

**INFORMATION PAPER FOR  
ANTIQUITIES ADVISORY BOARD (AAB)**

---

**ARCHAEOLOGICAL WORK AT THE SACRED HILL AREA FOR  
THE SHATIN TO CENTRAL LINK (SCL) -  
TAI WAI TO HUNG HOM SECTION (TAW-HUH)**

**PURPOSE**

1. This paper serves to update and address concerns of Members of the Antiquities Advisory Board (AAB) on MTR's proposal to protect T1 area of the launching shaft area (LSA) with a protection wall scheme presented in a briefing to the AAB on 15 May 2014.

**BACKGROUND**

2. At present, most of the archaeological work in the LSA has been completed except the T1 area. In order to provide the protection of the exposed archaeological features and cultural relics in T1 area from wet weather, MTR has presented a protection wall proposal using push-in sheet piles in a briefing to the AAB on 15 May 2014. In addition, this method allows the construction works to continue at the remaining parts of the LSA which is crucial to the commissioning of SCL TAW-HUH.
3. A follow-up briefing was given by MTR to the AAB on 29 May 2014 to answer queries raised by Members in relation to MTR's proposal. At the conclusion of this briefing, the Chairman also expressed his concern about the stability of the unprotected T1 area during the rainy season and requested MTR to start implementing a protection scheme as soon as the method is finalized and agreed. The Chairman summarized actions required for MTR as follows:
  - 3.1 To review the T1 protection wall proposal and address the following concerns expressed by Members:
    - a) The distance of 1.8m between the sheet pile protection wall and the square-shaped well in T1 area is considered very close and that its installation may have adverse impact on the stability of the square-shaped well;
    - b) Shifting of the launching shaft eastwards by 23m should be considered in order to keep T1 area away from the launching shaft construction activities; and
    - c) More details should be given on the monitoring scheme on the stability of archaeological features, in particular the square-shaped well in T1.
  - 3.2 To consider more alternative protection options; and
  - 3.3 To seek comments from Development Bureau on MTR's proposed protection method.

## ACTIONS TAKEN BY MTR IN RESPONSE TO AAB'S COMMENTS

4. To address Member's comment in 3.2, MTR have considered various options of protection work and came up with the following options considered:

4.1	Option 1	To re-commence archaeological excavation in T1 in parallel with shaft excavation (not supported after AMO's meeting)
	Option 2	Install pipe piles at the existing bored pile wall along T1 Area
	Option 3	Install sheet piles at the north side of bored pile wall along T1 Area (distance of about 3.3m)
	Option 4	Install sheet piles at the north side of bored pile wall near the existing wall J1 (distance of about 3.3m) and other sheet piles installed at south side of bored pile wall
	Option 5	Reduce the size of the launching shaft so that it is entirely to the east of T1 Area
	Option 6	Install sheet piles at the south side of bored pile wall along T1 Area (closest distance of about 1.8m)

4.2 The assessment on the practicality, and the effect on the stability of the archaeological features, for the above Options 2 to 6 are given in detail in the attached Annex of this paper.

4.3 To address Members' concern in 3.1(a), Options 2, 3 and 4 gave a distance of more than 1.8m between the installed sheet piles and the square-shaped well. Option 2 was found not feasible; Options 3 and 4 require a deeper sheet pile installation which would encounter rock resulting in a more adverse impact on the archaeological features during installation. Options 3 and 4 will also result in an unsafe working condition for workers in the launching shaft area as it will reduce the width of the Tunnel Boring Machine (TBM) working platform from 1.2m to 0.3m.

4.4 To address Members' concern in 3.1(b), Option 5 will reduce the size of the proposed launching shaft so that it is entirely to the east, just outside the T1 Area. The installed bored piles which form the current west headwall cross the TBM route. These will need to be removed. The removal of these bored piles will introduce significant impact on the stability of the existing archaeological features and impact an area not yet excavated. This is not acceptable in addition to significant time and cost impact.

4.5 To address Members' concern in 3.1(c), an enhanced monitoring scheme is presented in 5.4. Digital in-place inclinometers will be installed to monitor horizontal movements along the depth of Well J1. Laser scanning will be carried out in advance of the works to ensure the stability of the archaeological features is maintained during and after construction of the protection wall.

