

Grab Dredger

Hazard Ref.	What If	Hazard	Description of Consequence	Existing Safeguards		Risk Assessment			Recommendation	Remarks	Justifications
				Engineering	Procedural	Likelihood	Consequence	Risk Level			
1. Arrival/Departure of Grab Dredger/Barge/Tug Boat at the Dredging Area											
G1-001-01	Anchor drops from working vessel (i.e. grab dredger/barge/tug boat) to the seabed unintentionally when it is near the submarine pipeline with rock armour (e.g. due to mechanical failure or human error)	The anchor is dragged over the seabed while the working vessel is traveling, hooks up and causes 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 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.	1. Non anchor zone of 100m from both sides of the submarine pipeline will be applied and enforced.	Unlikely	Major	Medium	1. Recommend the Engineer (as hired by HKE 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. 2. Recommend to provide a buoy for anchor location and possibly to provide buoys above submarine pipeline alignment.	Action: HKE to check with the Marine Department of HK to confirm the necessary actions required to get an approval for deploying the buoy.	In the 2011 QRA Study for HKE Subsea Gas Pipeline, a review of the accident records for subsea pipelines and installations in Overseas and HK was conducted. It was observed that anchor drop/drag is the dominant cause of failure or damage to subsea pipeline. Consider rock armour is provided for the pipeline section within the channel that provides protection for anchors as heavy as 15.8 tonnes, and the enforcement of non-anchor zone for 100m on each side of the pipeline, the likelihood of pipeline damage caused by anchor drop/drag is classified as "Unlikely". In review of the offshore gas pipeline incidents in the US DOT database from 2002 to 2008, there were 191 incidents reported in which only 2 incidents led to ignition and 1 incident resulted in explosion, no fatality was reported out of these 191 incidents. The causes for the two ignition incidents were Internal Corrosion and Dredging of Ship Channel by Third Party. For the explosion incident, a large sea anchor was found on a 12" pipeline. Hence, the consequence is classified as "Major" which is considered conservative.
G1-001-02	Anchor drops from working vessel (i.e. grab dredger/barge/tug boat) to the seabed unintentionally when it is near the submarine pipeline without rock armour (e.g. due to mechanical failure or human error)	The anchor is dragged over the seabed while the working vessel is traveling, hooks up 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.	1. Non anchor zone of 100m from both sides of the submarine pipeline will be applied and enforced.	Possible	Major	High	1. Recommend the Engineer (as hired by HKE 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. 2. Recommend to provide a buoy for anchor location and possibly to provide buoys above submarine pipeline alignment.	Action: HKE to check with the Marine Department of HK to confirm the necessary actions required to get an approval for deploying the buoy.	In the 2011 QRA Study for HKE Subsea Gas Pipeline, a review of the accident records for subsea pipelines and installations in Overseas and HK was conducted. It was observed that anchor drop/drag is the dominant cause of failure or damage to subsea pipeline. The enforcement of non-anchor zone for 100m on each side of the pipeline can help preventing this kind of incident from happening. However, rock armour is not provided for protection against anchor impact. The likelihood of pipeline damage caused by anchor drop/drag is increased to "Possible". In review of the offshore gas pipeline incidents in the US DOT database from 2002 to 2008, there were 191 incidents reported in which only 2 incidents led to ignition and 1 incident resulted in explosion, no fatality was reported out of these 191 incidents. The causes for the two ignition incidents were Internal Corrosion and Dredging of Ship Channel by Third Party. For the explosion incident, a large sea anchor was found on a 12" pipeline. Hence, the consequence is classified as "Major" which is considered conservative.

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G1-002	Collision with third party vessel due to adverse weather (e.g. fog, heavy rain, typhoon/strong monsoon, gust wind, rough sea)	The working vessel/third party vessel breaks down and 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. Navigation lights and markers on the working vessels as required by the Engineer or Marine Department shall be provided by the Contractor during the execution of works.	1. When the visibility is reduced to two nautical miles, Vessel Traffic Centre of the Marine Department of HK will broadcast navigational warnings and advise vessels to proceed with safe speed in the waters of Hong Kong. 2. Typhoon moorings for all marine plant shall be arranged and provided by the Contractor throughout the work period. 3. All marine operations shall be terminated and marine plant sent to the designated typhoon moorings when No.3 typhoon signal is hoisted. 4. Mariner Notice will be sent out by Marine Department of HK to notify the dredging works area.	Unlikely	Major	Medium	1. Recommend the Contractor to avoid the working vessel travelling after sunset or under low visibility when the works area is near the submarine pipeline. 2. Recommend the Contractor to check the weather information from Marine Department before deploying the vessel to the dredging zone. 3. Recommend the Contractor to deploy a guard boat to alert third party vessel not to travel inside the dredging works area.		As highlighted in the 2011 QRA Study for HKE Subsea Gas Pipeline, there were 446 vessels sinking incidents in Hong Kong waters between 1990 to 2005 with an average of 28 cases per year. Vessel sinking incidents are more likely to occur in areas with high intensity of marine activities. The vessel movements within the West Lamma Channel is expected to be Low according to the vessel density data. Consider the dredging works area will be notified by Marine Department throughout the dredging period, and the existing procedural control under adverse weather is in place, the likelihood of pipeline damage caused by sinking vessel is classified as "Unlikely".
G1-003	Collision with third party vessel due to insufficient separation distance or close proximity between working area and jetty	The working vessel/third party vessel breaks down and sinks to the seabed, 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 drop sensor, to minimize the gas leakage.	1. The marine traffic arrangement strategy during the dredging works will have to be coordinated and agreed between the Contractor, the Engineer and the Marine Department of HKSAR. 2. The Contractor will be requested to comply with all the requirements provided by the Marine Department of HKSAR for safe traveling in the waters of Hong Kong during dredging period. 3. The Engineer is requested to oversee and evaluate the effectiveness of the implemented traffic arrangement.	Rare	Major	Medium	1. Recommend the Contractor to avoid the working vessel travelling after sunset or under low visibility when the works area is near the submarine pipeline. 2. Recommend the Contractor to avoid the working vessel travelling during berthing and unberthing of coal vessel.		As the marine traffic arrangement will be coordinated between the Contractor, HKE and Marine Department throughout the dredging period, the likelihood of pipeline damage caused by sinking vessel is classified as "Rare".

