Appendix 10.1 Baseline Conditions – Marine Archaeological Review Methodology

1 Marine Archaeological Review

To date, nine Marine Archaeological Investigations have been completed for the Tai O area. They were all examined in detail to look for information relevant to this study.

- June 1999. Marine Archaeological Investigation for Tai O Bay Sheltered Boat Anchorage. Agreement No. CE 41/98. For: Scott Wilson (Hong Kong) Ltd. SDA Marine Ltd.
- April 2000. Marine Archaeological Investigation. Tai O Sheltered Boat Anchorage. For: Antiquities and Monuments Office. SDA Marine Ltd.
- January 2001. Marine Archaeological Investigation. Tai O Bay Phase II Diving Inspection. For: Antiquities and Monuments Office. SDA Marine Ltd.
- May 2003. Tai O Development – Sheltered Boat Anchorage – Marine Geophysical Survey. IGGE (Hong Kong) Engineering Geophysical Company Ltd. For: Cinotech Consultants Ltd.
- July 2003. Tai O Development – Sheltered Boat Anchorage. Contract CV/2002/09. Report on Intertidal Archaeological Investigation: MAI Phase 1. Prepared by Archaeological Assessments for Cinotech Consultants Ltd.
- July 2003. Tai O Development – Sheltered Boat Anchorage. Contract CV/2002/09. Report on Diving Inspection: MAI Phase1. Prepared by Archaeological Assessments for Cinotech Consultants Ltd.
- September 2003. Tai O Development – Sheltered Boat Anchorage. Contract CV/2002/09. Marine Archaeological Investigation: Report on Diving Inspection, Phase II Anomalies S36 and S53. Prepared by Archaeological Assessments for Cinotech Consultants Ltd.
- January 2004. Tai O Development – Sheltered Boat Anchorage .Contract CV/2002/09. Marine Archaeological Investigation: Report on Diving Inspection, Phase III Anomalies S41, S42, S44 and S54. Prepared by Archaeological Assessments for Cinotech Consultants Ltd.
- November 2007. Agreement No. CE 64/2006 (CE). Improvement Works for Tai O Facelift. Marine Archaeological input for site selection. For: Meinhardt China. Prepared by SDA Marine Ltd.

2 Baseline Conditions

A Baseline review was undertaken to compile a comprehensive inventory of cultural heritage resources of the Study Area. The Review established the historical profile and potential for cultural heritage sites and included:

- Marine charts and records held in the UK Hydrographic Office, and National Maritime Museum Library in London;
- Publications on local historical, architectural, anthropological, archaeological and other cultural studies;
- Unpublished papers, records, archival and historical documents held in local libraries and other government departments.

3 Geophysical Survey

EGS were commissioned by Gammon Construction Ltd under Works Order No. CE15/2010

(DS) issued by the Civil Engineering and Development Department.

The survey was carried out on the 16th and 17th November 2011.

The table below presents the geophysical method type and specific objectives.

SURVEY TYPE	OBJECTIVE
Single beam echo sounding (SBES)	To measure seabed depth
Swath bathymetry (Swath/MBES)	To measure seabed topography
Seismic sub bottom profiling (SBP)	To identify sub bottom features and stratigraphy
Side Scan Sonar (SSS)	To locate seabed features and map sediment type on the seabed
Magnetic	To study the magnetic intensity within the survey area to determine if ferrous material/object is present.

3.1 Equipment List

A Class I licenced vessel Wing Hung 2 (WH2) and a speedboat were used to carry out the survey. The following equipment was mobilised on board:

TYPE	EQUIPMENT
Horizontal positioning	C-Nav Globally Corrected GPS (GcGPS) system
Single beam echo sounding	Knudsden 320M dual frequency echo sounder
Swath	R2 Sonic 2024 MBES system, 350kHz
Side scan sonar	KLEIN 3000 digital side scan sonar
Seismic sub-bottom profile	C-Boom low voltage boomer system C-Phone hydrophone system
Magnetometer	SeaSPY Overhauser Marine Magnetometer
Software	C-View Nav computerised navigations suite C-View digital recording and processing system
Tide gauge	Valeport Model 740 pressure tide gauge
Others	A/C generators, computers and bar check equipment

3.2 Location Control

Horizontal
The survey vessel was located with a Globally Corrected Global Positioning System (GcGPS) unit called the C-Nav. The system provides corrected positions to an accuracy of +/- 0.3m.

The EGS computerized navigation system was added to the positioning system to control the steering of the boat along the traverses specified, and to log all horizontal and vertical control data.

This system provides the user with a dynamic analogue and digital screen display on which the following are continuously updated:

Skewed grid set parallel to the desired line direction
Boat position
Water depth
Date and Time
GcGPS diagnostics enabling quality control

The positioning system was calibrated by checking the co-ordinates displayed by the navigation system at a control point located at Yau Ma Tai. The quality assurance checking procedure ensured a horizontal positioning accuracy of +/- 1m.

Vertical
Tidal measurements were recorded by measuring water levels at the pier at Tai O. Measurements were taken continuously every 15 minutes during the survey period. The tidal data collected were used to reduce all echo sounding data to Principal Datum, Hong Kong (PD).

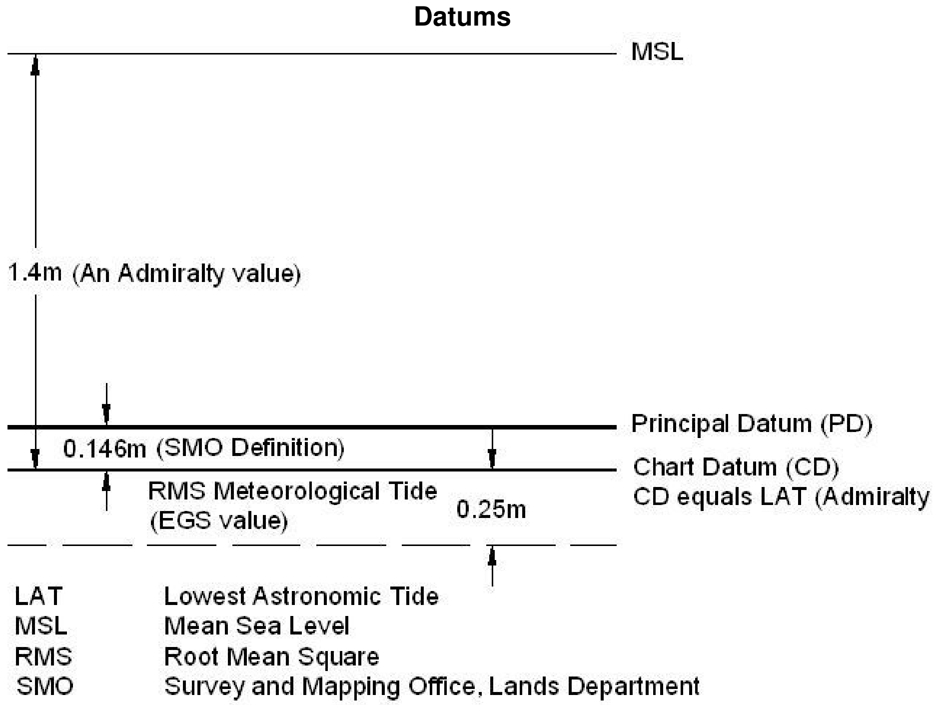


Figure 1 Hong Kong Datums

3.3 Operating System on Board the Survey Vessels and in the Office

EGS has developed the C-View operating and interpretation software package. This system was installed on survey vessels and in the office, to carry out the following functions:

During the survey, the system provided screen displays for seismic profiling and side scan systems. Full operating system coverage was provided, to enable the best survey records to be obtained. All raw data was logged digitally.

While interpretation of SSS data was conducted with C-view software, and interpretation files were uploaded to AutoCAD without the need for further re-digitizing, seismic data interpretation was carried out on paper rolls.

3.4 Field procedures

Single beam echo sounding, seismic sub-bottom profile, side scan sonar and magnetic surveys over the shallow water area were conducted from a speedboat. For the rest of the area, single beam and multibeam echo sounding, seismic sub-bottom profile and side scan sonar surveys were carried out from WH2. It also acted as the mother boat for transporting the staff, equipment and speedboat to the survey area. The vessels used in the current survey are shown in the following photographs.

Figure 2 Small speed boat and main survey vessel WH2

3.5 Coverage

The survey covered an area of about 400m x 180m. One side of the survey area is constrained by the coastline. The following survey traverse intervals were completed.

SURVEY TYPE	SURVEY SPACING
Single Beam Echo Sounding/Swath	15m x 30m
Seismic and Side Scan Sonar	15m x 30m
Magnetic	5m line interval

The survey area was designed to be significantly greater than the impact area to allow for any changes to the alignment during the design phase.

Single Beam Echo Sounding Bathymetry

Seabed level observations were made with a single beam echo sounder system with the transducer mounted under the hull of the survey speedboat.

The single beam echo sounder transducers produce pulses of acoustic wave at set intervals, and records the time required to receive the seabed reflection signal. Seabed depth is then calculated by inputting the speed of sound in seawater. The two ways travel time recorded by the single beam echo sounder correlated to seabed depth by sinking a metal plate at known depths below the transducer. This process, known as “bar check”, was carried out each day before and after carrying out the survey.

The single beam echo sounder operates in two frequencies (high and low). In the present survey, both high and low frequency channel were used to provide accurate survey results.

3.6 Swath Bathymetry

Seabed level observations were made with a multibeam echo sounder (MBES) system with the transducers mounted over the starboard side of the survey vessel. The GcGPS antenna was mounted directly above the transducers and as such the swath transducer acted as the datum for the survey vessel.

The MBES system requires careful calibration. A potential source of error relates to the speed of sound in water; the MBES system requires the speed of sound be measured through the water column, and for these data to be entered into a file which is accessed by the MBES acquisition and processing software. In addition, due to the fact that the speed of sound can vary significantly near the sea surface, a speed velocity probe is installed at MBES transducer so that measurements are recorded at all times during the survey and the corresponding corrections can be made within the MBES system in real-time.

In addition, a patch test is required to calibrate system components, as follows:

Navigation Delay
A survey line is set exactly over a well-defined feature, such as a rock outcrop, a significant slope or a man-made structure. The line is run twice in the same direction, once at the slowest possible speed and once at the highest speed

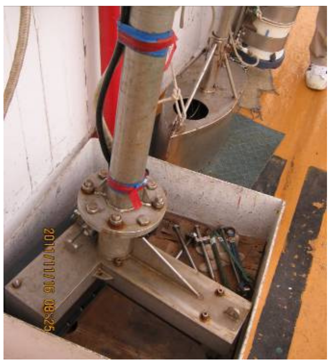
Pitch Offset
A survey line is set exactly over a well-defined feature. The line is run in opposite directions at the same speed

Roll Offset
A survey line is set over an area with a flat and featureless seabed. The line is run in opposite direction at the same speed

Yaw (Heading) Offset
Two parallel lines are set to either side of a well-defined feature with the feature positioned in the middle of the two lines. The off-track distance between the feature and the lines are selected according to water depth and the fan width of the MBES system, so that the feature will be detected at the outer part of sounding "fan". The lines are run in the same direction at the same speed; once passing the feature to Port and once to Starboard.

By applying appropriate algorithms to match the apparent differences in the positions of the selected feature and the seabed topography measured in the individual calibration line, these calibration factors can be determined and are entered into the acquisition system to correct the seabed level measurements in real-time.

Figure 3: Swath bathymetry system



The transducer of the swath system

3.7 Side Scan Sonar Survey

Prior to the commencement of the survey, the side scan sonar system was wet tested to ensure the system was working properly.

The side scan sonar was towed behind the vessel with 6m cable out. For the shallow water region, the tow fish was front-towed on speed boat to ensure data coverage.

The recording parameters for the side scan survey were as follows:

- Vessel speed: ~ 1.1 – 1.4m/sec
- Fix interval: 10 seconds
- Source frequency: 100 kHz and 500 kHz
- Slant range: 50m range

All data was logged by the C-View software in which 4 channels (100kHz and 500kHz; port and starboard) were simultaneously recorded with navigation, fix, vessel heading, fish heading and water depth.

Detailed log sheets were filled on site with survey line number, start fix and end fix of each survey line, survey time, SSS range, frequency and offset parameters. The corresponding C-View data file name was also recorded in the log sheets.

Figure 4: The side scan sonar tow fish

3.8 Seismic Reflection Survey

Prior to the commencement of survey, the C-Boom low voltage boomer was wet tested to ensure that the system is functioning properly. The boomer was towed behind the survey vessel at a distance of around 20m, such that noise induced by the survey vessel was kept to minimum.

The recording parameters for the seismic reflection survey were as follows:

- Vessel Speed: ~ 1.1 – 1.4m/sec
- Fix Interval: 10 seconds
- Source frequency: 1.76 kHz dominant
- Sweep: 250ms
- Delay: 0ms
- Sample rate: 20,000 Hz

3.9 Magnetic Survey

A magnetic survey was conducted for finding any metal objects above or buried within the seabed sediments. During the survey, the magnetometer transducer was towed 15m behind the speedboat and the tow fish was kept at around 2m from seabed.

Figure 5: The marine magnetometer sensor

3.10 Data Interpretation

Echo Sounding Data
The single beam echo sounding data were processed using EGS in-house editing software with the following procedures:

- Application of tidal corrections to reduce recorded data to Hong Kong PD
- Application of filters to remove obvious 'noise'
- Manual editing to remove low level 'noise'

Swath (Multibeam) Data
Tidal correction and simple filter are applied before the data sets are edited manually. Judgement is required at this stage, to identify small features which are real reflections from low-level noise. In general, two or more mutually consistent soundings which are higher or lower than the general sea bed level are accepted, especially if the same anomalous soundings are present on separate survey traverses.

The processed data were gridded on to a 0.5m spacing dataset. During the gridding process, median sounding values were used. These gridded data were then plotted at a standard spacing of 6mm at the charting scale, to provide a sounding plan for the whole area surveyed. This gridded plot was then contoured using the 0.5m spacing dataset and coloured using 'C-View Bathy' processing and charting software, to provide the sounding plans.

Side Scan Sonar Data
Processing and interpretation of side scan sonar data was carried out using the C-View interpretation software. All features were individually marked or grouped into regions using on- screen digitising. All offsets and laybacks were applied to the C-View system. The subsequently generated interpretation files were then imported to the AutoCAD environment on a line by line basis where the interpretation was reconciled and a detailed check was performed.

4. RESULTS

4.1 REVIEW OF PREVIOUS WORK WITHIN THE STUDY AREA

1. June 1999. Marine Archaeological Investigation for Tai O Bay Sheltered Boat Anchorage. Agreement No. CE 41/98. *For:* Scott Wilson (Hong Kong) Ltd. SDA Marine Ltd.

This study comprised a desk based assessment and geophysical survey undertaken by the Survey Division of the Civil Engineering Department. The baseline review established high archaeological potential. The geophysical survey data was not of sufficient quality for accurate assessment of either seabed features or sediment stratigraphy.

The results of vibrocore seabed sampling programme undertaken to facilitate the design of the sheltered boat anchorage, offshore breakwater and access channels were reviewed. Vibrocores generated from the investigation were inspected for their potential archaeological significance. Vibrocores have the ability to provide palaeo-environmental data, but in this instance there was no evidence indicating previous human occupation or use. It was, therefore, assumed that there are no inundated occupation sites within the Study Area. The focus of the investigation was therefore potential shipwreck sites and their associated artefacts. No marine archaeological resources were located.

