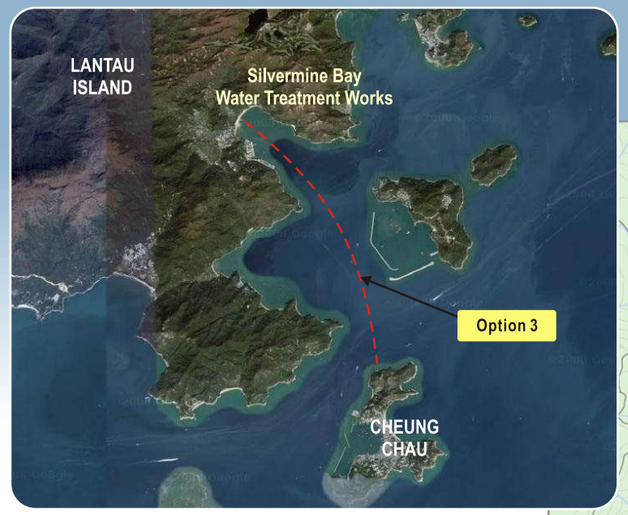
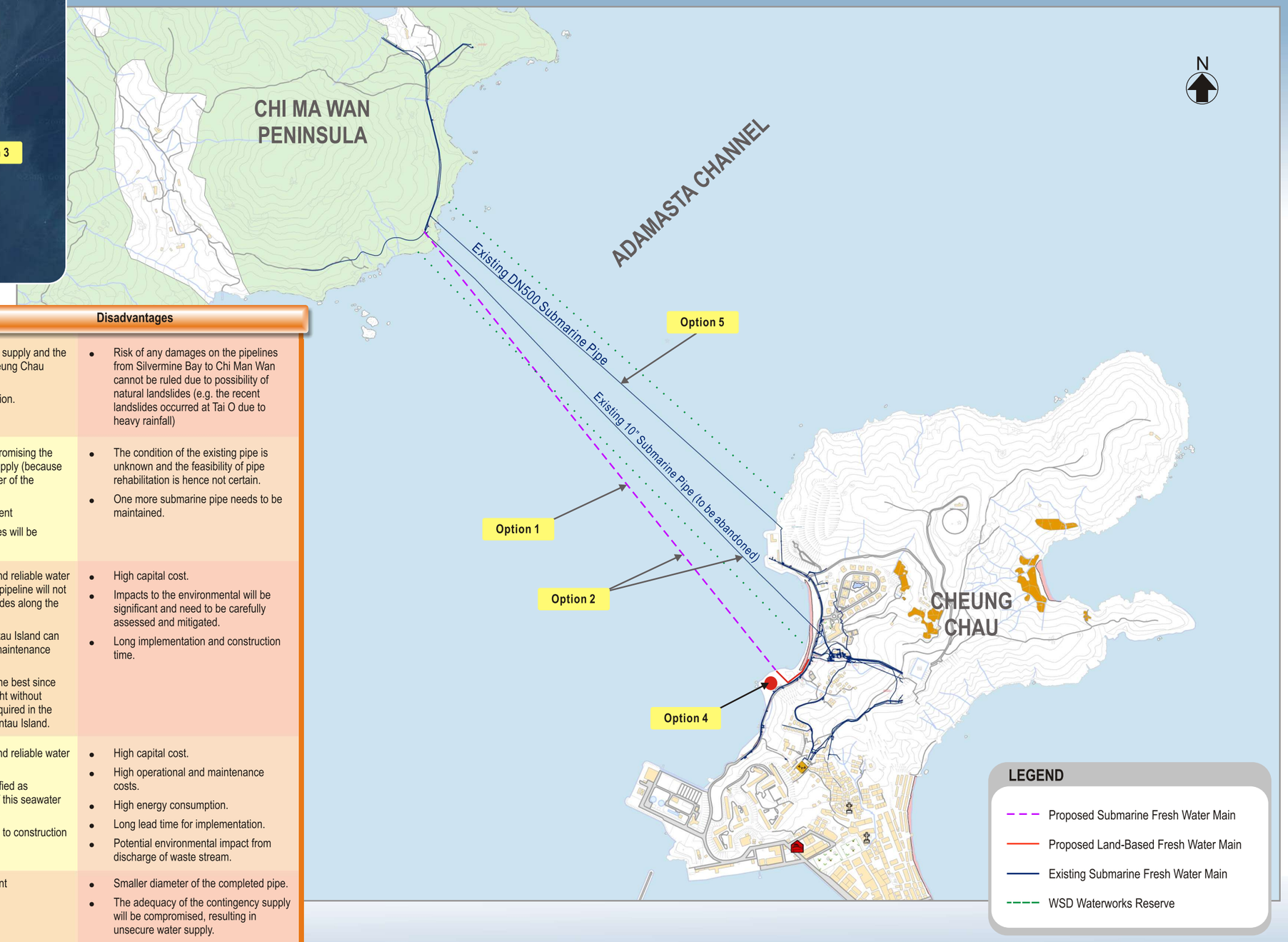
Appendix 2

