill Date: 11-03-2018
Logged By: KS & SA
Elevation: 11 m Below Spot Level
Easting: 320856
Northing: 2734208
Rev: BY: AA
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk
CLAY
End of Log @ 22.5 (m)


Log BHT-07
Project : GI for Feasibility of Deepening
Client : Techno Consult International
Location : Port Qasim, Karachi
Job No. : K18-1039-101
Depth: 30 (m)
Chart Datum: 0.6 (m)
Drill Date: 24.03.2018
Logged By: KS & SA
Elevation: 0.3m below Spot Level
Easting: 0322804.00
Northing: 278298.70
Rev: BY: AA
Soil Testing Services
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk
STS
SAND
SILT
CLAY / SILT
SAND
CLAY / SILT
CLAY


Log BHT-07
Project : GI for Feasibility of Deepening
Client : Techno Consult International
Location : Port Qasim, Karachi
Job No. : K18-1039-101
Depth: 30 (m)
Chart Datum: 0.6 (m)
Drill Date: 24.03.2018
Logged By: KS & SA
Elevation: 0.3m below Spot Level
Easting: 0322804.00
Northing: 278298.70
Rev: BY: AA
Soil Testing Services
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk
STS
CLAY
CLAY / SILT
SILT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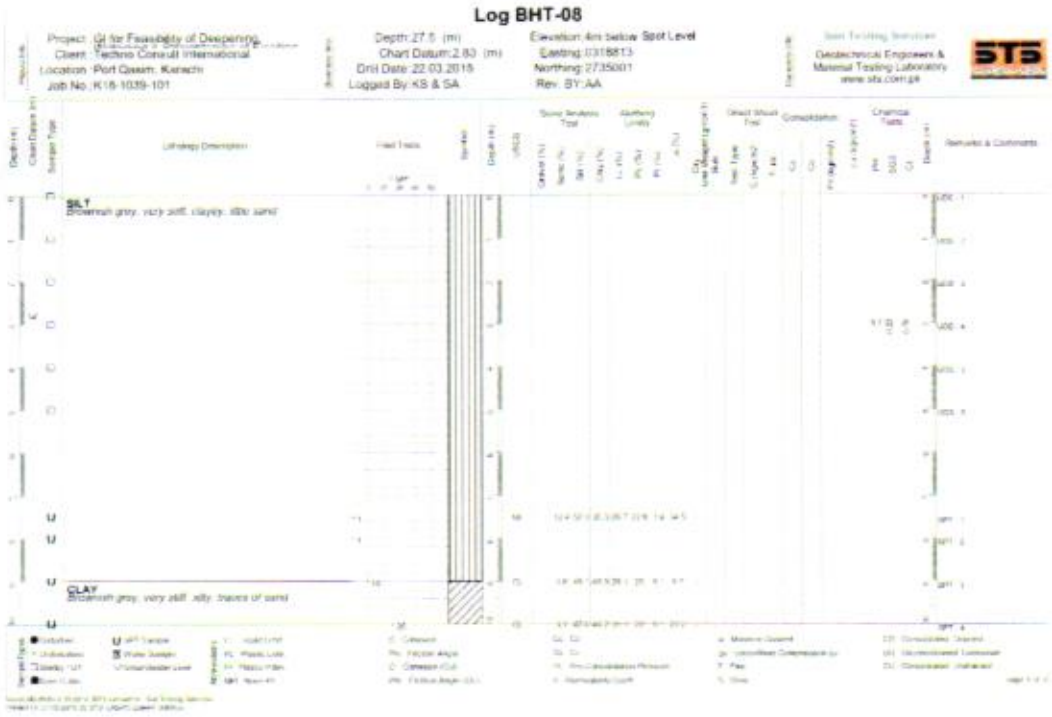
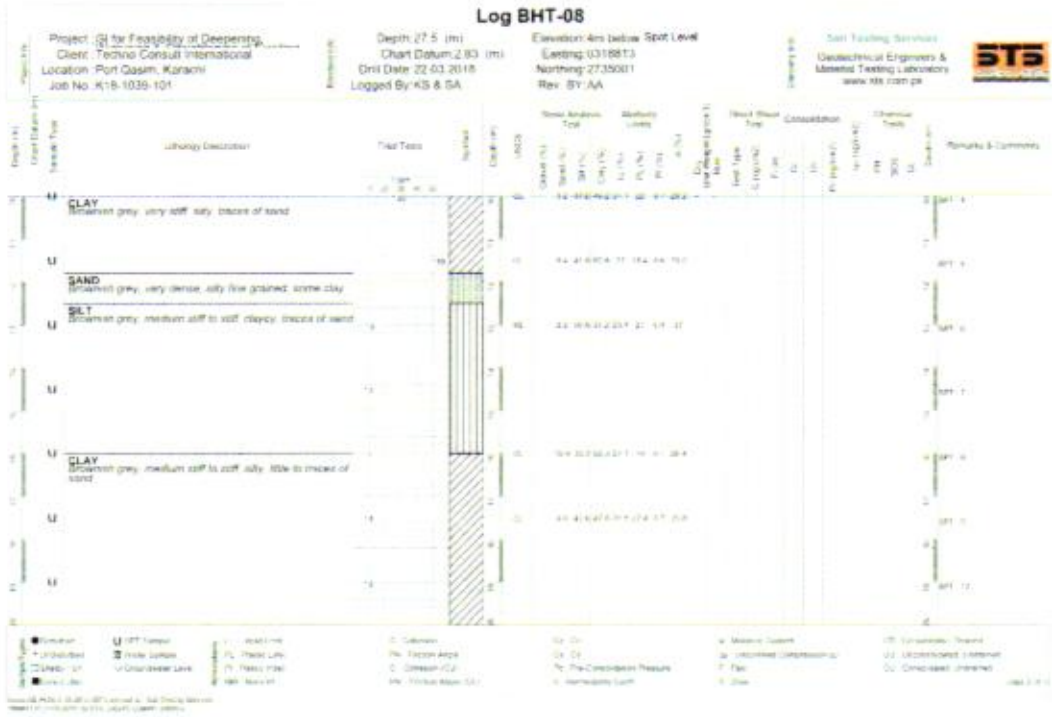
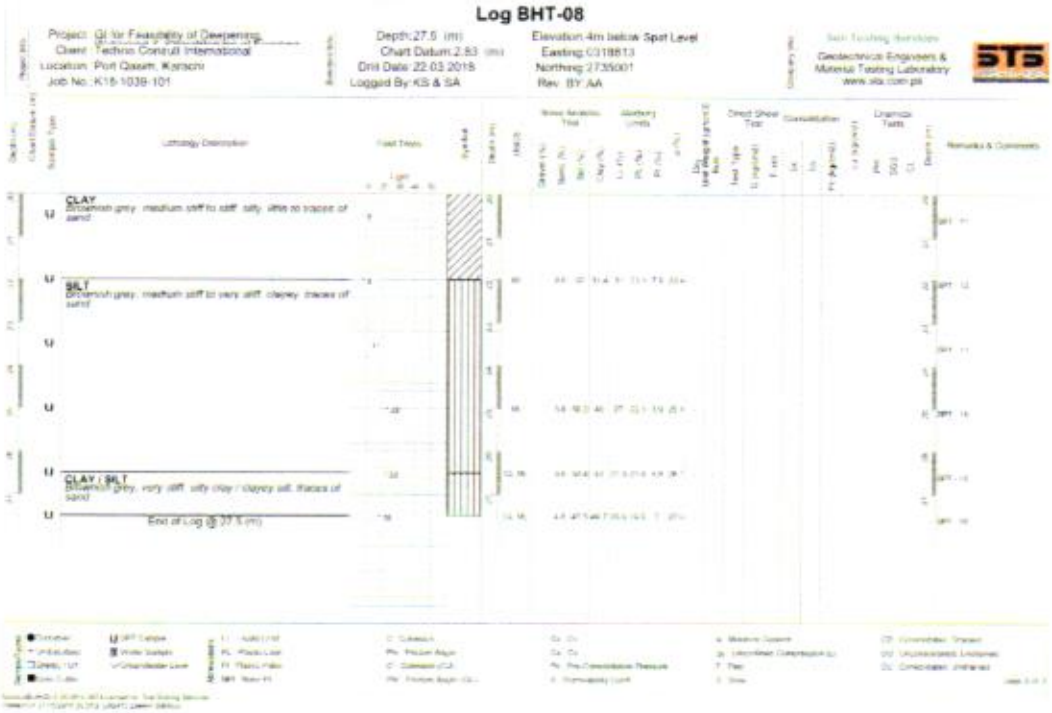
Client: Techno Consult International
Location: Port Qasim, Karachi
Job No.: K18-1039-101
Depth: 30 (m)
Chart Datum: 0.6 (m)
Drill Date: 24.03.2018
Logged By: KS & SA
Elevation: 0.3m below Spot Level
Easting: 0322804.00
Northing: 2780618.70
Rev: BY: AA
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk
STS
SILT
CLAY / SILT
(continued ...)
End of Log @ 30 (m)


Log BHT-08
Project : GI for Feasibility of Deepening
Client : Techno Consult International
Location : Port Qasim, Karachi
Job No : K18-1039-101
Depth: 27.5 (m)
Chart Datum: 2.83 (m)
Drill Date: 22.03.2018
Logged By: KS & SA
Elevation: 4m below Spot Level
Easting: 0318813
Northing: 2735001
Rev: BY: AA
Soil Testing Services
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk
STS
Lithology Description
Field Tests
Sonic Analysis Tool
Atterberg Limits
Direct Shear Test
Consolidation
Chemical Tests
Remarks & Comments
SILT
Brownish grey, very stiff, clayey, silty sand
CLAY
Brownish grey, very stiff, silty, traces of sand