2. April 2000. Marine Archaeological Investigation. Tai O Sheltered Boat Anchorage. *For*: Antiquities and Monuments Office. SDA Marine Ltd.

SDA Marine Ltd was commissioned by the AMO to contract EGS to re-survey the whole area due to the limitations with the previous survey. This was completed and the data revealed: 16 anomalies on the seabed and 41 buried at 1.5m or deeper below in the seismic profiler data and 48 anomalies in the side scan sonar data. The geophysical data confirmed that soft deep marine mud covers the whole area which would provide a good preservation environment for archaeological remains.

3. January 2001. Marine Archaeological Investigation. Tai O Bay Phase II Diving Inspection. *For*: Antiquities and Monuments Office. SDA Marine Ltd.

A seabed inspection of the sonar targets identified during the geophysical survey. The divers located a large volume of modern debris and no archaeological deposits. 26 of the targets were buried too deep to be accessed by the divers. It was concluded and accepted by the AMO that a monitoring brief should be conducted during the dredging due to the high potential of the study area.

4. May 2003. Tai O Development – Sheltered Boat Anchorage – Marine Geophysical Survey. IGGE (Hong Kong) Engineering Geophysical Company Ltd. For: Cinotech Consultants Ltd.

IGGE carried out echo sounding, side scan sonar and single channel seismic reflection surveys at the eastern end of the study areas, in shallow water near the entrance to the Tai O River. The side scan sonar and echo sounder surveys identified anomalies on the seabed which were highlighted for investigation. The seismic survey data was not of sufficient quality to draw reliable conclusions due to the problems of the very shallow water depth.

5. July 2003. Tai O Development – Sheltered Boat Anchorage. Contract CV/2002/09. Report on Intertidal Archaeological Investigation: MAI Phase 1. Prepared by Archaeological Assessments for Cinotech Consultants Ltd.

The limitations of the geophysical data resulted in a revised methodology and a visual inspection of the intertidal area was undertaken. Archaeologists walked east-west survey transects at 10m intervals at low tide. They recorded a lot of modern debris and evidence of extensive previous disturbance. It was concluded that no further archaeological investigation was required in this area.

6. July 2003. Tai O Development – Sheltered Boat Anchorage. Contract CV/2002/09. Report on Diving Inspection: MAI Phase1. Prepared by Archaeological Assessments for Cinotech Consultants Ltd.

Divers were used to locate and identify 7 sonar targets identified in the IGGE side scan sonar survey. Modern debris such as wood, building debris, rope and modern sherds were found. None of the material identified comprised archaeological objects, assemblages or *in situ* deposits. It was therefore recommended that no further action was needed for the study area.

7. September 2003. Tai O Development – Sheltered Boat Anchorage. Contract. CV/2002/09. Marine Archaeological Investigation: Report on Diving Inspection, Phase II Anomalies S36 and S53. Prepared by Archaeological Assessments for Cinotech Consultants Ltd.

Divers were employed to inspect two anomalies identified in the 2000 EGS geophysical survey. It was not possible to investigate these anomalies during earlier dive inspections as they were buried from 1.8m to 6.0m below the surface of the seabed. The AMO approved the use of a large grab dredge to remove mud deposits so that the anomalies could be reached by a diver. Both targets were located and identified as deposits of mixed modern debris. Investigation of S53 exposed a rare example of the species of bivalve *placuna,* rarely found in Hong Kong waters as it is very sensitive to pollution levels. *Placuna* are found frequently in prehistoric and historic archaeological contexts and appear to have died out as a result of recent increases in pollution levels. This sub-seabed deposit therefore reflects an historic change in environmental conditions in Tai O harbour. The report concluded that since neither target comprised archaeological objects, assemblages or deposits there was no need for further assessment or mitigation.

8. January 2004. Tai O Development – Sheltered Boat Anchorage. Contract. CV/2002/09. Marine Archaeological Investigation: Report on Diving Inspection, Phase III Anomalies S41, S42, S44 and S54. Prepared by Archaeological Assessments for Cinotech Consultants Ltd.

Divers located and inspected four additional anomalies identified in the 2000 EGS geophysical survey. Each one was found to be of modern origin, principally domestic debris. The report concluded that since neither target comprised archaeological objects, assemblages or deposits there was no need for further assessment or mitigation.

9. November 2007. Agreement No. CE 64/2006 (CE). Improvement Works for Tai O Facelift. Marine Archaeological input for site selection. For: Meinhardt China. Prepared by SDA Marine Ltd.

The MAI only comprised a Baseline Review. This established high archaeological potential for the study area but did not locate any specific references to marine archaeological remains.

4.2 Baseline Review

Tai O Bay is strategically located at the heart of the Hong Kong-Macau-Guangzhou triangle. It provides an excellent natural harbour and has been the focus for a range of maritime activities. Archaeological evidence indicates that the waters of Hong Kong have been used by seafarers for over 6,000 years, since the prehistoric period (Bard, 1988). The profusion of sea shore sites and an apparent absence of permanent habitation sites together suggest that the earliest inhabitants were seafarers living on boats, making frequent but brief landings ashore. While there have not been archaeological finds from underwater, the location of coastal sites testifies to the early use of water transport.

From the Qin (221-206 BC) and Han (206 BC-220 AD) periods, Guangzhou became the starting point of the maritime trade route over the South China Sea. Its position as a prime centre for maritime trade continued to grow. By the Tang (618-907 AD) and Song Dynasty (960-1279 AD), Guangzhou had grown into the largest commercial port in China. It was the first Chinese city to have a government office to administer foreign trade. The importance of this centre and the volume of foreign shipping in the Pearl River Delta was always a concern for the Imperial Government.

From as early as 411 a pirate band named Lo Ting had established itself on Lantau and harassed shipping in the area. To safeguard the seaward approaches to Guangzhou and minimize piracy, the Government established war junk patrols and forts at suitable anchorages. The initial base for the war junks was situated at Tuen Mun. It had been established sometime prior to the mid 8th century, as there are records that in 743 troops were transported from Tuen Mun to the Yangtse River to combat a pirate fleet. The war junks were not always successful as in 758 Guangzhou was sacked by an Arab fleet.

Lantau was of interest to the Government at this time through its salt making capabilities. An assistant to the Imperial Salt Commissioner based in Guangzhou was responsible for the production of salt on Lantau. His responsibilities included clamping down on illicit salt working, preventing salt smuggling and to protect the ships conveying sale to Guangzhou. Salt pans and works may have been established at Tai O at this time. Salt production remained a key activity at Tai O until the 20th century.

Figure 6: Salt making at Tai O (1956)

During the 12th century as the Song capital moved from Hangchow to Kaifeng, Government interest and presence in Lantau increased which in turn resulted in a 50 year rebellion on the Island as the Government sought to control fishing and salt working activities. It is recorded in the 1819 gazetteer of Xin'an that there was an attempt in 1197 to stop private trading in salt on Lantau. The islanders successfully repulsed a government invasion force by mining their harbours with wooden stakes and engaging them in a sea battle. They captured merchant ships and killed more than 300 people. Tai O is very likely to have been one of the harbours involved in the rebellion. Since Tai O was a well established salt producing area at this time it is very likely that Tai O was one of the harbours mined with wooden stakes.

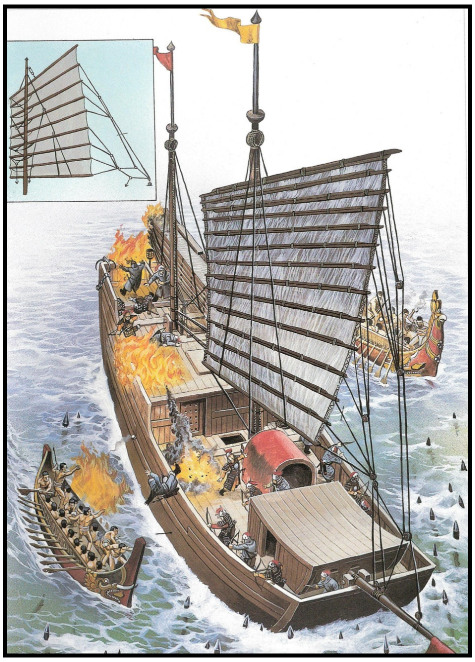


Figure 7: An artist's impression of a staked harbour during a battle

When in the Ming (1368-1644) and Qing (1644-1911) periods, China enforced a policy which closed ports to foreign trade, an exemption was made for Guangzhou for a large part of that period. Guangzhou was thus in a unique position to conduct trade with foreign countries and the waters and harbours around Hong Kong would have been full of ships associated with both international and local trade.

During the Ming Dynasty (1368-1644) there arose an increased need for coastal defence. This was due to the appearance of a variety of pirates, including the Japanese wako, Chinese pirates and Europeans.

In 1511 the first Europeans, the Portuguese arrived in their vessels at the Pearl River. The Portuguese realization of the importance of Guangzhou as a lucrative trade centre spurred them to make an attempt to seize an area on the coast at the entrance to the Pearl River. They did so in 1514 and were not expelled until 1521 after a sea battle resulted in a decisive Chinese victory. There is evidence to suggest that they may have seized Lantau and constructed a fortified settlement at Tung Chung or Tai O. The sea battle itself seems to have taken place between Lantau and Sha Chau. The Portuguese lost up to one warship and three unarmed sailing vessels (Lo, 1963).

Influenced by the Portuguese attack, six guard stations were established in the Hong Kong region, with one at Tai O (Siu, 1988). These stations were tasked not only to prevent further European incursions but also to control piracy.

Throughout the 16th century pirate attacks became more frequent. During the Ming dynasty the Government took the extreme measure of expelling all coastal inhabitants to the hinterland. Until rescinded in 1668, Lantau was effectively uninhabited except for pirates and smugglers.

In the latter part of the Ming dynasty, around 1536, war boats were added to the wei-so (districts and military divisions) system which had largely been a land based defensive system. The Nam Tau headquarters dispatched war boats to patrol the area from Long Pak, to the south of Macau to the Tai Pang Wan (Mirs Bay) in the east. Within this area, six guard stations were established one of which is recorded as being at Tai O. Its location testifies to the strategic importance of Tai O.

During the Qing dynasty (1644-1911) there was a change in the distribution of military outposts. There were a total of twenty-one within San On County of which seven were situated within the Hong Kong region. There is no longer one listed for Tai O, with the nearest one being at Tuen Mun.

Towards the end of the Yung-cheng reign (1723-1735), Cheng Lin Fuk, a descendant of Cheng Kin made Lantau Island his hideout against government forces (Siu, 1986). Piracy was at its worst between 1807-10 (Murray, 1987). Richard Glasbrooke, the mate of an East Indiaman who was captured by them, gave an interesting account of an enforced stay of eleven weeks and three days with a pirate fleet in 1809. According to the record in Neumann's account of these pirates, this fleet spent a long time on and near Lantau, which probably suffered from their levies and depredations. One of these pirates, Cheung Po-tsai was notorious in Hong Kong waters (Lo, 1963). With the help of the Macau authorities whose squadron fought a sea battle Lantau in January 1810, Cheung Po-tsai was blockaded in the shallow waters of the bay of Hsiang-shan and was induced to capitulate with over 270 junks, 16,000 men, 5,000 women, 7,000 swords and 1,200 guns (Monalto de Jesus, 1926). These figures clearly indicate the scale of the pirate activities in the region. The pirate tradition on Lantau was so prevalent that the Tanka people of Tai O have a song which celebrates the exploits of the female pirate, Lady Cheng I Sao and her confederate Chang Pao-tsai (Balfour, 1941).

In the 19th century the Qing Government gave the task of protecting the coastal area of Hong Kong to the Tai Pang Battalion which in 1831 was elevated to the status of a Brigade. It was increased and divided into the Left and Right Battalions. The Right Battalion was composed of four hundred and eighty two soldiers and five patrol boats. Its headquarters were located at the Tung Chung Walled City which was built in the same year. After 1847, the Right Battalion had a Garrison of six hundred and forty one soldiers including forty stationed at Tai O (Guangdong Gazetteer, 1879).

The garrison could not have been that effective as in November 1854, an expedition was sent to Tai O to deal with pirate junks that had fired on *Queen*, an American naval steamer. After shelling and attack by the hastily collected squadron of European vessels, the pirate junks and storehouses were destroyed. An American naval officer, Lieutenant G. H. Prebble, who kept a now published diary of these events, captured a pirate flag inscribed with the characters which stated '*it is the flag of Lue-ming-suy-ming of the Hong Shing-tong Company, Chief of the Sea Squadron, and that he takes from the rich and not from the poor, and his flag can fly anywhere*'. Local people probably did not see him in this light, for Prebble records '*no sooner had we destroyed the piratical vessels, than a large fleet of fishing junks came into Tai O Bay rejoicing and anchored. These persons had to drive off a pirate attempt to take their lives and make off in their boats during the night*.' The next morning a deputation of the chief men of the village came on board his steamer '*with a present of chickens, pork, fish etc*.' to thank him of defeating the pirates (Hayes, 1983). Another account of this expedition is given in the personal narrative of J.S. Tronson (1959).

In additional to the documentary evidence the physical remains of Fan Lau Fort are located on the south western tip of Lantau, 7 km to the south along the coast from Tai O Bay. It is referred to in the Chinese Gazetteer as Kai Yik Kok Fort. It was erected around 1720-23 when Yang Lin was the governor general of Kwantung and Kwangsi provinces. Its location confirms the strategic importance of the sea passage leading into the Pearl River Estuary and on to Canton (Siu, 1979). It guards the waterway to the south of Lantau and has eight cannon places and 20 guard houses.

Little is recorded about Fan Lau Fort; it probably formed part of the coastal defence chain built in the middle of the 17th century. The Chinese Gazetteer refers neither to the year of its construction nor its eventual evacuation. British sources describe it as in ruins by 1841-2: in contradiction to this, however, Chinese sources provide evidence that it was manned until 1898, the year the New Territories were leased. The fort was in ruins until 1985 when it was repaired and declared a historical building of significance to the history of Hong Kong by the AMO.

The presence of the military installations at Tai O testifies to the prevalence of piracy and smuggling in the area. Throughout the south China region these two factors dominated maritime activities until they were finally suppressed in the late nineteenth century.

4.3 ARCHIVE SEARCH

The UK Hydrographic Office (UKHO), Taunton holds a database of surveyed shipwrecks in Hong Kong, including many not shown on Admiralty Charts. The database does not contain any records of shipwrecks within the study area. However, the Hydrographic Office only charts wrecks which are a potential hazard to navigation. It is therefore possible that there are other wrecks within the study area which are partially or totally buried and thus not recorded.

4.4 GEOPHYSICAL SURVEY

4.4.1 Interpretation of the Geological Succession

The interpretation of the seismic records has sought to quantify the following four elements of marine geological succession:

Geological Unit	Age
Marine Deposits (Hang Haul Formation)	Holocene
Alluvium (Chek Lap Kok Formation)	Pleistocene
Highly to Completely Decomposed Rock	Jurassic-Cretaceous
Presumed Moderately Decomposed Rock (Grade III rock)	Jurassic-Cretaceous

Marine Deposits are generally soft or very soft clays or silts, and as such are readily identifiable on seismic records as a clear conformable horizon sometimes with an unconformity represented by a desiccated layer or by local re-working of deposits by the water currents regime. The Marine Deposits are an ideal preservation environment for archaeological remains.