Evaluation of Options for Improving the Adequacy and Reliability of the Water Supply to Cheung Chau



	Advantages	Disadvantages
Option 1 **Lay a DN 500 submarine pipe**	• A conventional method of water supply and the supply from Chi Ma Wan to Cheung Chau should be reliable. • Least lead time for implementation.	• Risk of any damages on the pipelines from Silvermine Bay to Chi Man Wan cannot be ruled due to possibility of natural landslides (e.g. the recent landslides occurred at Tai O due to heavy rainfall)
Option 2 **Lay a DN 300 submarine pipe and rehabilitate the existing 10” pipe when necessary**	• Least capital cost without compromising the adequacy of the contingency supply (because the new pipe is of same diameter of the existing pipe) • Lesser impacts to the environment • Smaller HDD plant and drill holes will be required.	• The condition of the existing pipe is unknown and the feasibility of pipe rehabilitation is hence not certain. • One more submarine pipe needs to be maintained.
Option 3 **Construction of a new 10 km of submarine pipeline from Silvermine Bay Water Treatment Works to Cheung Chau**	• One of the most independent and reliable water supplies to Cheung Chau. This pipeline will not be damaged by possible landslides along the coast of Lantau Island. • The existing pipeline along Lantau Island can be adopted as backup so that maintenance cost will be reduced • Hydraulic efficiency should be the best since the pipe alignment will be straight without headloss in bends which are required in the land main along the coast of Lantau Island.	• High capital cost. • Impacts to the environmental will be significant and need to be carefully assessed and mitigated. • Long implementation and construction time.
Option 4 **A desalination plant**	• One of the most independent and reliable water supplies to Cheung Chau. • Existing 10” mains can be modified as seawater intake to share part of this seawater supply to the desalination plant. • Impacts to the environment due to construction are negligible.	• High capital cost. • High operational and maintenance costs. • High energy consumption. • Long lead time for implementation. • Potential environmental impact from discharge of waste stream.
Option 5 **Rehabilitate the existing 10” pipe**	• Least impacts to the environment	• Smaller diameter of the completed pipe. • The adequacy of the contingency supply will be compromised, resulting in unsecure water supply.



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APPENDIX 2
Figure 1
Basic Options for Improvement of Water Supply to Cheung Chau

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Section 1

1. Outside WSD Reserve Limit.
2. Steep coastline not suitable for HDD launching.
3. Long land main is required.

Section 2

1. Close to the existing DN500 submarine pipe.
2. Duplicate pipe alignments on land will be running along Cheung Kwai Road.

Section 3

1. Landfall location is not feasible due to the presence of the existing Refuse Transfer Station (which is likely a private land as shown on the DLO's land plans). Land is an issue unless the station can be re-allocated.

Section 4

1. Landfall location is not feasible due to the angle of orientation with respect to Lantau Island.
2. Bending radius of HDD will not be feasible to reach there from Lantau Island.
3. Zoned as Coastal Protection Area
4. Partially encroaches into Tai Kwai Wan Archaeological Site

Section 5

1. Close to Scenic Garden which is a noise sensitive receiver.
2. Encroachment onto Tai Kwai Wan Archaeological Site and beach areas.
3. Zoned as Coastal Protection Area

Section 6

1. Width of Cheung Kwai Road is not sufficient for the HDD setup.
2. Partially encroaches into Tai Kwai Wan Archaeological Site.
3. Zoned as Coastal Protection Area