Log BHT-08
Project : GI for Feasibility of Deepening
Client : Techno Consult International
Location : Port Qasim, Karachi
Job No : K18-1039-101
Depth: 27.5 (m)
Chart Datum: 2.83 (m)
Drill Date: 22.03.2018
Logged By: KS & SA
Elevation: 4m below Spot Level
Easting: 0318813
Northing: 2735001
Rev: BY: AA
Soil Testing Services
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk
STS
Lithology Description
Field Tests
Sonic Analysis Tool
Atterberg Limits
Direct Shear Test
Consolidation
Chemical Tests
Remarks & Comments
CLAY
Brownish grey, very stiff, silty, traces of sand
SAND
Brownish grey, very dense, silty fine grained, some clay
SILT
Brownish grey, medium stiff to stiff, clayey, traces of sand
CLAY
Brownish grey, medium stiff to stiff, silty, little to traces of sand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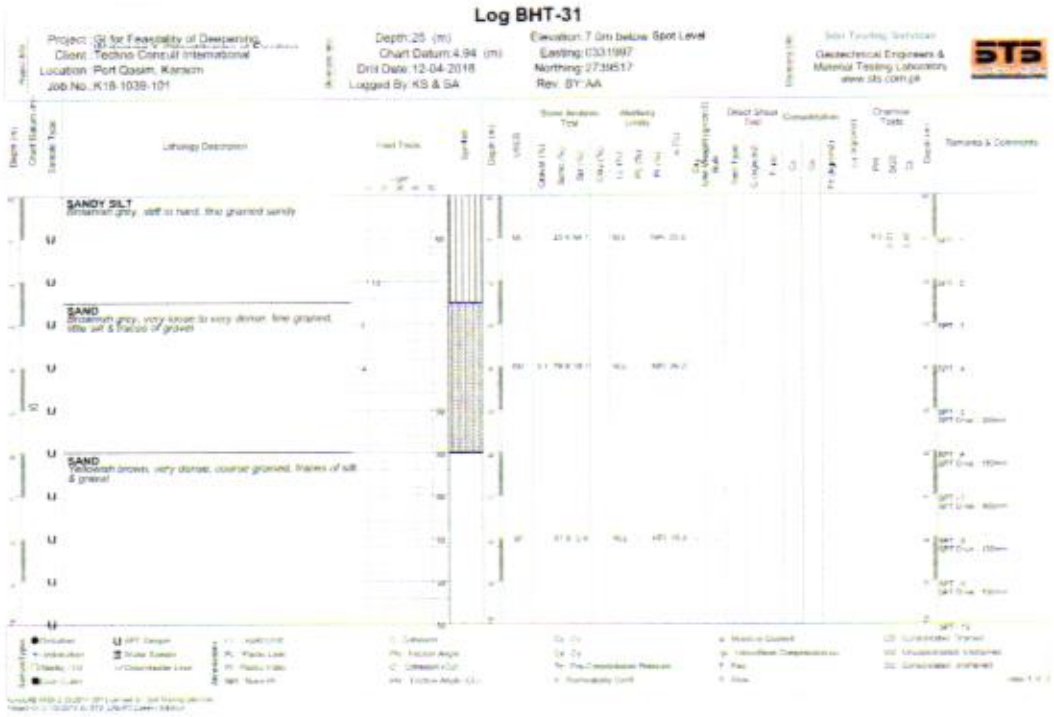
Client: Techno Consult International
Location: Port Qasim, Karachi
Job No.: K15-1039-101
Depth:27.5 (m)
Chart Datum:2.83 (m)
Drill Date:22.03.2015
Logged By:KS & SA
Elevation 4m below Spot Level
Easting:0318813
Northing:2735001
Rev: BY:AA
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk
CLAY
SILT
CLAY / SILT
End of Log @ 27.5 (m)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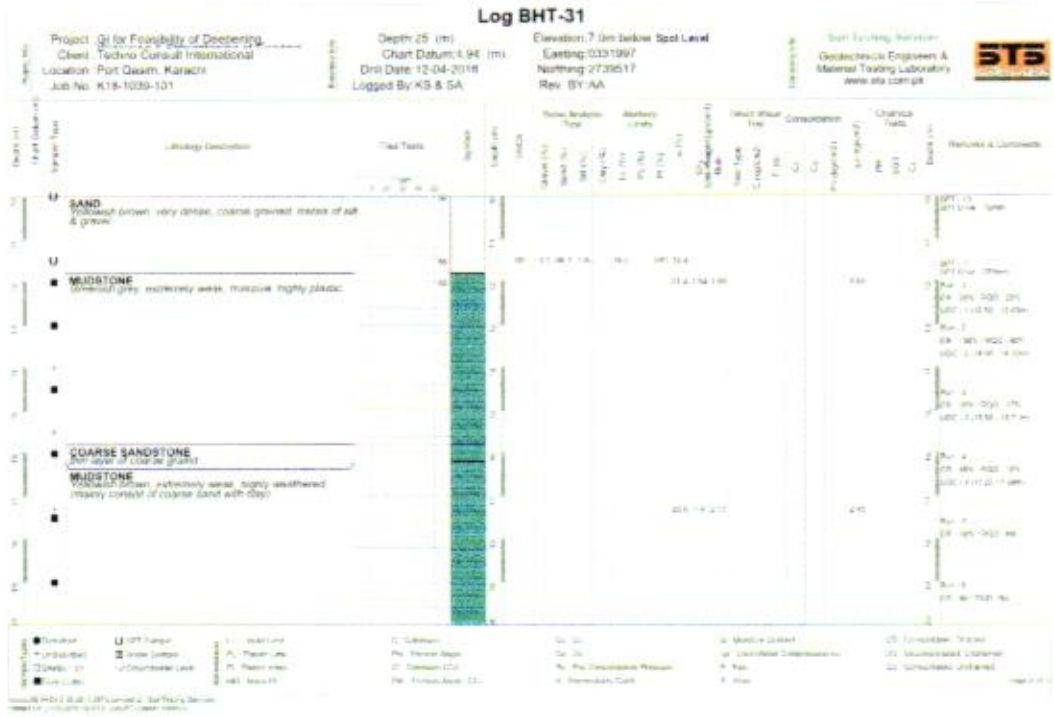
Project: GI for Feasibility of Deepening
Client: Techno Consult International
Location: Port Qasim, Karachi
Job No.: K18-1039-101
Depth: 25 (m)
Chart Datum: 4.94 (m)
Drill Date: 12-04-2018
Logged By: KS & SA
Elevation: 7.0m below Spot Level
Easting: 0331997
Northing: 2739517
Rev: BY: AA
Geotechnical Engineers & Material Testing Laboratory
www.stb.com.pk
SANDY SILT
SAND
SAND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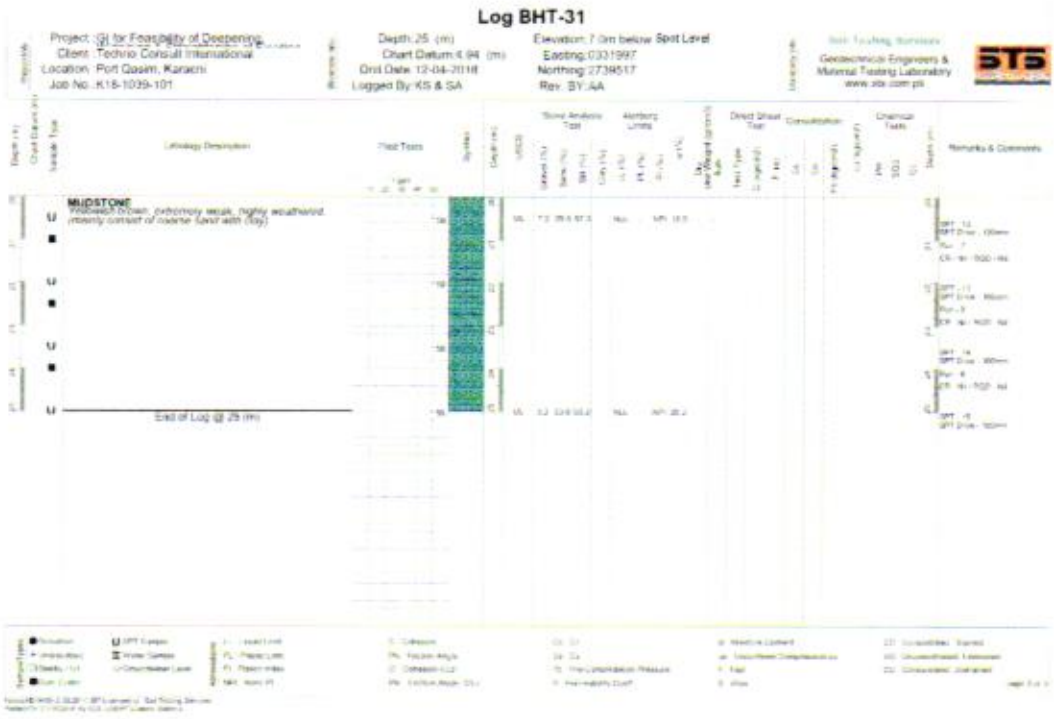
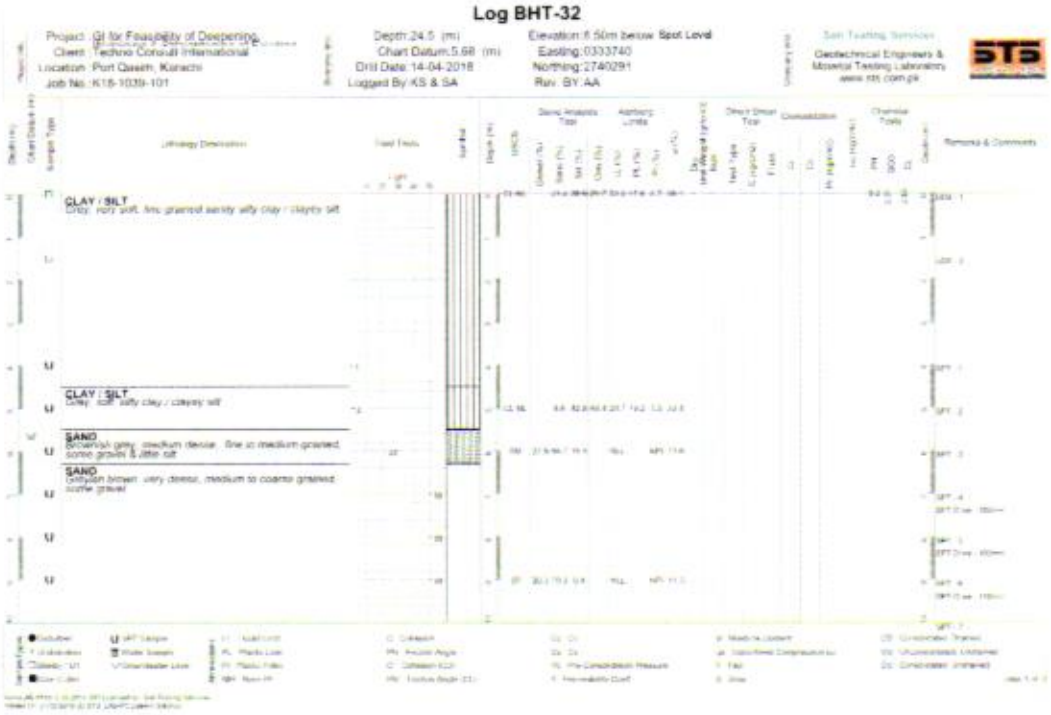
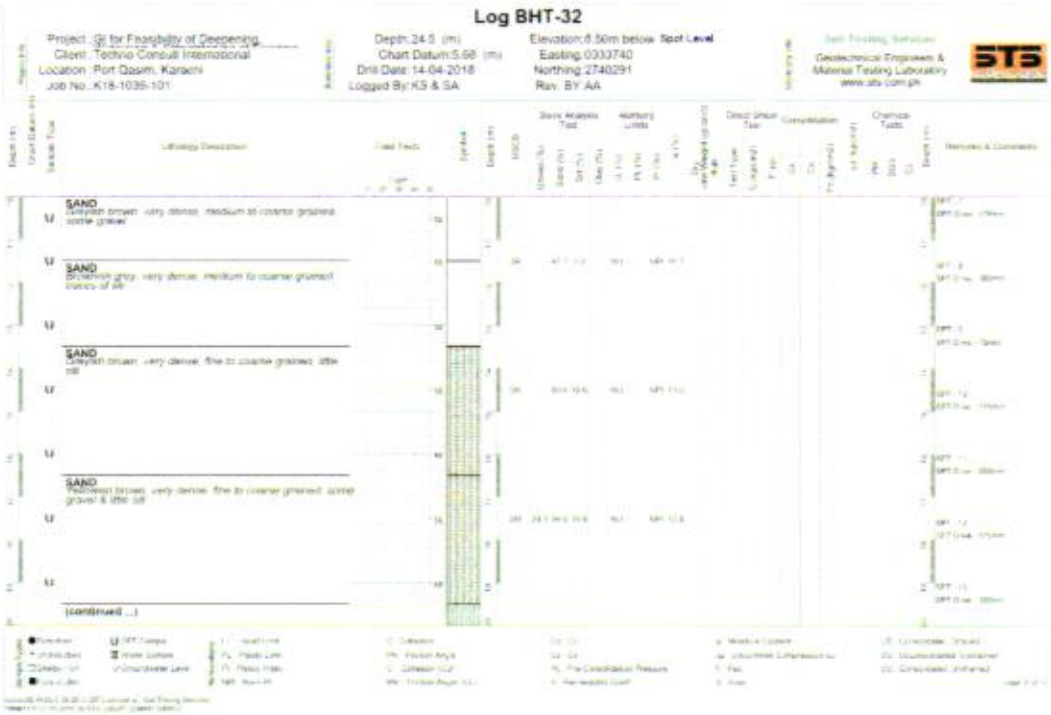
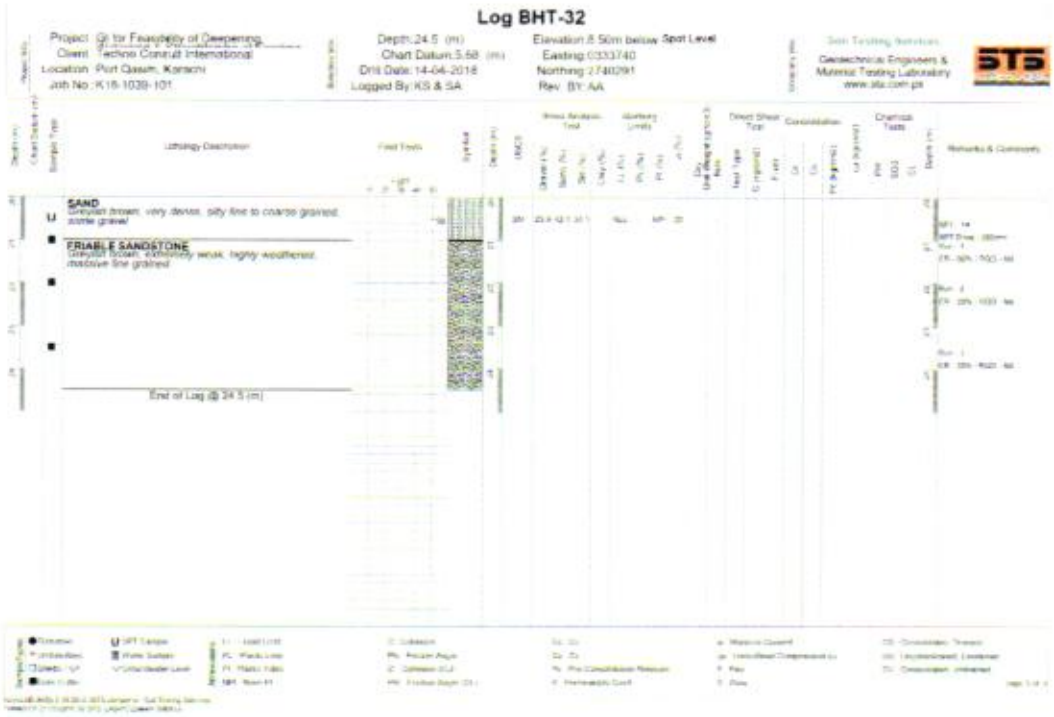
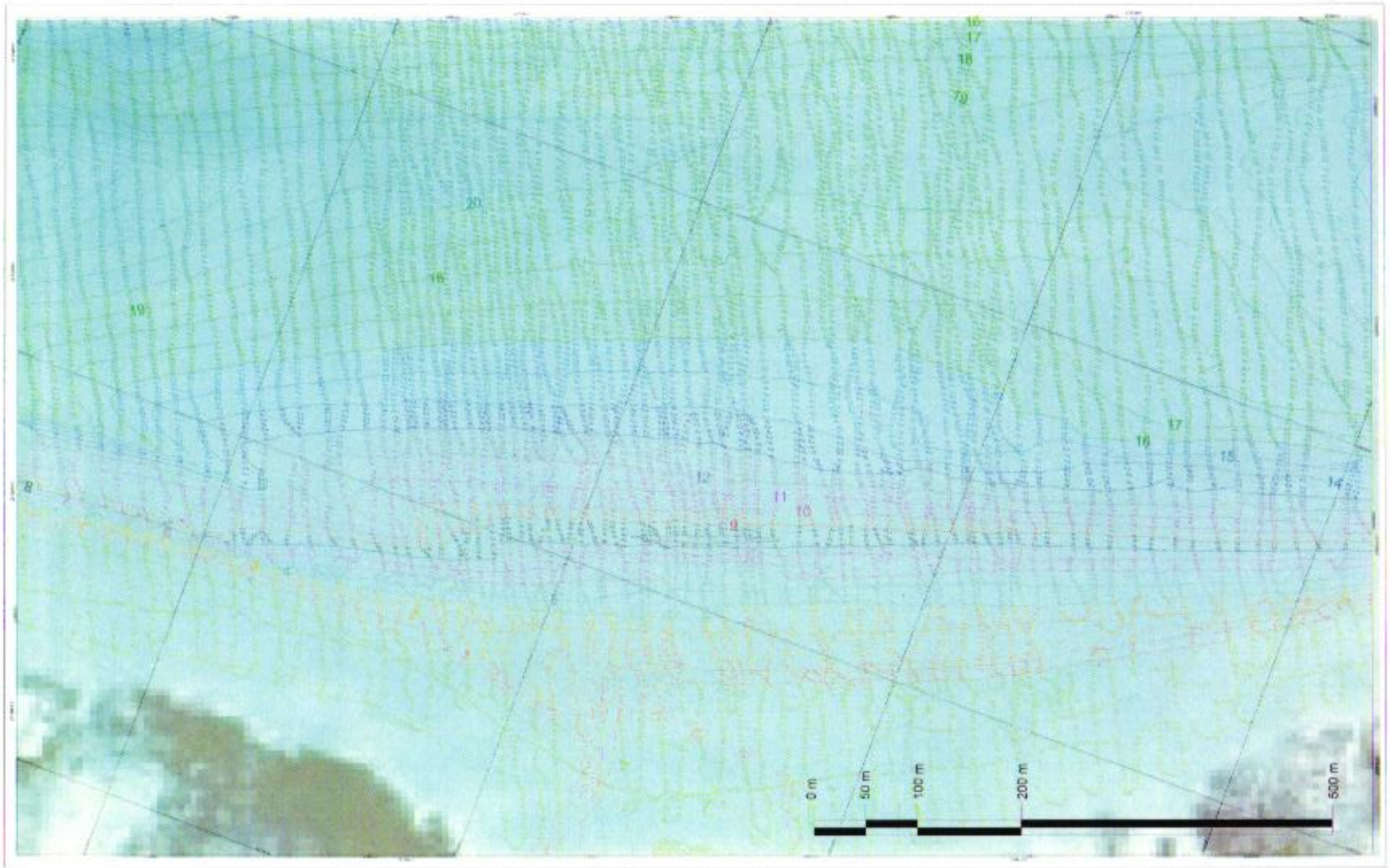
Project: GI for Feasibility of Deepening
Client: Techno Consult International
Location: Port Qasim, Karachi
Job No.: K18-1039-101
Depth: 25 (m)
Chart Datum: 4.94 (m)
Drill Date: 12-04-2018
Logged By: KS & SA
Elevation: 7.0m below Spot Level
Easting: 0331997
Northing: 2739517
Rev: BY: AA
Geotechnical Engineers & Material Testing Laboratory
www.stb.com.pk
SAND
MUDSTONE
COARSE SANDSTONE
MUDSTONE