Interpretation was carried out as follows:

- The seismic horizons were interpreted in accordance with the list above, and drawn on paper copies of the seismic records during preliminary interpretation.
- All traverse crossing points were then calculated and marked on the seismic records.
- The records were then correlated at all traverse crossing points.
- Finally, the correlated horizons were digitized, plotted and contoured.

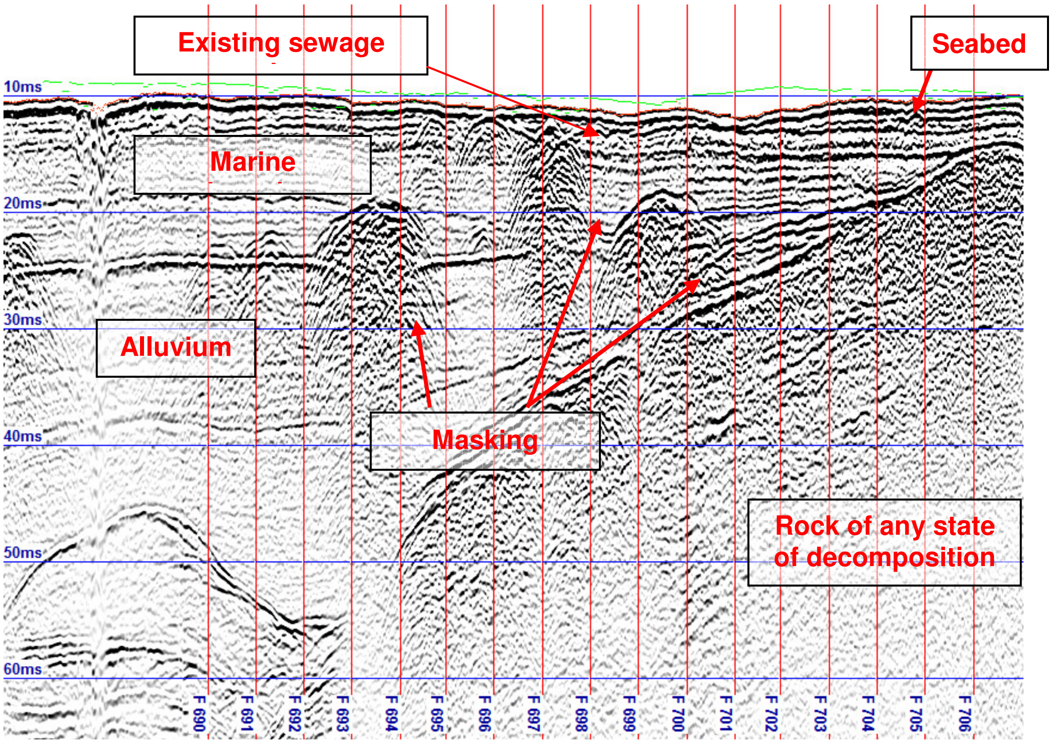


Figure 8: An example of seismic profiler data from the survey

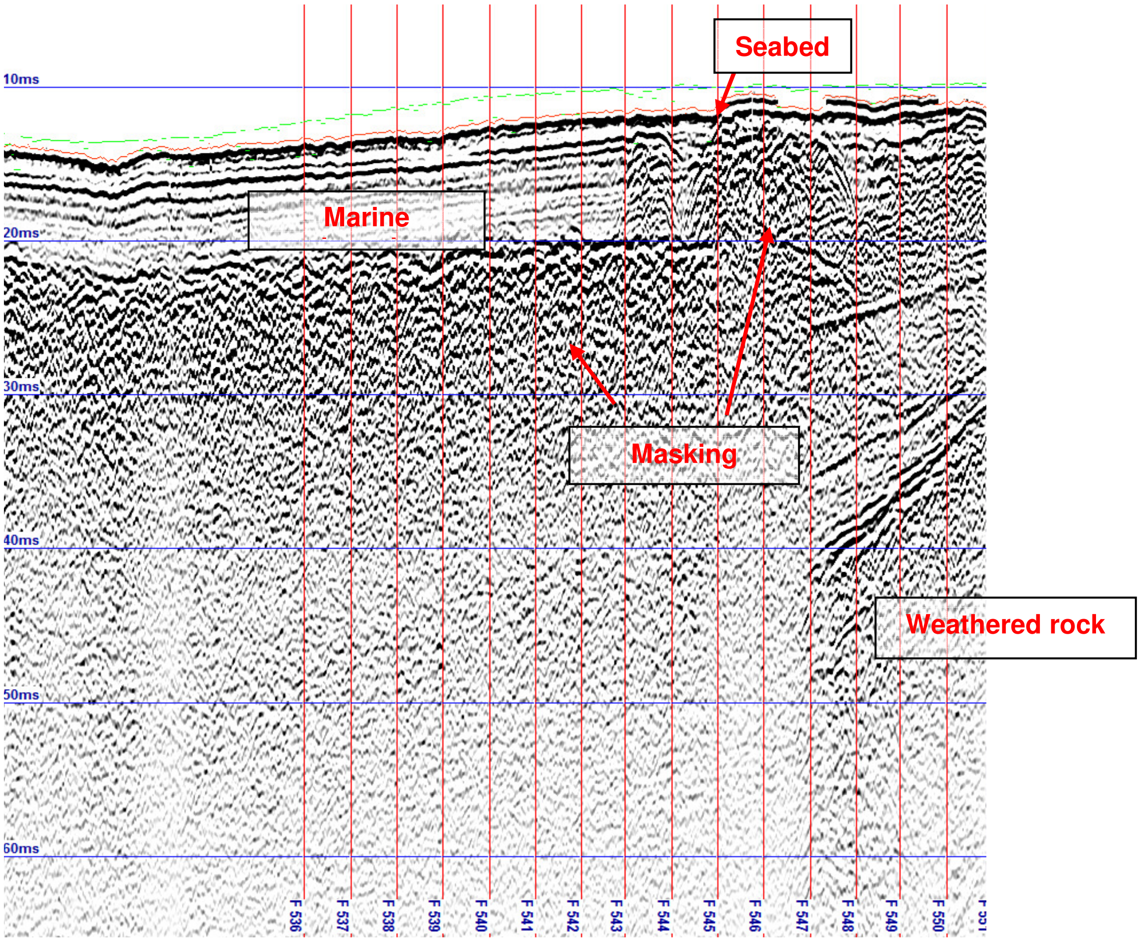


Figure 9: Seismic Profiler Data Showing Organic Masking

4.4.2 Organic Masking

Masking is caused by the presence of organic materials and gas bubbles in the water column and within sediments. It absorbs and/or scatters seismic energy which limits reflections from deeper horizons.

In this survey, about half of the survey area towards the sea was covered by masking 7-10m below seabed. It was probably caused by the gas within the Holocene sediments by the natural biogenic breakdown of plant materials. The masking near the existing outfall is much closer to the top of seabed and may be caused by the discharge from the existing outfall.

4.4.3 Detailed Data

The survey data is presented in summary charts as follows:

Survey Track Plot (Chart Figures 1, 2 and 3)
The survey tracks were plotted to show the exact data coverage in echo sounding, swath, seismic, side scan and magnetic surveys.

Single Beam Echo Sounding and Colour Contoured Swath Bathymetry Plan
(Chart Figure 4)

The seabed is gently inclined with depths vary from 0.0mPD near the coast to -7.5mPD in a NW direction.

Numerous shallow elongated depressions (bed forms) with an average depth of 1m were found within the survey area. Those bed forms were probably caused by sediment movement by Tide or Current in the survey area.

Sea bed Features (Chart Figure 5)

As shown in Figure 5, more than half of the survey area was covered by silty clay (Marine Deposits). Scattered trawl scars were found mainly in the NW end of the survey area. Numerous linear depressions (bed forms) were observed in the middle of the survey area. The coastline is characterized by rock and isolated boulders. Three sonar contacts were identified within the survey area. Those contacts were interpreted as unknown objects and the details are presented in the table below.

Contact number	**Latitude Longitude**	**Easting Northing**	**Description**
SC001	22° 15.8439' N 113° 51.2860' E	803319.8E 813846.5N	2.2x2.1xnmh* Unknown object
SC002	22° 15.8304' N 113° 51.2746' E	803300.2E 813821.7N	2.2x2.2xnmh Unknown object
SC003	22° 15.7818' N 113° 51.2380' E	803237.0E 813732.2N	2.6x1xnmh Unknown object
*no measurable height			

SC003 is outside the study area for the MAI and would only be impacted if there was a significant change to the existing proposed outfall alignment.

Marine Deposits (Figures 6 and 9)

Figure 6 illustrates the general regime of the base of the marine deposits. It varies from -8.2mPD to -19.7mPD in general.

Isopachs of marine deposits are presented on Figure 9. The thickness of marine deposits increased rapidly from shoreline towards offshore. The thickness varies from 5m to 12.6m.

Alluvium (Chart Figures 7 and 10)

Figure 7 shows the level on the top of highly to completely decomposed rock, equivalent to the base of Alluvium where present. Isopachs of Alluvium is presented on Figure 10.

As shown in Figures 7 and 10, this horizon was missing in north-western part of the survey area due to an acoustic blanking (gas masking) 7m to 10m below the seabed in that area.

The level of base of Alluvium (top of highly to completely rock) varies from -8.7mPD in the south and significantly deepens seawards, reaching a maximum of -37.4mPD at the northern survey boundary.
Alluvium presents at least 60m away from the shoreline (and 35m from the rocky coastline). Thickness of the layer of alluvium varies from 0.0m to 19.4m. It is thinner at the south and became thicker to the north near the masking area.

Highly to Completely Decomposed Rock (Chart Figures 8 and 11)

The topographic variation of the base level of highly to completely decomposed rock corresponds to the top level of fresh to moderately decomposed rock (bedrock). This horizon is presented in Figure 8.

The top level of fresh to moderately decomposed rock varies from -8.5mPD near the coast (55m from the coast, 24.4 from rocky coastline) to below -24mPD at the northern boundary of the survey area. Isopachs of Highly to Completely Decomposed Rock are presented in Figure 11. It only appeared in the middle portion of the survey area and the maximum thickness is about 7.3m near the northern boundary of the survey area.

Magnetic Data Presentation (Chart Figure 13)

The objective of the magnetic measurements was to map the metallic object above and below the shallow seabed. The magnetic data collected was passed through two stages of in-house data processing after the completion of data acquisition.

Stage 1 Median processing

Marine magnetic data was processed through a band-pass median filter in space domain to remove the magnetic effects of the regional geology, diurnal variations, any other long-wave components of the observed magnetic field and short wavelength noise. The band-pass filter wavelength interval in this case was 5m - 20m.

Stage 2 Hilbert transform to generate the analytical envelope

The median-filtered magnetic field intensity values can be considered as the real component of an analytical phasor. These median values were passed through a Hilbert Transform operator. The Hilbert Transform calculates the orthogonal component of the phasor (known as the imaginary or quadrature component). The phasor's components in Cartesian coordinates were converted to cylindrical coordinates to generate the analytical amplitude and phase. The analytical amplitude (the 'envelope function') was gridded and contoured, and the results are presented in Figure 13.

Generally for raw magnetic data sets there is no unique standard for comparison of the intensity of magnetic anomalies due to the directions of magnetization. Quazi- (or pseudo-) analytic signal representation is hence applied, to make such a comparison possible. The filtered magnetic field is transformed to its analytical signal (Hillbert envelope) series. The magnitude of this analytical series approximates to the total magnetic field over the magnetic anomaly sources, regardless of the direction of magnetization.

Variations in the magnetic intensity of the survey area were fairly low. 5 discontinuous linear contacts were observed along the existing sewage pipe. Those linear contacts were interpreted as the existing sewage pipe. A total of 41 magnetic contacts were also observed locally within the survey corridor and they were interpreted as unknown features. Those localized magnetic contacts were probably attributed to dumped materials or unknown metallic object. The magnetic contacts are listed as below.

Contact number	Latitude Longitude	Easting Northing	Description
MC001	22° 15.7268' N 113° 51.3351' E	803403.6E 813630.3N	Unknown feature
MC002	22° 15.7307' N 113° 51.3329' E	803400.0E 813637.5N	Unknown feature
MC003	22° 15.7352' N 113° 51.3460' E	803422.5E 813645.8N	Unknown feature
MC004	22° 15.7415' N 113° 51.3444' E	803419.8E 813657.3N	Unknown feature
MC005	22° 15.7464' N 113° 51.3387' E	803409.9E 813666.5N	Unknown feature
MC006	22° 15.7448' N 113° 51.3463' E	803423.1E 813663.5N	Unknown feature
MC007	22° 15.7370' N 113° 51.3547' E	803437.3E 813649.0N	Unknown feature
MC008	22° 15.7404' N 113° 51.3634' E	803452.4E 813655.3N	Unknown feature
MC009	22° 15.7449' N 113° 51.3652' E	803455.5E 813663.5N	Unknown feature
MC010	22° 15.7466' N 113° 51.3616' E	803449.2E 813666.7N	Unknown feature
MC011	22° 15.7515' N 113° 51.3565' E	803440.5E 813675.8N	Unknown feature
MC012	22° 15.7483' N 113° 51.3493' E	803428.1E 813669.9N	Unknown feature
MC013	22° 15.7538' N 113° 51.3471' E	803424.4E 813680.0N	Unknown feature
MC014	22° 15.7550' N 113° 51.3321' E	803398.6E 813682.3N	Unknown feature
MC015	22° 15.7595' N 113° 51.3354' E	803404.3E 813690.6N	Unknown feature

Contact number	Latitude Longitude	Easting Northing	Description
MC016	22° 15.7625' N 113° 51.3271' E	803390.0E 813696.2N	Unknown feature
MC017	22° 15.7675' N 113° 51.2992' E	803342.2E 813705.6N	Unknown feature
MC018	22° 15.7741' N 113° 51.2954' E	803335.7E 813717.8N	Unknown feature
MC019	22° 15.7628' N 113° 51.3667' E	803458.1E 813696.6N	Unknown feature
MC020	22° 15.7886' N 113° 51.3093' E	803359.6E 813744.3N	Unknown feature
MC021	22° 15.7721' N 113° 51.3554' E	803438.6E 813713.8N	Unknown feature
MC022	22° 15.7917' N 113° 51.3224' E	803382.1E 813750.1N	Unknown feature
MC023	22° 15.7985' N 113° 51.3182' E	803375.0E 813762.6N	Unknown feature
MC024	22° 15.8031' N 113° 51.3263' E	803388.8E 813771.0N	Unknown feature
MC025	22° 15.8063' N 113° 51.3092' E	803359.5E 813777.1N	Unknown feature
MC026	22° 15.8305' N 113° 51.2751' E	803301.0E 813821.8N	Unknown feature
MC027	22° 15.8593' N 113° 51.3141' E	803368.2E 813874.8N	Unknown feature
MC028	22° 15.8216' N 113° 51.3294' E	803394.2E 813805.2N	Unknown feature
MC029a	22°15.8218'N 113°51.3293'E	803394.0 813805.6	Unknown feature associated with diffuser?
MC029	22° 15.8251' N 113° 51.3343' E	803402.7E 813811.7N	Linear contact, sewage pipe?
MC030	22° 15.7973' N 113° 51.3630' E	803451.9E 813760.3N	Linear contact, sewage pipe?
MC031	22° 15.7850' N 113° 51.3794' E	803480.1E 813737.6N	Linear contact, sewage pipe?
MC032	22° 15.7789' N 113° 51.3872' E	803493.3E 813726.1N	Linear contact, sewage pipe?
MC033	22° 15.7634' N 113° 51.4058' E	803525.3E 813697.6N	Linear contact, sewage pipe?
MC034	22° 15.7900' N 113° 51.3954' E	803507.6E 813746.6N	Unknown feature
MC035	22° 15.7922' N 113° 51.4018' E	803518.5E 813750.7N	Unknown feature
MC036	22° 15.7857' N 113° 51.4058' E	803525.5E 813738.6N	Unknown feature
MC037	22° 15.7610' N 113° 51.4278' E	803563.1E 813693.0N	Unknown feature
MC038	22° 15.7566' N 113° 51.4243' E	803557.1E 813684.8N	Unknown feature
MC039	22° 15.7503' N 113° 51.4217' E	803552.5E 813673.4N	Unknown feature

