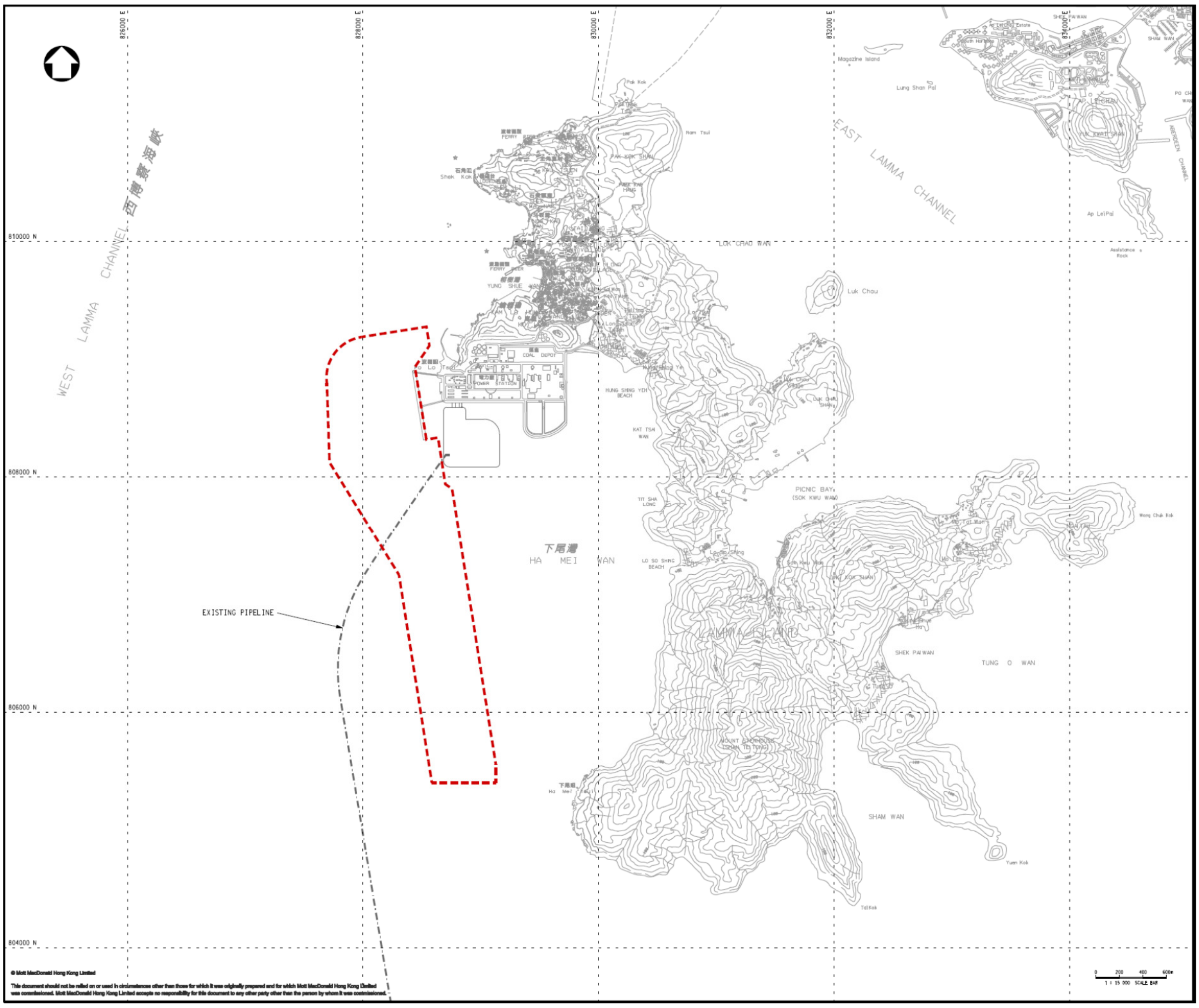
6 Hazard to Life Assessment

6.1 Introduction

6.1.1 Project Background

The Lamma Power Station Navigation Channel (the “Channel”) is located adjacent to the Lamma Power Station (LPS) near the western coast of Lamma Island, as shown in **Figure 1.1**.

Figure 6-1: Location of the Lamma Power Station Navigation Channel



The Channel was originally formed in 1981 to facilitate the delivery of coal to the existing Lamma Power Station by ocean going vessels. As a mainly coal-fired power station that relies on coal-fired units for base load operations, access for ocean going vessels carrying coal to the Lamma Power Station is essential for ensuring the continuity of electricity supply to Lamma and Hong Kong Islands.

In order to maintain safe clearance of these vessels through the Channel, dredging of naturally accumulating sediment in the Channel is required to maintain a minimum depth of the seabed from sea level as specified by the Hong Kong Marine Department. Since 2008, the Hong Kong Marine Department stipulates the current minimum channel depth for marine passage to be no less than -15.5 mCD (approx. -15.65 mPD). To ensure compliance with this minimum depth, dredging works need to be carried out periodically in the Channel. In light of the continued dredging requirement to maintain safe passage throughout the operation of the Channel, an Environmental Impact Assessment (EIA) is required to confirm the environmental acceptability of the continued dredging works.

Based on the preferred options identified in **Section 2.5**, dredging via closed grab dredger and/or trailer suction hopper dredgers would be adopted, and the dredging quantity would be up to approx. 3.2 Mm^3 for construction phase and up to approx. 2.9 Mm^3 for recurring operation phase. Both estimates are dependent on actual accrued siltation rates, while the recurring operation phase dredging quantity is also dependent on the time elapsed since the previous dredging activity.

As the dredging operation will exceed 500,000 m^3, the Project is thus classified as a Designated Project under C.12 of Part I Schedule 2 of the Environmental Impact Assessment Ordinance (EIAO).

6.1.2 Objectives

There is currently one existing submarine natural gas pipeline passing through the Channel where the proposed dredging works will be undertaken. Since the proposed dredging and other associated activity may interfere with the submarine gas pipeline and pose a safety risk to the workers and public working on or navigating through the Channel, the EIA Study Brief (ESB-282/2014) requires that a hazard to life assessment be conducted to qualitatively assess the risks posed by the dredging works.

The objective of the hazard to life assessment is to determine a comprehensive list of foreseeable hazardous scenarios and to determine their initial consequential effects taking full consideration of the existing engineered and operational safeguards. Where the existing control measures are insufficient to mitigate the risk, recommendations will be made.

6.1.3 Scope of Work

Pursuant to Clause 3.4.5 of the EIA Study Brief No. ESB-282/2014, the scopes of the assessment shall include:

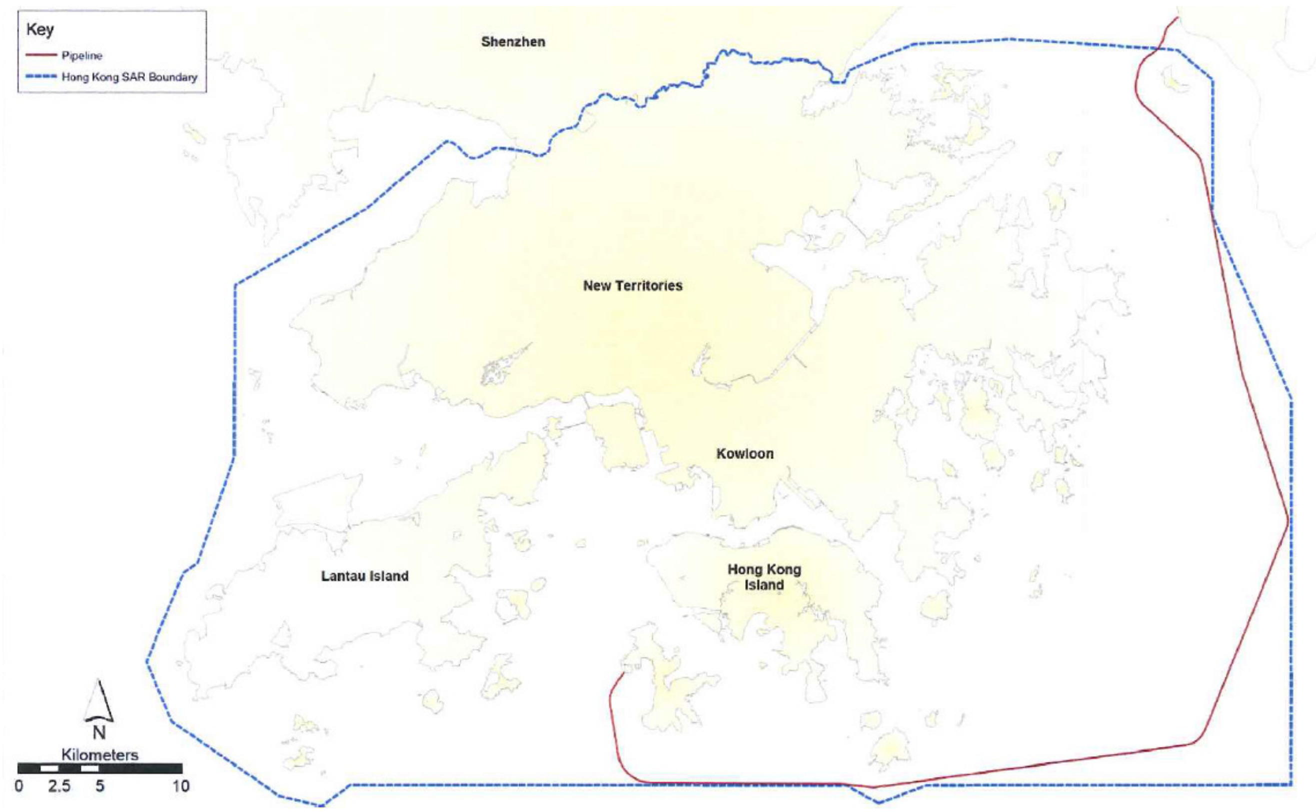
- identifying the possible hazards associated with the dredging works to the public, in particular the potential risks to damage the submarine pipeline during the dredging works; and
- identifying sufficient mitigation measures to minimize the risks posed to the submarine pipeline taking into account the requirements stated in previous risks assessments or EIA for the submarine pipeline.