Log BHT-31
Project : GI for Feasibility of Deepening
Client : Techno Consult International
Location : Port Qasim, Karachi
Job No. : K18-1039-101
Depth: 25 (m)
Chart Datum: 6.94 (m)
Drill Date: 12-04-2018
Logged By: KS & SA
Elevation: 7.0m below Spot Level
Easting: 0331997
Northing: 2738517
Rev: BY: AA
Geotechnical Engineers & Material Testing Laboratory
www.stb.com.pk
STB
Lithology Description
Field Tests
Symbols
Sieve Analysis Test
Atterberg Limits
Direct Shear Test
Consolidation
Chemical Tests
Remarks & Comments
MUDSTONE
Yellowish Brown, extremely weak, highly weathered, intensly consist of coarse Sand with (Clay)
End of Log @ 25 (m)


Log BHT-32
Project : GI for Feasibility of Deepening
Client : Techno Consult International
Location : Port Qasim, Karachi
Job No. : K18-1039-101
Depth: 24.5 (m)
Chart Datum: 5.68 (m)
Drill Date: 14-04-2018
Logged By: KS & SA
Elevation: 6.50m below Spot Level
Easting: 0333740
Northing: 2740291
Rev: BY AA
Soil Testing Services
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk
STS
CLAY / SILT
CLAY / SILT
SAND
SAND


Log BHT-32
Project : GI for Feasibility of Deepening
Client : Techno Consult International
Location : Port Qasim, Karachi
Job No. : K18-1039-101
Depth: 24.5 (m)
Chart Datum: 5.68 (m)
Drill Date: 14-04-2018
Logged By: KS & SA
Elevation: 6.50m below Spot Level
Easting: 0333740
Northing: 2740291
Rev: BY AA
Soil Testing Services
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk
STS
SAND
SAND
SAND
SAND
(continued ...)