Contact number	Latitude Longitude	Easting Northing	Description
MC040	22° 15.7501' N 113° 51.4300' E	803566.8E 813673.0N	Unknown feature
MC041	22° 15.7472' N 113° 51.4153' E	803541.5E 813667.6N	Unknown feature
MC042	22° 15.7545' N 113° 51.4444' E	803591.5E 813681.0N	Unknown feature
MC043	22° 15.7390' N 113° 51.4182' E	803546.4E 813652.4N	Unknown feature
MC044	22° 15.7356' N 113° 51.4264' E	803560.5E 813646.1N	Unknown feature
MC045	22° 15.7467' N 113° 51.4482' E	803598.1E 813666.6N	Unknown feature
MC046	22° 15.7415' N 113° 51.4576' E	803614.2E 813656.9N	Unknown feature

5. CONCLUSION

The Marine Archaeological Review and the Baseline Review established high archaeological potential. The side scan sonar survey located 3 unidentified objects on the seabed all of which were outside the impact area. There were no buried anomalies. The magnetic survey located 46 buried magnetic anomalies. Five of these are associated with the existing sewage pipe and therefore of no archaeological potential. The remaining 30 inside the impact area require further investigation to assess thier archaeological value. The original survey area was significantly larger than the impact area to allow changes to the alignment during the design phase. It was therefore possible to exclude anomalies which were located outside the impact area. Diver inspection of the magnetic anomalies is required to assess their archaeological significance.

6. REFERENCES

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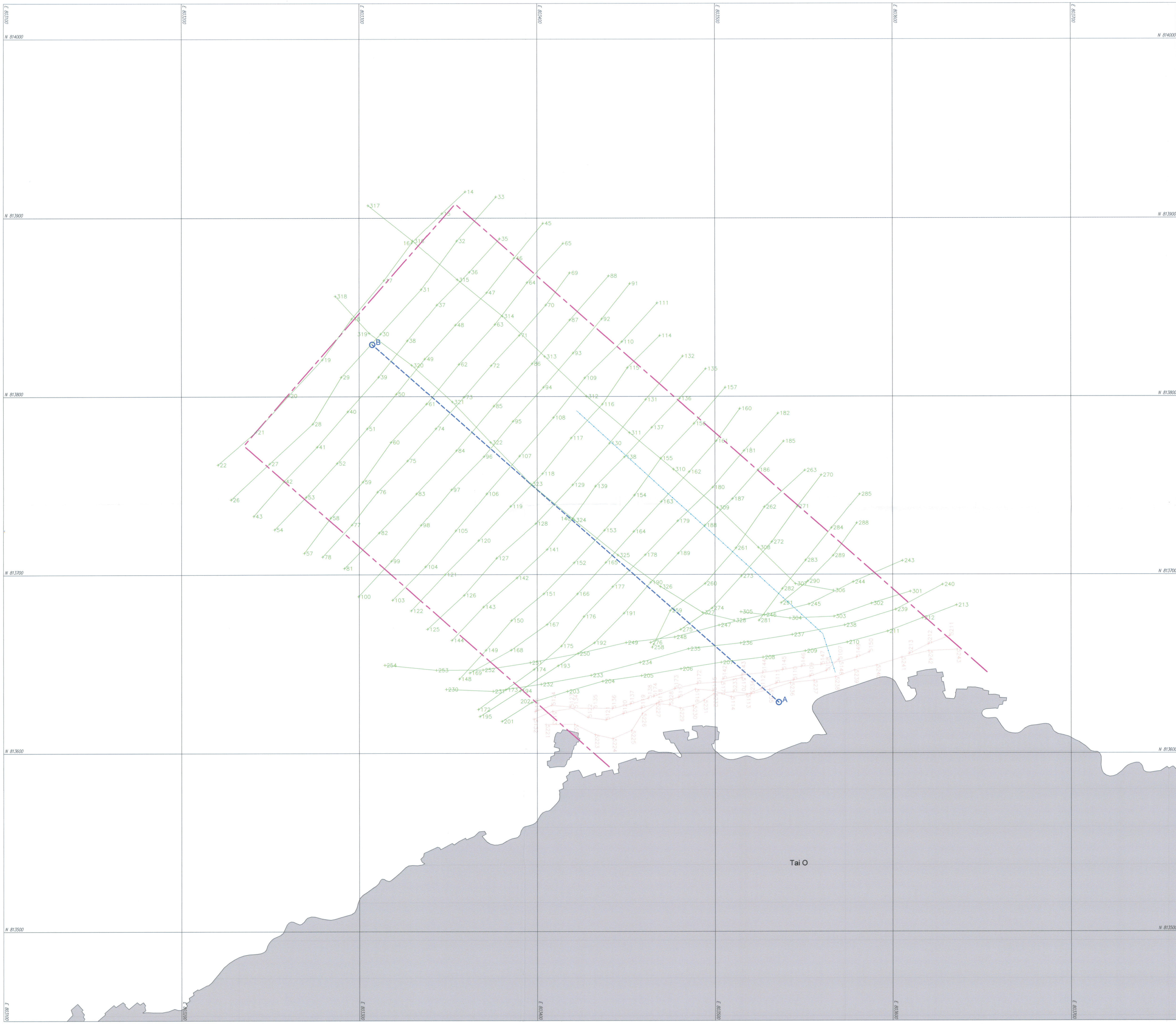
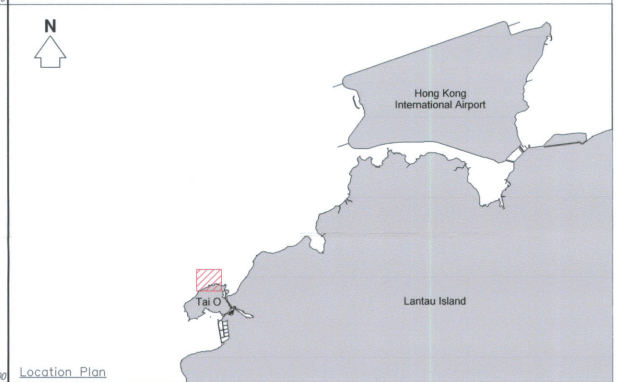


Legend :

- Single beam echo sounding track with fix positions
- Multibeam echo sounding track with fix positions
- Existing sewage pipe
- Proposed sewage pipe
- Survey boundary



Location Plan

Project :

WORKS ORDER NUMBER GE/2010/02.48A
AGREEMENT NO. CE 15/2010 (DS)
UPGRADING OF CHEUNG CHAU AND TAI O SEWAGE COLLECTION, TREATMENT AND DISPOSAL FACILITIES - DESIGN AND CONSTRUCTION
GEOPHYSICAL SURVEY AT TAI O

FIGURE NUMBER : 1

Drawing Title :

SINGLE BEAM AND MULTIBEAM ECHO SOUNDING TRACK PLOT

Notes :

1. Survey Date : 16–17/11/2011
2. Survey Grid : HK1980 Grid System
3. Survey Datum : Hong Kong Principal Datum
4. Positioning : C-Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
   Knudsen 320M Echo Sounder
   Klein 3000 Side Scan Sonar System
   R2Sonic Sonic 2024 Multibeam Echo Sounder System
   Seaspy (GSM-19MD) Magnetometer
6. Coastline taken from 1:1,000 Survey Sheets, Survey and Mapping Office, Lands Department

Revision No.	Date	Drawn by	Checked by	Approved by	Remarks
0	30/11/2011	Agnes Siu	Margie Chen	R E Hale	Preliminary

METRIC SCALE 1:1000

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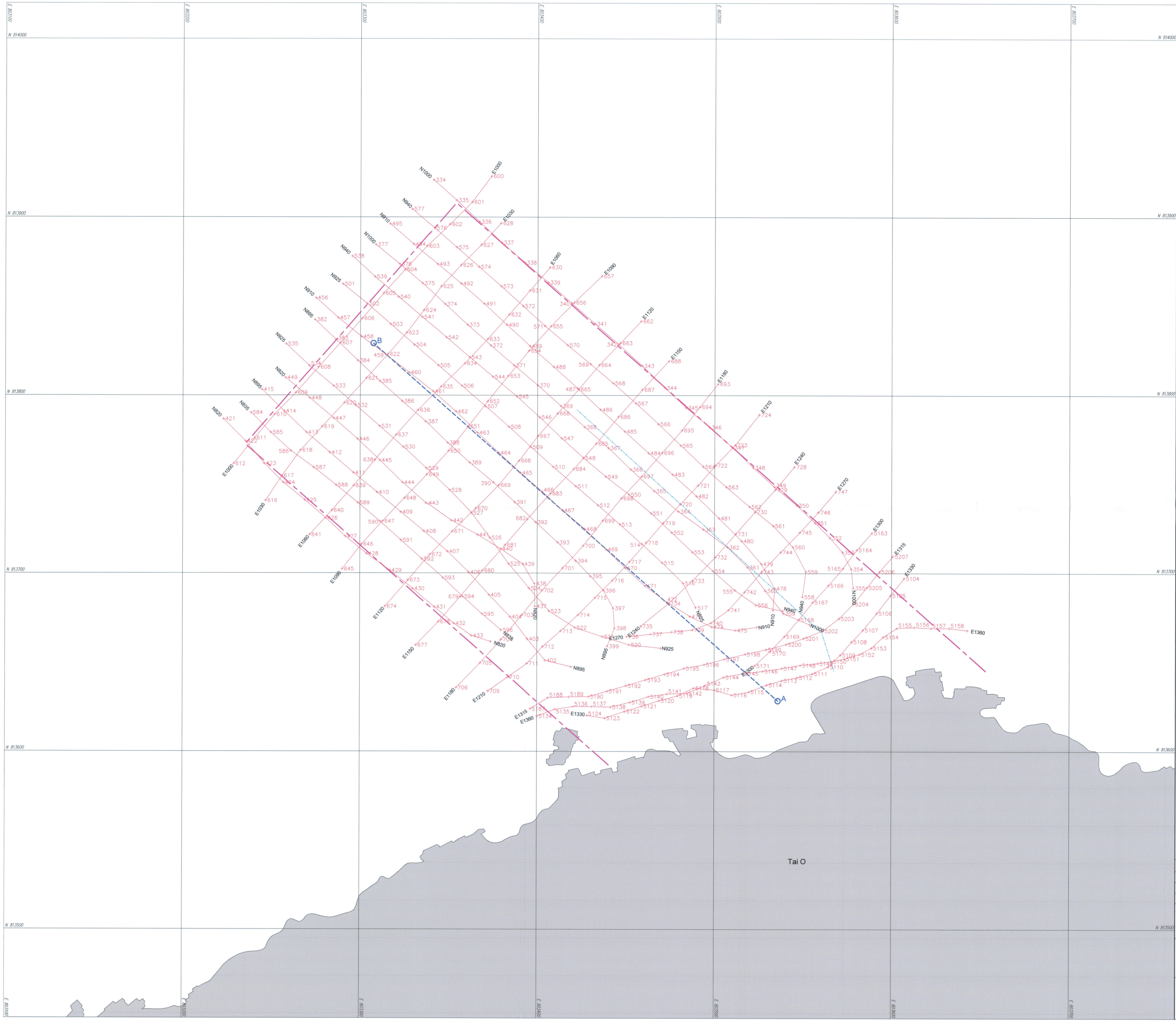
Client : Civil Engineering and Development Department

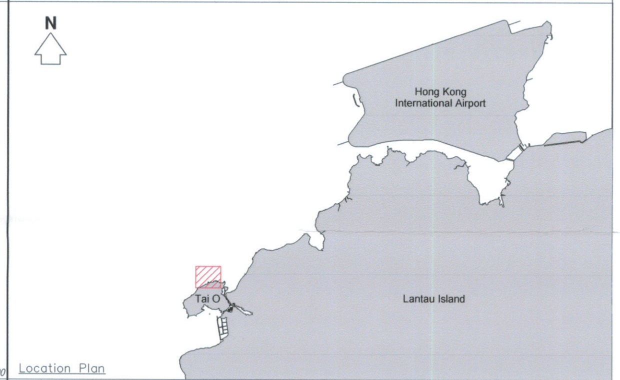
Surveyor : EGS (ASIA) LIMITED

JOB NO. : HK224611



Legend :

- Hydrophone and side scan sonar track with fix positions and line number
- Existing sewage pipe
- Proposed sewage pipe
- Survey boundary



Project :

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UPGRADING OF CHEUNG CHAU AND TAI O SEWAGE COLLECTION, TREATMENT AND DISPOSAL FACILITIES - DESIGN AND CONSTRUCTION
GEOPHYSICAL SURVEY AT TAI O

FIGURE NUMBER : 2

Drawing Title :

SEISMIC AND SIDE SCAN SONAR TRACK PLOT

Notes :

1. Survey Date : 16-17/11/2011
2. Survey Grid : HK1980 Grid System
3. Survey Datum : Hong Kong Principal Datum
4. Positioning : C-Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
   Knudsen 320M Echo Sounder
   Klein 3000 Side Scan Sonar System
   R2Sonic Sonic 2024 Multibeam Echo Sounder System
   Seaspy (GSM-19MD) Magnetometer
6. Coastline taken from 1:1,000 Survey Sheets, Survey and Mapping Office, Lands Department