Section 7

1. Outside the WSD Reserve Limit.
2. Good potential site for HDD construction.
3. Longer HDD construction.

SECTIONS 1 & 2

SECTION 3

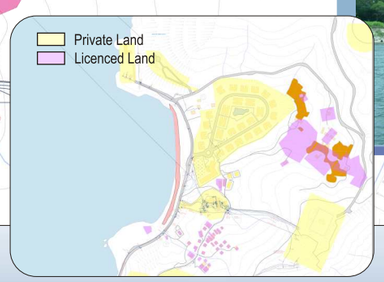
SECTIONS 4 & 5

SECTION 5

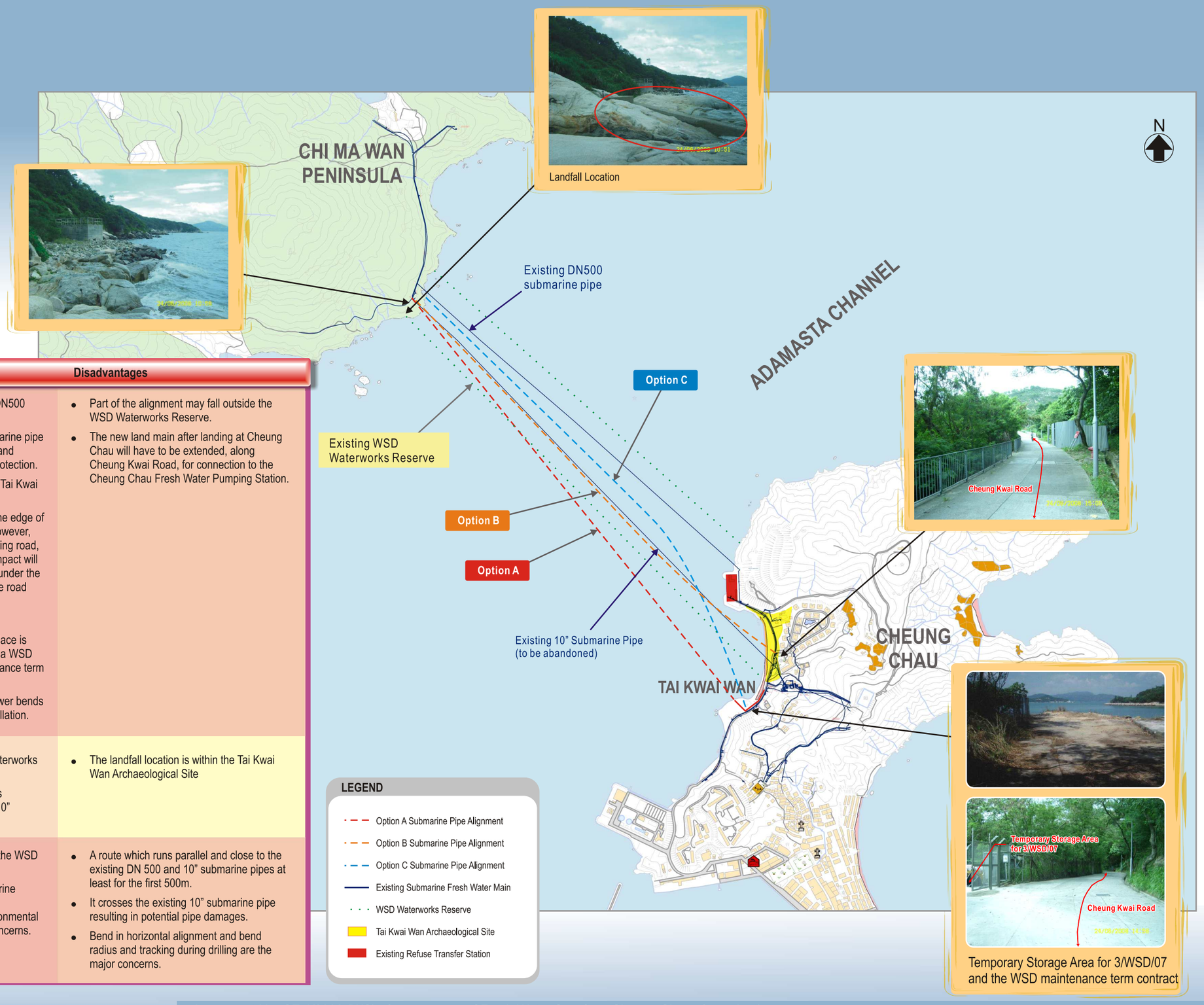
SECTION 6

SECTION 7

FURTHER SOUTH OF SECTION 7



FACTOR	DETAILS
1. WSD Waterworks Reserve	It is preferable to be within the reserve. Consent from DLO is required to revise the limit of the WSD Reserve if the new pipe alignment is outside the current reserve limits.
2. Tai Kwai Wan Archaeological Site	It is preferable to avoid encroachment onto the site. This factor is in conflict with that of WSD Reserve because choice of alignment will likely be outside the Reserve if it needs to be located out of the archaeological site.
3. Sufficient separation distance from existing submarine pipes	1. It is preferable to have a sufficient separation from the existing submarine pipe (particularly the existing DN 500 submarine pipe) so that potential damages to the existing pipes can be minimized during construction of the proposed pipeline. 2. It is not preferable to go underneath any of the two existing pipelines so as to minimize the difficulties in maintenance.
4. Alignment to be distinct from the existing DN 500 submarine pipe	1. It is not preferable to have the new alignment similar to that of the DN 500 pipe (i.e. running parallel or with landfall locations close to each other) since reliability of supply could be effectively reduced. Existing cathodic protection of the pipeline could be affected if the pipe alignments are close.
5. Bathing beach (Tai Kwai Wan)	Avoid encroachment onto the beach areas as far as practicable.
6. Coastal Protection Area (CPA) Zone	According to the Notes of the outline zoning plan, filling of land or excavation of land within 'CPA' requires planning permission from Town Planning Board.
6. Land issues	The Refuse Transfer Station has occupied and limited the choice of the proposed pipe alignment, such that having a straight horizontal pipe alignment between the two existing submarine pipelines is not feasible. The proposed landfall will likely fall on areas zoned 'Coastal Protection Area' (CPA).
7. Bending radius of HDD installation	A minimum radius of installation is 1000 times the steel pipe (as sleeve pipe) diameter. The alignment must be designed so that feasible drill path and necessary plant can be identified.