6.2 Description of Existing Submarine Natural Gas Pipeline

6.2.1 Submarine Natural Gas Pipeline

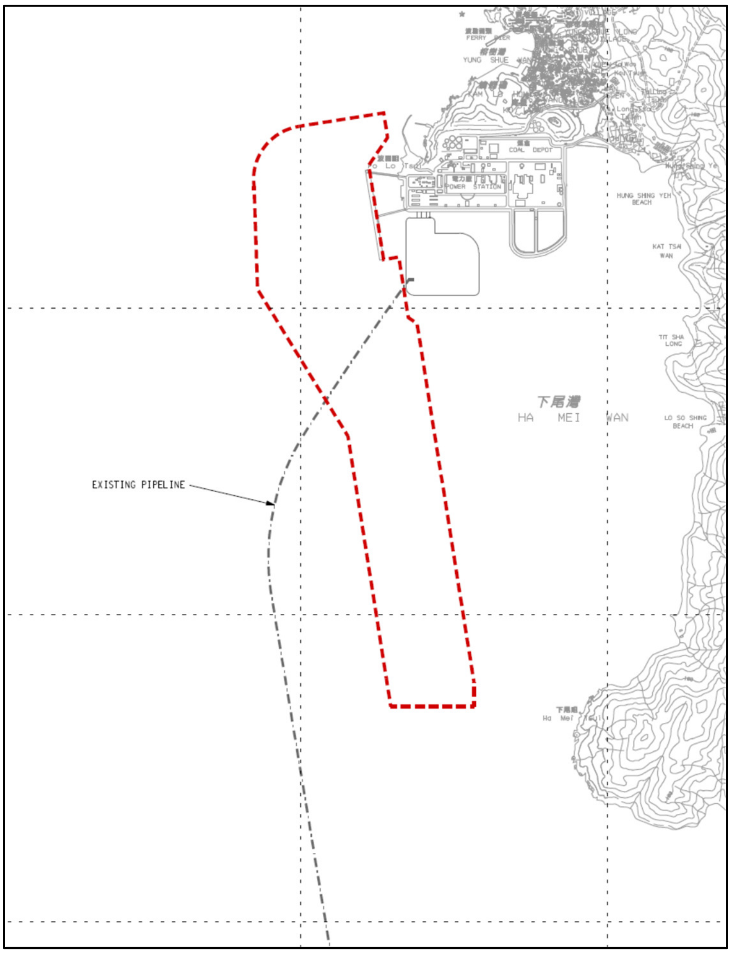
Natural gas is supplied from the Launcher station at LNG terminal at Cheng Tou Jiao of Shenzhen to the Lamma Gas Receiving Station in the Lamma Power Station (LPS) through a submarine pipeline as shown in **Figure 6-2**. The pipeline is made of mild steel (API 5L X65, PSL2) with a maximum operating pressure of 98 barg. The pipeline has an outer diameter of 508 mm and a wall thickness of 12.7mm.

Figure 6-2: Alignment of the Submarine Pipeline



The natural gas pipeline at the LPS transits gradually from onshore to about 3m below the seabed. The submarine natural gas pipeline passes through the Channel near the LPS, as shown in **Figure 6-3**, and extend all the way to the Cheng Tou Jiao Launcher station. For the submarine pipeline passing through the Channel, rock armour is provided for the first 750m of the submarine pipeline from onshore while the rest (i.e. 150m) is covered by coarse sediments only (i.e. no rock armour). In this study, only the section of the pipeline passing through the Channel will be considered.

Figure 6-3: Submarine Pipeline across Lamma Power Station Navigation Channel



6.2.2 Physical Properties of Natural Gas

Natural gas is mainly composed of methane (≥ 84 mol%) and is flammable with the lowest flammability limit of 2.5 vol%. The gas is lighter than air as its density at 20°C and at atmospheric pressure is only 0.76kg/m^3. Upon release, the gas from the submarine pipeline will emerge to the surface and rise up to the atmosphere. When the dispersed gas comes across an ignition source (e.g. hot vessel engine) and within the Flammable Limit, it will be ignited.

6.3 Description of Dredging Methods

In this assessment, the two preferred dredging methods as determined in **Section 2.5.2** have been considered, namely Grab Dredging method and Trailing Suction Hopper Dredging method (TSHD). The grab dredger has a clamshell-like grab that can be lowered to the seabed to dredge up the accumulated sediment in the Channel. For TSHD, sediment is sucked up by a suction pipe which is connected to the TSHD. Descriptions about the two dredging methods are provided in the following sections.

6.3.1 Grab Dredging

6.3.1.1 Pre-dredging Works

Before the dredging works take place, the alignment and elevation of the submarine natural gas pipeline will be verified by a surveyor in accordance with the data provided by HK Electric. An anchor exclusion zone will be defined where anchor is not allowed to be dropped within this zone. All relevant data such as the area of the anchor prohibiting zone, the alignment of the submarine natural gas pipeline, etc. are input and highlighted in the dredging grid plan prepared by the surveyor in advance and all operatives on board of the dredging team shall be fully aware of the restriction.

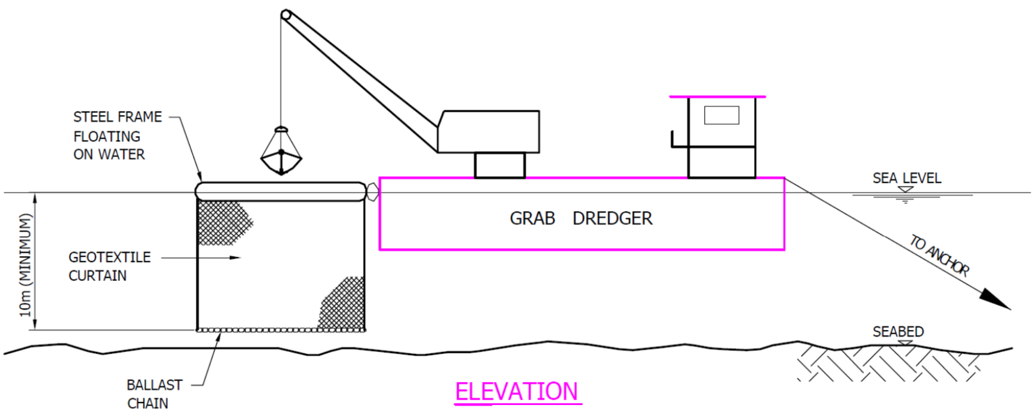
The Clamshell Grab Dredger, as shown in **Figure 6-4**, is non-propelled and will be towed by tug-boat to the work area. After arriving at the work location, the anchors of the dredger will be carried by tug boat to the pre-defined location where they are lowered into the sea. The tug boat is equipped with Differential Global Position System (GPS) to ensure the anchor exclusion zone can be correctly located and with the anchors dropped outside the zone. The locations of the anchors are also indicated by means of floating buoy with proper flashing lighting automatically turned on after sunset. No anchor dropping will be carried out after sunset.

Figure 6-4: Clamshell Grab Dredger

Cage type silt curtain will be set up to surround the dredging area in order to contain the potential spillage of dredged material from the clamshell grab. An example of the silt curtain is shown in **Figure 6-5** and **Figure 6-6**.

Figure 6-5: Cage Type Silt Curtain

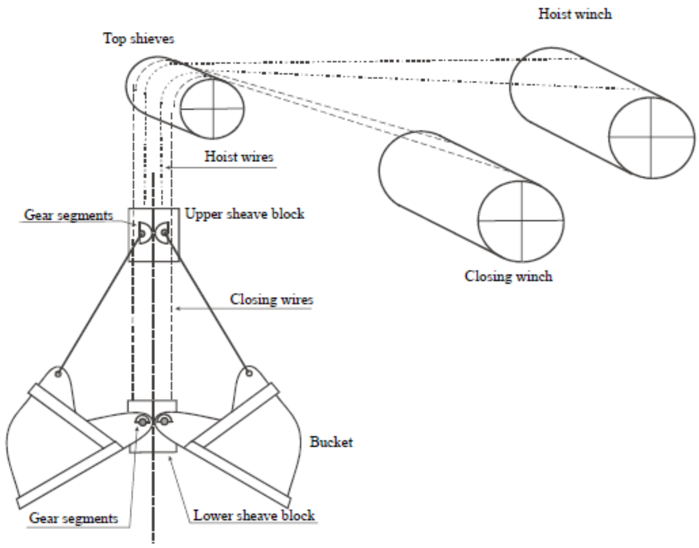
Figure 6-6: Cross-section of Cage Type Silt Curtain Arrangement



6.3.1.2 Operation of Grab Dredger

The dredger begins the dredging operation by lowering the grab, which is shown in **Figure 6-7**, from a designated position above the water level, and dropping to the seabed by gravity. The downward digging force is generated by the weight of the grab. The grab is closed up by tightening the wire cables of the crane. As the grab is closed, the seabed material is sheared up and contained in the bucket compartment. The grab is then withdrawn from the water and swung to an adjacent barge. The material is then released into the barge by opening the sides of the bucket.

Figure 6-7: Clamshell installed in Grab Dredger



GPS antenna is mounted on top of the dredge boom to receive the signal from 4 numbers of satellites and display the exact location of the dredger to the dredger's operating panel.

As the dredger has completed the removal of material to the desired depth at the given location, it is moved to the next location by using winches and anchors' system. When the area governed by the winches and anchor system is completed, the dredger is shifted to the next area by tug boat,that can be monitored by GPS on board.

A tug boat equipped with GPS on board will be allocated next to the dredger when the dredging operation is in progress. It will tow the non-engine barge to dump the dredged material to a designated unloading area after it is fully loaded.

Daily checking of dredged profiles by means of chain sounding or echo sounding will be conducted to minimise the potential overdredge.

6.3.2 Trailing Suction Hopper Dredging

6.3.2.1 Description of TSHD

The TSHD which is shown in **Figure 6-8**, is a self-propelled vessel equipped with a hopper and a dredging system. The hopper is a large container where the sediment is temporarily stored after being drawn in from the seabed, while the dredging system is used to suck up the sediment.

The dredging system consists of a draghead, suction pipe, suction pipe gantries, dredge pump and swell compensator.