- 4.6 To address Members' comment in 3.3, MTR have presented the considered options to Development Bureau in a meeting on 5 June 2014 chaired by the Permanent Secretary, Mr CS Wai. Mr Wai's comments on MTR's proposal for the protection of T1 Area are as follows:
- a) The use of push-in sheet pile method (*Giken Silent Piler Method*) is a suitable method for installation of the protection wall.
  - b) The technical constraints that the sheet pile cannot be moved further from the 1.8m at the nearest location were confirmed valid and MTR was asked to consider if the sheet piles could be moved further at the localized area of the Well J1 area (Option 4 as stated above was added and it was also discussed in the meeting).
  - c) In addition to the proposed monitoring method by settlement and vibration monitoring points, more advanced technology should be applied to enhance the monitoring method for the stability of the square-shaped well during and after construction of the protection.

#### **ENHANCED PROTECTION PROPOSAL**

5. Option 6 mentioned in 4.1 has been further developed to form the enhanced protection proposal with reasons and details as follows.
- 5.1 From the summary table in Annex H, it can be seen that Option 2 is not feasible and the concerns of Options 3, 4 and 5 cannot be satisfactorily addressed. In contrast, the concern of Option 6 is considered to be adequately addressed by the use of *Giken silent piler method*. Recent measurements conducted in similar ground conditions and witnessed by Highways Department show that the vibration induced at a distance of 1.8m from the pile installation can be controlled to less than the admissible limit agreed with AMO. This provides further confidence that the proposed *Giken silent piler method* is both reliable and appropriate.
- 5.2 Under Option 6, the proposed sheet pile installation will start from the southeast corner of T1 area which is more than 15m away from the archaeological features, before moving progressively closer. Through continuously monitoring, there is ample time available for analysis and fine-tuning of the pile installation method to ensure minimal disturbance to the archaeological features. Dr Liu Wensuo, the archaeologist who is the AWB licence holder, has clearly indicated that he considered this arrangement appropriate at the follow-up briefing given by MTR to the AAB on 29 May 2014.
- 5.3 The following precautionary measures will be taken during sheet pile installation proposed under Option 6:
- a) Prior to the commencement of sheet piling works, Well J1 will be filled with sand to prevent distortion. The filling arrangement will be agreed with the appointed archaeologist.
  - b) Sand bags will be placed around Well J1.

- c) Well J1 will be fenced off to make sure that no plant will operate and no works will be carried out within 1.5m of the well.
- d) The sheet piling will be carried out by experienced operators and supervised by a competent person.
- e) The condition of all archaeological features in T1 area will also be monitored by the full time archaeologist during the sheet pile installation.

5.4 In response to the Development Bureau's request in 4.6(c), an enhanced monitoring scheme will be implemented as described in Fig. 1 to ensure minimal disturbance by adjacent SCL construction works to T1 area during and after installation of the protection wall proposed under Option 6. The enhanced monitoring scheme includes:

- a) 3D laser scanning carried out before any protection measure and thereafter to capture 3D models of the archaeological features for comparison to detect any significant distortion caused by the surrounding construction activities;
- b) 2 digital in-place inclinometers installed along the full depth of Well J1 to measure horizontal displacements;
- c) 5 ground settlement markers to measure any vertical displacement; and
- d) 2 vibration monitoring points to measure the vibration induced at Well J1 and feature F3.