Log BHT-32
Project: @ for Feasibility of Deepening
Client: Techno Consult International
Location: Port Qasim, Karachi
Job No.: K18-1039-101
Depth: 24.5 (m)
Chart Datum: 5.68 (m)
Drill Date: 14-04-2018
Logged By: KS & SA
Elevation 8.56m below Spot Level
Easting: 0333740
Northing: 2748291
Rev. BY: AA
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk
STS
SAND
Greyish brown, very dense, silty fine to coarse grained, some gravel
FRIABLE SANDSTONE
Greyish brown, extremely weak, highly weathered, massive fine grained
End of Log @ 24.5 (m)

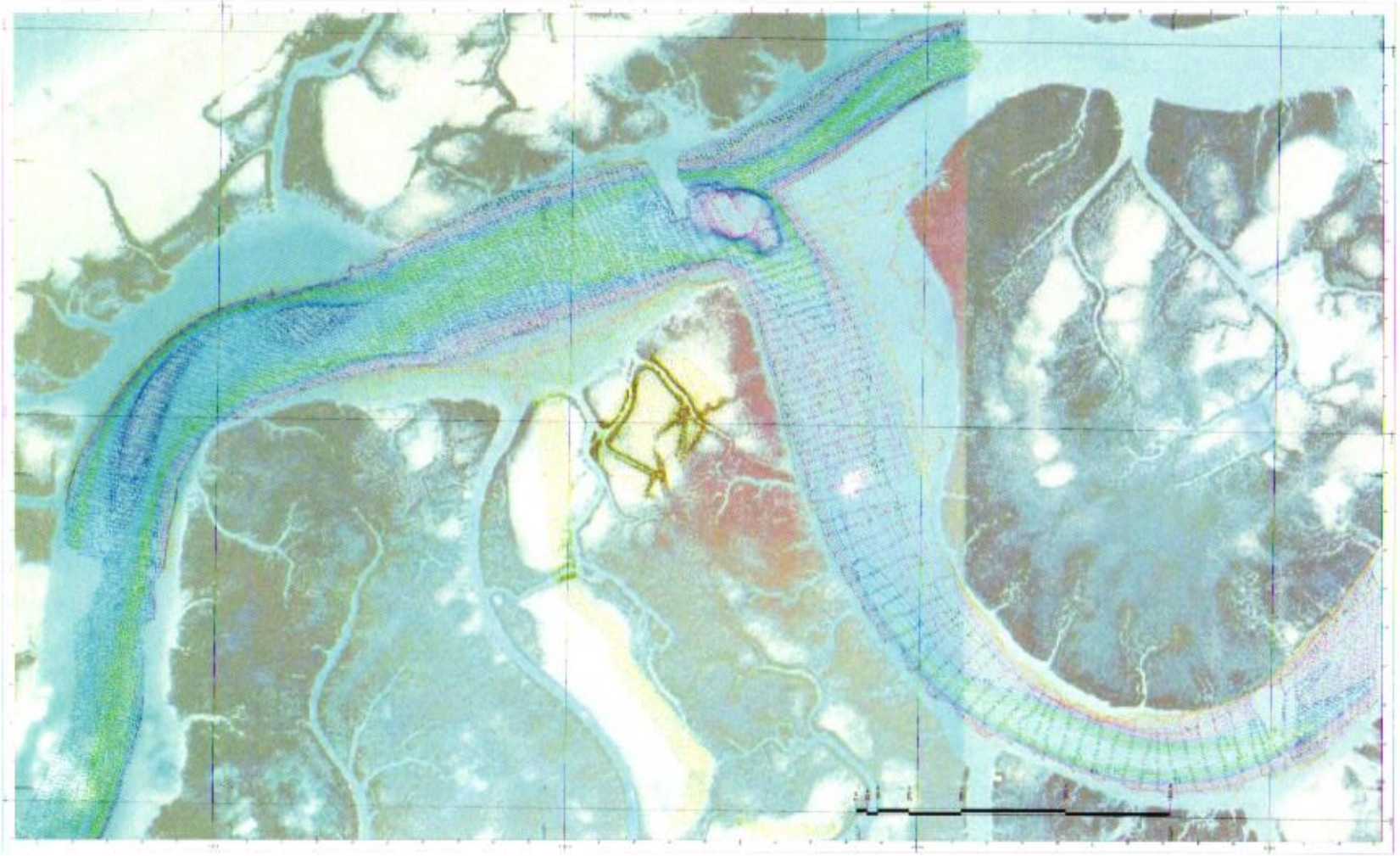


Key Plan

TABEER ENERGY JGC Corporation

Pakistan FSRU Project
Mitsubishi

Berthing Basin



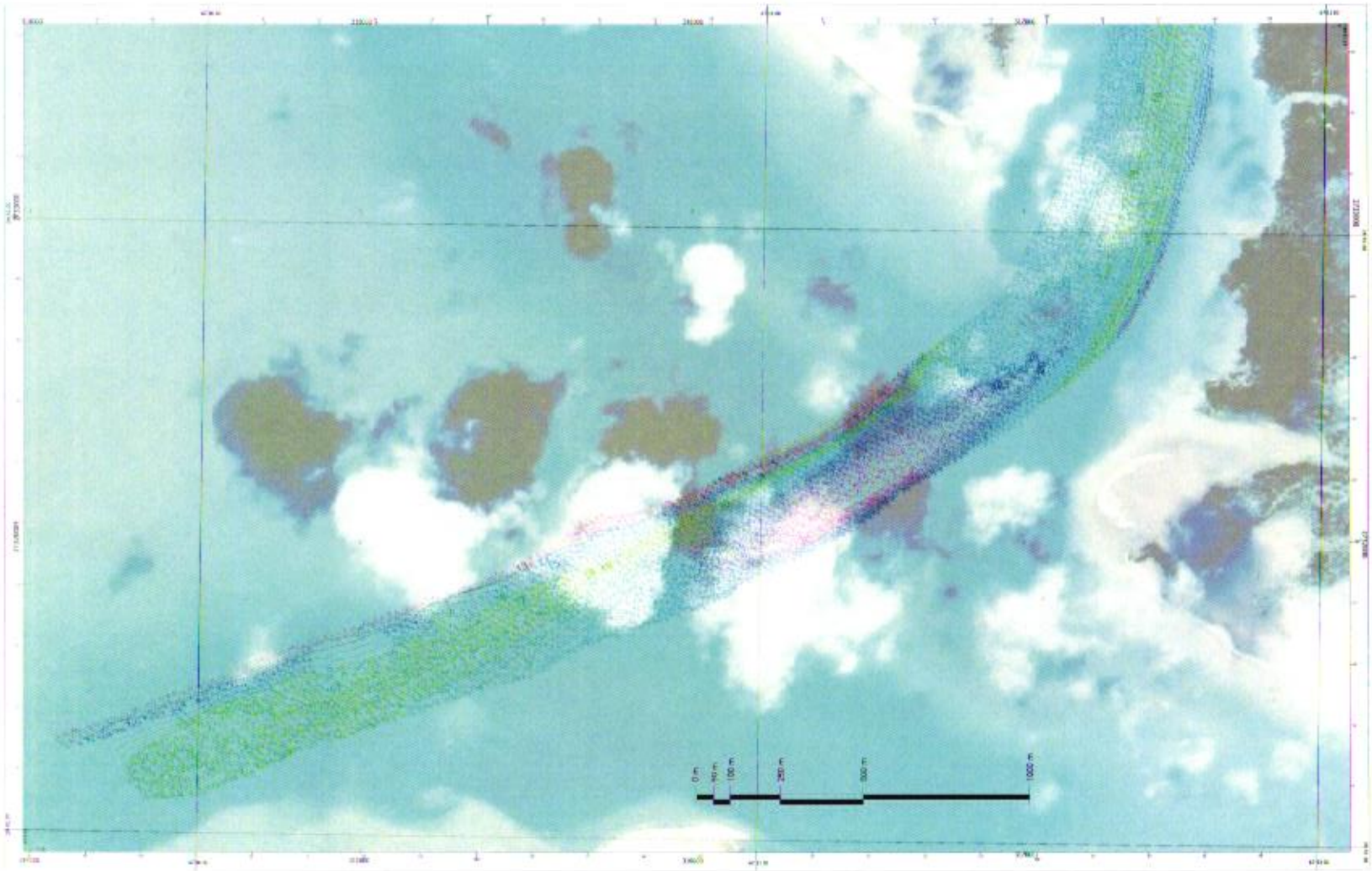
Key Plan

TABEER ENERGY JGC Corporation

Pakistan FSRU Project
Mitsubishi

Chanwaddo - Jhan Bathymetry

617



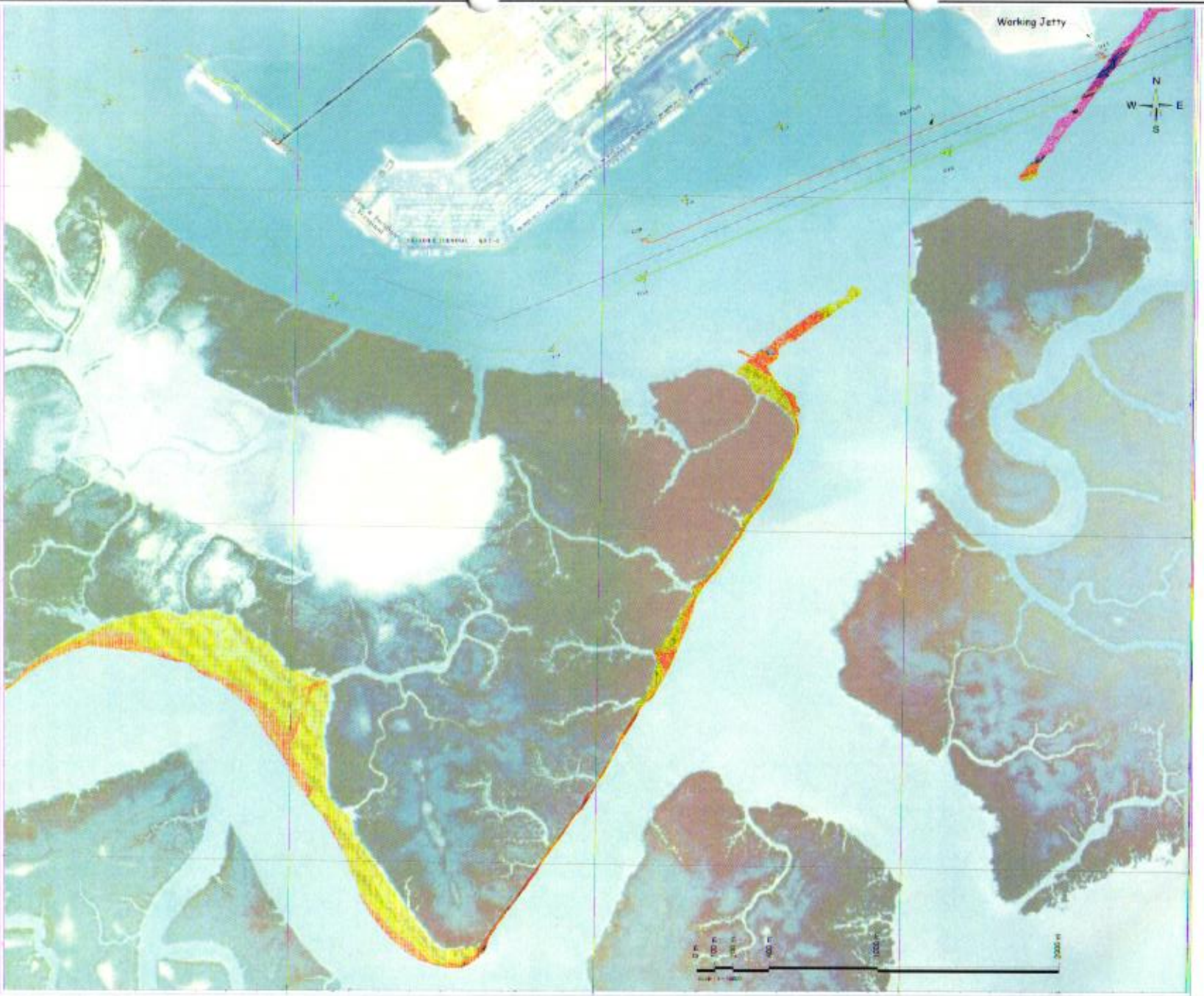
Key Plan:

TABEER ENERGY JGC JGC Corporation

Jacobs Consult International

Pakistan FSRU Project
Mitsubishi

Chanwaddo Bathymetry



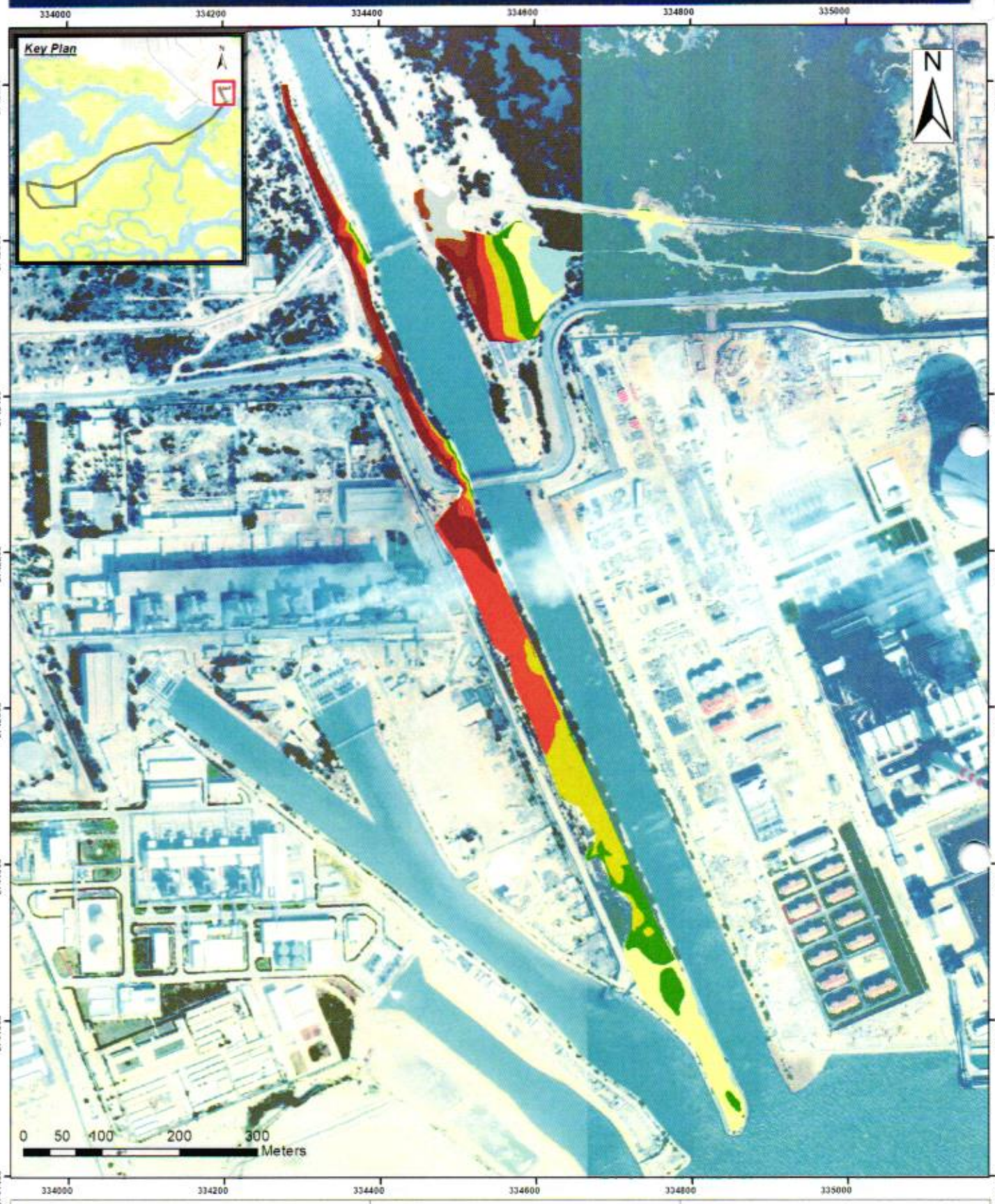
Key Plan:

TABER ENERGY JGC Corporation

Pakistan FSRU Project
Mitsubishi

Pipe Route Bathymetry

TOPOGRAPHIC SURVEY OF 50 METER WIDE STRIP AT PORT QASIM
PAKISTAN FSRU PROJECT - MITSUBISHI



Legend

Elevation Model (meters)
At Chart Datum

2.54 - 3.43	5.1 - 6.01
3.44 - 4.2	6.02 - 6.96
4.21 - 5.09	6.97 - 7.76
	7.77 - 8.38
	8.39 - 9.05
	9.06 - 10.4

Project
PAKISTAN FSRU PROJECT MITSUBISHI

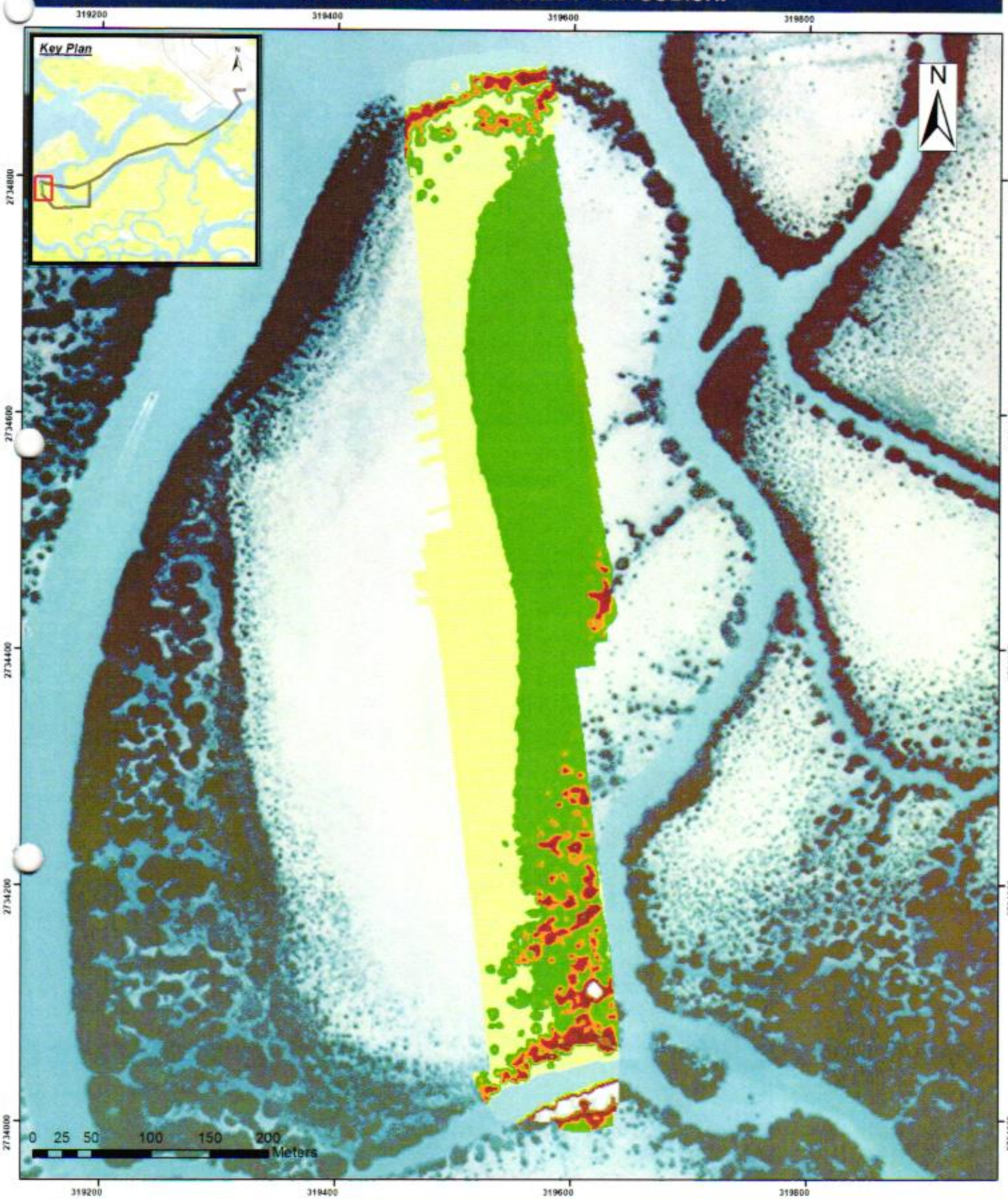
Drawing No.
ED-GIS-230-TOPO-006

NOTE:
Elevation values transformed into Chart Datum with reference to the GCP S040 Chart Datum provided by PQA officials

Client
JGC Corporation
TABEER ENERGY

Consultant
Techno-Consult International

TOPOGRAPHIC SURVEY OF PORT QASIM
PAKISTAN FSRU PROJECT - MITSUBISHI



Legend

Elevation Model (meters)
At Chart Datum

1.6 - 2.79	4.15 - 4.63
2.8 - 3.37	4.64 - 5.21
3.38 - 3.69	5.22 - 6.04
3.7 - 4.14	6.05 - 7.07
	7.08 - 8.04
	8.05 - 9.81