The draghead is connected to the suction pipe as shown in **Figure 6-9** and it is considered as the suction mouth of the TSHD. During the dredging operation, the suction pipe is lowered down from the vessel until the draghead reaches the seabed surface. As the draghead is towed on the seabed, the sediment is stirred up and drawn into the suction pipe with the help of a dredge pump. The sucked-up sediment is then transported along the suction pipe and discharged to the hopper.

The suction pipe is swung outboard to the sea by suction pipe gantries. The suction pipe gantries are divided into intermediate gantry and draghead winch gantry. The intermediate gantry controls the movement of the upper part of the suction pipe while the draghead winch gantry controls the lower part of the suction pipe.

The vertical movement of the TSHD or the irregularities of the contour of the seabed affects the contact between the draghead and the seabed. In order to overcome the problem, swell compensator, as shown in **Figure 6-10**, is installed in the draghead winch gantry. The hydraulic system in the swell compensator maintains a constant pressure of the draghead on the seabed and, as a result, keeps a good contact between the draghead and the seabed.

6.3.2.2 Operation of TSHD

Upon arriving at the work area, the speed of the TSHD is reduced to about 3 knots and suction pipes are swung outboard to the sea by the intermediate gantry and the draghead is lowered down by the winch gantry. Dredge pump is switched on when the draghead is positioned onto the seabed. When the draghead is towed along the seabed, the swell compensator reacts by rising of the swell compensator cylinders.

During the dredging, the draghead is dragged over the seabed by the moving TSHD to suck up sediment. The sediment is then transported to the hopper for temporarily storage. When the hopper is full, the dredging is stopped and the suction pipe is lifted up. After that, the TSHD sails to an unloading area for discharging the sediment. Since the TSHD does not dredge on a fixed position, it does not require anchorage system to position the vessel during dredging.

The area to be dredged can be input into an electronic map in advance of the dredging operation and the map is shown on the screen during the dredging. The information about the position, direction and course of the TSHD are automatically shown on the control panel as well.

Figure 6-8: Trailing Suction Hopper Dredger

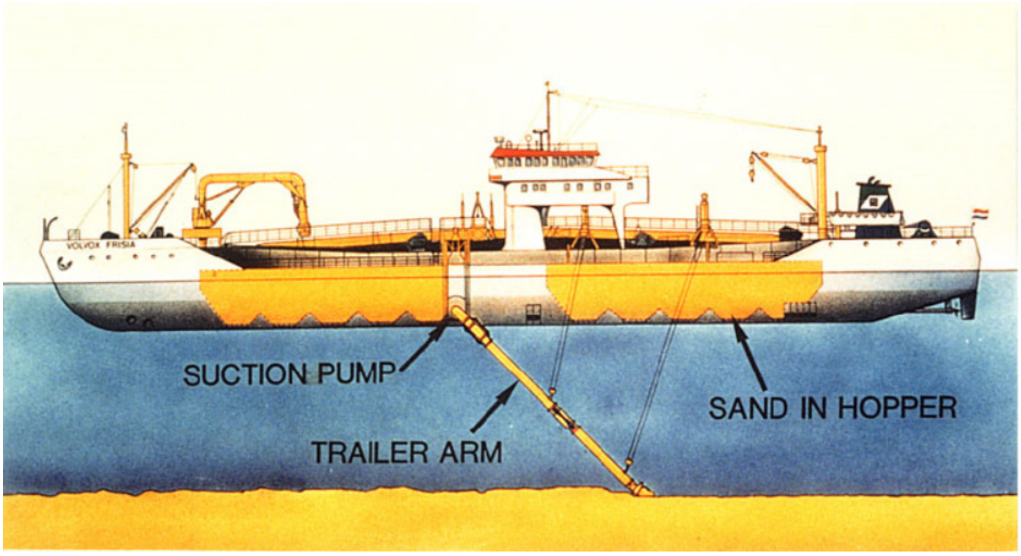


Figure 6-9: Draghead and Suction Pipe

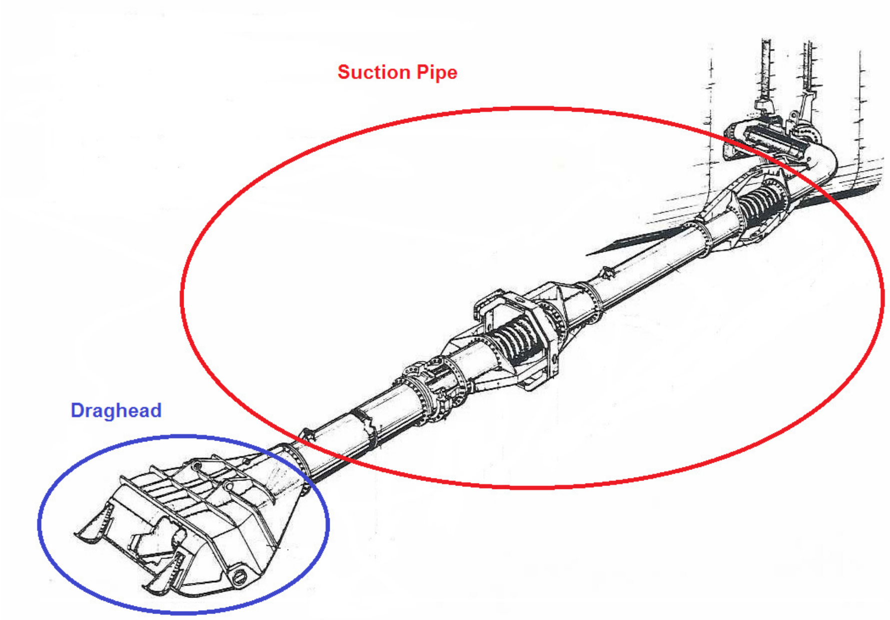
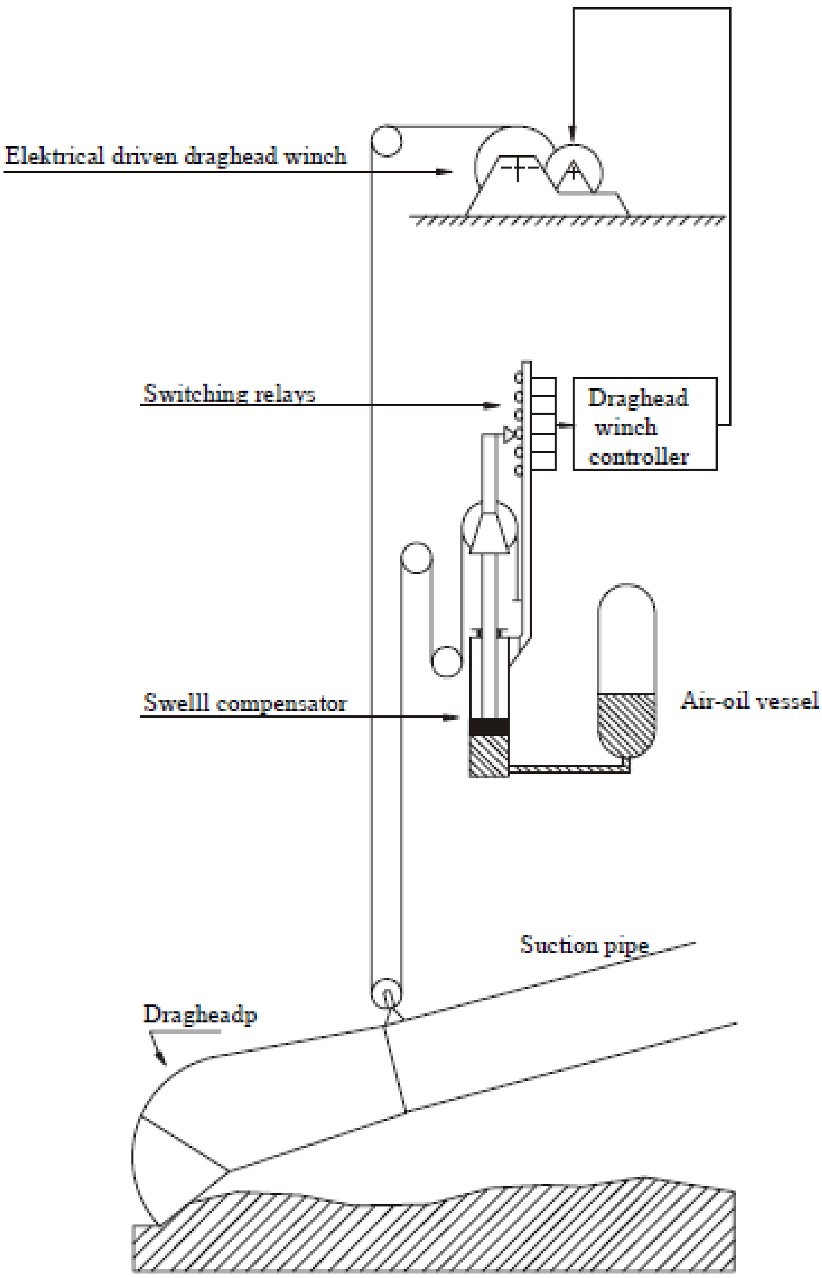


Figure 6-10: Swell Compensator



6.4 Risk Assessment Methodology

6.4.1 Qualitative Risk Assessment Approach

A qualitative risk assessment has been adopted in the current study to identify, in a systematic and comprehensive manner, the hazards associated with the dredging and associated activities to the public in vicinity to the navigation channel and provide an assessment of whether these hazards could result in an unacceptable level of risk. The approach is same as the previously approved Hazard to Life Assessment for the Installation of Submarine Gas Pipelines and Associated Facilities from To Kwa Wan to North Point for Former Kai Tak Airport Development.

The qualitative risk assessment consisting of Hazard Identification, Risk Analysis, Risk Evaluation and Risk Treatment, are described in the following subsections.

6.4.2 Hazard Identification

A desktop review has been conducted to examine both the potential hazardous scenarios and mitigation measures due to the dredging works and associated activities near the submarine gas pipeline. A review of the technical information and method statements in relation to the proposed improvement dredging works has been conducted. Also, the existing safeguards and requirements stated in the previous risk assessment or EIA for the submarine pipeline has been considered when identifying the relevant hazard scenarios. A Hazard Identification workshop has been arranged with the various stakeholders including Hongkong Electric and EIA consultant for verifying the hazardous scenarios identified during the desktop review and to identify new hazards in consideration of the following items:

- Dredging methodology and rates;
- Dredging profile, depth of channel; and
- Frequency and pattern of future phased or staged implementation.