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G1-004	Collision with third party vessel due to working vessel interfere with the navigation path of the coal vessel	The working vessel/third party vessel breaks down and sinks to the seabed, 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 drop sensor, to minimize the gas leakage.	1. 24 hours preliminary advance notice will be given to the Contractor by HKE prior to any coal vessel movement and 6 hours advance notice for confirmation of berthing/unberthing of coal vessel. 2. Any dredger plant or vessel occupying the navigation channel shall be removed at least 3 hours before berthing and unberthing of coal vessel.	Unlikely	Major	Medium	1. Recommend the Contractor to consider the preliminary coal vessel shipping plan provided by HKE when scheduling the programme of the dredging works.		Coal vessel shipping plan will be provided by HKE to the Contractor for programming the dredging works, and sufficient advance notice will be given to the Contractor to evacuate the dredging works area to avoid interference with the coal vessels, thus the likelihood of pipeline damage caused by sinking vessel is classified as "Unlikely".
G1-005-01	Large object drops from the working vessel near the submarine pipeline with 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. 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.	1. Large and moveable objects or equipment will have to be tightly secured on the working vessel by lashing.	Unlikely	Major	Medium	1. Recommend the Engineer (as hired by HKE 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.		Objects or equipment may be dropped from vessels passing over the pipeline. As rock armour is provided for the pipeline section within the channel that provides protection for anchors as heavy as 2 tonnes, the dropping of objects of sufficient size and weight to cause pipeline failure is expected to be infrequent. The likelihood of pipeline damage caused by dropped object is classified as "Unlikely".
G1-005-02	Large object drops from the working vessel near the submarine 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.	1. Large and moveable objects or equipment will have to be tightly secured on the working vessel by lashing.	Possible	Major	High	1. Recommend the Engineer (as hired by HKE 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.		Objects or equipment may be dropped from vessels passing over the pipeline. The likelihood of pipeline damage caused by dropped object is increased to "Possible" as rock armour is not provided.
G1-006	Fire happens on the working vessel (e.g. due to kitchen fire, smoking etc.)	The working vessel breaks down and 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.	1. Fire fighting equipment (e.g. extinguishers) are provided in the working vessel. 2. Engineer will review and inspect the fire fighting facilities and licence of the dredger prior to commencement of dredging works.	Rare	Major	Medium	1. Recommend vessel owners use electrical appliance for cooking and smoking onboard is not allowed when the dredging works is within non-anchoring zone. 2. Recommend vessel owners to store dangerous goods in an explosion proof cabinet, if any, according to the statutory requirements at all times.		Based on the marine traffic accident statistics provided by the Marine Department of HK, only 5% of the accidents happened within Hong Kong Waters from 2009 to 2014 are due to fire/explosion. Consider the low frequency of fire incidents on vessels in Hong Kong and the provision of fire fighting equipment on board the dredger, likelihood of pipeline damage caused by sinking vessel is classed as "Rare".

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G1-007	Collision of the working vessels with the section of the submarine pipeline transiting from onshore to the seabed as they are in close proximity to the seawall of Lamma Power Plant	The collision causes 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. Movement of dredger will be controlled by winches after anchoring, excessive movement beyond the controlled area is not expected		Unlikely	Major	Medium	1. Recommend the Engineer (as hired by HKE 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. 2. 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. 3. 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. 4. Recommend the foreman to ensure the visibility is good before the working vessel travels near the seawall in each time. 5. 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. 5. Recommend the Engineer to impose a safe traveling speed to the working vessels when they are traveling or working near the seawall.		Although the dredging area is in close proximity with the seawall, the pipeline transiting to onshore is contained within the slipway and protected by rock armour, given that the vessel movement is controlled by the anchoring system and travel speed of vessel is limited when approaching the dredging area near sea wall, damage by vessel impact is minimised. The likelihood of pipeline damage caused by vessel is classified as "Unlikely".
G1-008	Working vessel sinking due to loss of power/structural failure	The working vessel sinks to the seabed, 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.	1. 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.	Unlikely	Major	Medium	1. Recommend the Engineer (as hired by the HKE to manage the dredging works) to request the Contractor (i.e. dredging operator) to provide maintenance records of the working vessel. 2. Recommend the working vessel not to stay right above the submarine pipeline unless it is necessary.		In the 2011 QRA Study for HKE Subsea Gas Pipeline, it was stated that for the years 1990 to 2005, there were 446 incidents of vessel sinking in Hong Kong waters. This averaged 28 cases per year. Most of the recorded incidents involved mainly smaller vessels of less than 1,000 dwt which will have less impact on a pipeline buried 3m below the seabed. The probability that a vessel sinking incident will impact the pipeline is therefore classified as "Unlikely".

2. Deploying Anchor by Tug Boat

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Hazard Ref.	What If	Hazard	Description of Consequence	Existing Safeguards		Risk Assessment			Recommendation	Remarks	Justifications
				Engineering	Procedural	Likelihood	Consequence	Risk Level			
G2-001-01	Dropping anchor right above the submarine pipeline with rock armour, mistakenly during anchor deployment (e.g. due to human error)	The anchor hits and causes damage to the 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. Rock armour of about 2.0 m thick is provided along the submarine pipeline inside the Channel for an overall length of 730m 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.	1. Procedure to enforce anchoring is not allowed inside the anchor exclusion zone.	Unlikely	Major	Medium	1. Recommend the Engineer (as hired by HKE 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. 2. Recommend the Engineer to verify the accuracy of all GPS/DGPS system.		In the 2011 QRA Study for HKE Subsea Gas Pipeline, a review of the accident records for subsea pipelines and installations in Overseas and HK was conducted. It was observed that anchor drop/drag is the dominant cause of failure or damage to subsea pipeline. Consider rock armour is provided for the pipeline section within the channel that provides protection for anchors as heavy as 15.8 tonnes, and the enforcement of non-anchor zone for 100m on each side of the pipeline, the likelihood of pipeline damage caused by anchor drop/drag is classified as "Unlikely".
G2-001-02	Dropping anchor right above the submarine pipeline without rock armour, mistakenly during anchor deployment (e.g. due to human error)	The anchor hits and causes damage to the 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.	1. Procedure to enforce anchoring is not allowed inside the anchor exclusion zone.	Possible	Major	High	1. Recommend the Engineer (as hired by HKE 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. 2. Recommend the Engineer to verify the accuracy of all GPS/DGPS system.		In the 2011 QRA Study for HKE Subsea Gas Pipeline, a review of the accident records for subsea pipelines and installations in Overseas and HK was conducted. It was observed that anchor drop/drag is the dominant cause of failure or damage to subsea pipeline. The enforcement of non-anchor zone for 100m on each side of the pipeline can minimize the chance of pipeline damage caused by anchor drop/drag. However, rock armour is not provided to offer protection to a section of pipeline . The likelihood is classified as "Possible"