Project
PAKISTAN FSRU PROJECT MITSUBISHI

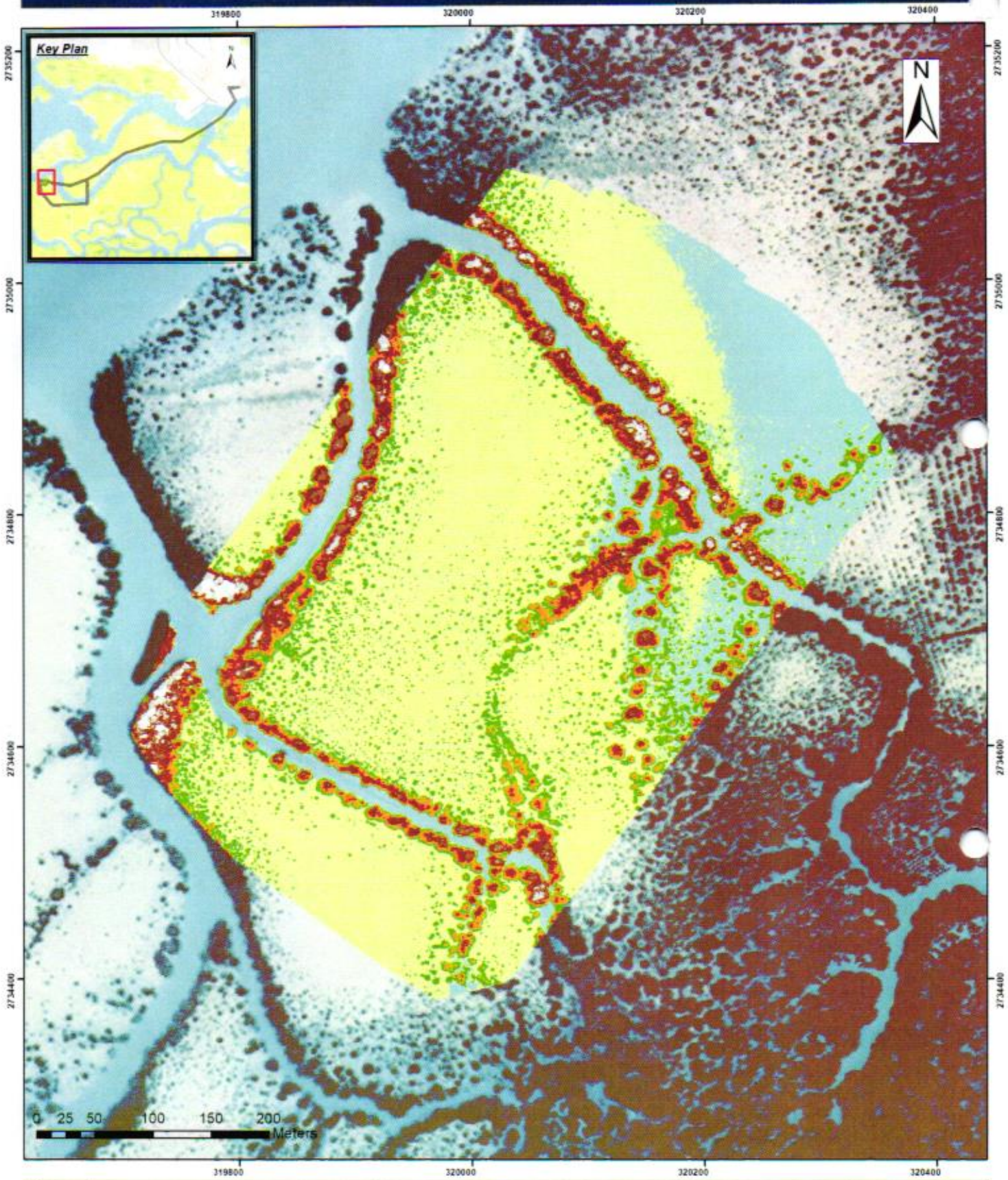
Drawing No
ED-GIS-230-TOPO-001

NOTE:
Elevation values transformed into Chart Datum with reference to the Tidal Station T5 Chart Datum

Client
JGC Corporation
TABEER ENERGY

Consultant
Techno-Consult International

TOPOGRAPHIC SURVEY OF PORT QASIM
PAKISTAN FSRU PROJECT - MITSUBISHI



Legend

Elevation Model (meters) At Chart Datum

1.88 - 2.91	4.81 - 5.47
2.92 - 3.4	5.48 - 6.1
3.41 - 4.08	6.11 - 6.73
4.09 - 4.8	6.74 - 7.5
	7.51 - 8.53
	8.54 - 13.3

Project
PAKISTAN FSRU PROJECT MITSUBISHI

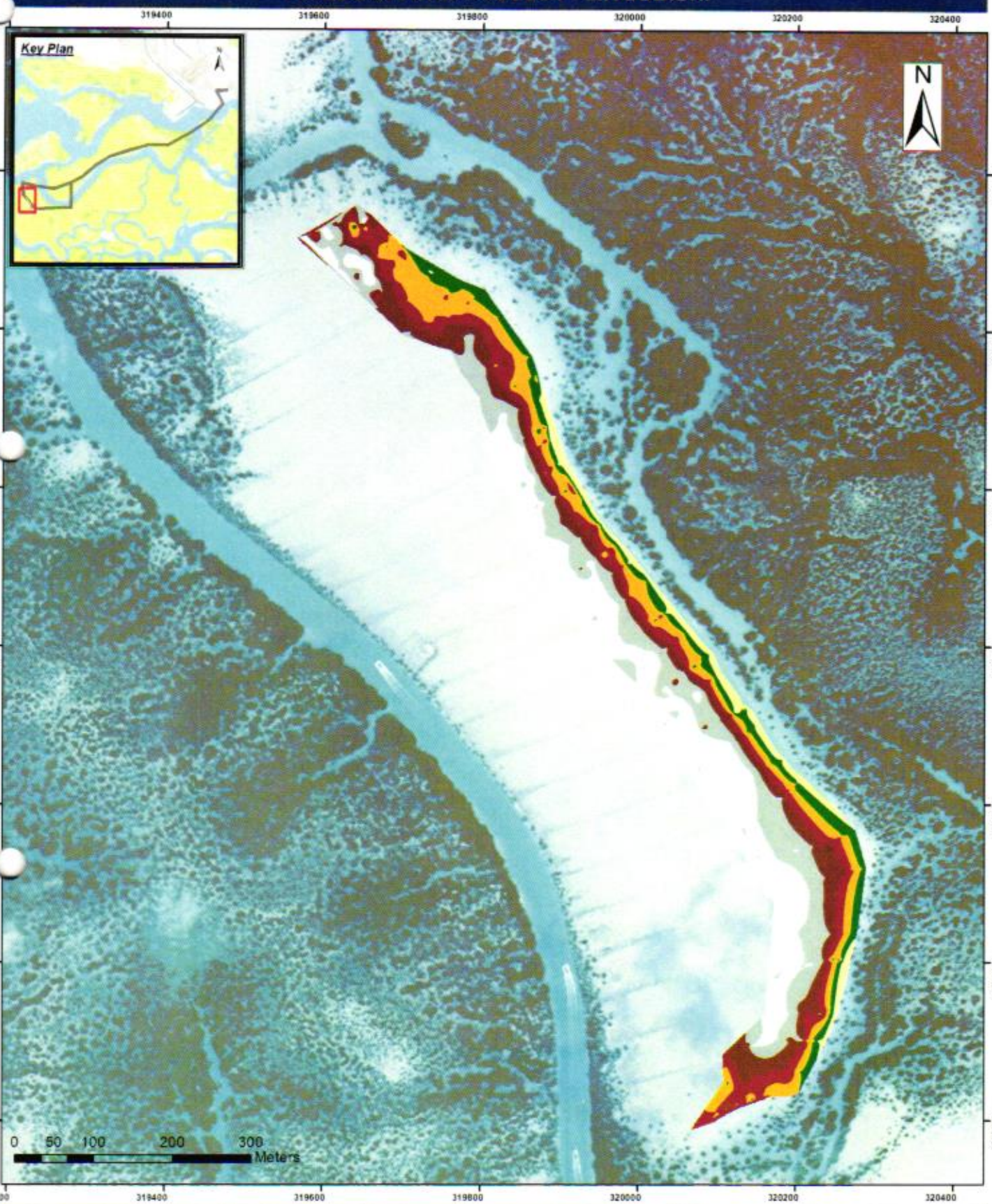
Drawing No.
ED-GIS-230-TOPO-002

NOTE:
Elevation values transformed into Chart Datum with reference to the Tidal Station T5 Chart Datum

Client
JGC Corporation
TABEER ENERGY

Consultant
Techno-Consult International

TOPOGRAPHIC SURVEY OF PORT QASIM
PAKISTAN FSRU PROJECT - MITSUBISHI



Legend

Elevation Model (meters)

At Chart Datum

2.4 - 2.58	2.72 - 2.76
2.59 - 2.65	2.77 - 2.81
2.66 - 2.71	2.82 - 2.86
	2.87 - 2.9
	2.91 - 3.06

Project

PAKISTAN FSRU PROJECT MITSUBISHI

Drawing No.

ED-GIS-230-TOPO-003

NOTE:

Elevation values transformed into Chart Datum with reference to the Tidal Station T5 Chart Datum