8. Existing water mains on land (i.e. location of the existing pumping station near Cheung Kwai Street)	Ease of connection to the existing water mains on both Lantau and Cheung Chau needs to be considered during the preliminary and detailed designs. A landfall location, north of the existing DN 500 submarine pipe, may not be preferable because: I. The alignment will be too similar/close to that of the existing DN 500 submarine pipe thus reducing the reliability of the supply. ii. Longer land main is required iii. Probably the landfall pipe will be outside the WSD Reserve Iv. Location is not suitable for HDD launching
9. Close to noise sensitive receivers (NSR) on Cheung Chau	Noise impacts to the nearby NSRs along Cheung Kwai Road are to be assessed.



Temporary Storage Area for 3/WSD/07 and the WSD maintenance term contract

	Advantages	Disadvantages
Option A	• A route distinct from that of the existing DN500 submarine pipe. • A good clearance from the existing submarine pipe to prevent damages during construction and potential effect of the existing cathodic protection. • The landfall location is far away from the Tai Kwai Wan Archaeological Site. • A short section of land mains will be on the edge of the Tai Kwai Wan Archaeological Site. However, since the alignment will be along an existing road, Cheung Kwai Road, no archaeological impact will be likely encountered as the subsurface under the road must have been disturbed during the road and underground utilities construction. • Vehicular access nearby. • Good site location for HDD setup (This place is currently occupied as the works areas of a WSD Stage 2 R&R contract and WSD maintenance term contract) • Straight alignment on plan resulting in fewer bends for better drilling operation and pipe installation.	• Part of the alignment may fall outside the WSD Waterworks Reserve. • The new land main after landing at Cheung Chau will have to be extended, along Cheung Kwai Road, for connection to the Cheung Chau Fresh Water Pumping Station.
Option B	• The entire pipeline is within the WSD Waterworks Reserve. • Minimum marine archaeological impact is expected for working within the existing 10" submarine pipe construction trench.	• The landfall location is within the Tai Kwai Wan Archaeological Site
Option C	• Majority of the pipe alignment are within the WSD Waterworks Reserve. • An area between the two existing submarine pipes, which had been disturbed during construction, should have the least environmental impact and the marine archaeological concerns.	• A route which runs parallel and close to the existing DN 500 and 10" submarine pipes at least for the first 500m. • It crosses the existing 10" submarine pipe resulting in potential pipe damages. • Bend in horizontal alignment and bend radius and tracking during drilling are the major concerns.