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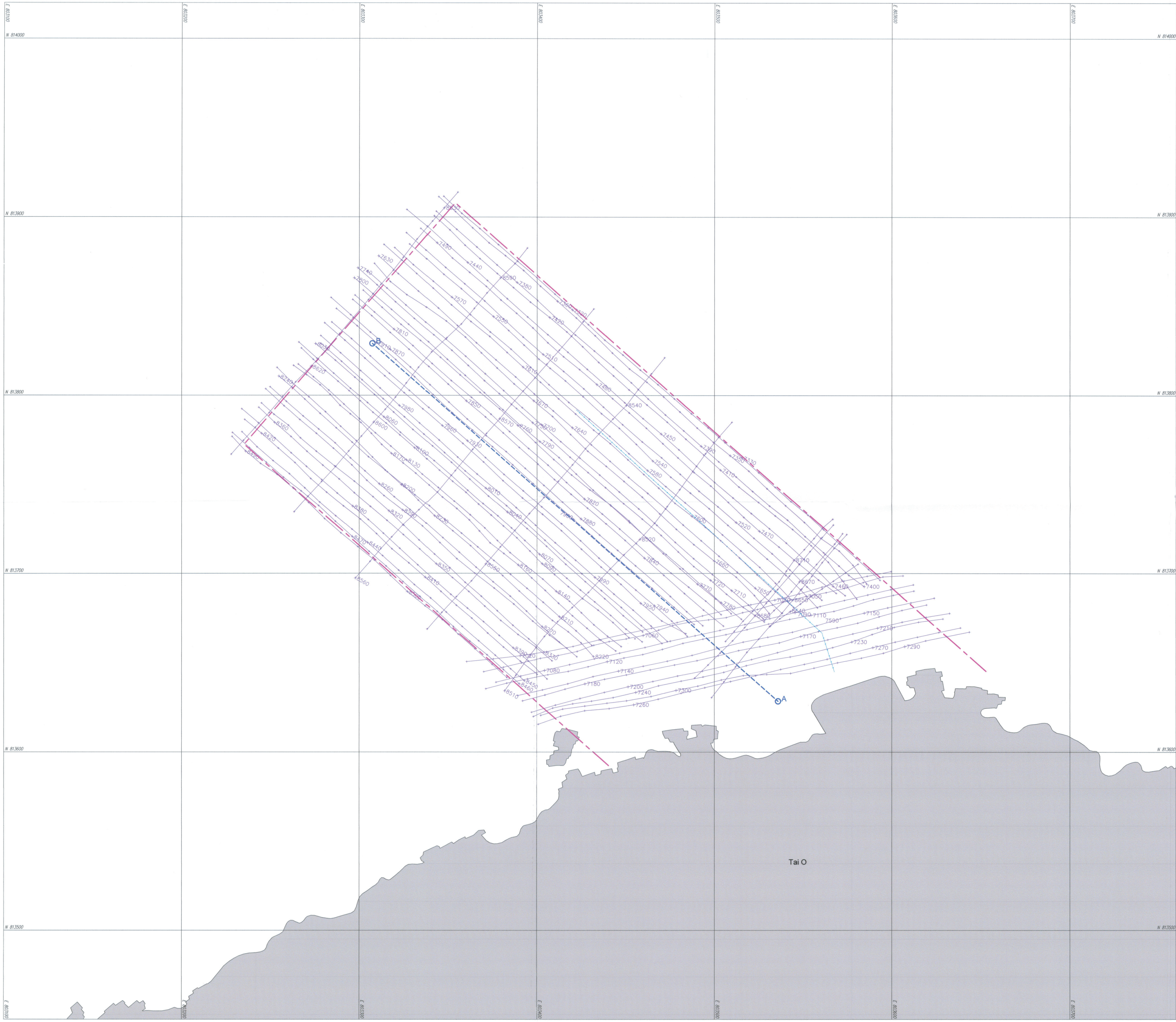
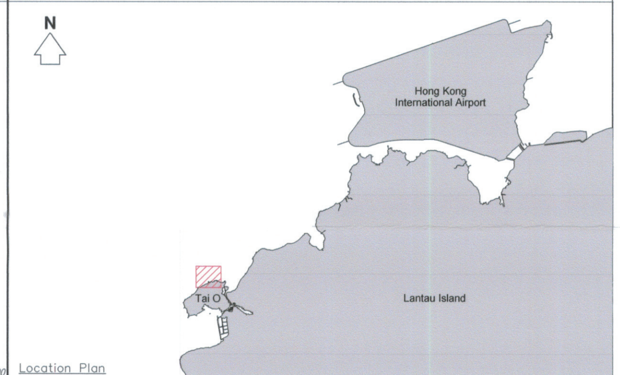


Legend :

260	Magnetic track with fix positions
	Existing sewage pipe
	Proposed sewage pipe
	Survey boundary



Project :

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AGREEMENT NO. CE 15/2010 (DS)
UPGRADING OF CHEUNG CHAU AND TAI O SEWAGE COLLECTION, TREATMENT AND DISPOSAL FACILITIES - DESIGN AND CONSTRUCTION
GEOPHYSICAL SURVEY AT TAI O

FIGURE NUMBER : 3

Drawing Title :

MAGNETIC TRACK PLOTS

Notes :

1. Survey Date : 16-17/11/2011
2. Survey Grid : HK1980 Grid System
3. Survey Datum : Hong Kong Principal Datum
4. Positioning : C-Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
   Knudsen 320M Echo Sounder
   Klein 3000 Side Scan Sonar System
   R2Sonic Sonic 2024 Multibeam Echo Sounder System
   Seaspy (GSM-19MD) Magnetometer
6. Coastline taken from 1:1,000 Survey Sheets, Survey and Mapping Office, Lands Department

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METRIC SCALE 1:1000

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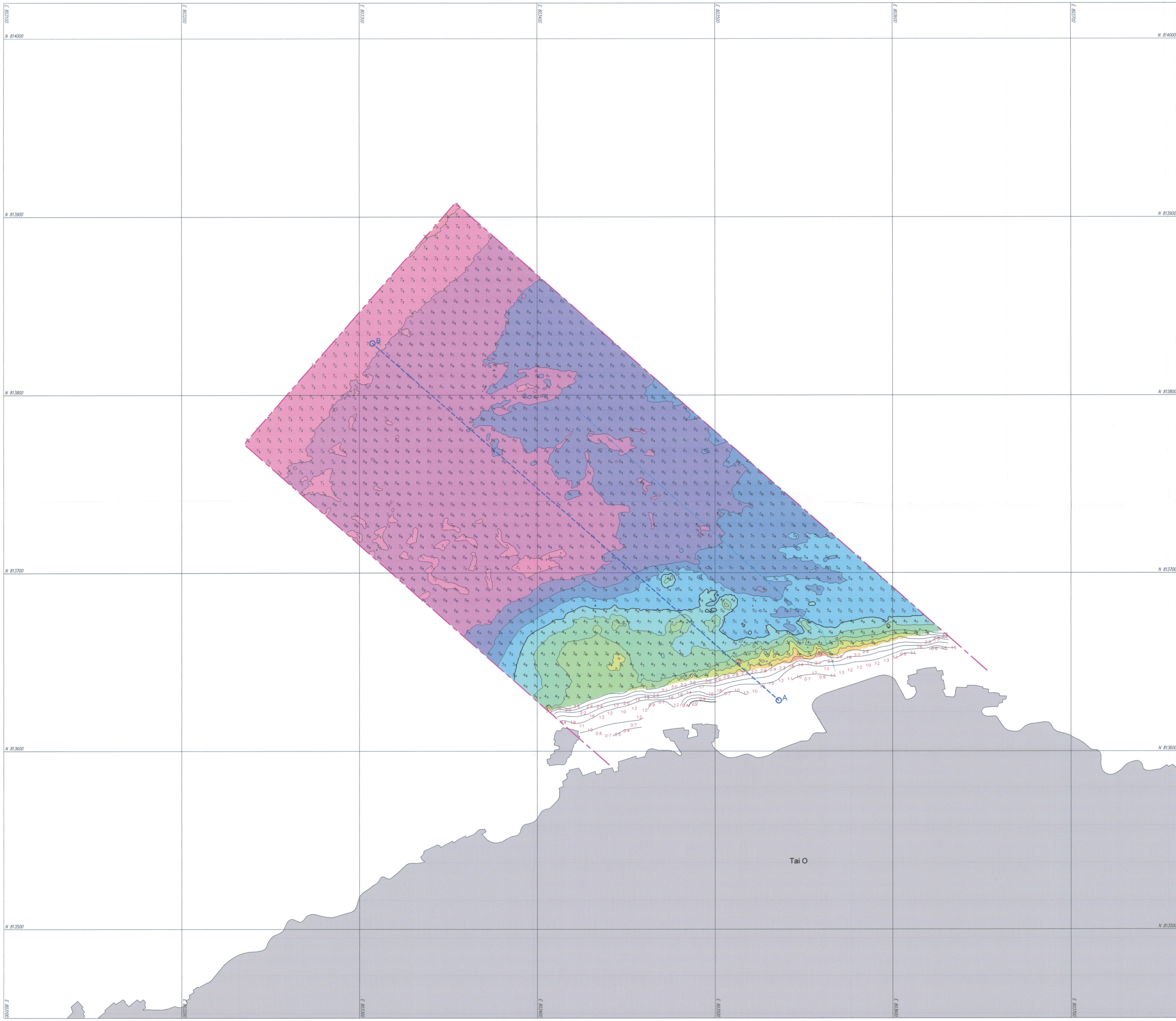

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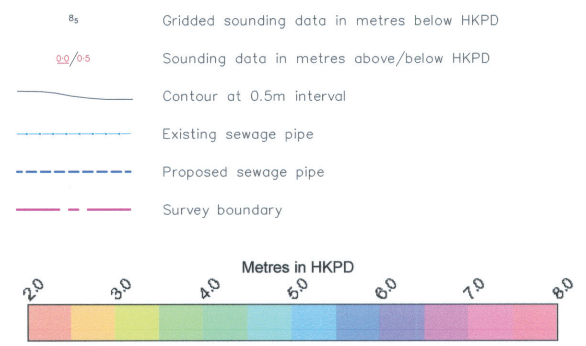

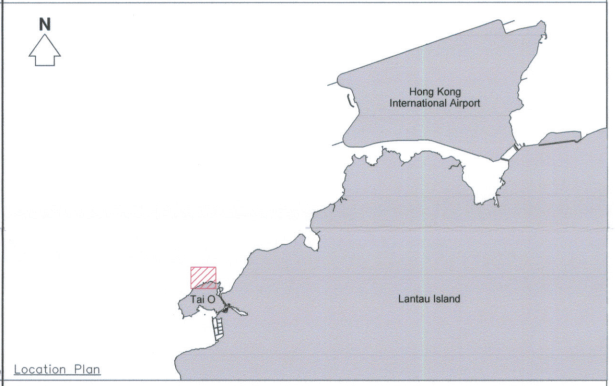

Location Plan

Project :

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UPGRADING OF CHEUNG CHAU AND TAI O SEWAGE COLLECTION, TREATMENT AND DISPOSAL FACILITIES - DESIGN AND CONSTRUCTION
GEOPHYSICAL SURVEY AT TAI O

FIGURE NUMBER : 4

Drawing Title :

SINGLE BEAM ECHO SOUNDING AND COLOUR CONTOURED SWATH BATHYMETRY PLAN

Notes :

1. Survey Date : 16–17/11/2011
2. Survey Grid : HK1980 Grid System
3. Survey Datum : Hong Kong Principal Datum
4. Positioning : C–Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
   Knudsen 320M Echo Sounder
   Klein 3000 Side Scan Sonar System
   R2Sonic Sonic 2024 Multibeam Echo Sounder System
   Seaspy (GSM–19MD) Magnetometer
6. Coastline taken from 1:1,000 Survey Sheets, Survey and Mapping Office, Lands Department

Revision No.	Date	Drawn by	Checked by	Approved by	Remarks
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METRIC SCALE 1:1000

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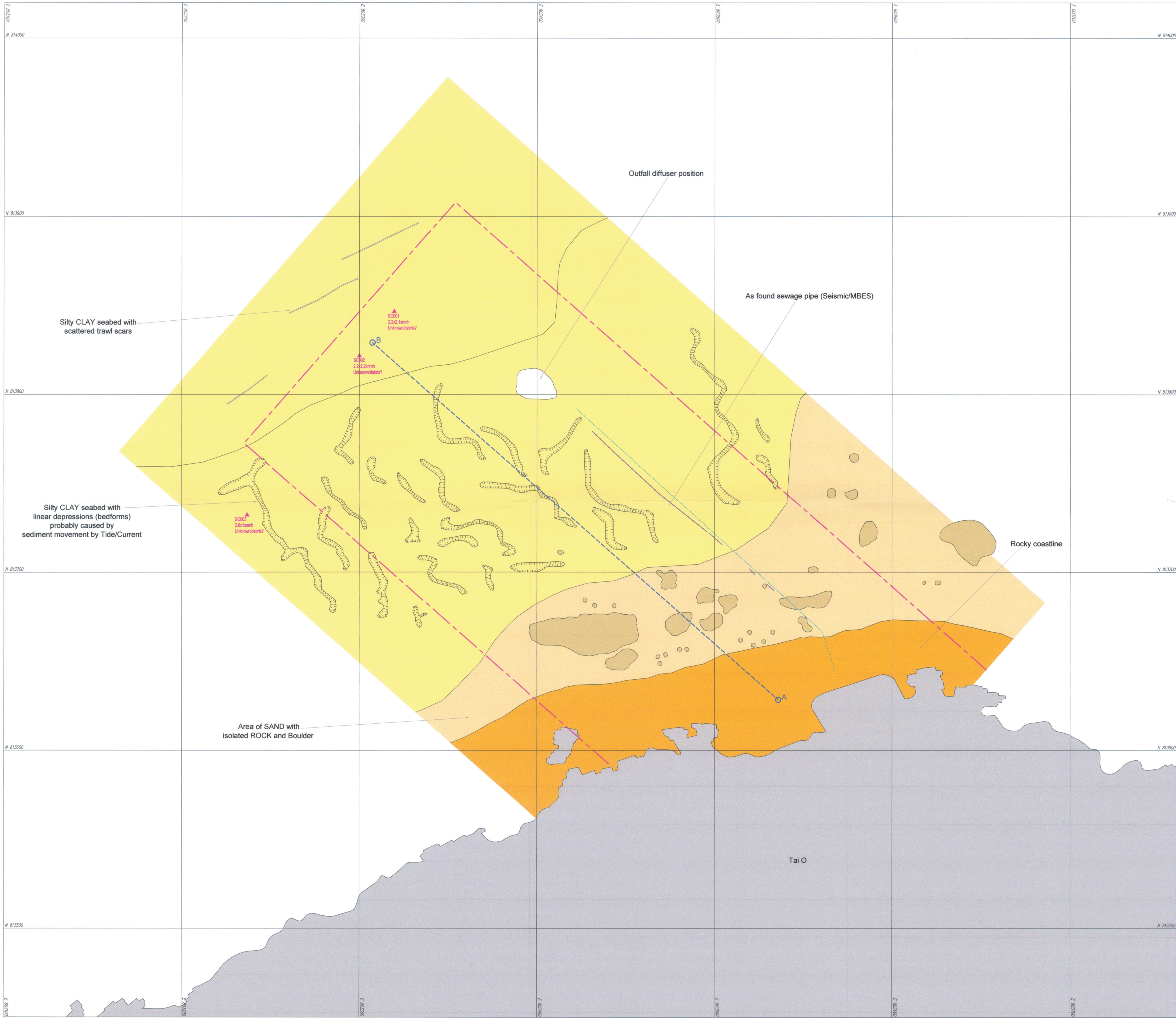

Legend :

- Sonar contact with reference number (length x width x height in metres where measurable; nmh = no measurable height)
- Silty CLAY
- SAND
- Isolated ROCK
- ROCK
- Seabed DEPRESSION
- Seabed scar (trawl or anchor)
- As found sewage pipe
- Existing sewage pipe
- Proposed sewage pipe
- Survey boundary

Location Plan

Project :

WORKS ORDER NUMBER GE/2010/02.48A
AGREEMENT NO. CE 15/2010 (DS)
UPGRADING OF CHEUNG CHAU AND TAI O SEWAGE COLLECTION, TREATMENT AND DISPOSAL FACILITIES - DESIGN AND CONSTRUCTION
GEOPHYSICAL SURVEY AT TAI O