For each of the specific topics, structured ‘what if’ questions have been posed taking full consideration of the operational modes, sub-system functionality and dependencies, and human interactions, to determine if deviations would result in a foreseeable hazardous state. A list of guidewords has been used to help prompt discussions where necessary. All the identified hazards has been documented in worksheets which detail the nature of the hazard, the cause and both the existing and potential mitigation measures.

In order to facilitate the workshop, both Grab Dredging method and TSHD method have been broken down in different stages which are:

Grab Dredging method

1) Arriving/departing of the Grab Dredger/Barge/Tug Boat at the dredging area
2) Deploying anchors by tug boats;
3) Setting up a cage type silt curtain into the sea;

4) Carrying out dredging (i.e. dropping the grab from vessel to the seabed, closing the grab to shear up the sediment at the seabed, lifting up the grab, and transferring the collected sediment to the barge next to the grab dredger);
5) Re-positioning the grab dredger to a new dredging area by winches and anchor's system; and
6) Dumping the sediment from the barge to the designated disposal pit.

<u>TSHD method</u>

1) Arriving/departing of the self-propelled Trailing Suction Hopper Dredger at the dredging area;
2) Lowering suction pipe and draghead to seabed;
3) Carrying out dredging (i.e. switching on dredge pump and navigating the vessel); and
4) Dumping the sediment to a designated disposal pit.

6.4.3 Risk Analysis

Risk analysis is the process of measuring the level of risk exposure to the public posed by the dredging activities in vicinity to the submarine natural gas pipeline. The level of risk exposure is a product of the likelihood of the risk event occurring and its consequence to public.

With reference to the Risk Management User Manual published by the Environment Transport and Works Bureau, the likelihood criteria and consequence criteria as shown in **Table 6-1** and **Table 6-2** has been adopted for the purpose of this qualitative risk assessment. The selection of likelihood and potential consequence for a particular hazard has drawn experience from historical accident records (if any), experience of the participants in the hazard identification workshop, and engineering judgement.

Table 6-1: Likelihood Criteria for the Cause of Incident

Descriptor	Description of Frequency
Rare	May occur in exceptional circumstances (can be assumed not to occur during period of the project)
Unlikely	Event is unlikely to occur, but it is possible during period of the project
Possible	Event could occur during period of the project
Likely	Event likely to occur once or more during period of the project
Frequent	Event occurs many times during period of the project

Table 6-2: Consequence Criteria for the Cause of Incident

Descriptor	Description of Consequence
Insignificant	No injuries
Minor	First aid treatment or out-patients
Moderate	A number of injuries or hospitalisation
Major	Extensive injuries, hospitalisation or long term treatment
Catastrophic	Fatality or significant irreversible effects to a number of persons

6.4.4 Risk Evaluation

The purpose of the risk evaluation is to gain an understanding of the level of risk to facilitate decisions about future actions and to better define priorities. Decisions may include:

- Whether a risk needs treatment;
- Whether an activity should be undertaken; and
- Priorities for treatment.

When the likelihood and consequence for each risk event have been determined, the corresponding risk level can be evaluated by referring to the Risk Analysis Matrix as shown in **Table 6-3**. The matrix has made reference to the Risk Management User Manual published by the Environment Transport and Works Bureau.

Comparison of estimated levels of risk against pre-established criteria will allow the prioritisation of risks for risk treatment and mitigation; and differentiate risks that require active management with those that are considered acceptable and do not require any treatment. The risk evaluation criteria for the current study is shown in **Table 6-4** which has made reference to the Risk Management User Manual published by the Environment Transport and Works Bureau.

Table 6-3: Risk Analysis Matrix

		Consequence				
		Insignificant	Minor	Moderate	Major	Catastrophic
Probability (likelihood)	Rare	Low	Low	Low	Medium	Medium
	Unlikely	Low	Low	Medium	Medium	High
	Possible	Low	Medium	Medium	High	High
	Likely	Medium	Medium	High	High	Very High
	Frequent	Medium	High	High	Very High	Extreme

Table 6-4: Risk Evaluation Criteria

Level of Risk	Recommended Action
Extreme	Immediate senior management attention is needed, action plans must be developed, with clear assignment of individual responsibilities and timeframes.
Very High High	Senior management attention is needed, action plans must be developed, with clear assignment of individual responsibilities and timeframes.
Medium	Risk requires specific ongoing monitoring and review, to ensure level of risk does not increase. Otherwise manage by routine procedures.
Low	Risk can be accepted or ignored. Manage by routine procedures, however, unlikely to need specific application of resources.

6.4.5 Risk Treatment

Following the evaluation process, the risks identified as requiring risk treatment has been clearly identified in the Risk Registers. When considering risk treatment there are a number of options that can be considered, these include:

- Avoiding a risk entirely;
- Transferring or sharing a risk;
- Reducing the probability and / or consequence of the risk; or
- Accepting or retaining the risk.

Action plans has been prepared for those risks that are considered to have “High” to “Extreme” level, they are the formal means to instruct those charged with the responsibility to implement the risk treatment related to the risk in question.

6.5 Review of Previous Risk Assessment for the Submarine Pipeline of the HK Electric

6.5.1 Background of Previous Risk Assessments for the Submarine Pipeline

In 1998, a qualitative risk assessment was conducted, based on the preliminary design information, to identify the potential hazards associated with the construction and operation of the submarine pipeline for the Lamma Power Station. Mitigation measures were recommended in the assessment. All the findings were documented in the EIA Study Report for the 1800MW Gas-fired Power Station at Lamma Extension.

In 2003, a quantitative risk assessment was conducted for the operation of the submarine pipeline. In the assessment, the potential causes of failure of the submarine pipeline were explored. The risk level of the submarine pipeline was evaluated and assessed against the Hong Kong Risk Guidelines. The assessment was further updated in 2011 by HK Electric, and this report is currently the most updated version.

In order to identify the potential risks of dredging works posed onto the submarine pipeline section within the Channel, the previous risk assessments conducted for the construction and operation of submarine pipeline have been reviewed, with a particular focus on the identified causes of failure of the submarine pipelines and the associated mitigation measures. These relevant information formed the basis of the hazard identification workshop conducted for the current study.

The following two reports have been referenced:

1) ERM (1999), EIA for 1800 MV Gas-fired Power Station at Lamma Extension, Volume 2, Part D (The Gas Pipeline).
2) ERM (2011), Lamma Power Station Extension: QRA for Subsea Gas Pipeline.

6.5.2 Potential Causes of Failure of the Submarine Pipeline

Potential causes of failure of the submarine pipeline were identified in the referenced risk assessments. A brief description for each of the causes and its relevance to the current study is provided in the following sections.

6.5.2.1 Anchor Drop

Anchor drop is considered as the dominant cause of failure to the submarine pipeline. It can happen when a vessel's anchor is set off unintentionally or in the event of emergency. If an anchor is dropped and hits the submarine pipeline directly, it can damage the concrete coating, cause a dent or tear open the pipeline. The degree of damage to the submarine pipeline depends on the size of anchor and other factors such as whether the pipeline is buried.

This failure cause is considered relevant to the operation of the dredging works as the dredger or tug boat will have to set off the anchor for mooring inside the Channel.

6.5.2.2 Anchor Drag

Anchor drag happens when an anchor is dragged over some distance after it is dropped from a vessel. Depending on the speed of the vessel and the seabed conditions, the drag distance can be of the order of 200m.

If the submarine pipeline is buried along the anchor drag path, anchor drag may result in localised buckling or denting of the pipeline or over-stressing from bending if the tension on the anchor is sufficient to laterally displace the pipeline. A dragged anchor may also hook onto the pipeline during retrieval and cause damage as a result of lifting the pipeline.

This failure cause is considered relevant to the operation of the dredging works as the dredger will have to set off the anchor for mooring inside the Channel.

6.5.2.3 Anchor Chain Abrasion

Anchor chain abrasion is abrasion of the pipeline or pipeline coating due to the sawing or scraping action of the anchor chains or cables. Abrasion from anchor chains is mostly associated with construction/maintenance barges, which can be anchored for extended periods within the vicinity of the pipelines.

This failure cause is considered not relevant to the operation of the dredging works as the submarine pipeline is either covered by rock armour or laid down 3 m below seabed.

6.5.2.4 Vessel Sinking

A vessel may sink due to various factors such as bad weather conditions, collision or grounding due to loss of power or navigational error. Vessels may also sink due to structural failure, serious fire or explosion. If the sunken vessel impacts the submarine pipeline, it will likely damage the pipeline.

From 1990 to 2005, most of the recorded incidents of vessel sinking occurred in Victoria Harbour and the Ma Wan Channel and involved mainly smaller vessel which will have less impact on the pipeline that is protected by rock armour.

This failure cause is considered relevant to the operation of the dredging works as the dredger may sink under abnormal situation.

6.5.2.5 Dropped Objects

A large object that is insecurely fixed on the vessel may drop into the sea and hit the submarine pipeline. It is considered very unlikely for dropped objects to cause failure to the pipeline if rock armour is provided.

Nevertheless, this failure cause is still considered relevant to the operation of the dredging works as the dredger may have large objects or equipment loosely fixed on the deck during operation.

6.5.2.6 Fishing Activity

Fishing activity such as bottom trawling vessels can pose hazard to the submarine pipeline, by either impact with the pipeline, snagging or pull-over of the trawl gear.

The dredging activities do not involve fishing activities. This failure cause is therefore considered irrelevant to the operation of the dredging activities and it will not be further considered in the current study.

6.5.2.7 Dredging Activity

Dredging operation involving cutting heads may cause damage to the submarine pipelines.

This failure cause is considered relevant to the operation of the dredging works as the clamshell grab used in the Grab Dredging or draghead of TSHD may pose the same impact to the pipeline as that of the cutting heads from other types of dredgers.

6.5.2.8 Corrosion

Corrosion is one of the main contributors to submarine pipeline failure. It can be caused by the environment in which the pipeline is installed and the substance it carries.

This failure cause is considered irrelevant to the operation of the dredging works as it will not change the environment in which the pipeline is installed and the substance it carries. It will, therefore, not be further considered in the current study.