Client

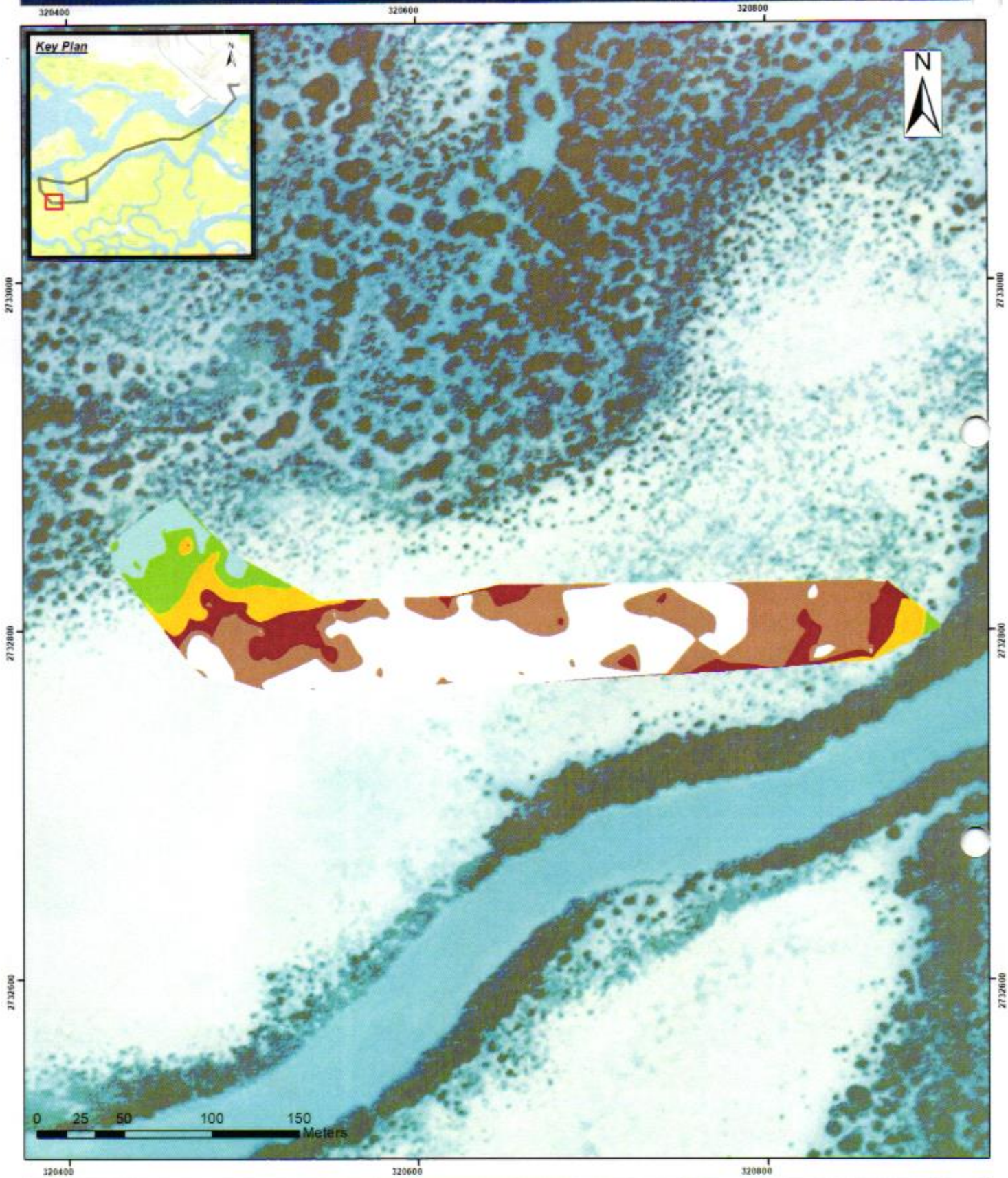
JGC Corporation

TABEER ENERGY

Consultant

Techno-Consult International

TOPOGRAPHIC SURVEY OF PORT QASIM
PAKISTAN FSRU PROJECT - MITSUBISHI



Legend

Elevation Model (meters)
At Chart Datum

- 2.67 - 2.75
- 2.76 - 2.79
- 2.8 - 2.83
- 2.84 - 2.87
- 2.88 - 2.89
- 2.9 - 2.95

Project
PAKISTAN FSRU PROJECT MITSUBISHI

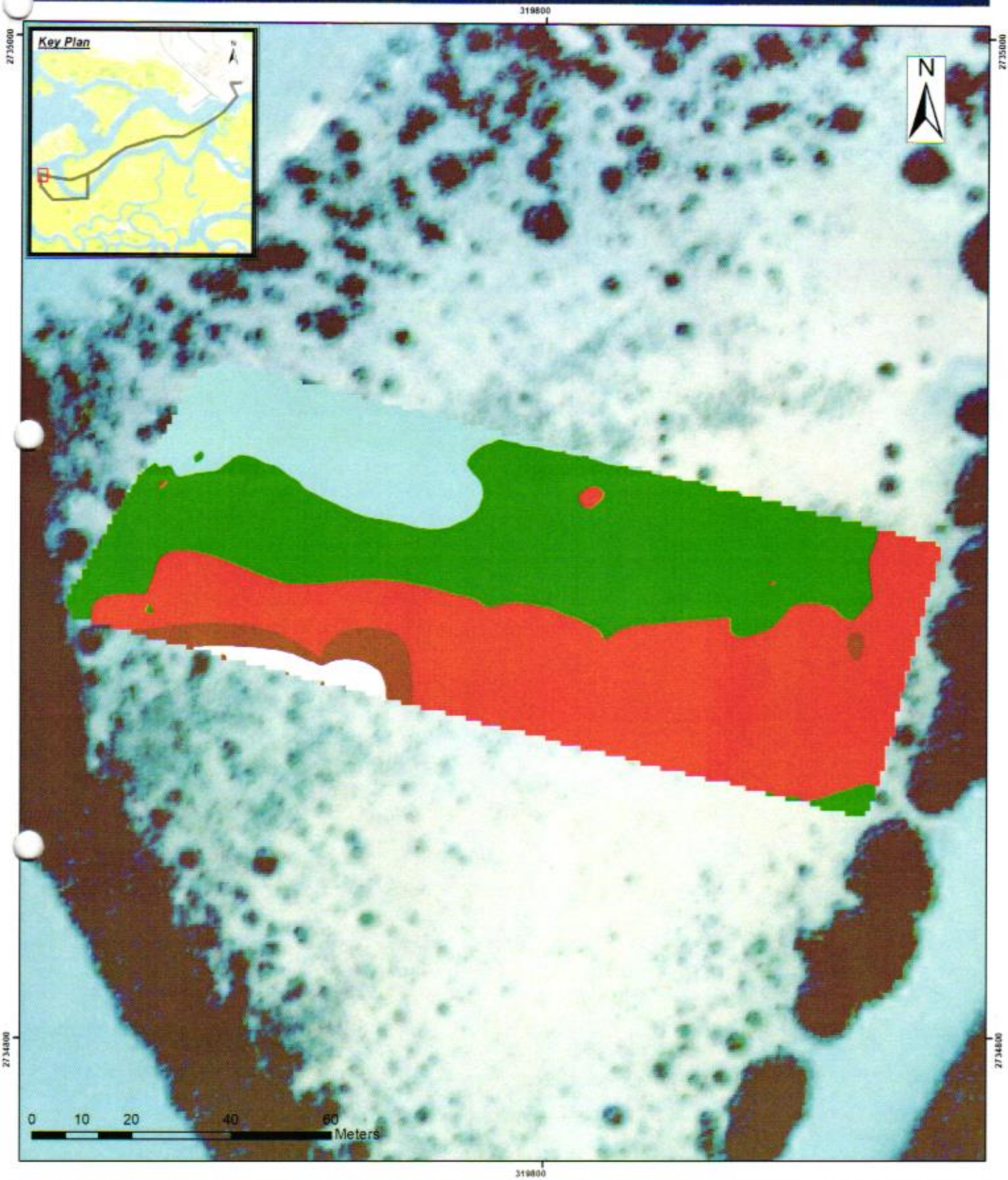
Drawing No.
ED-GIS-230-TOPO-004

NOTE:
Elevation values transformed into Chart Datum with reference to the Tidal Station T5 Chart Datum

Client
JGC Corporation
TABEER ENERGY

Consultant
Techno-Consult International

TOPOGRAPHIC SURVEY OF PORT QASIM
PAKISTAN FSRU PROJECT - MITSUBISHI



Legend

Elevation Model (meters) At Chart Datum

- 2.95 - 3.03
- 3.04 - 3.08
- 3.09 - 3.13
- 3.14 - 3.2
- 3.21 - 3.33

Project
PAKISTAN FSRU PROJECT MITSUBISHI

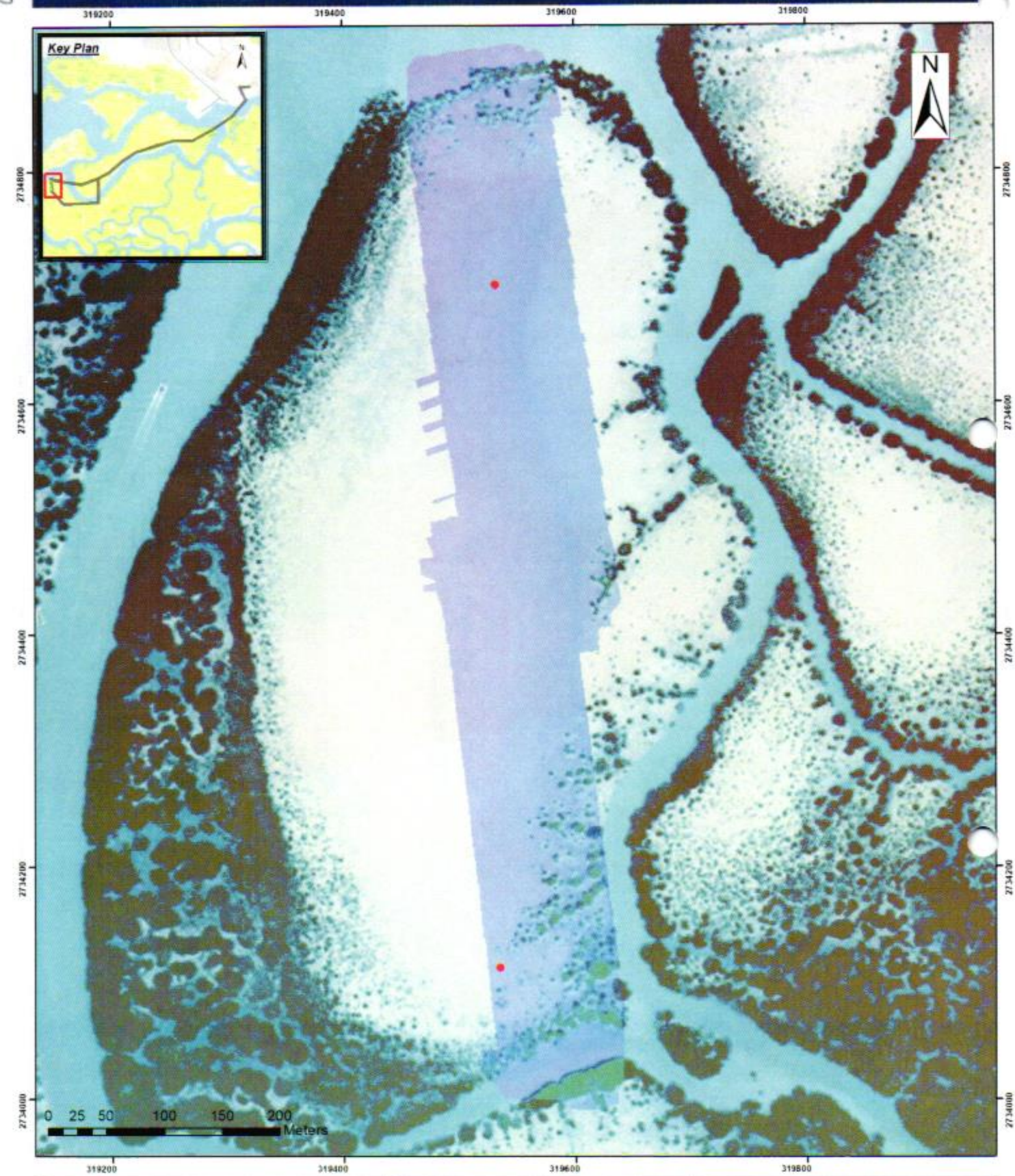
Drawing No.
ED-GIS-230-TOPO-005

NOTE:
Elevation values transformed into Chart Datum with reference to the Tidal Station T5 Chart Datum

Client
JGC Corporation
TABEER ENERGY

Consultant
Techno-Consult International

METAL DETECTION SURVEY OF PORT QASIM
PAKISTAN FSRU PROJECT - MITSUBISHI



Legend

- Metal Detection Anomalies

Topography

Value
- High : 9.81
- Low : 1.6005

Project
PAKISTAN FSRU PROJECT MITSUBISHI

Drawing No
ED-GIS-230-MET-001

NOTE:
Elevation values transformed into Chart Datum with reference to the Tidal Station T5 Chart Datum