FIGURE NUMBER : 5

Drawing Title :

SEABED FEATURES

Notes :

1. Survey Date : 16-17/11/2011
2. Survey Grid : HK1980 Grid System
3. Survey Datum : Hong Kong Principal Datum
4. Positioning : C-Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
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   Klein 3000 Side Scan Sonar System
   R2Sonic Sonic 2024 Multibeam Echo Sounder System
   Seaspy (GSM-19MD) Magnetometer
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METRIC SCALE 1:1000

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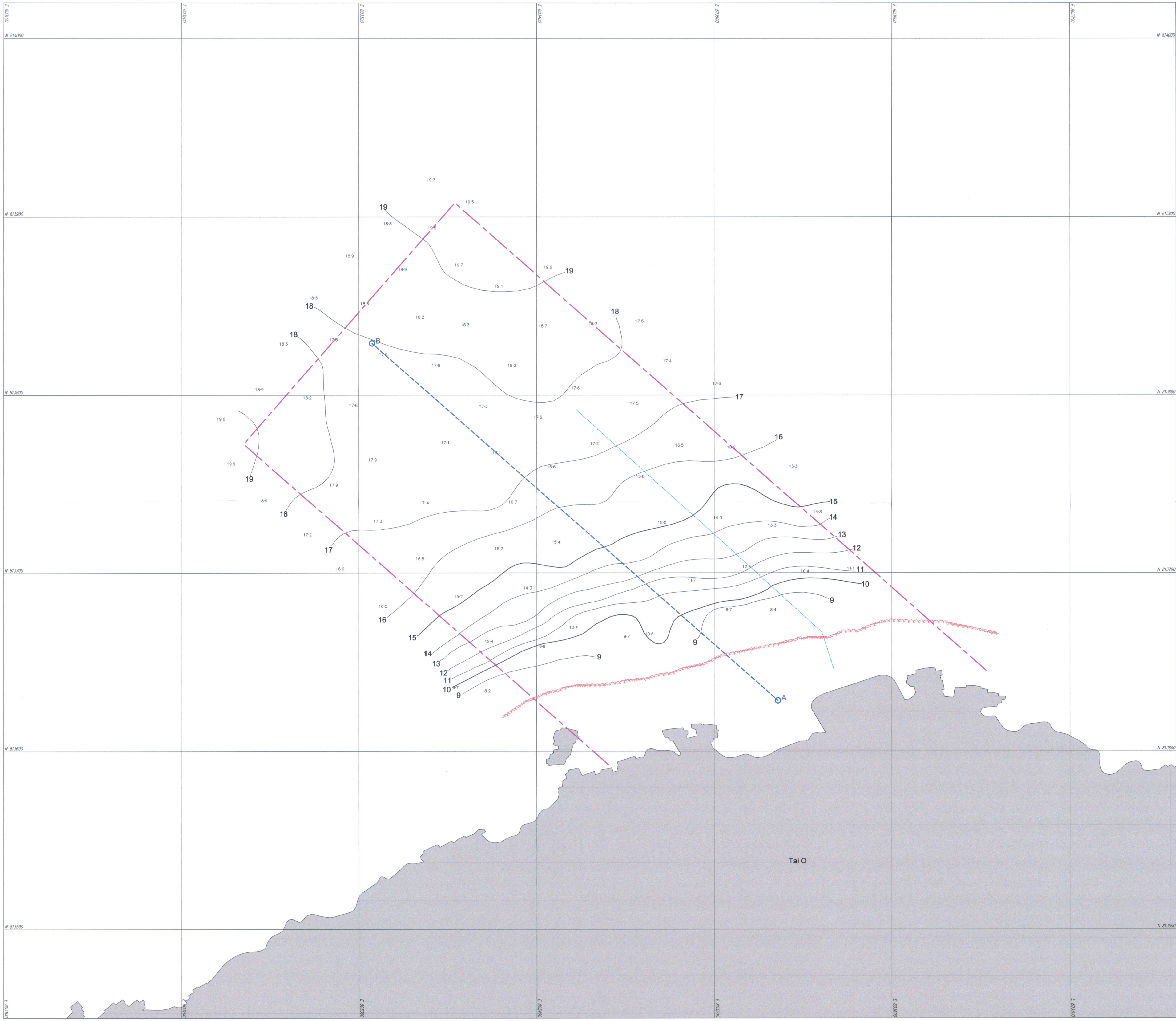
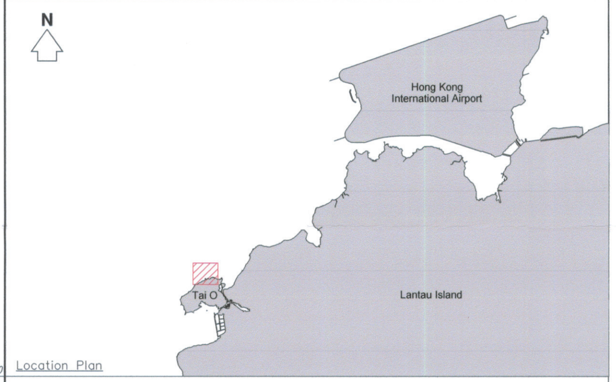


Legend :

9·5	Spot value in metres below HKPD
	Contour at 1m interval
	Existing sewage pipe
	Proposed sewage pipe
	Rocky coastline
	Survey boundary



Location Plan

Project :

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UPGRADING OF CHEUNG CHAU AND TAI O SEWAGE COLLECTION, TREATMENT AND DISPOSAL FACILITIES - DESIGN AND CONSTRUCTION
GEOPHYSICAL SURVEY AT TAI O

FIGURE NUMBER : 6

Drawing Title :

CONTOURED LEVELS AT THE BASE OF MARINE DEPOSITS

Notes :
1. Survey Date : 16–17/11/2011
2. Survey Grid : HK1980 Grid System
3. Survey Datum : Hong Kong Principal Datum
4. Positioning : C-Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
   Knudsen 320M Echo Sounder
   Klein 3000 Side Scan Sonar System
   R2Sonic Sonic 2024 Multibeam Echo Sounder System
   Seaspy (GSM-19MD) Magnetometer
6. Coastline taken from 1:1,000 Survey Sheets, Survey and Mapping Office, Lands Department

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METRIC SCALE 1:1000

50 40 30 20 10 0 50 100

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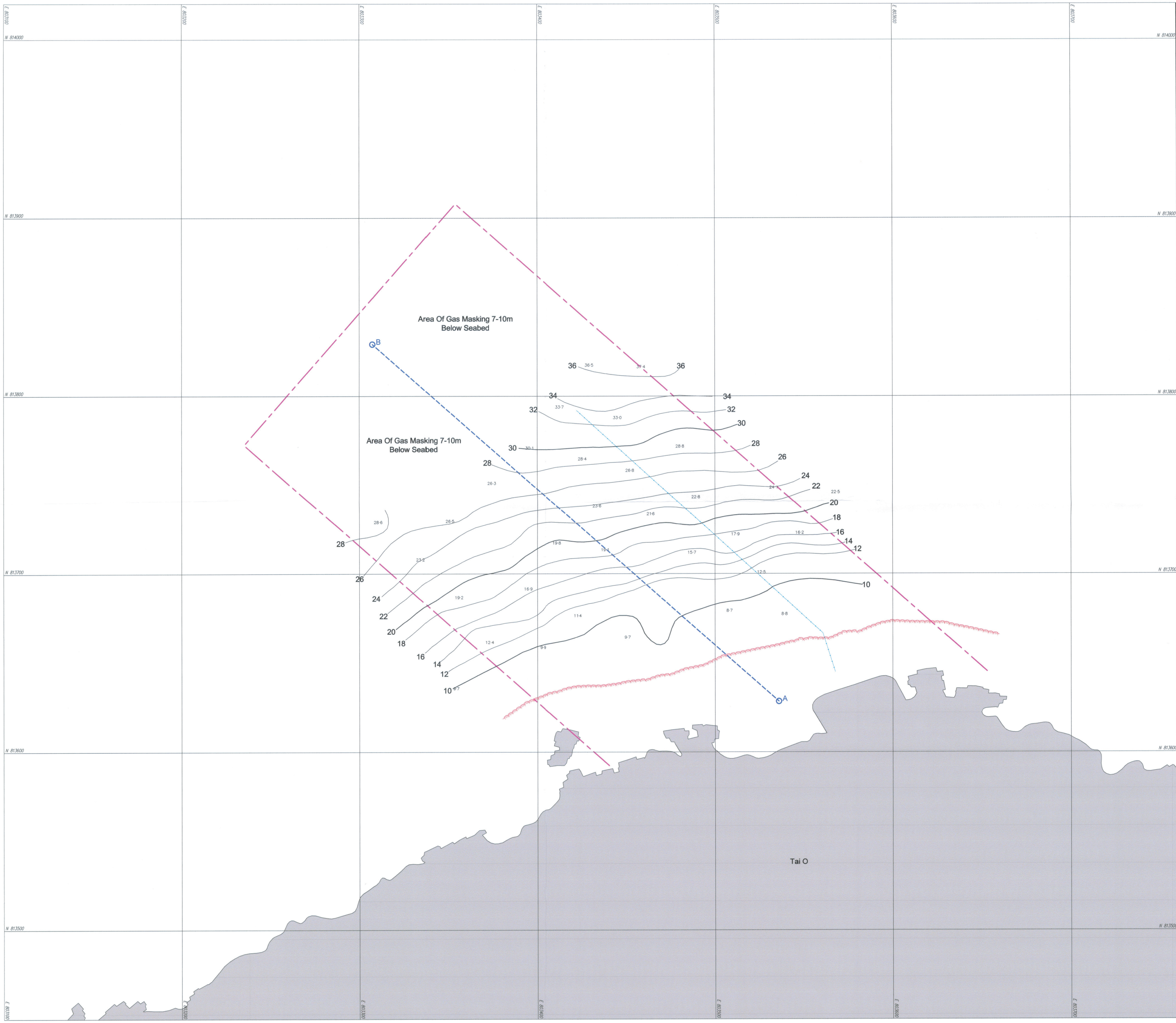
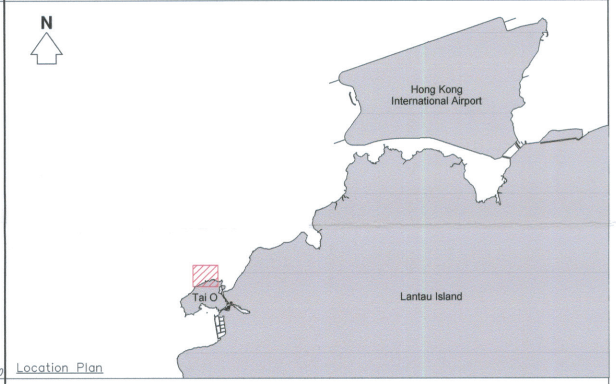


Legend :

9.5	Spot value in metres below HKPD
	Contour at 2m interval
	Existing sewage pipe
	Proposed sewage pipe
	Rocky coastline
	Survey boundary



Location Plan

Project :

WORKS ORDER NUMBER GE/2010/02.48A
AGREEMENT NO. CE 15/2010 (DS)
UPGRADING OF CHEUNG CHAU AND TAI O SEWAGE COLLECTION, TREATMENT AND DISPOSAL FACILITIES - DESIGN AND CONSTRUCTION
GEOPHYSICAL SURVEY AT TAI O

FIGURE NUMBER : 7

Drawing Title :

CONTOURED LEVELS ON TOP OF HIGHLY TO COMPLETELY DECOMPOSED ROCK

Notes :
1. Survey Date : 16–17/11/2011
2. Survey Grid : HK1980 Grid System
3. Survey Datum : Hong Kong Principal Datum
4. Positioning : C–Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
   Knudsen 320M Echo Sounder
   Klein 3000 Side Scan Sonar System
   R2Sonic Sonic 2024 Multibeam Echo Sounder System
   Seaspy (GSM–19MD) Magnetometer
6. Coastline taken from 1:1,000 Survey Sheets, Survey and Mapping Office, Lands Department

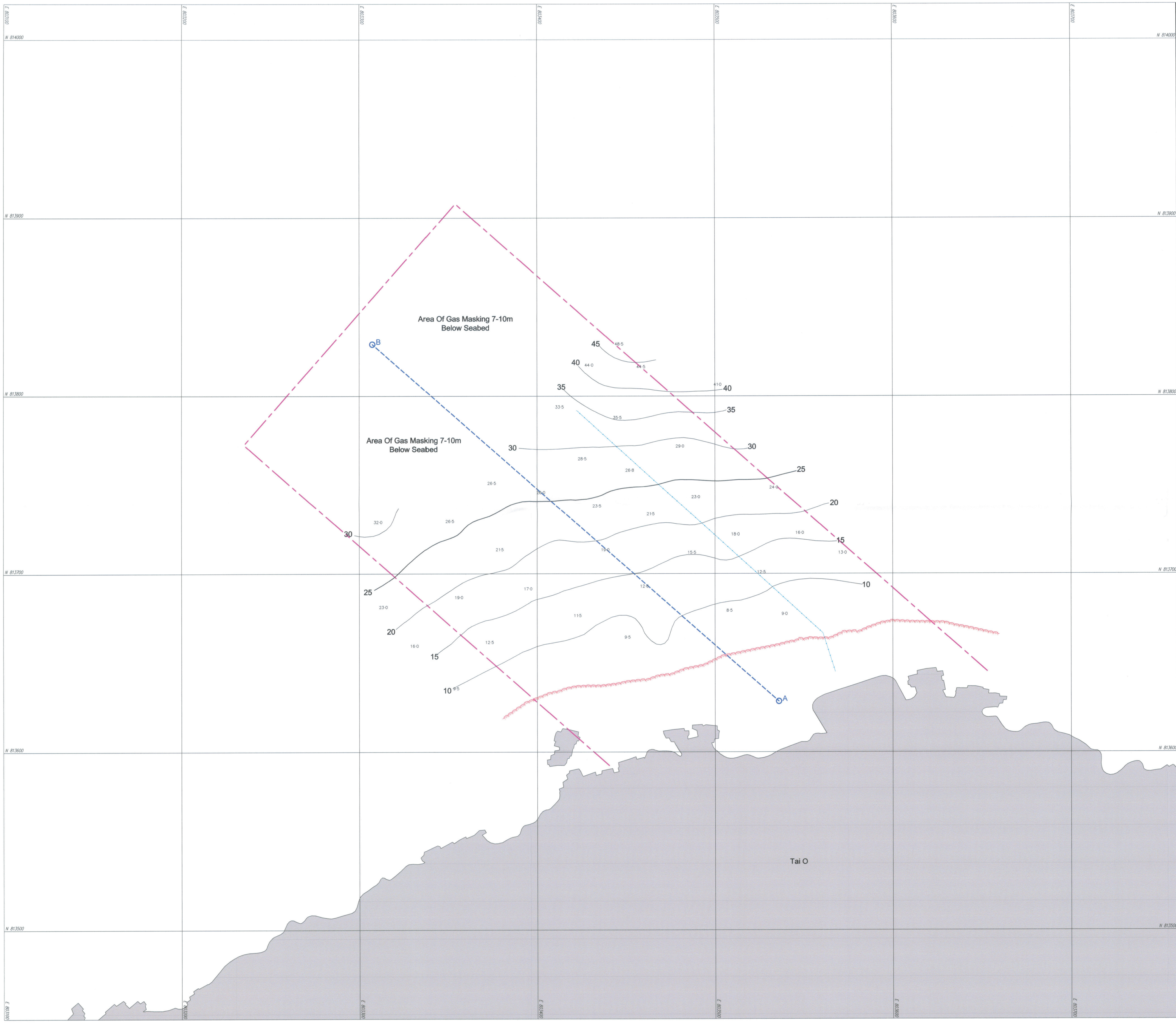
Revision No.	Date	Drawn by	Checked by	Approved by	Remarks
0	30/11/2011	Agnes Siu	Margie Chen	R E Hale	Preliminary