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G2-002	Insufficient length of the anchor chain is lowered to the tug boat for anchor deployment	The anchor chain is stretched between the tugboat and the dredger, the anchor swings on the deck of the tug boat	The swinging anchor causes damage to the tug boat and nearby third party vessel.	1. A 2-frequency VHF radio communications network shall be provided by the Contractor to enable close communication between tug boat and dredger during anchor deployment	1. A competent trained person will be deployed in the tug boat to oversee the anchor deployment process.	Possible	Moderate	Medium	1. 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. 2. 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 anchors.	This hazard shall not affect the submarine pipeline.	
G2-003	When the anchor is dropped outside the non-anchor zone, the anchor chain is above the sea surface	The anchor chain above sea surface interferes the path of a traveling third party vessel	Damage to the third party vessel.	-	1. Mariner Notice will be issued by the Marine Department about the dredging works area	Possible	Moderate	Medium	1. Recommend the Contractor to deploy a guard boat to monitor the separation distance between the anchor chain and other incoming vessel.	This hazard shall not affect the submarine pipeline.	
G2-004	Drifting of the vessel due to tidal conditions or high current velocities	Anchors unable to secure the dredger in the work area	Impact with third party vessel or jetty, damage to third party vessel or power station facilities	1. The dredger shall be secured by lowering at least four anchors.	1. Positions of anchor shall be monitored regularly	Unlikely	Moderate	Medium	1. 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. 2. 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. 3. 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.	This hazard shall not affect the submarine pipeline.	
3. Setting Up Cage Type Silt Curtain into the Sea											
G3-001-01	The weight attached to the bottom of the silt curtain falls onto the submarine pipeline with rock armour	The weight causes 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 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.	-	Rare	Major	Medium	1. Recommend the Contractor to check the depth of the seabed and maintain the bottom of the silt curtain to be above the seabed	-	With reference to the similar dredging works organised by HKE in the past, the silt curtain would consist of steel chain of 5kg/m and fabric sheet. Its total weight should be insignificant as compared with the protection offered by the rock armour. As rock armour is provided for the pipeline section within the channel that provides protection for anchors as heavy as 15.8 tonnes, the dropping of objects of sufficient size and weight to cause pipeline failure is expected to be infrequent. Provided that the weight of the silt curtain is not significant and the bottom of silt curtain is maintained above the seabed, the likelihood of pipeline damage caused by silt curtain is classified as "Rare".
G3-001-02	The weight attached to the bottom of the silt curtain falls onto the submarine pipeline without rock armour	The weight 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.	-	Unlikely	Major	Medium	1. Recommend the Contractor to check the depth of the seabed and maintain the bottom of the silt curtain to be above the seabed	-	With reference to the similar dredging works organised by HKE in the past, the silt curtain would consist of steel chain of 5kg/m and fabric sheet. Its total weight should not be significant as compared with the protection offered by the steel reinforced concrete coating layer along the pipeline. Provided that the weight of the silt curtain is not significant and the bottom of silt curtain is maintained above the seabed, the likelihood of pipeline damage caused by silt curtain is classified as "Unlikely".
4. Carrying out the Dredging											

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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	The downward force of the free-falling grab causes damage to the pipeline	Loss of containment, release of natural gas, potential subsequent ignition.	<p>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.</p> <p>2. Rock armour of about 2.0 m thick is provided along the submarine pipeline inside the Channel for an overall length of 730m</p> <p>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.</p>	<p>1. The as-built record of alignment and elevation of the submarine pipeline will be provided by the HKE and the record will be reviewed by the Engineer and Contractor.</p> <p>2. 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.</p> <p>3. The dredger operator will hold the grab by braking system to a level limit without reaching the submarine pipeline.</p>	Possible	Major	High	<p>1. Recommend the Engineer (as hired by HKE 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.</p> <p>2. Recommend the Engineer (as hired by HKE to manage the dredging works) to put buoys in the sea to indicate the transition point.</p> <p>3. Recommend the Engineer (as hired by HKE 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.</p> <p>4. 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.</p> <p>5. 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 HKE during the trial run.</p> <p>6. Recommend the Engineer (as hired by HKE to manage the dredging works) to verify the accuracy of the GPS/DGPS system before the dredging works is started in the vicinity of submarine gas pipeline.</p> <p>7. Recommend operator to regularly monitor the pressure fluctuation in the submarine pipeline during the dredging works near the pipeline.</p> <p>8. Recommend to use a much smaller grab for dredging works with control movement near the submarine pipeline.</p> <p>9. 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.</p> <p>10. 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.</p>		As rock armour is provided for the pipeline section within the channel that provides protection for anchors as heavy as 15.8 tonnes, the chance of pipeline damage by dropped grab is reduced. The pipeline alignment will be shown on the grid plan and made aware to all the operatives on board the dredger, the likelihood of pipeline damaged by dredging is classified as "Possible".