Client
JGC Corporation
TABEER ENERGY

Consultant
Techno-Consult International

METAL DETECTION SURVEY OF PORT QASIM
PAKISTAN FSRU PROJECT - MITSUBISHI

Legend

- Metal Detection Anomalies

Topography

Value
- High : 13.34
- Low : 1.87

Project
PAKISTAN FSRU PROJECT MITSUBISHI

Drawing No.
ED-GIS-230-MET-002

NOTE:
Elevation values transformed into Chart Datum with reference to the Tidal Station T5 Chart Datum

Client
JGC Corporation
TABEER ENERGY

Consultant
Techno-Consult International

METAL DETECTION SURVEY OF PORT QASIM
PAKISTAN FSRU PROJECT - MITSUBISHI

Legend

- Metal Detection (No Anomalies Found)

Topography

Value

- High : 3.05
- Low : 2.39

Project

PAKISTAN FSRU PROJECT MITSUBISHI

Drawing No

ED-GIS-230-MET-003

NOTE:

Elevation values transformed into Chart Datum with reference to the Tidal Station T5 Chart Datum

Client

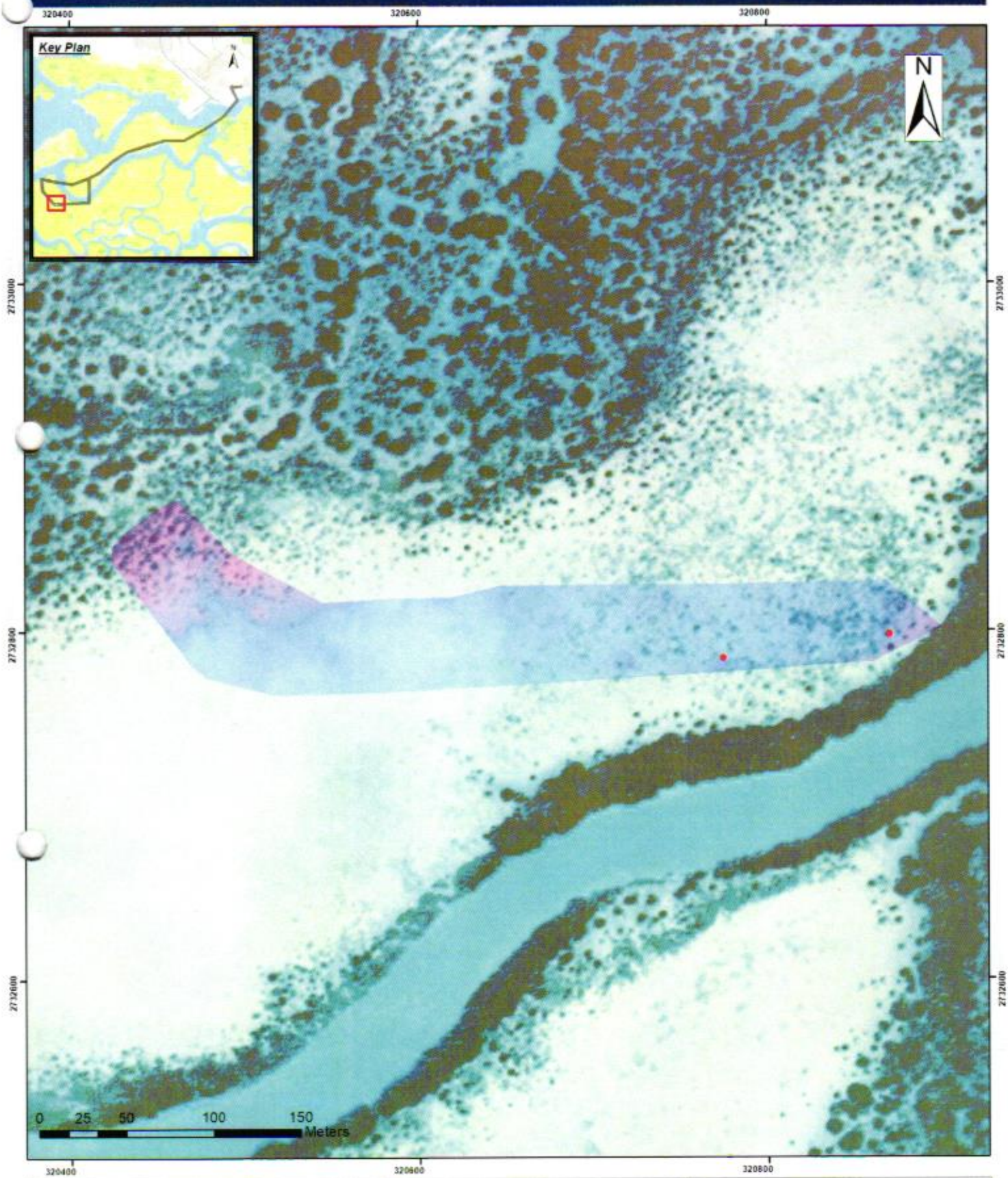
JGC Corporation

TABEER ENERGY

Consultant

Techno-Consult International

METAL DETECTION SURVEY OF PORT QASIM
PAKISTAN FSRU PROJECT - MITSUBISHI



Legend

- Metal Detection Anomalies

Topography

Value

- High : 2.94
- Low : 2.67

Project

PAKISTAN FSRU PROJECT MITSUBISHI

Drawing No

ED-GIS-230-MET-004

NOTE:

Elevation values transformed into Chart Datum with reference to the Tidal Station T5 Chart Datum

Client

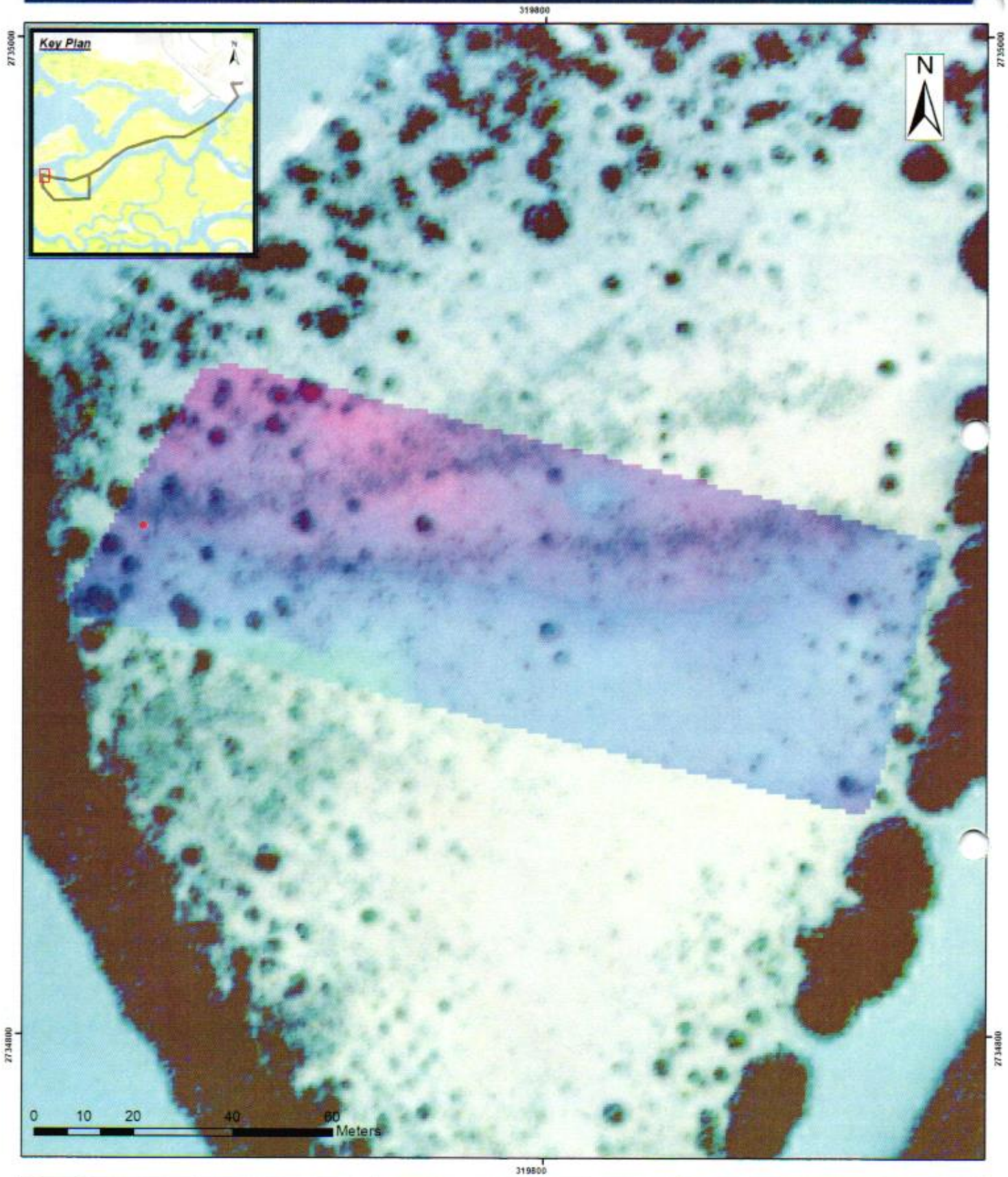
JGC Corporation

TABEER ENERGY

Consultant

Techno-Consult International

METAL DETECTION SURVEY OF PORT QASIM
PAKISTAN FSRU PROJECT - MITSUBISHI



Legend

- Metal Detection Anomalies

Topography

Value
- High : 3.32
- Low : 2.94

Project
PAKISTAN FSRU PROJECT MITSUBISHI

Drawing No.
ED-GIS-230-MET-005

NOTE:
Elevation values transformed into Chart Datum with reference to the Tidal Station T5 Chart Datum

Client
JGC Corporation
TABEER ENERGY

Consultant
Techno-Consult International

METAL DECTECTION SURVEY OF 50 METER WIDE STRIP AT PORT QASIM PAKISTAN FSRU PROJECT - MITSUBISHI

Legend

- Metal Detection Anomalies

Topography

Value

High : 11.57

Low : 2.53

Project

PAKISTAN FSRU PROJECT MITSUBISHI

Drawing No.

ED-GIS-230-MET-006

NOTE:

Elevation values transformed into Chart Datum with reference to the GCP S040 Chart Datum provided by PQA officials

Client

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	JOB No.	DOC. No.	Rev.
TABEER ENERGY	0-7918-20	S-000-1250-002	1
	DATE 23 - Aug - 2018	SHEET 1 OF 4	
	PREP'D	K. Uchino	
	CHK'D	D. Akinlade	
	APP'D	T. Sakamoto	

QRA and Navigation Simulations

For

LNG Terminal at Port Qasim

Pakistan LNG Receiving Facilities/Site Selection Follow-up Activities

FOR FEED

REV.	Date	Page	DESCRIPTION	PRE'D	CHK'D	APP'D
0	23-Aug-18	ALL	FOR REVIEW	K. Uchino	D. Akinlade	T. Sakamoto
1	04-Dec-18	Att1&5	FOR FEED	K. Uchino	D. Akinlade	T. Sakamoto

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