METRIC SCALE 1:1000
50 40 30 20 10 0 50 100

Client :
Civil Engineering and Development Department

Surveyor :
EGS (ASIA) LIMITED

JOB NO. : HK224611



Legend :

9·5	Spot value in metres below HKPD
	Contour at 5m interval
	Existing sewage pipe
	Proposed sewage pipe
	Rocky coastline
	Survey boundary

Location Plan

Project :

WORKS ORDER NUMBER GE/2010/02.48A
AGREEMENT NO. CE 15/2010 (DS)
UPGRADING OF CHEUNG CHAU AND TAI O SEWAGE COLLECTION, TREATMENT AND DISPOSAL FACILITIES - DESIGN AND CONSTRUCTION
GEOPHYSICAL SURVEY AT TAI O

FIGURE NUMBER : 8

Drawing Title :

CONTOURED LEVELS ON TOP OF PRESUMED MODERATELY DECOMPOSED ROCK

Notes :

1. Survey Date : 16–17/11/2011
2. Survey Grid : HK1980 Grid System
3. Survey Datum : Hong Kong Principal Datum
4. Positioning : C–Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
   Knudsen 320M Echo Sounder
   Klein 3000 Side Scan Sonar System
   R2Sonic Sonic 2024 Multibeam Echo Sounder System
   Seaspy (GSM–19MD) Magnetometer
6. Coastline taken from 1:1,000 Survey Sheets, Survey and Mapping Office, Lands Department

Revision No.	Date	Drawn by	Checked by	Approved by	Remarks
0	30/11/2011	Agnes Siu	Margie Chen	R E Hale	Preliminary

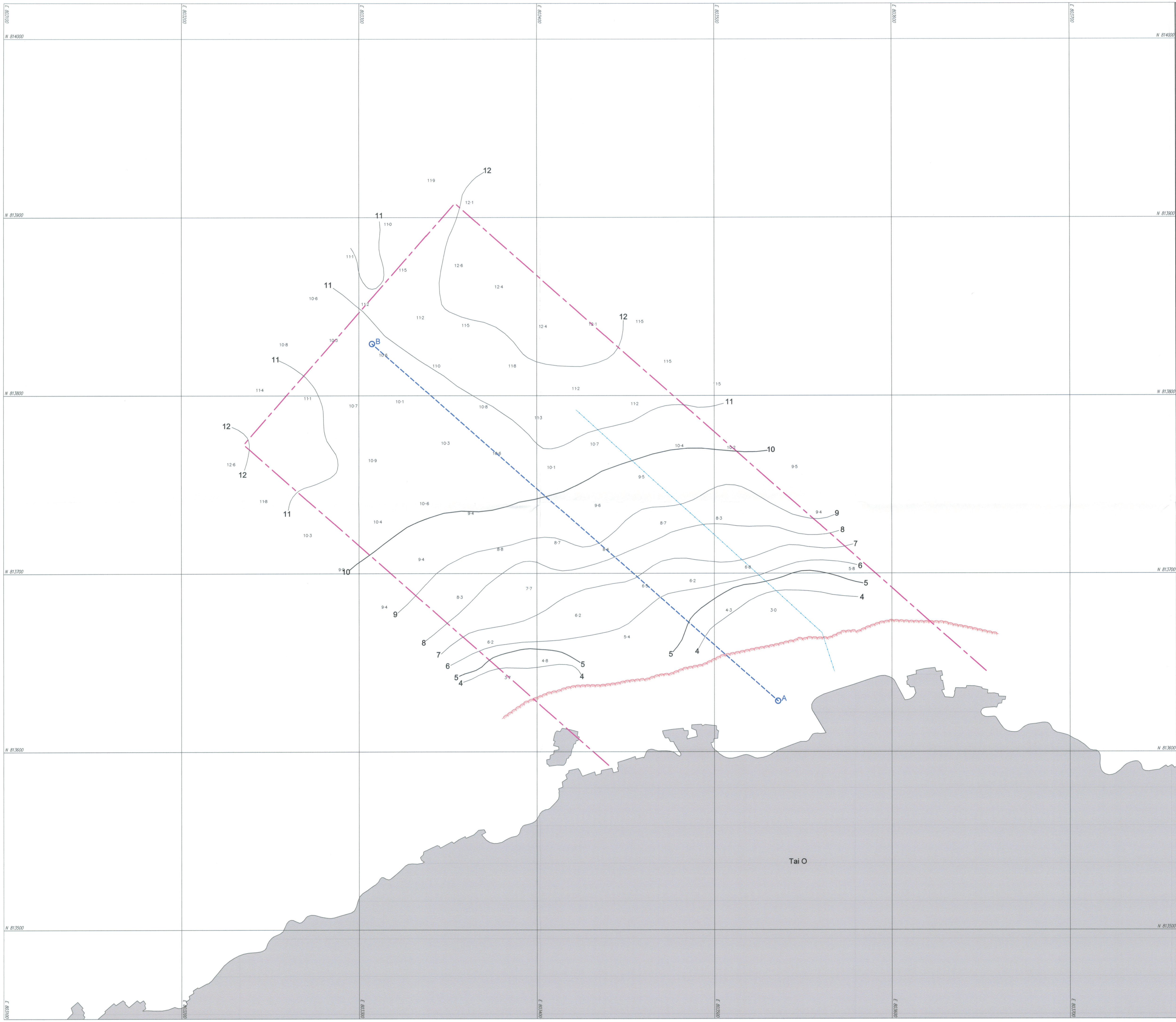
METRIC SCALE 1:1000

50 40 30 20 10 0 50 100

Client : Civil Engineering and Development Department

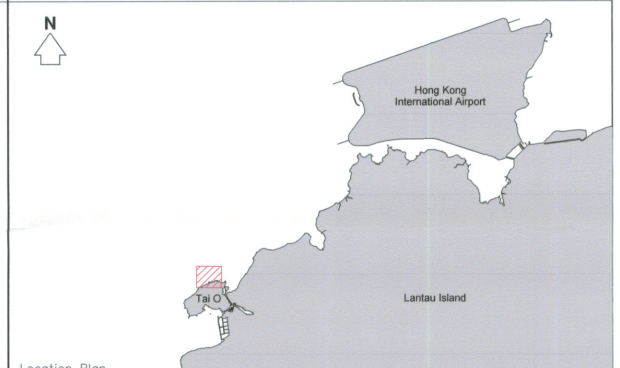
Surveyor : EGS (ASIA) LIMITED
9/F SOUTH, SOMERSET HOUSE, TAIKOO PLACE, 979 KING'S ROAD, QUARRY BAY, HONG KONG

JOB NO. : HK224611



Legend :

9·5	Isopachs value in metres (Thickness of the layer)
	Contour at 1m interval
	Existing sewage pipe
	Proposed sewage pipe
	Rocky coastline
	Survey boundary



Location Plan

Project :

WORKS ORDER NUMBER GE/2010/02.48A
AGREEMENT NO. CE 15/2010 (DS)
UPGRADING OF CHEUNG CHAU AND TAI O SEWAGE COLLECTION, TREATMENT AND DISPOSAL FACILITIES - DESIGN AND CONSTRUCTION
GEOPHYSICAL SURVEY AT TAI O

FIGURE NUMBER : 9

Drawing Title :

CONTOURED ISOPACHS OF MARINE DEPOSITS

Notes :

1. Survey Date : 16–17/11/2011
2. Survey Grid : HK1980 Grid System
3. Survey Datum : Hong Kong Principal Datum
4. Positioning : C–Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
   Knudsen 320M Echo Sounder
   Klein 3000 Side Scan Sonar System
   R2Sonic Sonic 2024 Multibeam Echo Sounder System
   Seaspy (GSM–19MD) Magnetometer
6. Coastline taken from 1:1,000 Survey Sheets, Survey and Mapping Office, Lands Department

Revision No.	Date	Drawn by	Checked by	Approved by	Remarks
0	30/11/2011	Agnes Siu	Margie Chen	R E Hale	Preliminary

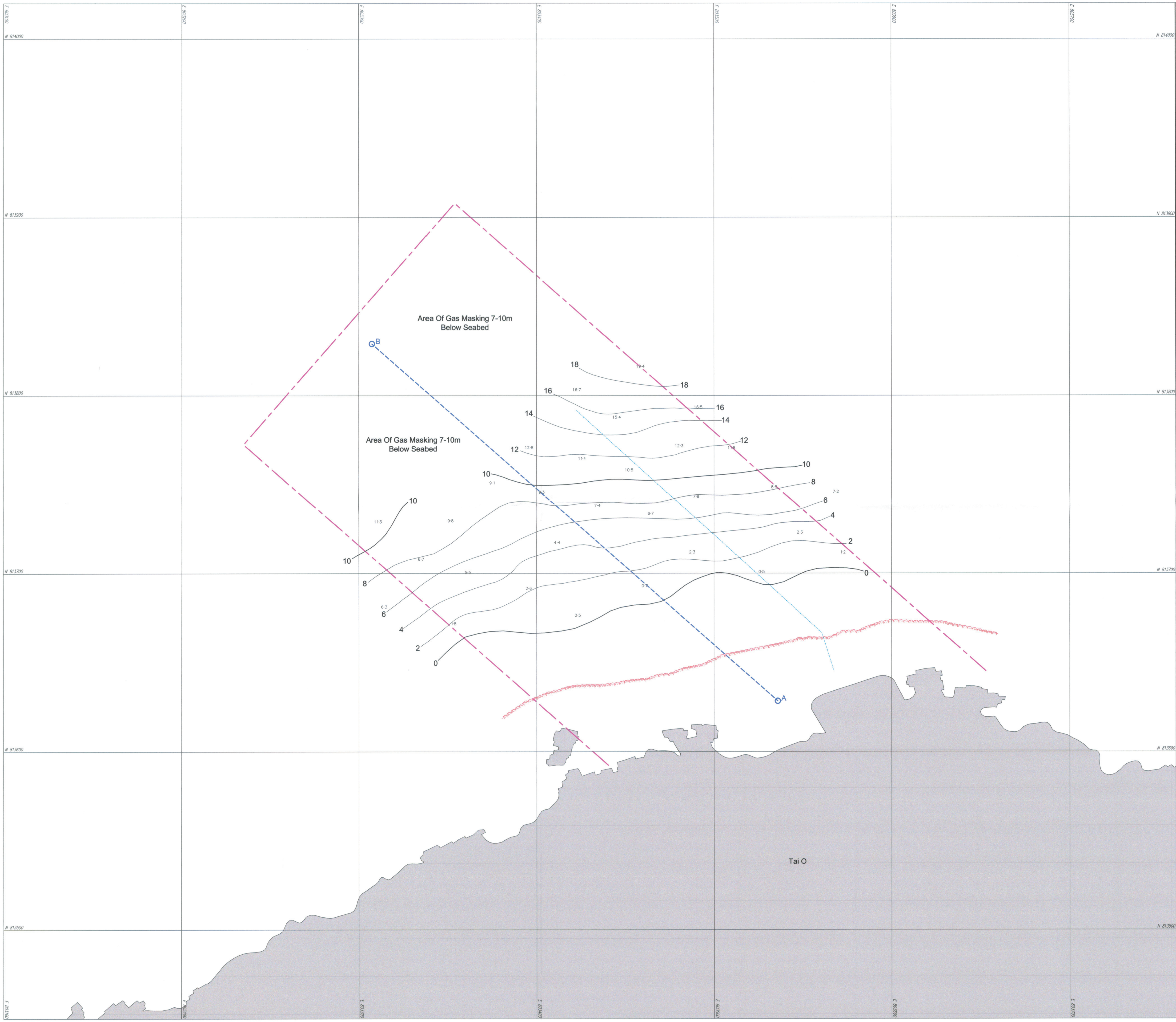
METRIC SCALE 1:1000

50 40 30 20 10 0 50 100

Client : Civil Engineering and Development Department

Surveyor : EGS (ASIA) LIMITED

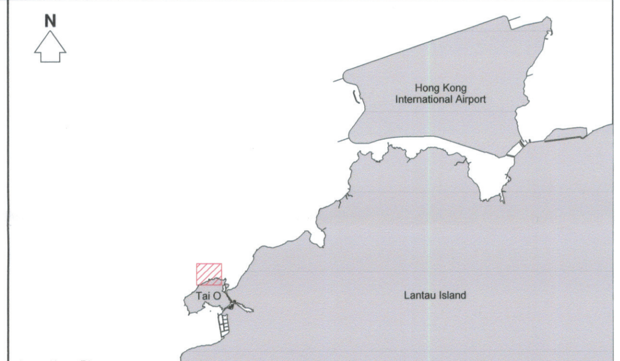
JOB NO. : HK224611



N

Legend :

9.5	Isopachs value in metres (Thickness of the layer)
	Contour at 2m interval
	Existing sewage pipe
	Proposed sewage pipe
	Rocky coastline
	Survey boundary



Location Plan

Project :

WORKS ORDER NUMBER GE/2010/02.48A
AGREEMENT NO. CE 15/2010 (DS)
UPGRADING OF CHEUNG CHAU AND TAI O SEWAGE COLLECTION, TREATMENT AND DISPOSAL FACILITIES - DESIGN AND CONSTRUCTION
GEOPHYSICAL SURVEY AT TAI O

FIGURE NUMBER : 10

Drawing Title :

CONTOURED ISOPACHS OF ALLUVIUM

Notes :
1. Survey Date : 16–17/11/2011
2. Survey Grid : HK1980 Grid System
3. Survey Datum : Hong Kong Principal Datum
4. Positioning : C-Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
   Knudsen 320M Echo Sounder
   Klein 3000 Side Scan Sonar System
   R2Sonic Sonic 2024 Multibeam Echo Sounder System
   Seaspy (GSM–19MD) Magnetometer
6. Coastline taken from 1:1,000 Survey Sheets, Survey and Mapping Office, Lands Department

Revision No.	Date	Drawn by	Checked by	Approved by	Remarks
0	30/11/2011	Agnes Siu	Margie Chen	R E Hale	Preliminary