6.5.2.9 Mechanical Failure/Material Defect

Material defect, weld failure etc. are the contributors for this failure cause. Stringent procedures for pipeline material procurement, welding and hydrotesting should effectively mitigate these hazards.

This failure cause is considered irrelevant to the operation of the dredging works as it is the inherent properties of the pipeline, it will not be further considered in the current study.

6.5.2.10 Operational/Maintenance Error

Human error during operation or maintenance of the pipeline, including non-routine or abnormal operations, start-up and shutdown, may result in the loss of integrity of the pipeline.

This failure cause is considered irrelevant to the operation of the dredging works as the operation and maintenance of the submarine pipeline will not be affected by the dredging activities.

6.5.2.11 Construction Damage

During the construction of the submarine pipeline, the pipeline can be directly exposed to the hazards such as dropped object/anchor since it has not yet been covered by rock armour or soil layer. This failure cause was identified in the 2003 QRA study as the pipeline would still be under construction until 2006. However, the pipeline has been in operation since 2006, this failure cause is no longer relevant and has not been considered in the 2011 QRA report.

This failure cause is therefore considered irrelevant to the operation of the dredging works and it will not be further considered in the current study.

6.5.2.12 Natural Hazards

Natural hazards such as subsidence, earthquake and typhoon may cause varying degrees of damage to the pipeline.

This failure cause is not initiated by the operation of the dredging works, but it will indirectly affect the operation and potentially cause the sinking or collision of vessels. Natural hazards will therefore be considered in the current study.

6.5.3 Recommended Mitigation Measures from Previous Assessments

In the 1999 risk assessment study, the following mitigation measures were proposed to mitigate the hazards:

1. To equip the pipeline with concrete weight coating, together with trenching to a depth of 3 m and either backfilling with rock armour or provision of grout mattresses. For risers, protection is usually afforded by suitable location of the riser and if necessary, protection by fenders (for protection against third party damage);
2. To optimize the pipeline routing (for protection against third party damage);
3. To impose navigational restriction (for protection against third party damage);
4. To impose anchoring restriction (for protection against third party damage);
5. To provide an asphalt enamel coating together with cathodic protection using a sacrificial anode (for protection against corrosion);
6. To have a pipeline integrity monitoring system, including inspection and leak detection. Pipeline inspection activities include techniques such as use of "intelligent" pigs (to detect buckles and dents, loss of wall thickness and pipe wall defects) and visual surveys (use of remote-operated vehicles to detect gross movements, scour and free spans, as well as damage to coating and anodes) (for protection against corrosion);
7. To prepare an effective safety management system (for protection against operational and maintenance error); and
8. To have an emergency planning which covers the contingency so that suitable actions can be taken to mitigate the effects of the release on members of the public.

In the 2011 QRA study report, it is stated that further mitigation measure was not required as the risks of all the sections of the submarine pipelines were found to be within the "Acceptable" region.

6.6 Hazard Identification Workshop

A hazard identification workshop was conducted on 8 January 2016 in the Hongkong Electric Centre. The hazard identification adopted Structured What If Technique (SWIFT) to systematically identifying hazards. SWIFT considers deviations from normal operations identified by brainstorming, with questions beginning "What if…?" or "How could….?". The brainstorming is supported by checklists to help avoid overlooking hazards. The workshop was led by an experienced SWIFT chairman with expert inputs from the representatives of HK Electric. An attendance sheet is enclosed in **Appendix 6.1**.

A SWIFT Log Sheet was developed for this project and used to record the proceedings as an integral part of the workshop. All the identified hazards and the associated safeguards were recorded in the SWIFT Log Sheet enclosed in **Appendix 6.2**. Qualitative evaluation of hazards were also included subsequent to the workshop.

6.6.1 Results

For the Grab Dredging method, a total of 30 hazards have been identified, with 13 hazards being ranked in High Risk level while 17 hazards are in Medium Risk level. For the TSHD method, a total of 23 hazards have been identified, with 15 hazards being ranked in High Risk level while 8 hazards are in Medium Risk level. A detailed breakdown of the hazard identification results is show in **Table 6-5** and **Table 6-6** respectively. A summary of the high risk hazards for both the grab dredging method and TSHD method is shown in **Table 6-7** and **Table 6-8** respectively.

Table 6-5: Risk Ranking for SWIFT Log Sheets – Grab Dredging Method

Risk Level	Number of Hazard Items in the Risk Level						Total
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	
Low	0	0	0	0	0	0	0
Medium	8	4	2	1	1	1	17
High	2	1	0	9	1	0	13
Very High	0	0	0	0	0	0	0
Extreme	0	0	0	0	0	0	0

Table 6-6: Risk Ranking for SWIFT Log Sheets – TSHD Method

Risk Level	Number of Hazard Items in the Risk Level				Total
	Stage 1	Stage 2	Stage 3	Stage 4	
Low	0	0	0	0	0
Medium	7	0	0	1	8
High	3	4	8	0	15
Very High	0	0	0	0	0
Extreme	0	0	0	0	0

Table 6-7: Summary of Hazards in High Risk Level – Grab Dredging Method

Hazard Ref.	Hazard Description	Possible Consequence	Existing Safeguards
G1-001-02	Anchor drops from working vessel (i.e. grab dredger/barge/tug boat) to the seabed un-intentionally when it is near the submarine pipeline without rock armour (e.g. due to mechanical failure or human error)	Damage to submarine pipeline, loss of containment, release of natural gas, potential subsequent ignition.	1. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage 2. Non anchor zone of 100 m from both sides of the submarine pipeline will be applied and enforced.
G1-005-02	Large object drops from the working vessel near the submarine pipeline without rock armour	Damage to submarine pipeline, loss of containment, release of natural gas, potential subsequent ignition.	1. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage 2. Large and moveable objects or equipment will have to be tightly secured on the working vessel by lashing.

Hazard Ref.	Hazard Description	Possible Consequence	Existing Safeguards
G2-001-02	Dropping anchor right above the submarine pipeline, without rock armour, mistakenly during anchor deployment (e.g. due to human error)	Damage to submarine pipeline, loss of containment, release of natural gas, potential subsequent ignition.	1. Before the dredging works is started, an anchor exclusion zone will be pre-designed and agreed by the Engineer. All relevant data will be input into the GPS by surveyor. 2. During anchoring, the tugboat masters will make use of the GPS on board of tug boat to assure the anchor dropping point is exactly within the designated anchorage area. 3. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 4. Procedure to enforce anchoring is not allowed inside the anchor exclusion zone.
G4-001-01	Strong impact force from the grab to the seabed in close proximity of the submarine pipeline with rock armour, due to free falling of the grab from above seawater.	Damage to submarine pipeline, loss of containment, release of natural gas, potential subsequent ignition.	1. Differential Global Position System antenna (DGPS) will be mounted on top of the dredge boom (at the dredger) to receive the signal from satellites and the exact location will be displayed at the screen for the dredger operator's guidance. 2. Rock armour of about 2.0 m thick is provided along the submarine pipeline inside the Channel for an overall length of 730m. 3. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 4. The as-built record of alignment and elevation of the submarine pipeline will be provided by the HK Electric and the record will be reviewed by the Engineer and Contractor. 5. The location of the submarine pipeline will be highlighted at the dredging grid plan and all operatives on board of the dredging team will be fully aware of their existence. 6. The dredger operator will hold the grab by braking system to a level limit without reaching the submarine pipeline.
G4-001-02	Strong impact force from the grab to the seabed in close proximity of the submarine pipeline without rock armour, due to free falling of the grab from above seawater.	Damage to submarine pipeline, loss of containment, release of natural gas, potential subsequent ignition.	1. Differential Global Position System antenna (DGPS) will be mounted on top of the dredge boom (at the dredger) to receive the signal from satellites and the exact location will be displayed at the screen for the dredger operator's guidance. 2. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 3. The as-built record of alignment and elevation of the submarine pipeline will be provided by the HK Electric and the record will be reviewed by the Engineer and Contractor. 4. The location of the submarine pipeline will be highlighted at the dredging grid plan and all operatives on board of the dredging team will be fully aware of their existence. 5. The dredger operator will hold the grab by braking system to a level limit without reaching the submarine pipeline.

Hazard Ref.	Hazard Description	Possible Consequence	Existing Safeguards
G4-002-01	Free falling of the grab to the seabed right above the submarine pipeline with rock armour due to broken wire cable of the grab hoisting system.	Damage to submarine pipeline, loss of containment, release of natural gas, potential subsequent ignition.	1. Rock armour of about 2.0 m thick is provided along the submarine pipeline inside the Channel for an overall length of 730m. 2. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 3. Floating plant shall be maintained by the Contractor in a satisfactory and seaworthy condition, and shall have adequate attendance by competent seamen at all times. The plant shall be fully provided with sound and satisfactory ropes, lines and moorings and shall be fully equipped with lights.
G4-002-02	Free falling of the grab to the seabed right above the submarine pipeline without rock armour due to broken wire cable of the grab hoisting system.	Damage to submarine pipeline, loss of containment, release of natural gas, potential subsequent ignition.	1. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 2. Floating plant shall be maintained by the Contractor in a satisfactory and seaworthy condition, and shall have adequate attendance by competent seamen at all times. The plant shall be fully provided with sound and satisfactory ropes, lines and moorings and shall be fully equipped with lights.
G4-003-01	Some rocks will be removed from the rock armour for the submarine pipeline, due to over dredging near the submarine pipeline with rock armour.	Weakening the protection and possible damage to the submarine pipeline. Loss of containment, release of natural gas, potential subsequent ignition.	1. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 2. Chain sounding or echo sounding will be conducted during trial run by the Contractor to check the dredged profile in order to ensure over-dredging will not happen when the dredging works is near the submarine pipeline. 3. The dredger operator will hold the grab in around 100 mm layer by layer approaching from existing seabed to the final design level. 4. The dredger operator will hold the grab by braking system to a level limit without any over-dredge allowance.
G4-003-02	Movement of alluvium on seabed due to over dredging near the submarine pipeline without rock armour	Damage to submarine pipeline, loss of containment, release of natural gas, potential subsequent ignition.	1. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 2. Chain sounding or echo sounding will be conducted during trial run by the Contractor to check the dredged profile in order to ensure over-dredging will not happen when the dredging works is near the submarine pipeline. 3. The dredger operator will hold the grab in around 100 mm layer by layer approaching from existing seabed to the final design level. 4. The dredger operator will hold the grab by braking system to a level limit without any over-dredge allowance.