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				Engineering	Procedural	Likelihood	Consequence	Risk Level			
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	The downward force of the free-falling grab causes damage to the pipeline	Loss of containment, release of natural gas, potential subsequent ignition.	<p>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.</p> <p>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.</p>	<p>1. The as-built record of alignment and elevation of the submarine pipeline will be provided by the HKE and the record will be reviewed by the Engineer and Contractor.</p> <p>2. 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.</p> <p>3. The dredger operator will hold the grab by braking system to a level limit without reaching the submarine pipeline.</p>	Likely	Major	High	<p>1. Recommend the Engineer (as hired by HKE 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.</p> <p>2. Recommend the Engineer (as hired by HKE to manage the dredging works) to put buoys in the sea to indicate the transition point.</p> <p>3. Recommend the Engineer (as hired by HKE 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 without rock armour every time the dredger arrives at the project site boundary or when it needs to be relocated.</p> <p>4. 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.</p> <p>5. Recommend to have a trial run for the dredging works when it is conducted right above and in close proximity of the submarine pipeline where the rock armour is not provided. An established communication network should be maintained between the dredger's operator, the foreman, the Engineer and HKE during the trial run.</p> <p>6. Recommend the Engineer (as hired by HKE to manage the dredging works) to verify the accuracy of the GPS/DGPS system before the dredging works is started in the vicinity of submarine gas pipeline.</p> <p>7. Recommend operator to regularly monitor the pressure fluctuation in the submarine pipeline during the dredging works near the pipeline.</p>	As rock armour is not provided for the pipeline section within the channel, the chance of pipeline damage by dropped grab is increased to "Likely".	
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	The downward force of the free-falling grab causes damage to the submarine pipeline	Loss of containment, release of natural gas, potential subsequent ignition.	<p>1. Rock armour of about 2.0 m thick is provided along the submarine pipeline inside the Channel for an overall length of 730m</p> <p>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.</p>	<p>1. 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.</p>	Possible	Major	High	<p>1. Recommend to use a much smaller grab for dredging works with control movement near the submarine pipeline.</p> <p>2. The type of grab (e.g. size, weight) used for the dredging works near the submarine has to be reviewed by the Engineer, taking the design of the rock armour into account, before the dredging works is started.</p> <p>3. 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.</p> <p>4. Recommend the grab is retrieved back to inside the dredger after the completion of dredging works in each working day.</p> <p>5. Recommend the Engineer (as hired by the HKE 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.</p>	As rock armour is provided for the pipeline section within the channel that provides protection for anchors as heavy as 15.8 tonnes, the chance of pipeline damage by dropped grab is reduced. The dredger will be maintained to a condition that ensure equipment are safe and sound, the likelihood of pipeline damaged by dredging is classified as "Possible".	

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Hazard Ref.	What If	Hazard	Description of Consequence	Existing Safeguards		Risk Assessment			Recommendation	Remarks	Justifications
				Engineering	Procedural	Likelihood	Consequence	Risk Level			
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	The downward force of the free-falling grab 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.	1. 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.	Likely	Major	High	1. Recommend the grab is retrieved back to inside the dredger after the completion of dredging works in each working day. 2. Recommend the Engineer (as hired by the HKE 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. 3. Recommend the Engineer (as hired by the HKE to manage the dredging works) to have a visual examination of the integrity of the wire cable of the grab hoisting system before the dredging is allowed to move near the submarine pipeline without rock armour.		As rock armour is not provided for the pipeline section within the channel, the chance of pipeline damage by dropped grab is increased to "Likely".
G4-003-01	Over dredging near the submarine pipeline with rock armour	Some rocks will be removed from the rock armour for the submarine pipeline, 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.	1. 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. 2. The dredger operator will hold the grab in around 100mm layer by layer approaching from existing seabed to the final design level. 3. The dredger operator will hold the grab by braking system to a level limit without any over-dredge allowance.	Possible	Major	High	1. 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 HKE to manage the dredging works). 2. Recommend the Engineer (as hired by HKE 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. 3. The dredged profile measurement has to be conducted with the presence of the foreman. 4. 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. 5. The measurement results have to be submitted to the Engineer for review at the same day the measurement is conducted. 6. 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. 7. Recommend the Contractor to conduct underwater survey by diver at the location of submarine gas pipeline immediately after completion of dredging works there.		When dredging is conducted near the submarine pipeline, a trial run will be conducted to confirm the dredging profile and dredging will be conducted in a controlled manner with limit set to prevent over dredging. The likelihood of pipeline damaged by dredging is classified as "Possible".

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Hazard Ref.	What If	Hazard	Description of Consequence	Existing Safeguards		Risk Assessment			Recommendation	Remarks	Justifications
				Engineering	Procedural	Likelihood	Consequence	Risk Level			
G4-003-02	Over dredging near the submarine pipeline without rock armour	Movement of alluvium on seabed, loss of localised support to submarine pipeline causing high stress	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.	1. 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. 2. The dredger operator will hold the grab in around 100mm layer by layer approaching from existing seabed to the final design level. 3. The dredger operator will hold the grab by braking system to a level limit without any over-dredge allowance.	Likely	Major	High	1. 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 HKE to manage the dredging works). 2. Recommend the Engineer (as hired by HKE 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. 3. The dredged profile measurement has to be conducted with the presence of the foreman. 4. 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. 5. The measurement results have to be submitted to the Engineer for review at the same day the measurement is conducted. 6. Recommend the Contractor to conduct underwater survey by diver at the location of submarine gas pipeline immediately after completion of dredging works there.		When dredging is conducted near the submarine pipeline, a trial run will be conducted to confirm the dredging profile and dredging will be conducted in a controlled manner with limit set to prevent over dredging. However, rock armour is not provided. The likelihood of pipeline damaged by dredging is increased to "Likely".
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 (free falling of the grab is allowed when it is away from the submarine 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 730m 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.	1. The as-built record of alignment and elevation of the submarine pipeline will be provided by the HKE and the record will be reviewed by the Engineer and Contractor. 2. 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. 3. Dredging works performed at close proximity to the submarine pipeline shall be performed in day time.	Possible	Major	High	1. Recommend the Engineer (as hired by HKE 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. 2. Recommend the Engineer (as hired by HKE to manage the dredging works) to verify the accuracy of GPS/DGPS system before the dredging works is started. 3. Recommend the Contractor to check any loosen of anchoring system on board regularly to avoid drifting of the working vessel. 4. 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.		As rock armour is provided for the pipeline section within the channel that provides protection for anchors as heavy as 2 tonnes, the chance of pipeline damage by dropped grab is reduced. The pipeline alignment will be shown on the grid plan and made aware to all the operatives on board the dredger, the likelihood of pipeline damaged by dredging is classified as "Possible".