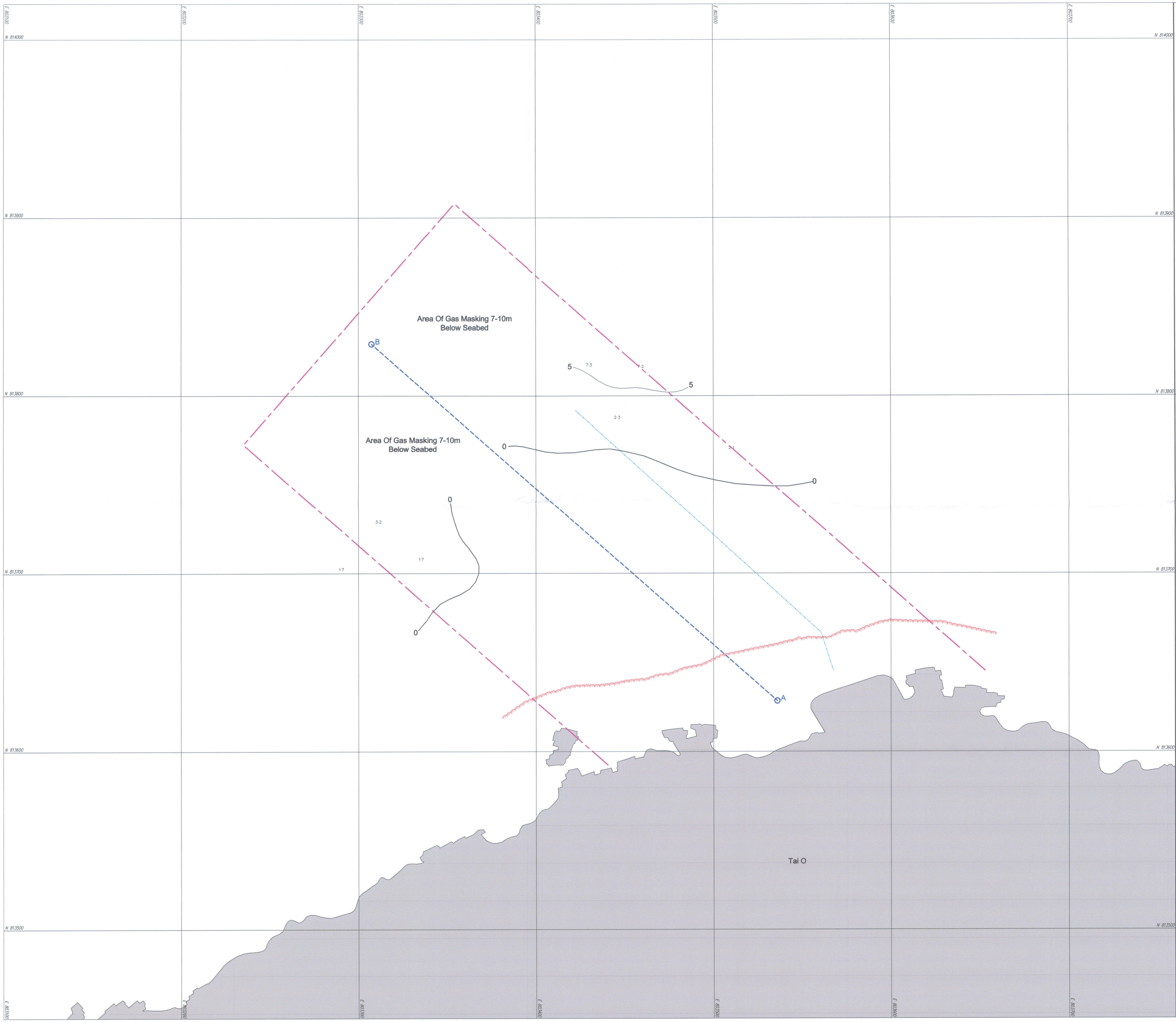
METRIC SCALE 1:1000

50 40 30 20 10 0 50 100

Client : Civil Engineering and Development Department

Surveyor : EGS (ASIA) LIMITED

JOB NO. : HK224611



Legend :

- Isopachs value in metres (Thickness of the layer)
- Contour at 5m interval
- Existing sewage pipe
- Proposed sewage pipe
- Rocky coastline
- Survey boundary

Location Plan

Project :

WORKS ORDER NUMBER GE/2010/02.48A
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UPGRADING OF CHEUNG CHAU AND TAI O SEWAGE COLLECTION, TREATMENT AND DISPOSAL FACILITIES - DESIGN AND CONSTRUCTION
GEOPHYSICAL SURVEY AT TAI O

FIGURE NUMBER : 11

Drawing Title :

CONTOURED ISOPACHS OF HIGHLY TO COMPLETELY DECOMPOSED ROCK

Notes :

1. Survey Date : 16–17/11/2011
2. Survey Grid : HK1980 Grid System
3. Survey Datum : Hong Kong Principal Datum
4. Positioning : C–Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
   Knudsen 320M Echo Sounder
   Klein 3000 Side Scan Sonar System
   R2Sonic Sonic 2024 Multibeam Echo Sounder System
   Seaspy (GSM–19MD) Magnetometer
6. Coastline taken from 1:1,000 Survey Sheets, Survey and Mapping Office, Lands Department

Revision No.	Date	Drawn by	Checked by	Approved by	Remarks
0	30/11/2011	Agnes Siu	Margie Chen	R E Hale	Preliminary

METRIC SCALE 1:1000

50 40 30 20 10 0 50 100

Client : Civil Engineering and Development Department

Surveyor : EGS (ASIA) LIMITED

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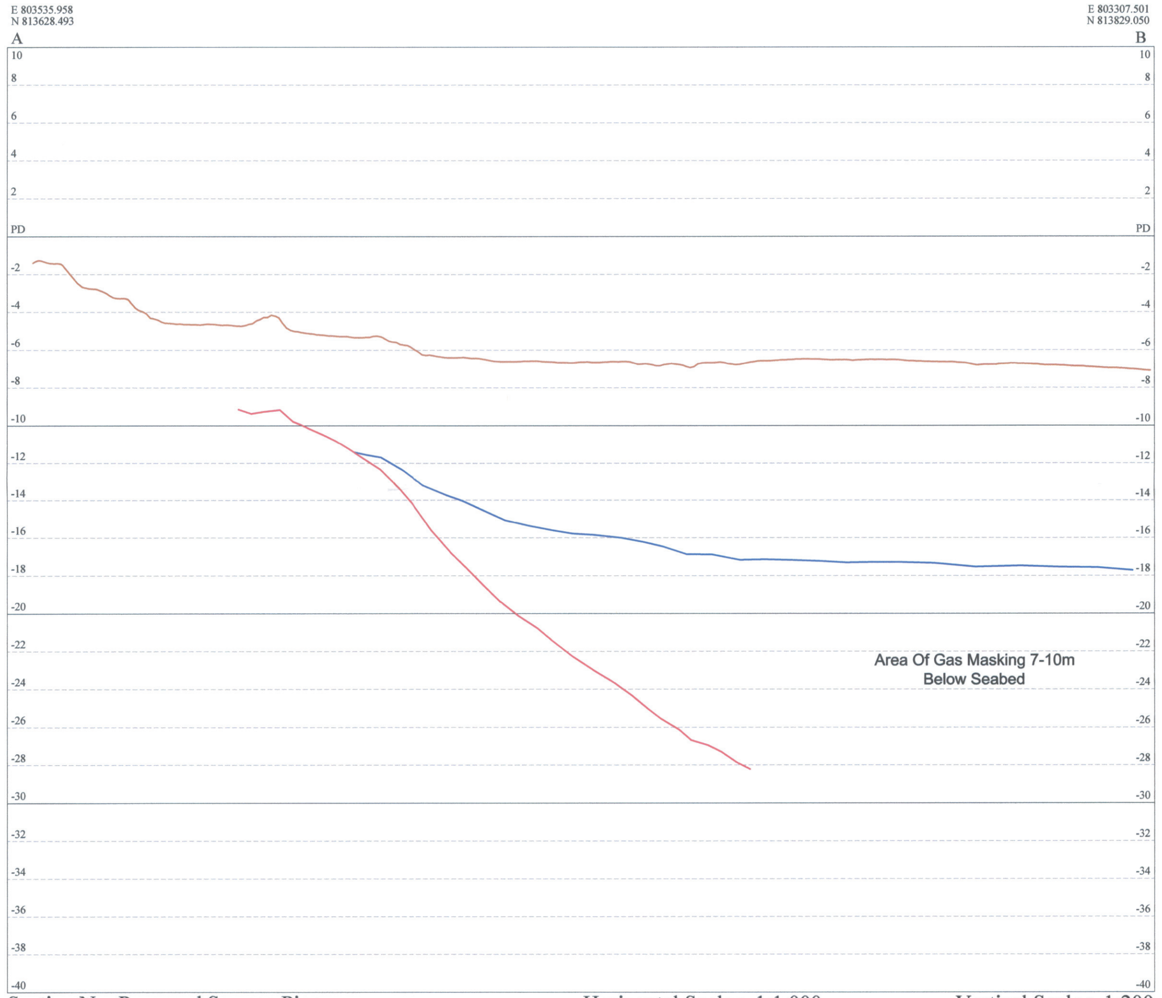
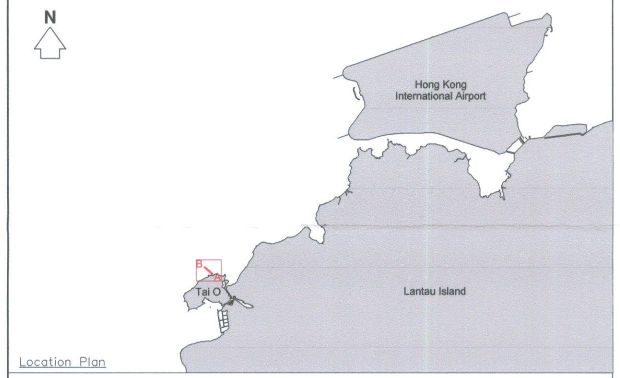


Section No. Proposed Sewage Pipe   Horizontal Scale : 1:1,000   Vertical Scale : 1:200

Legend :

- Seabed
- Base of Marine Deposits
- Top of Grade IV – V ROCK
- Top of Grade III ROCK



Project :

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AGREEMENT NO. CE 15/2010 (DS)
UPGRADING OF CHEUNG CHAU AND TAI O SEWAGE COLLECTION, TREATMENT AND DISPOSAL FACILITIES - DESIGN AND CONSTRUCTION
GEOPHYSICAL SURVEY AT TAI O

FIGURE NUMBER : 12

Drawing Title :

GEOLOGICAL PROFILE ALONG THE PROPOSED SEWAGE PIPE

Notes :

1. Survey Date : 16-17/11/2011
2. Survey Grid : HK1980 Grid System
3. Survey Datum : Hong Kong Principal Datum
4. Positioning : C-Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
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   R2Sonic Sonic 2024 Multibeam Echo Sounder System
   Seaspy (GSM-19MD) Magnetometer
6. Horizontal Scale: 1:1,000
   Vertical Scale : 1:200

Revision No.	Date	Drawn by	Checked by	Approved by	Remarks
0	30/11/2011	Clarence Siu	Margie Chen	R E Hale	Preliminary

METRIC SCALE 1:1000
50 40 30 20 10 0 50 100

Client : Civil Engineering and Development Department

Surveyor : EGS (ASIA) LIMITED
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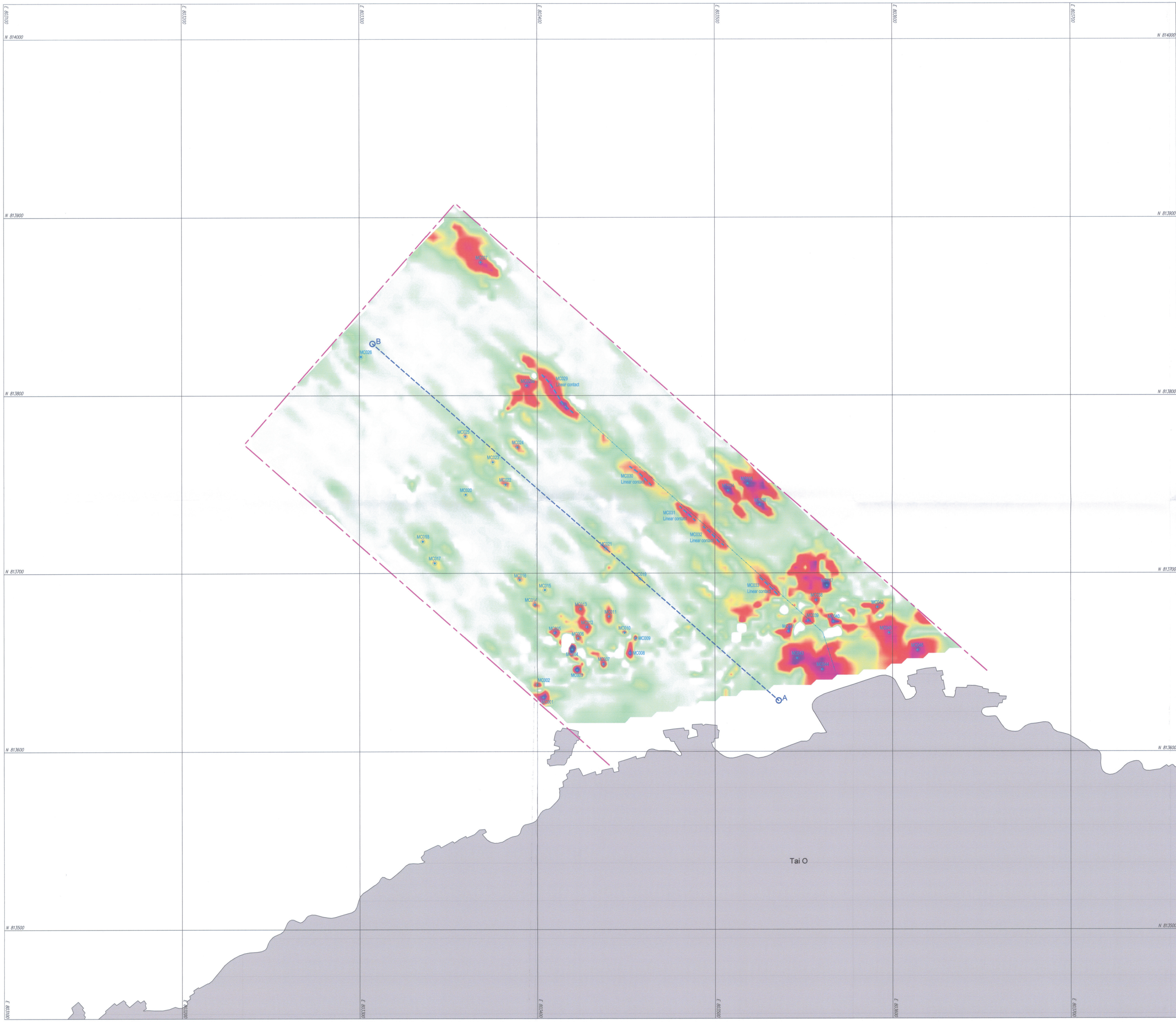
JOB NO. : HK224611



Legend :

- Magnetic contact with reference number
- Linear contact as determined by magnetometer
- Existing sewage pipe
- Proposed sewage pipe
- Survey boundary
- Magnetic track with fix positions

Magnetic Intensity in nanoTesla

0 5 10 15 20 25 30 35 40

Location Plan

Project :

WORKS ORDER NUMBER GE/2010/02.48A
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GEOPHYSICAL SURVEY AT TAI O

FIGURE NUMBER : 13

Drawing Title :

MAGNETIC ANOMALIES PLAN

Notes :

1. Survey Date : 16–17/11/2011
2. Survey Grid : HK1980 Grid System
3. Survey Datum : Hong Kong Principal Datum
4. Positioning : C–Nav GcGPS (Globally corrected GPS)
5. Equipment : EGS Boomer System
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