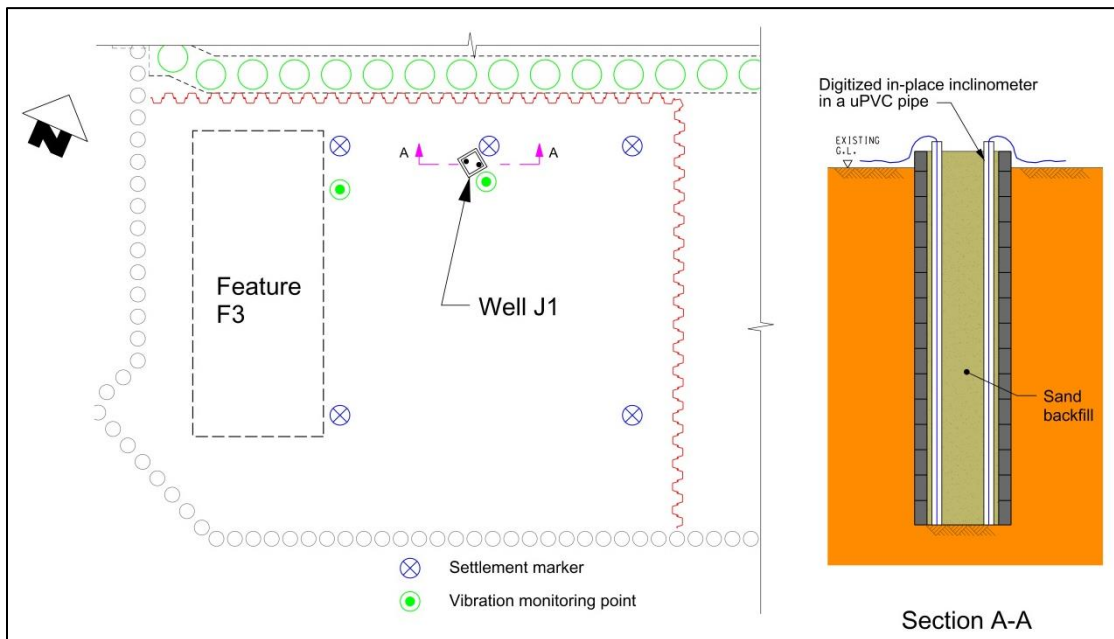


Figure 1 *Enhanced monitoring scheme*

## CONCLUSION

- 6.1 To protect the T1 area of the LSA with a view for the archaeological survey and the related excavation activities to be conducted in a safe manner, an enhanced protection plan has been developed with concerns of AAB Members taken on board.
- 6.2 The construction team of the Shatin to Central Link Project is committed to work closely with the appointed archaeologists and concerned authorities to provide updates on the status of the protection works, including the stability and any significant movement of Well J1 in a timely manner.
- 6.3 In view of the current rainy season and the current stability concern for Area T1, it is vital for the enhanced protection plan to be put in place immediately. Option 6 shall be adopted and the installation works will commence on 25 June 2014 after completing the setup of the monitoring scheme.

MTR Corporation  
18 June 2014

## ANNEX

A.	Current condition of LSA and T1 area	Page 6
B.	Option 1 Archaeological Survey Excavation can go in parallel with the Launching Shaft Excavation	Page 7
C.	Option 2 Protection of T1 area by extending the existing bored piled wall	Page 8
D.	Option 3 Protection of T1 area by installing sheet piles north of the existing bored piled wall	Pages 9-10
E.	Option 4 Protection of T1 area by installing sheet piles south of the existing bored piled wall except for the 5m section nearest to the archaeological features	Page 11
F.	Option 5 Protection of T1 area by reducing the size of the launching shaft	Page 12
G.	Option 6 Protection of T1 area by installing sheet piles south of the existing bored piled wall	Page 13
H.	Summary of Options	Page 14