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Hazard Ref.	What If	Hazard	Description of Consequence	Existing Safeguards		Risk Assessment			Recommendation	Remarks	Justifications
				Engineering	Procedural	Likelihood	Consequence	Risk Level			
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 (free falling of the grab is allowed when it is away from the submarine 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.	1. The as-built record of alignment and elevation of the submarine pipeline will be provided by the HKE and the record will be reviewed by the Engineer and Contractor. 2. 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. 3. Dredging works performed at close proximity to the submarine pipeline shall be performed in day time.	Likely	Major	High	1. Recommend the Engineer (as hired by HKE 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. 2. Recommend the Engineer (as hired by HKE to manage the dredging works) to put buoys in the seas to indicate the transition point. 3. Recommend the Engineer (as hired by HKE 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. 4. Recommend the Engineer (as hired by HKE to manage the dredging works) to verify the accuracy of GPS/DGPS system before the dredging works is started. 5. Recommend the Contractor to check any loosen of anchoring system on board regularly to avoid drifting of the working vessel. 6. 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.		As rock armour is not provided for the pipeline section within the channel, the chance of pipeline damage by dropped grab is increased to "Likely".
G4-005	Excessive stressing on seawall structure due to dredging operation	Collapse of seawall structure in vicinity to the pipeline, damage to submarine pipeline	Loss of containment, release of natural gas, potential subsequent ignition.	-		Possible	Major	High	1. Recommend the Engineer (as hired by HKE 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. 2. Based on the condition of the seawall structure, the Engineer (as hired by HKE to manage the dredging works) needs to recommend and impose a minimal separation distance between the seawall and the dredging works. 3. Recommend the Engineer (as hired by HKE 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. 4. Recommend the Engineer (as hired by HKE 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.		Considering the close proximity of the dredging works and the seawall, the likelihood of pipeline damaged is classified as "Possible"
G4-006	Overloading of the barge with sediments and sea mud	Sinking of barge due to overloading with dredged materials, damage to submarine pipeline	Loss of containment, release of natural gas, potential subsequent ignition.	1. Design capacity of the hopper barge will restrict over loading. 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.	1. Barges shall not be filled to a level that exceeds the maximum capacity of the hopper barge.	Unlikely	Major	Medium	1. 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. 2. Recommend the hopper barge operator to monitor the draught of barge to ensure that the hopper barge will not be overloaded.		The design of the hopper barge will restrict the loading such that overloading will be unlikely. Likelihood of pipeline damage caused by sinking of hopper barge is classified as "Unlikely".

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Hazard Ref.	What If	Hazard	Description of Consequence	Existing Safeguards		Risk Assessment			Recommendation	Remarks	Justifications
				Engineering	Procedural	Likelihood	Consequence	Risk Level			
5. Re-positioning the Grab Dredger to a New Dredging Area by Winches and Anchor's system											
G5-001-01	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 with rock armour	The anchor is dragged over the seabed and cause 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 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.	1. Non anchor zone of 100m from both side of the submarine pipeline will be applied.	Unlikely	Major	Medium	1. Recommend the Engineer (as hired by HKE 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. 2. 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.		Consider rock armour is provided for the pipeline section within the channel that provides protection for anchors as heavy as 15.8 tonnes, and the enforcement of non-anchor zone for 100m on each side of the pipeline, the likelihood of pipeline damage caused by anchor drop/drag is classified as "Unlikely".
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 and cause 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.	1. Non anchor zone of 100m from both side of the submarine pipeline will be applied.	Possible	Major	High	1. Recommend the Engineer (as hired by HKE 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. 2. Recommend to request the tug boat to travel around the dredger to observe if all the anchors have been completely lifted up before it tugs the dredger.		Consider the enforcement of non-anchor zone for 100m on each side of the pipeline while rock armour is not provided, the likelihood of pipeline damage caused by anchor drop/drag is classified as "Possible".
6. Dumping the Sediment from the Barge to the Designated Disposal Pit											
G6-001	Accidental dumping of mud right above the submarine pipeline	The weight of mud imposed extra loading onto the submarine pipeline causing damage	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. The split type hopper barge will have locking device to prevent accidental splitting and dumping of materials.	-	Unlikely	Major	Medium	1. 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.	Hopper barge capacity is 1000m ³	Hydraulic rams and locking device will be provided in hopper barge to ensure controlled opening operations and prevent accidental opening and dumping of materials. Likelihood of pipeline damage caused by dumping of mud is classified as "Unlikely".

Trailer Suction Hopper Dredger

Hazard Ref.	What If	Hazard	Description of Consequence	Existing Safeguards		Risk Assessment			Recommendation	Remarks	Justifications
				Engineering	Procedural	Likelihood	Consequence	Risk Level			
1. Arrival/Departure of TSHD at the Dredging Area											
T1-001-01	Anchor drops from working vessel (i.e. Trailing Suction Head Dredger (TSHD)) to the seabed un-intentionally when it is near the submarine pipeline with rock armour (e.g. due to mechanical failure or human error)	The anchor is dragged over the seabed while the working vessel is traveling, hooks up and causes 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 about 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.	1. Non anchor zone of 100m from both sides of the submarine pipeline will be applied and enforced. 2. The TSHD will only be allowed to moor outside the Channel, no anchoring is required during dredging operation.	Rare	Major	Medium	1. Recommend the Engineer (as hired by HKE 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.		In the 2011 QRA Study for HKE Subsea Gas Pipeline, a review of the accident records for subsea pipelines and installations in Overseas and HK was conducted. It was observed that anchor drop/drag is the dominant cause of failure or damage to subsea pipeline. Consider anchoring is not required for TSHD operation, rock armour is provided for the pipeline section within the channel that provides protection for anchors as heavy as 15.8 tonnes, and the enforcement of non-anchor zone for 100m on each side of the pipeline, the likelihood of pipeline damage caused by anchor drop/drag is classified as "Rare". In review of the offshore gas pipeline incidents in the US DOT database from 2002 to 2008, there were 191 incidents reported in which only 2 incidents led to ignition and 1 incident resulted in explosion, no fatality was reported out of these 191 incidents. The causes for the two ignition incidents were Internal Corrosion and Dredging of Ship Channel by Third Party. For the explosion incident, a large sea anchor was found on a 12" pipeline. Hence, the consequence is classified as "Major" which is considered conservative.
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)	The anchor is dragged over the seabed while the working vessel is traveling, hooks up 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.	1. Non anchor zone of 100m from both sides of the submarine pipeline will be applied and enforced. 2. The TSHD will only be allowed to moor outside the Channel, no anchoring is required during dredging operation.	Unlikely	Major	High	1. Recommend the Engineer (as hired by HKE 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.	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)