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APPENDIX 2
Figure 3

Comparison of Basic Options of Pipe Alignments between Chi Ma Wan and Tai Kwai Wan

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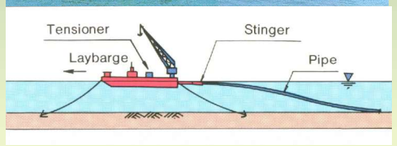
LAYING METHOD

Laybarge

Pipes are connected by welding on laybarge which moves to allow continuous length of connected pipes to descend to the trench.

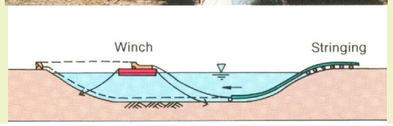
- Suitable to large-scale submarine pipeline installation
- Impact on marine traffic during pipelaying operation



Bottom Pull

Pipes stringing and launching are carried out ashore. The welded pipe string is towed on the sea bottom by a winch installed at the opposite side or a pulling barge.

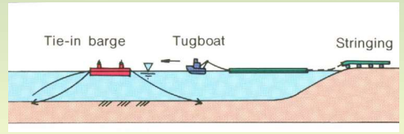
- Relatively smaller impact on marine traffic
- Working space on shore is required



Surface (Flotation) Towing

A pipes string prepared ashore or on sea surface is towed in the floating condition up to where it is installed. The pipe string is then welded on sea and laid down by a crane barge and a tie-in barge.

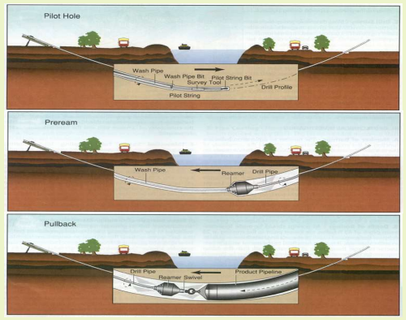
- Suitable for small-scale submarine operation



Horizontal Directional Drilling

A pilot hole is drilled along the pre-planned profile. The hole is enlarged by reaming process. The hole is stabilized by bentonite slurry before pipe installation.

- Severe variation in ground material can deviate the alignment
- Feasibility is limited by the length and diameter of pipeline
- Working space on shore is required



BURYING METHOD

Dredging • Grab dredging • Suction	Removal of marine sediments from the seabed to form the trench into which the pipelines are laid.	• Comparatively fast way • Suitable for areas where extra pipeline protection is required (eg rock armour protection) • Higher potential for impacts to water quality • Excavated sediments will require disposal off-site
Jetting (Trenching)	Water jets are used to break-up, remove or liquefy the soil from under a marine pipeline allowing the pre-installed pipeline to settle at an elevation below the seabed. The jet machine ejects plumes of fluidised soil out of the eductors on the sides of the machine in the bottom portion of the water column.	• Fluidised soil has the potential to become entrained in the water column and affect water quality.
Jetting (Injection)	Jetting machine uses two swords to cut into the sediments and then fluidise the marine sediments in front of the machine and between the two swords. The pipeline positioned between the two swords settles down into the fluidised material.	• May require up to several passes to lay the pipelines at the required depth • Little material is entrained into the water column and unlikely to cause adverse impacts to water quality