**OPTION 1 - ARCHAEOLOGICAL SURVEY EXCAVATION CAN GO IN PARALLEL WITH THE LAUNCHING SHAFT EXCAVATION**

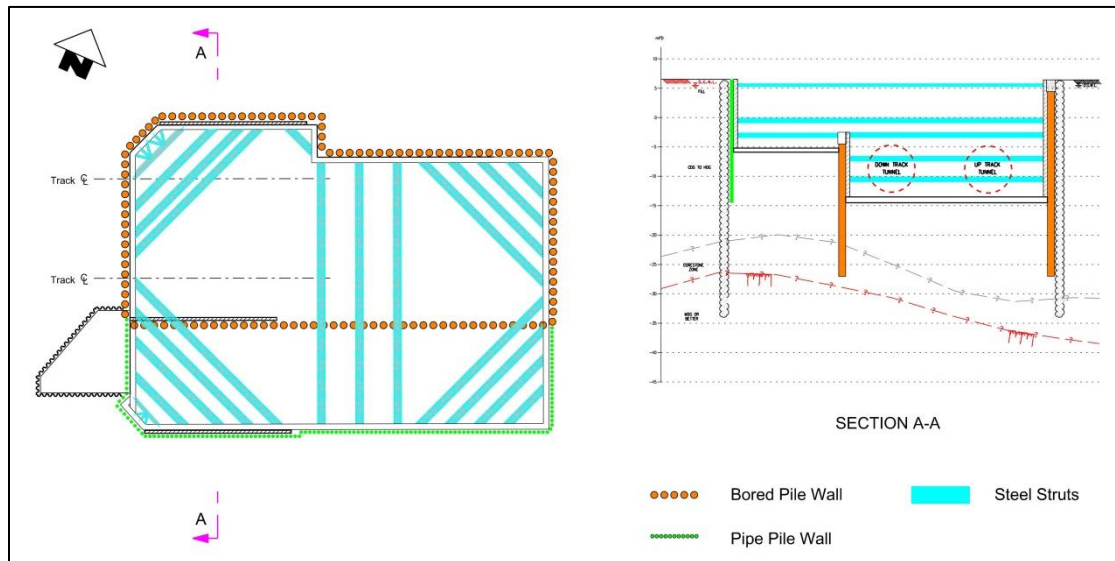


Figure B1 *Excavation and lateral support in accordance with the original design*

Under this scenario, excavation within T1 area will go in parallel with the launching shaft excavation. All archaeological features found in T1 area will be removed after detailed record taking under the supervision of AMO. Lateral support will be installed in accordance with the original design.

## OPTION 2 - PROTECTION OF T1 AREA BY EXTENDING THE EXISTING BORED PILED WALL

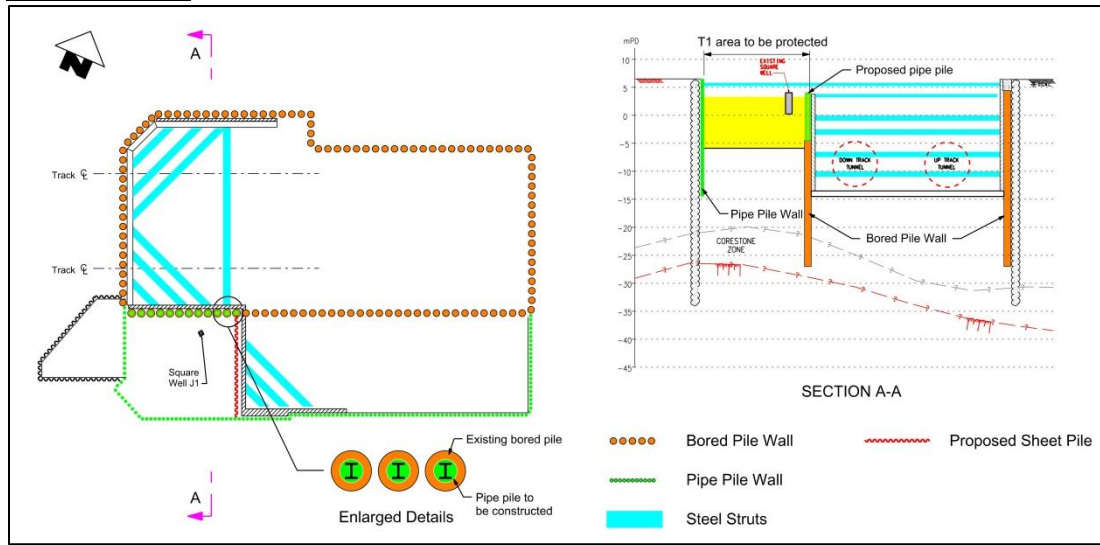


Figure C1 Option 2 - Install pipe piles into bored piled wall

Under this option, it is proposed to extend the existing bored piled wall along the northern edge of T1 area to provide the protection wall. This can be done by constructing 610mm dia pipe piles from the current T1 area ground level of +3 mPD downwards and anchoring them into the existing bored piles which had been cut off at -4.4 mPD in accordance with the original design. Sheet piles will be used to form the protection wall along the eastern edge of area T1.