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Hazard Ref.	What If	Hazard	Description of Consequence	Existing Safeguards		Risk Assessment			Recommendation	Remarks	Justifications
				Engineering	Procedural	Likelihood	Consequence	Risk Level			
T1-002	Collision with third party vessel due to adverse weather (e.g. fog, heavy rain, typhoon/strong monsoon, gust wind, rough sea)	The working vessel/third party vessel breaks down and 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. Navigation lights and markers on TSHD as required by the Engineer or Marine Department shall be provided by the Contractor during the execution of works	1. When the visibility is reduced to two nautical miles, Vessel Traffic Centre of the Marine Department will broadcast navigational warnings and advise vessels to proceed with safe speed in the waters of Hong Kong. 2. Typhoon moorings for all marine plant shall be arranged and provided by the Contractor throughout the works period 3. All marine operations shall be terminated and marine plant sent to the designated typhoon moorings when No.3 typhoon signal is hoisted 4. Mariner Notice will be sent out by Marine Department of HK to notify the dredging works area.	Unlikely	Major	Medium	1. Recommend the Contractor to avoid the working vessel travelling after sunset or under low visibility when they are working near the submarine pipeline. 2. Recommend the Contractor to check the weather information from Marine Department before deploying the vessel to the dredging zone.		As highlighted in the 2011 QRA Study for HKE Subsea Gas Pipeline, there were 446 vessels sinking incidents in Hong Kong waters between 1990 to 2005 with an average of 28 cases per year. Vessel sinking incidents are more likely to occur in areas with high intensity of marine activities. The vessel movements within the West Lamma Channel is expected to be Low according to the vessel density data. Consider the dredging works area will be notified by Marine Department throughout the dredging period, and the existing procedural control under adverse weather is in place, the likelihood of pipeline damage caused by sinking vessel is classified as "Unlikely".
T1-003	Collision with third party vessel due to insufficient separation distance or close proximity between working area and jetty	The working vessel/third party vessel breaks down and 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 drop sensor, to minimize the gas leakage.	1. The marine traffic arrangement strategy during the dredging works will have to be coordinated and agreed between the Contractor, the Engineer and the Marine Department of HKSAR. 2. The Contractor will be requested to comply with all the requirements provided by the Marine Department of HKSAR for safe traveling in the waters of Hong Kong during dredging period. 3. The Engineer is requested to oversee and evaluate the effectiveness of the implemented marine traffic arrangement.	Rare	Major	Medium	1. Recommend the Contractor to avoid the working vessel travelling after sunset or under low visibility. 2. Recommend the Contractor to avoid the working vessel travelling during berthing and unberthing of coal vessel.		As the working area near the submarine pipeline is far away from the jetty, and marine traffic arrangement will be coordinated between the Contractor, HKE and Marine Department throughout the dredging period, the likelihood of pipeline damage caused by sinking vessel is classified as "Rare".

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Hazard Ref.	What If	Hazard	Description of Consequence	Existing Safeguards		Risk Assessment			Recommendation	Remarks	Justifications
				Engineering	Procedural	Likelihood	Consequence	Risk Level			
T1-004	Collision with third party vessel due to TSHD vessel interfere with the navigation path of the coal vessel	The working vessel/third party vessel breaks down and sinks to the seabed, 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 drop sensor, to minimize the gas leakage.	1. 24 hours preliminary advance notice will be given to the Contractor by HKE prior to any coal vessel movement and 6 hours advance notice for confirmation of berthing and unberthing of coal vessel. 2. Any dredger plant or vessel occupying the navigation channel shall be removed at least 3 hours before berthing and unberthing of coal vessel.	Unlikely	Major	Medium	1. Recommend the Contractor to consider the preliminary coal vessel shipping plan provided by HKE when scheduling the programme of the dredging works.		Coal vessel shipping plan will be provided by HKE to the Contractor for programming the dredging works, and sufficient advance notice will be given to the Contractor to evacuate the dredging works area to avoid interference with the coal vessels, thus the likelihood of pipeline damage caused by sinking vessel is classified as "Unlikely".
T1-005-01	Large object drops from the working vessel near pipeline with 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. 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.	1. Large and moveable objects or equipment will have to be tightly secured on the working vessel by lashing.	Unlikely	Major	Medium	1. Recommend the Engineer (as hired by HKE 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.		Objects or equipment may be dropped from vessels passing over the pipeline. As rock armour is provided for the pipeline section within the channel that provides protection for anchors as heavy as 15.8 tonnes, the dropping of objects of sufficient size and weight to cause pipeline failure is expected to be infrequent. The likelihood of pipeline damage caused by dropped object is classified as "Unlikely".
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.	1. Large and moveable objects or equipment will have to be tightly secured on the working vessel by lashing.	Possible	Major	High	1. Recommend the Engineer (as hired by HKE 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.		Objects or equipment may be dropped from vessels passing over the pipeline. The likelihood of pipeline damage caused by dropped object is increased to "Possible" as rock armour is not provided.
T1-006	Fire happens on the working vessel (e.g. due to engine fire, kitchen fire, smoking etc.)	The working vessel breaks down and sinks to the seabed, 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.	1. Fire fighting equipment (e.g. extinguishers) are provided in the working vessel. 2. Engineer will review and inspect the fire fighting facilities and license of the dredger prior to commencement of dredging works	Rare	Major	Medium	1. Recommend vessel owners use electrical appliance for cooking and smoking onboard is not allowed when the dredging works is within non-anchorage zone. 2. Recommend to request the working vessel to leave the Channel in case it is on fire. 3. Recommend vessel owners to store dangerous goods in an explosion proof cabinet, if any, according to the statutory requirements at all times.		Based on the marine traffic accident statistics provided by the Marine Department of HK, only 5% of the accidents happened within Hong Kong Waters from 2009 to 2014 are due to fire/explosion. Consider the low frequency of fire incidents on vessels in Hong Kong and the provision of fire fighting equipment on board the dredger, likelihood of pipeline damage caused by sinking vessel is classed as "Rare".