Hazard Ref.	Hazard Description	Possible Consequence	Existing Safeguards
G4-004-01	Dredger being carried away from the original location to right above the submarine pipeline with rock armour, due to tidal conditions or strong sea current.	The downward force of the free-falling grab causes damage to the pipeline. Loss of containment, release of natural gas, potential subsequent ignition.	1. At least four anchors will be deployed to fix the position of the dredger. 2. Differential Global Position System antenna (DGPS) will be mounted on top of the dredge boom (at the dredger) to receive the signal from satellites and the exact location will be displayed at the screen for the dredger operator's guidance. 3. Rock armour of about 2.0 m thick is provided along the submarine pipeline inside the Channel for an overall length of 730 m. 4. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 5. The as-built record of alignment and elevation of the submarine pipeline will be provided by the HK Electric and the record will be reviewed by the Engineer and Contractor. 6. The location of the submarine pipeline will be highlighted at the dredging grid plan and all operatives on board of the dredging team will be fully aware of their existence. 7. Dredging works performed at close proximity to the submarine pipeline shall be performed in day time.
G4-004-02	Dredger being carried away from the original location to right above the submarine pipeline without rock armour, due to tidal conditions or strong sea current.	The downward force of the free-falling grab causes damage to the pipeline. Loss of containment, release of natural gas, potential subsequent ignition.	1. At least four anchors will be deployed to fix the position of the dredger. 2. Differential Global Position System antenna (DGPS) will be mounted on top of the dredge boom (at the dredger) to receive the signal from satellites and the exact location will be displayed at the screen for the dredger operator's guidance. 3. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 4. The as-built record of alignment and elevation of the submarine pipeline will be provided by the HK Electric and the record will be reviewed by the Engineer and Contractor. 5. The location of the submarine pipeline will be highlighted at the dredging grid plan and all operatives on board of the dredging team will be fully aware of their existence. 6. Dredging works performed at close proximity to the submarine pipeline shall be performed in day time.
G4-005	Excessive stressing on seawall structure due to dredging operation	Collapse of seawall structure in vicinity to the pipeline. Loss of containment, release of natural gas, potential subsequent ignition.	-

Hazard Ref.	Hazard Description	Possible Consequence	Existing Safeguards
G5-001-02	Not all the anchors of the dredger have been lifted up from the seabed before the dredger is relocated by tug boat (e.g. due to human error) near the submarine pipeline without rock armour	The anchor is dragged over the seabed. Loss of containment, release of natural gas, potential subsequent ignition.	1. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 2. Non anchor zone of 100 m from both side of the submarine pipeline will be applied.

Table 6-8: Summary of Hazards in High Risk Level – TSHD Method

Hazard Ref.	Hazard Description	Possible Consequence	Existing Safeguards
T1-001-02	Anchor drops from working vessel (i.e. TSHD) to the seabed un-intentionally when it is near the submarine pipeline without rock armour (e.g. due to mechanical failure or human error)	Damage to the submarine pipeline, loss of containment, release of natural gas, potential subsequent ignition.	1. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 2. Non anchor zone of 100 m from both sides of the submarine pipeline will be applied and enforced. 3. The TSHD will only be allowed to moor outside the Channel, no anchoring is required during dredging operation.
T1-005-02	Large object drops from the working vessel near pipeline without rock armour	Large object sinks to the seabed and causes damage to the submarine pipeline. Loss of containment, release of natural gas, potential subsequent ignition.	1. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 2. Large and moveable objects or equipment will have to be tightly secured on the working vessel by lashing.
T1-007	Collision of the working vessels with the section of the submarine pipeline transitting from onshore to the seabed as they are in the close proximity to the seawall of Lamma Power Plant	Damage to the submarine pipeline, loss of containment, release of natural gas, potential subsequent ignition.	1. The section of pipeline rising from seabed to onshore is embedded inside the slipway and covered by armour rocks, not being exposed. 2. The project site boundary will be marked with flags, marker buoys and lights in accordance with the International Association of Lighthouse Authorities Maritime Buoyage System. 3. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure drop sensor, to minimize the gas leakage. 4. THSD will be equipped with twin propulsion engines to avoid losing all propulsion force.

Hazard Ref.	Hazard Description	Possible Consequence	Existing Safeguards
T2-001-01	The suction pipe may be lowered to the seabed in an un-controlled manner, due to breakage of intermediate gantry wire/ draghead winch gantry wire upon lowering the suction pipe.	Damage to the submarine pipeline with rock armour, loss of containment, release of natural gas, potential subsequent ignition.	1. Rock armour of about 2.0 m thick is provided along the submarine pipeline inside the Channel for an overall length of 730 m. 2. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 3. Floating plant shall be maintained by the Contractor in a satisfactory and seaworthy condition, and shall have adequate attendance by competent seamen at all times. The plant shall be fully provided with sound and satisfactory ropes, lines and moorings and shall be fully equipped with lights.
T2-001-02	The suction pipe may be lowered to the seabed in an un-controlled manner, due to breakage of intermediate gantry wire/ draghead winch gantry wire upon lowering the suction pipe.	Damage to the submarine pipeline without rock armour, loss of containment, release of natural gas, potential subsequent ignition.	1. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 2. Floating plant shall be maintained by the Contractor in a satisfactory and seaworthy condition, and shall have adequate attendance by competent seamen at all times. The plant shall be fully provided with sound and satisfactory ropes, lines and moorings and shall be fully equipped with lights.
T2-002-01	Draghead is dragged across the submarine pipeline and hook up the pipeline due to suction pipe and draghead are unable to be retrieved back to the TSHD due to winch failure	Damage to the submarine pipeline with rock armour, loss of containment, release of natural gas, potential subsequent ignition.	1. Rock armour of about 2.0 m thick is provided along the submarine pipeline inside the Channel for an overall length of 730 m. 2. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 3. Floating plant shall be maintained by the Contractor in a satisfactory and seaworthy condition, and shall have adequate attendance by competent seamen at all times. The plant shall be fully provided with sound and satisfactory ropes, lines and moorings and shall be fully equipped with lights. 4. TSHD shall manoeuvre away from the submarine pipeline in case the draghead cannot be retrieved back to the TSHD. 5. The path of the TSHD dredging operation will be designed to be in parallel with the submarine pipeline alignment.
T2-002-02	Draghead is dragged across the submarine pipeline and hook up the pipeline due to suction pipe and draghead are unable to be retrieved back to the TSHD due to winch failure	Damage to the submarine pipeline without rock armour, loss of containment, release of natural gas, potential subsequent ignition.	1. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 2. Floating plant shall be maintained by the Contractor in a satisfactory and seaworthy condition, and shall have adequate attendance by competent seamen at all times. The plant shall be fully provided with sound and satisfactory ropes, lines and moorings and shall be fully equipped with lights. 3. TSHD shall manoeuvre away from the submarine pipeline in case the draghead cannot be retrieved back to the TSHD. 4. The path of the TSHD dredging operation will be designed to be in parallel with the submarine pipeline alignment.

Hazard Ref.	Hazard Description	Possible Consequence	Existing Safeguards
T3-001-01	Draghead is stuck with the rock armour/ seabed while the TSHD is moving	The suction pipe breaks or the rocks are dislocated from the rock armour causing damage to the submarine pipeline with rock armour.	1. Rock armour of about 2.0 m thick is provided along the submarine pipeline inside the Channel for an overall length of 730m. 2. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 3. The path of the TSHD dredging operation will be designed to be in parallel with the submarine pipeline alignment.
T3-001-02	Draghead is stuck with the seabed while the TSHD is moving	Suction pipe is pulled by the moving TSHD, the suction pipe breaks, causing damage to the submarine pipeline without rock armour	1. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 2. The path of the TSHD dredging operation will be designed to be in parallel with the submarine pipeline alignment.
T3-002-01	A constant pressure exerted by the draghead on the seabed cannot be maintained, due to failure of compensator near the submarine pipeline with rock armour.	A constant pressure exerted by the draghead on the seabed cannot be maintained, larger pressure is applied causing damage to the submarine pipeline.	1. Rock armour of about 2.0 m thick is provided along the submarine pipeline inside the Channel for an overall length of 730 m. 2. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 3. Floating plant shall be maintained by the Contractor in a satisfactory and seaworthy condition, and shall have adequate attendance by competent seamen at all times. The plant shall be fully provided with sound and satisfactory ropes, lines and moorings and shall be fully equipped with lights.
T3-002-02	A constant pressure exerted by the draghead on the seabed cannot be maintained, due to failure of compensator happening near the submarine pipeline without rock armour.	A constant pressure exerted by the draghead on the seabed cannot be maintained, larger pressure is applied causing damage to the submarine pipeline.	1. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 2. Floating plant shall be maintained by the Contractor in a satisfactory and seaworthy condition, and shall have adequate attendance by competent seamen at all times. The plant shall be fully provided with sound and satisfactory ropes, lines and moorings and shall be fully equipped with lights.