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	Horizontal Directional Drilling (HDD)	Remarks for HDD	Conventional Laying Methods (CLM)	Remarks for CLM
Pipe				
Constraints on pipe alignment	****	Pipe alignment can be steered in curve alignments which are governed with a maximum bending radius of about 100 times the pipe diameter.	**	Pipe alignment needs to be straight with little curvature due to the direct laying of pipes onto the seabed.
Constraints on landfall location	**	Landfall locations will be the launching and receiving pits which need to be considered carefully.	***	Should have fewer constraints as compared with HDD option.
Length of submarine pipe	****	The longer the pipeline, the lower unit cost of installation.	***	The effect as mentioned for the HDD technique is less significant.
Pipe configuration /protection	*****	A PE pipe for convey of water will be installed within a steel sleeve pipe. Furthermore, since the pipe will be installed within the bedrock, the chance of being damaged by ship anchor or hydrodynamic forces is negligible.	**	The steel pipe will be protected by rock fill at the top of pipe. The chance of being damaged by excavation nearby, ship anchor or hydrodynamic forces cannot be completely ruled out.
Environmental Impacts				
Marine Ecological Impact	*****	Negligible impact to marine ecology is anticipated as minimal disturbance to the sea and seabed.	**	Impact to marine ecology is anticipated due to disturbance to the sea and seabed. Mitigation measures are required.
Marine Archaeological Impact	*****	Negligible impact to marine archaeology is anticipated since excavation is below the rockhead.	**	Impact to marine archaeology is anticipated due to disturbance to the sea and seabed. More stringent requirements on the impact assessment will be expected.
Fisheries Impact	****	If frac out and inadvertent inflow can be eliminated, there should be minimal impact.	**	Dredging work will definitely have a negative impact. See further comment below regarding the construction period.
Water Quality Impact	****	Negligible impact on water quality as minimal disturbance to the sea and seabed. Drilling fluid needs to be properly managed.noise impact is anticipated at the launching site. Mitigation measures are required.	**	Adverse water quality impact due to disturbance of marine sediment.
Noise Impact	**	Potential noise impact is anticipated at the launching site. Mitigation measures are required.	**	Noise impact from marine vessels during dredging and pipelaying needs to be mitigated.
Air Impact	*****	Negligible impact is anticipated.	**	Air impact due to the smoke/fume released from marine vessels for dredging and pipelaying needs to be mitigated.
Impact by wastes	***	Drilling fluid needs to be properly disposal of after construction. Overspill at launching and receiving pits needs to be controlled.	*	Significant dredging is required and disposal of the marine mud is a major environmental concern.
Visual and Landscape Impact	*****	The section above the sea level will be still kept below ground. Minimal impact to the visual aspect is anticipated.	**	The section above the sea level is often laid on the seabed with concrete surround to prevent flotation and provide protection. Visual impact due to the concrete surround is a concern.

	Horizontal Directional Drilling (HDD)	Remarks for HDD	Conventional Laying Methods (CLM)	Remarks for CLM
Traffic Impacts				
Marine Traffic	*****	Negligible impact to the marine traffic.	*	Severe impact is anticipated due to the busy marine traffic at Adamasta Channel.
Land Traffic	****	More impacts due to the stretch out of long pipe string prior to installation but it is only an issue of the pedestrian traffic which can be easily mitigated.	****	Less impact is anticipated.
Other Considerations				
Cost	**	It will be more difficult to have an accurate construction cost estimates without a comprehensive site investigation.	****	Construction cost can be more accurately estimated based on past experience.
Land Requirement	**	Temporary land allocation for launching and receiving pits are required.	****	Fewer requirements are anticipated.
Construction Considerations				
Site Investigation	*	Accurate and adequate site investigation is required.	****	Since works are mainly on the surface of the seabed, the requirements of site investigation should be less stringent than that required under HDD.
Construction Period	*****	• If proper and sufficient investigation and planning works are conducted, the construction can be completed within 3 years. • Drilling operation can be carried out during night time if necessary and permitted.	**	• Construction period could be lengthened since marine activities will have an adverse impact on the marine traffic and marine ecology, which may need restriction period. • Day light is required for most of the work.
Risks associated during construction	****	There can be a lot of major risks during construction if proper and sufficient investigation and planning works have not been conducted. Comprehensive site investigation (as mentioned above) is therefore critically required so as to minimize the risks.	***	Less risks as compared to HDD as pipes are to be laid on the seabed with dredging and excavation from the seabed surface. Potential impacts can be more readily estimated and foreseen during construction.
Operation and Maintenance				
Ease of Operation	*****	• Air valves will be installed at the launching and receiving pits • No complaints on operation from WSD have been received on watermains laid by HDD.	*****	Air valves will be installed on both land sections and no particular constraints are anticipated.
Maintenance requirements	*****	Pipe burst or leakage is not anticipated since the water carrying pipe is of PE material which is free of corrosion and is securely protected by the sleeve pipe and bedrock.	**	Potential damages by others and corrosion (if steel pipes are used) cannot be ruled out completely. Any pipe repair is extremely difficult and expensive, apart from the public inconvenience due to supply interruption if pipe burst occurs.

Legend:

***** Least impacts/requirements/difficulties/ concerns/constraints as appropriate