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Hazard Ref.	What If	Hazard	Description of Consequence	Existing Safeguards		Risk Assessment			Recommendation	Remarks	Justifications
				Engineering	Procedural	Likelihood	Consequence	Risk Level			
T1-007	Collision of the working vessels with the section of the submarine pipeline transiting from onshore to the seabed as they are in the close proximity to the seawall of Lamma Power Plant	The collision causes 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.		Possible	Major	High	1. Recommend the dredging path to consider potential infringement to nearby structure (e.g. seawall). 2. 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. 3. 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. 4. Recommend the Engineer (as hired by HKE 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. 5. Recommend the Engineer (as hired by HKE to manage the dredging works) 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. 5. Recommend the Engineer (as hired by HKE to manage the dredging works) to impose a safe traveling speed to the working vessels when they are traveling or working near the seawall.	Twin propulsion engines are assumed to be installed in the TSHD according to the specification provided by HKE for a potential dredging contractor (Jan De Nul) (http://www.jan-denu.com/en/equipment/fleet/trailing-suction-hopper-dredger)	Although the dredging area is in close proximity with the seawall, the pipeline transiting to onshore is contained within the slipway and protected by rock armour, given that the travel speed of vessel is limited when approaching the dredging area near sea wall, damage by vessel impact is minimised. The likelihood of pipeline damage caused by vessel is classified as "Possible".
T1-008	Working vessel sinking due to loss of power/structural failure	The working vessel sinks to the seabed, 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.	1. 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.	Unlikely	Major	Medium	1. Recommend the Engineer (as hired by the HKE 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. 2. Recommend the working vessel not to stay right above the submarine pipeline unless it is necessary.		In the 2011 QRA Study for HKE Subsea Gas Pipeline, it was stated that for the years 1990 to 2005, there were 446 incidents of vessel sinking in Hong Kong waters. This averaged 28 cases per year. Most of the recorded incidents involved mainly smaller vessels of less than 1,000 dwt which will have less impact on a pipeline buried 3m below the seabed. The probability that a vessel sinking incident will impact the pipeline is therefore classified as "Unlikely".
2. Lowering Suction Pipe and Draghead to Seabed											
T2-001-01	Breakage of intermediate gantry wire/draghead winch gantry wire upon lowering the suction pipe to the seabed	The suction pipe may be lowered to the seabed in an un-controlled manner, causing 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 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.	1. 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.	Possible	Major	High	1. Recommend the Engineer (as hired by the HKE 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. 2. 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. 3. 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.		As rock armour is provided for the pipeline section within the channel that provides protection for anchors as heavy as 15.8 tonnes, the chance of pipeline damage by dropped draghead is reduced. The dredger will be maintained to a condition that ensure equipment are safe and sound, the likelihood of pipeline damaged by dredging is classified as "Possible".

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Hazard Ref.	What If	Hazard	Description of Consequence	Existing Safeguards		Risk Assessment			Recommendation	Remarks	Justifications
				Engineering	Procedural	Likelihood	Consequence	Risk Level			
T2-001-02	Breakage of intermediate gantry wire/draghead winch gantry wire upon lowering the suction pipe to the seabed	The suction pipe may be lowered to the seabed in an un-controlled manner, causing 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.	1. 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.	Likely	Major	High	1. Recommend the Engineer (as hired by the HKE 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. 2. 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. 3. 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.		The dredger will be maintained to a condition that ensure equipment are safe and sound, however, rock armour is not provided for the pipeline, the likelihood of pipeline damaged by dredging is classified as "Likely".
T2-002-01	Suction pipe and draghead are unable to be retrieved back to the TSHD due to winch failure	Draghead is dragged across the submarine pipeline and hook up the pipeline, causing 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-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.	1. 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. 2. TSHD shall manoeuvre away from the submarine pipeline in case the draghead cannot be retrieved back to the TSHD. 3. The path of the TSHD dredging operation will be designed to be in parallel with the submarine pipeline alignment.	Possible	Major	High	1. 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.		As rock armour is provided for the pipeline section within the channel that provides protection for anchors as heavy as 15.8 tonnes, the chance of pipeline damage by dragging of suction pipe is reduced. The dredger will be maintained to a condition that ensure equipment are safe and sound, the likelihood of pipeline damaged by dredging is classified as "Possible".

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Hazard Ref.	What If	Hazard	Description of Consequence	Existing Safeguards		Risk Assessment			Recommendation	Remarks	Justifications
				Engineering	Procedural	Likelihood	Consequence	Risk Level			
T2-002-02	Suction pipe and draghead are unable to be retrieved back to the TSHD due to winch failure	Draghead is dragged across the submarine pipeline and hook up the pipeline, causing 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.	1. 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. 2. TSHD shall manoeuvre away from the submarine pipeline in case the draghead cannot be retrieved back to the TSHD. 3. The path of the TSHD dredging operation will be designed to be in parallel with the submarine pipeline alignment.	Likely	Major	High	1. 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.		The dredger will be maintained to a condition that ensure equipment are safe and sound, however, rock armour is not provided, the likelihood of pipeline damaged by dredging is classified as "Likely".
3. Carrying out the Dredging											
T3-001-01	Draghead is stuck with the rock armour/seabed while the TSHD is moving	Suction pipe is pulled by the moving TSHD, the suction pipe breaks or the rocks are dislocated from the rock armour causing 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 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.	1. The path of the TSHD dredging operation will be designed to be in parallel with the submarine pipeline alignment.	Possible	Major	High	1. 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). 2. Recommend the TSHD to travel in a slow speed when the dredging works is near the submarine pipeline. 3. 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.	-	As rock armour is provided for the pipeline section within the channel that provides protection for anchors as heavy as 15.8 tonnes, the chance of pipeline damage by dragging of draghead is reduced. The path of the TSHD will be designed in parallel with the pipeline alignment, the likelihood of pipeline damaged by dredging is classified as "Possible".
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	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.	1. The path of the TSHD dredging operation will be designed to be in parallel with the submarine pipeline alignment.	Likely	Major	High	1. Recommend the Engineer to provide the Contractor (i.e. dredging operator) the design details and location of the submarine pipeline. 2. Recommend the TSHD to travel in a slow speed when the dredging works is near the submarine pipeline. 3. 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 seabed.	-	The path of the TSHD will be designed in parallel with the pipeline alignment, however, rock armour is not provided. The likelihood of pipeline damaged by dredging is classified as "Likely".

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Hazard Ref.	What If	Hazard	Description of Consequence	Existing Safeguards		Risk Assessment			Recommendation	Remarks	Justifications
				Engineering	Procedural	Likelihood	Consequence	Risk Level			
T3-002-01	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	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.	1. 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.	Possible	Major	High	1. Recommend the Engineer (as hired by the HKE 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. 2. Recommend the Engineer (as hired by HKE 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.	Recommendation on item 2 is made reference to Section 1.4.5.2 of Introduction to Dredging Equipment prepared by Prof Ir W.J. Vlasblom of Delft University of Technology (2003).	As rock armour is provided for the pipeline section within the channel that provides protection for anchors as heavy as 15.8 tonnes, the chance of pipeline damage by dragging of draghead is reduced. The dredger will be maintained to a condition that ensure equipment are safe and sound, the likelihood of pipeline damaged by dredging is classified as "Possible".
T3-002-02	Failure of compensator, 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	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.	1. 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.	Likely	Major	High	1. Recommend the Engineer (as hired by the HKE 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. 2. Recommend the Engineer (as hired by HKE 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.	Recommendation on item 2 is made reference to Section 1.4.5.2 of Introduction to Dredging Equipment prepared by Prof Ir W.J. Vlasblom of Delft University of Technology (2003).	The dredger will be maintained to a condition that ensure equipment are safe and sound, however, rock armour is not provided. The likelihood of pipeline damaged by dredging is classified as "Likely"