Hazard Ref.	Hazard Description	Possible Consequence	Existing Safeguards
T3-003-01	Dislocate the rocks in the rock armour for the submarine pipeline, due to over dredging near the submarine pipeline with rock armour.	Weakening the protection and possible damage to the submarine pipeline. Loss of containment, release of natural gas, potential subsequent ignition.	1. Electronic sensors will be installed in the dragheads to provide continuous monitoring of the dredging depth. An alarm will be activated if the dredging depth is lower than the pre-set level. 2. TSHD is equipped with compensator which provides compensation for the vertical movement of the suction pipe. 3. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor to minimize the gas leakage. 4. Chain sounding or echo sounding will be conducted during trial run by the Contractor to check the dredged profile in order to ensure over-dredging will not happen when the dredging works is near the submarine pipeline.
T3-003-02	Dislocate the rocks in the rock armour for the submarine pipeline, due to over dredging near the submarine pipeline without rock armour.	Movement of alluvium on seabed, loss of localised support to the submarine pipeline causing high stress. Loss of containment, release of natural gas, potential subsequent ignition.	1. Electronic sensors will be installed in the dragheads to provide continuous monitoring of the dredging depth. An alarm will be activated if the dredging depth is lower than the pre-set level. 2. TSHD is equipped with compensator which provides compensation for the vertical movement of the suction pipe. 3. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 4. Chain sounding or echo sounding will be conducted during trial run by the Contractor to check the dredged profile in order to ensure over-dredging will not happen when the dredging works is near the submarine pipeline.
T3-004-01	Draghead is dragged across the submarine pipeline due to suction pipe is unable to be retrieved back to the TSHD upon completion of dredging works near the submarine pipeline with rock armour (e.g. breakage of intermediate gantry wire/draghead winch gantry wire)	Damage to the submarine pipeline, loss of containment, release of natural gas, potential subsequent ignition.	1. Rock armour of about 2.0 m thick is provided along the submarine pipeline inside the Channel for an overall length of 730 m. 2. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 3. Floating plant shall be maintained by the Contractor in a satisfactory and seaworthy condition, and shall have adequate attendance by competent seamen at all times. The plant shall be fully provided with sound and satisfactory ropes, lines and moorings and shall be fully equipped with lights. 4. TSHD shall manoeuvre away from the submarine pipeline in case the draghead cannot be retrieved back to the TSHD. 5. The path of the TSHD dredging operation will be designed to be in parallel with the submarine pipeline alignment.

Hazard Ref.	Hazard Description	Possible Consequence	Existing Safeguards
T3-004-02	Draghead is dragged across the submarine pipeline due to suction pipe is unable to be retrieved back to the TSHD upon completion of dredging works near the submarine pipeline without rock armour (e.g. breakage of intermediate gantry wire/draghead winch gantry wire)	Damage to the submarine pipeline, loss of containment, release of natural gas, potential subsequent ignition.	1. The submarine pipeline will be shut down by operator in case of a large release of natural gas is detected by inline pressure sensor, to minimize the gas leakage. 2. Floating plant shall be maintained by the Contractor in a satisfactory and seaworthy condition, and shall have adequate attendance by competent seamen at all times. The plant shall be fully provided with sound and satisfactory ropes, lines and moorings and shall be fully equipped with lights. 3. TSHD shall manoeuvre away from the submarine pipeline in case the draghead cannot be retrieved back to the TSHD. 4. The path of the TSHD dredging operation will be designed to be in parallel with the submarine pipeline alignment.

6.6.2 Recommendations of Risk Mitigation Measures

The following recommendations, in addition to the existing engineering measures and procedural controls, have been explored during the workshop and for ease of reference, these recommendations are grouped for each stage.

6.6.2.1 Grab Dredging

<u>Stage 1: Arriving/departing of the Grab Dredger/Barge/Tug Boat at the dredging area</u>

- Recommend the Engineer (as hired by HK Electric to manage the dredging works) to send a foreman, who is independent of the Contractor (i.e. dredging operator), to check and confirm all anchors are secured in position before the working vessels are allowed to travel inside the non-anchor zone.
- Recommend to provide a buoy for anchor location and possibly to provide buoys above submarine pipeline alignment.
- Recommend the Contractor to avoid the working vessel travelling after sunset or under low visibility when the works area is near the submarine pipeline.
- Recommend the Contractor to check the weather information from Marine Department before deploying the vessel to the dredging zone.
- Recommend the Contractor to deploy a guard boat to alert third party vessel not to travel inside the dredging works area.
- Recommend the Contractor to avoid the working vessel traveling during berthing and unberthing of coal vessel.
- Recommend the Contractor to consider the preliminary coal vessel shipping plan provided by HK Electric when scheduling the programme of the dredging works.
- Recommend the Engineer (as hired by HK Electric to manage the dredging works) to send a foreman, who is independent of the Contractor (i.e. dredging operator), to check and confirm that all large and

moveable objects must be tightly secured on the dredger by lashing, before it is allowed to travel inside the non-anchor zone. The condition of the lashing will be checked daily when the dredger is near the submarine pipeline and under adverse weather such as typhoon, strong monsoon, and rough sea condition.

- Recommend vessel owners use electrical appliance for cooking and smoking onboard is not allowed when the dredging works is within non-anchoring zone.
- Recommend vessel owners to store dangerous goods in an explosion proof cabinet, if any, according to the statutory requirements at all times.
- Recommend the Engineer (as hired by HK Electric to manage the dredging works) to send a foreman, who is independent of the Contractor (i.e. dredging operator), to check and confirm if the dredger maintains an enough separation distance with the seawall of Lamma Power Plant, every time it approaches near the seawall or needs to be relocated with anchor withdrawn.
- Recommend the Contractor to check any loosen of anchoring system on board regularly to avoid drifting of the working vessel towards slipway of gas pipeline.
- Recommend the Contractor to prepare and submit an Emergency Response Plan (ERP) to cater for drifting of working vessel to Engineer for review. The ERP provides the necessary safety actions required to avoid or minimize the impact of jetty facilities and submarine gas pipeline.
- Recommend the foreman to ensure the visibility is good before the working vessel travels near the seawall in each time.
- Recommend the Engineer to provide an indicator (e.g. flashing lamp) onshore at the point where the pipeline transits from onshore to seabed. The indicator should be able to be clearly seen from the working vessel's cabin at distance.
- Recommend the Engineer to impose a safe traveling speed to the working vessels when they are traveling or working near the seawall.
- Recommend the Engineer (as hired by the HK Electric to manage the dredging works) to request the Contractor (i.e. dredging operator) to provide maintenance records of the working vessel.
- Recommend the working vessel not to stay right above the submarine pipeline unless it is necessary.

<u>Stage 2: Deploying anchors by tug boats</u>

- Recommend the Engineer (as hired by HK Electric to manage the dredging works) to send a foreman, who is independent of the Contractor (i.e. dredging operator), to double-check if the anchor dropping point is within the designated anchorage area, before the anchor is dropped into the sea.
- Recommend the Engineer to verify the accuracy of all GPS/DGPS system.
- Recommend the tug boat to travel at a low speed in each time the anchor is placed on the tug boat. This allows the tugboat master to react for emergency.
- Recommend the Engineer and Contractor to check the length of anchor chain is sufficient to cover the non-anchor zone area and double check the anchorage location with respect to the length of anchor before dropping of anchor.
- Recommend the Contractor to deploy a guard boat to monitor the separation distance between the anchor chain and other incoming vessel.
- Recommend the Contractor to observe tidal conditions and sea current in the work area and take precautionary measures as necessary to enable safe working conditions.

- Recommend the Contractor to check any loosen of anchoring system on board regularly to avoid drifting of the working vessel towards jetty or slipway of gas pipeline.
- Recommend the Contractor to prepare and submit an Emergency Response Plan (ERP) to cater for drifting of working vessel to Engineer for review. The ERP provides the necessary safety actions required to avoid or minimize the impact of jetty facilities and submarine gas pipeline.

Stage 3: Setting up a cage type silt curtain into the sea

- Recommend the Contractor to check the depth of the seabed and maintain the bottom of the silt curtain to be above the seabed.

Stage 4: Carrying out dredging (i.e. dropping the grab from vessel to the seabed, closing the grab to shear up the sediment at the seabed, lifting up the grab, and transferring the collected sediment to the barge next to the grab dredger)

- Recommend the Engineer (as hired by HK Electric to manage the dredging works) to send a diver to the seabed to locate the point where the pipeline transits from the section with rock armour to that without rock armour.
- Recommend the Engineer (as hired by HK Electric to manage the dredging works) to put buoys in the sea to indicate the transition point.
- Recommend the Engineer (as hired by HK Electric to manage the dredging works) to send a foreman, who is independent of the Contractor (i.e. dredging operator), to verify if the dredger is near or right above the submarine pipeline every time the dredger arrives at the project site boundary or when it needs to be relocated.
- When the dredger is in close proximity of the submarine pipeline, it is recommended to prohibit the Contractor to allow free-falling of the grab when the dredging works is taken place near the submarine pipeline. The grab will always be lowered slowly to the seabed. The foreman should regularly check if this prohibition is followed.
- Recommend to have a trial run for the dredging works when it is conducted right above and in close proximity of the submarine pipeline. An established communication network should be maintained between the dredger's operator, the foreman, the Engineer and HK Electric during the trial run.
- Recommend the Engineer (as hired by HK Electric to manage the dredging works) to verify the accuracy of the GPS/DGPS system before the dredging works is started.
- Recommend operator to regularly monitor the pressure fluctuation in the submarine pipeline during the dredging works near the pipeline.
- Recommend to use a much smaller grab for dredging works with control movement near the submarine pipeline.
- The type of grab (e.g. size, weight) used for the dredging works near the submarine pipeline has to be reviewed by the Engineer, taking the design of the rock armour into account, before the dredging works is started.
- When the dredging is getting close to the submarine pipeline without rock armour, the type of grab (e.g. size, weight) used for the dredging works has to be reviewed by the Engineer, better to conservatively assume rock armour is not present.