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Hazard Ref.	What If	Hazard	Description of Consequence	Existing Safeguards		Risk Assessment			Recommendation	Remarks	Justifications
				Engineering	Procedural	Likelihood	Consequence	Risk Level			
T3-003-01	Over-dredging near the submarine pipeline with rock armour	Dislocate the rocks in the rock armour for the submarine pipeline, weakening the protection and possible damage to the submarine pipeline	Loss of containment, release of natural gas, potential subsequent ignition.	<p>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.</p> <p>2. TSHD is equipped with compensator which provides compensation for the vertical movement of the suction pipe.</p> <p>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.</p>	<p>1. 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.</p>	Possible	Major	High	<p>1. 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 HKE to manage the dredging works).</p> <p>2. Recommend the Engineer (as hired by HKE 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.</p> <p>3. The dredged profile measurement has to be conducted with the presence of the foreman.</p> <p>4. 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.</p> <p>5. The measurement results have to be submitted to the Engineer for review at the same day the measurement is conducted.</p> <p>6. Recommend the foreman to remind the dredger master to observe if liquid flow is reduced by clogging of suction pipe.</p> <p>7. Recommend the Contractor to conduct underwater survey by diver at the location of submarine gas pipeline immediately after completion of dredging works there.</p>		When dredging is conducted near the submarine pipeline, a trial run will be conducted to confirm the dredging profile and dredging will be conducted in a controlled manner with limit set to prevent over dredging. Rock armour is provided to protect the submarine pipeline. The likelihood of pipeline damaged by dredging is classified as "Possible".

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Hazard Ref.	What If	Hazard	Description of Consequence	Existing Safeguards		Risk Assessment			Recommendation	Remarks	Justifications
				Engineering	Procedural	Likelihood	Consequence	Risk Level			
T3-003-02	Over-dredging near the submarine pipeline without rock armour	Movement of alluvium on seabed, loss of localised support to submarine pipeline causing high stress	Loss of containment, release of natural gas, potential subsequent ignition.	<p>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.</p> <p>2. TSHD is equipped with compensator which provides compensation for the vertical movement of the suction pipe.</p> <p>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.</p>	<p>1. 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.</p>	Likely	Major	High	<p>1. 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 HKE to manage the dredging works).</p> <p>2. Recommend the Engineer (as hired by HKE 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.</p> <p>3. The dredged profile measurement has to be conducted with the presence of the foreman.</p> <p>4. 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.</p> <p>5. The measurement results have to be submitted to the Engineer for review at the same day the measurement is conducted.</p> <p>6. Recommend the Contractor to conduct underwater survey by diver at the location of submarine gas pipeline immediately after completion of dredging works there.</p>		When dredging is conducted near the submarine pipeline, a trial run will be conducted to confirm the dredging profile and dredging will be conducted in a controlled manner with limit set to prevent over dredging. Rock armour is however not provided. The likelihood of pipeline damaged by dredging is classified as "Likely".
T3-004-01	Breakage of intermediate gantry wire/draghead winch gantry wire during dredging near the submarine pipeline with rock armour	The suction pipe may not be able to be retrieved back to the TSHD upon completion of the dredging works. Draghead is dragged across the submarine pipeline, causing damage to the submarine pipeline	Loss of containment, release of natural gas, potential subsequent ignition.	<p>1. Rock armour of about 2.0 m thick is provided along the submarine pipeline inside the Channel for an overall length of 730m.</p> <p>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.</p>	<p>1. 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.</p> <p>2. TSHD shall manoeuvre away from the submarine pipeline in case the draghead cannot be retrieved back to the TSHD.</p> <p>3. The path of the TSHD dredging operation will be designed to be in parallel with the submarine pipeline alignment.</p>	Possible	Major	High	<p>1. Recommend the Engineer (as hired by the HKE 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.</p> <p>2. 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.</p>		As rock armour is provided for the pipeline section within the channel that provides protection for anchors as heavy as 15.8 tonnes, the chance of pipeline damage by dragging of suction pipe is reduced. The dredger will be maintained to a condition that ensure equipment are safe and sound, the likelihood of pipeline damaged by dredging is classified as "Possible".

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Hazard Ref.	What If	Hazard	Description of Consequence	Existing Safeguards		Risk Assessment			Recommendation	Remarks	Justifications
				Engineering	Procedural	Likelihood	Consequence	Risk Level			
T3-004-02	Breakage of intermediate gantry wire/draghead winch gantry wire during dredging near the submarine pipeline without rock armour	The suction pipe may not be able to be retrieved back to the TSHD upon completion of the dredging works. Draghead is dragged across the submarine pipeline, causing 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.	1. 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. 2. TSHD shall manoeuvre away from the submarine pipeline in case the draghead cannot be retrieved back to the TSHD. 3. The path of the TSHD dredging operation will be designed to be in parallel with the submarine pipeline alignment.	Likely	Major	High	1. Recommend the Engineer (as hired by the HKE 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. 2. 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.		The dredger will be maintained to a condition that ensure equipment are safe and sound, however, rock armour is not provided. The likelihood of pipeline damaged by dredging is classified as "Likely".
4. Dumping the Sediment to Designated Disposal Pit											
T4-001	Accidental dumping of mud right above the submarine pipeline	The weight of mud imposed extra loading onto the submarine pipeline causing damage	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. The TSHD will have locking device to prevent accidental splitting and dumping of materials.	-	Unlikely	Major	Medium	1. Recommend to request the TSHD not to stay near the submarine pipeline unless it is necessary and this will be confirmed by the foreman who is hired by the Engineer.	Locking device is assumed to be installed in the TSHD to prevent accidental separation of the hull due to ship motions and vibrations. This is made reference to Para 17.3.2 of Rules and Regulations for the Classification of Ships prepared by Lloyd's Register Group Limited 2014. Rock size is 600mm	Hydraulic rams and locking device will be provided in TSHD to ensure controlled opening operations and prevent accidental opening and dumping of materials. Likelihood of pipeline damage caused by dumping of mud is classified as "Unlikely".