- Recommend the foreman to confirm that only the type of grab approved by the Engineer is installed in the dredger before the dredging works is started near the submarine pipeline.
- Recommend the grab is retrieved back to inside the dredger after the completion of dredging works in each working day.
- Recommend the Engineer (as hired by the HK Electric to manage the dredging works) to request the Contractor (i.e. dredging operator) to provide maintenance records and valid examination certificates of lifting appliances and lifting gears to ensure that all lifting facilities on board are in good order.
- Recommend the Engineer (as hired by the HK Electric to manage the dredging works) to have a visual examination of the integrity of the wire cable of the grab hoisting system before dredging is allowed to move near the submarine pipeline without rock armour.
- Recommend the Contractor (i.e. dredging operator) to prepare a method statement for dredging works in close proximity of the submarine pipeline. In the method statement, the measurement technique and frequency have to be specified to ensure the dredged profile can be measured speedily and accurately with high resolution and to ensure over-dredging will not happen. The method statement has to be reviewed and approved by the Engineer (as hired by the HK Electric to manage the dredging works).
- Recommend the Engineer (as hired by HK Electric to manage the dredging works) to send a foreman, who is independent of the Contractor (i.e. dredging operator), to ensure the dredging works will be conducted in accordance with the method statement.
- The dredged profile measurement has to be conducted with the presence of the foreman.
- Recommend the foreman to have a proper knowledge/experience in conducting the dredged profile measurement. The foreman should also have the capability in interpreting the measurement result and take appropriate corrective action.
- The measurement results have to be submitted to the Engineer for review at the same day the measurement is conducted.
- Recommend the foreman to remind the dredger master to observe if there is any rock being dredged from the seabed when the dredging works is taken place in close proximity of the submarine pipeline.
- Recommend the Contractor to conduct underwater survey by diver at the location of submarine gas pipeline immediately after completion of dredging works there.
- Recommend the Engineer (as hired by HK Electric to manage the dredging works) to send a foreman, who is independent of the Contractor (i.e. dredging operator), to regularly check the location of the dredger using GPS to see if the dredger is carried away by sea current.
- Recommend the Contractor to check any loosen of anchoring system on board regularly to avoid drifting of the working vessel.
- Recommend the Contractor to prepare and submit an Emergency Response Plan (ERP) to cater for drifting of working vessel to Engineer for review. The ERP provides the necessary safety actions required to avoid or minimize the impact of jetty facilities and submarine gas pipelines.
- Recommend the Engineer (as hired by HK Electric to manage the dredging works) to conduct a thorough examination of the structural integrity of the existing seawall to ensure it is structurally sound for a nearby dredging works. If necessary, remedy action (e.g. providing temporary supporting structure) is taken before the dredging works is allowed

- Based on the condition of the seawall structure, the Engineer (as hired by HK Electric to manage the dredging works) needs to recommend and impose a minimal separation distance between the seawall and the dredging works.
- Recommend the Engineer (as hired by HK Electric to manage the dredging works) to send a foreman, who is independent of the Contractor (i.e. dredging operator), to monitor the condition of the seawall structure throughout the dredging works;
- Recommend the Engineer (as hired by HK Electric to manage the dredging works) to send a foreman, who is independent of the Contractor (i.e. dredging operator) to ensure the separation distance is maintained every time the dredger is relocated near the seawall structure.
- Recommend to request the hopper barge not to stay right above the submarine pipeline and this will be confirmed by the foreman who is hired by the Engineer.
- Recommend the hopper barge operator to monitor the draught of barge to ensure that the hopper barge will not be overloaded.

<u>Stage 5: Re-positioning the grab dredger to a new dredging area by winches and anchor's system</u>

- Recommend the Engineer (as hired by HK Electric to manage the dredging works) to send a foreman, who is independent of the Contractor (i.e. dredging operator), to confirm all the anchors have been completely retrieved from the seabed before allowing the dredger/barge to travel.
- Recommend to request the tug boat to travel around the dredger to observe if all the anchors have been completely retrieved before it tugs the dredger.

<u>Stage 6: Dumping the sediment from the barge to the designated disposal pit</u>

- Recommend to request the hopper barge not to stay near the submarine pipeline and this will be confirmed by the foreman who is hired by the Engineer.

6.6.2.2 Trailing Suction Hopper Dredging

<u>Stage 1: Arriving/departing of the self-propelled Trailing Suction Hopper Dredger at the dredging area</u>

- Recommend the Engineer (as hired by HK Electric to manage the dredging works) to send a foreman, who is independent of the Contractor (i.e. dredging operator), to check and confirm all anchors are secured in position before the working vessels are allowed to travel inside the non-anchor zone.
- Recommend the Contractor to avoid the working vessel travelling after sunset or under low visibility when they are working near the submarine pipeline.
- Recommend the Contractor to check the weather information from Marine Department before deploying the vessel to the dredging zone.
- Recommend the Contractor to avoid the working vessel traveling during berthing and unberthing of coal vessel.
- Recommend the Contractor to consider the preliminary coal vessel shipping plan provided by HK Electric when scheduling the programme of the dredging works.
- Recommend the Engineer (as hired by HK Electric to manage the dredging works) to send a foreman to check and confirm that all large and moveable objects must be tightly secured on the dredger by lashing, before it is allowed to travel inside the non-anchorage zone. The condition of the lashing will

be checked daily when the dredger is near the submarine pipeline and under adverse weather such as typhoon, strong monsoon and rough sea condition.

- Recommend vessel owners use electrical appliance for cooking and smoking onboard is not allowed when the dredging works is within non-anchoring zone.
- Recommend to request the working vessel to leave the Channel in case it is on fire.
- Recommend vessel owners to store dangerous goods in an explosion proof cabinet, if any, according to the statutory requirements at all times.
- Recommend the dredging path to consider potential infringement to nearby structure (e.g. seawall).
- Recommend the Contractor to check any loosen of anchoring system on board regularly to avoid drifting of the working vessel towards slipway of gas pipeline while the working vessel is in idle.
- Recommend the Contractor to prepare and submit an Emergency Response Plan (ERP) to cater for drifting of working vessel to Engineer for review. The ERP provides the necessary safety actions required to avoid or minimize the impact of jetty facilities and submarine pipeline.
- Recommend the Engineer (as hired by the HK Electric to manage the dredging works) to send a foreman to ensure the visibility is good before the working vessel travels near the seawall in each time.
- Recommend the Engineer (as hired by the HK Electric to manage the dredging works) to provide an indicator (e.g. flashing lamp) onshore at the point where the submarine pipeline transits from onshore to seabed. The indicator should be able to be seen clearly from the working vessel's cabin at distance.
- Recommend the Engineer (as hired by the HK Electric to manage the dredging works) to impose a safe traveling speed to the working vessels when they are traveling or working near the seawall
- Recommend the Engineer (as hired by the HK Electric to manage the dredging works) to request the Contractor (i.e. dredging operator) to provide maintenance records of the working vessel.
- Recommend the working vessel not to stay right above the submarine pipeline unless it is necessary.

<u>Stage 2: Lowering suction pipe and draghead to seabed</u>

- Recommend the Engineer (as hired by the HK Electric to manage the dredging works) to request the Contractor (i.e. dredging operator) to provide maintenance records and valid examination certificates of lifting appliances and lifting gears for the dredger to ensure the sea-worthiness of the dredgers.
- Recommend the TSHD not to lower the suction pipe in close proximity of the submarine pipeline. This has to be monitored by the foreman hired by the Engineer.
- Recommend to request the Contractor (i.e. dredging operator) to prepare and submit an Emergency Response Plan (ERP) to the Engineer for review. The ERP provides the necessary safety actions required to avoid or minimize the impact to the submarine pipeline due to failure of suction pipe gantries system.

<u>Stage 3: Carrying out dredging (i.e. switching on dredge pump and navigating the vessel)</u>

- Recommend the Engineer to provide the Contractor (i.e. dredging operator) the design details and location of the submarine pipeline (e.g. details of rock armour).
- Recommend the TSHD to travel in a slow speed when the dredging works is near the submarine pipeline.
- Recommend to request the Contractor (i.e. dredging operator) to prepare and submit an Emergency Response Plan (ERP) to the Engineer for review. The ERP provides the necessary safety actions

required to avoid or minimize the impact to the submarine pipeline when the draghead is stuck with the rock armour or the seabed.

- Recommend the Engineer (as hired by the HK Electric to manage the dredging works) to request the TSHD owner to provide maintenance records and valid examination certificates of the compensator to ensure it is in good order.
- Recommend the Engineer (as hired by HK Electric to manage the dredging works) to send a foreman who is independent of the Contractor (i.e. dredging operator), to confirm the operability of the compensator by observing the movement of the hydraulic cylinder of the compensator when the dredging works is carried out near the submarine pipeline.
- Recommend the Contractor (i.e. dredging operator) to prepare a method statement for dredging works in the close proximity of the submarine pipeline. In the method statement, the measurement technique and frequency have to be specified to ensure the dredged profile can be measured speedily and accurately with high resolution and to ensure over-dredging will not happen. The method statement has to be reviewed and approved by the Engineer (as hired by the HK Electric to manage the dredging works).
- Recommend the Engineer (as hired by HK Electric to manage the dredging works) to send a foreman, who is independent of the Contractor (i.e. dredging operator), to ensure the dredging works will be conducted in accordance with the method statement.
- The dredged profile measurement has to be conducted with the presence of the foreman.
- Recommend the foreman to have a proper knowledge/experience in conducting the dredged profile measurement. The foreman should also have the capability in interpreting the measurement result and take appropriate corrective action.
- The measurement results have to be submitted to the Engineer for review at the same day the measurement is conducted.
- Recommend the foreman to remind the dredger master to observe if liquid flow is reduced by clogging of suction pipe.
- Recommend the Contractor to conduct underwater survey by diver at the location of submarine gas pipeline immediately after completion of dredging works there.
- Recommend the Engineer (as hired by the HK Electric to manage the dredging works) to request the Contractor (i.e. dredging operator) to provide maintenance records and valid examination certificates of lifting appliances and lifting gears for the dredger to ensure the sea-worthiness of the dredgers.
- Recommend to request the Contractor (i.e. dredging operator) to prepare and submit an Emergency Response Plan (ERP) to the Engineer for review. The ERP provides the necessary safety actions required to avoid or minimize the impact to the submarine pipeline due to failure of suction pipe gantries system.

Stage 4: Dumping the sediment from the barge to the designated disposal pit

- Recommend to request the TSHD not to stay near the submarine pipeline and this will be confirmed by the foreman who is hired by the Engineer.

6.7 Environmental Monitoring and Audit

Implementation of the recommended mitigation measures should be checked as part of the environmental monitoring and audit procedures during the dredging operation.

6.8 Conclusions

A SWIFT workshop has been organized with various stakeholders including HK Electric and EIA consultant to identify the hazards associated with the dredging works using the Grab Dredging method and TSHD method near the existing natural gas submarine pipeline. For each of the identified hazards, both existing and potential mitigation measures have been explored. The findings have been properly recorded in the SWIFT Log Sheets.

The Hazard Analysis has evaluated the risk based on the risk acceptability defined in the ETWB Risk Management User Manual and has considered all the existing engineering measures and procedural controls in order to reduce the risks to acceptable level. Where the level of risk is initially assessed as high, additional safeguards have been recommended by the attendees during the workshop that will be effective in controlling the risk to an acceptable level. All the risk items will be subject to ongoing review and monitoring to ensure the level of risk will not increase throughout the dredging operation of the project.

6.9 References

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