Positive impact of Option 2:

- The pipe piles to be constructed will be more than 2.5m away from the nearest archaeological feature in T1 area.
- This option can make good use of the rigidity of the bored piles that had already been constructed along the northern edge of T1 area.

Negative impact of Option 2:

- The existing bored piles are quite heavily reinforced. The steel reinforcement of the bored piles will become obstructions that have to be overcome if the proposed pipe piles are to be anchored into the bored piles. The down-the-hole hammer technique used in the construction of pipe piles will not be able to overcome steel reinforcement. This technique will also generate large movement and vibration which may have adverse impact to the archaeological features in T1 area.
- A high degree of accuracy is required in the verticality control of the pipe pile construction to make sure that the pipe pile drilling which is to start at a level of +3 mPD will stay within the 1.2m dia bored pile at the cut off level of -4.4 mPD and below. It is also not possible to ascertain the as-built positions of the bored piles without first excavating and exposing the pile heads. Any off-centre drilling will be obstructed by steel reinforcement and cannot proceed.

In view of the lack of mitigation measures that can satisfactorily address the construction difficulties highlighted above, it is concluded that Option 2 is technically not feasible.



### OPTION 3 - PROTECTION OF T1 AREA BY INSTALLING SHEET PILES NORTH OF THE EXISTING BORED PILED WALL

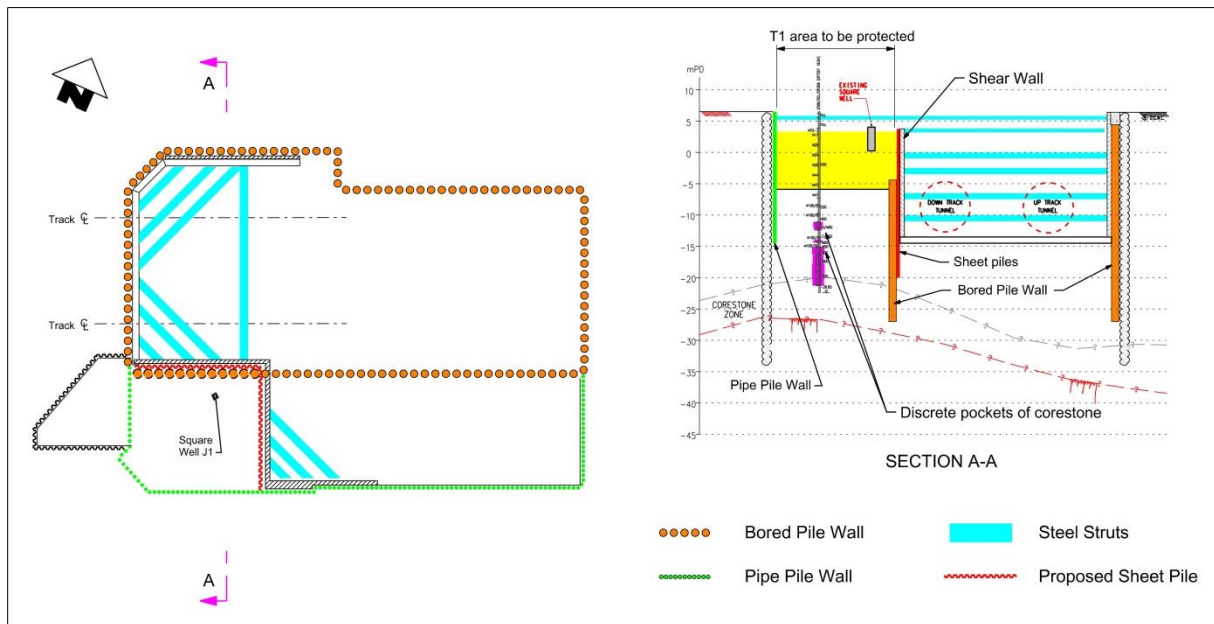


Figure D1 Option 3 - Sheet pile north of bored piled wall

Under this option, it is proposed to install 20m long sheet piles north of the existing bored piled wall using Giken silent piler to provide the protection wall.

Positive impact of Option 3:

- Sheet piles to be installed are more than 3m away from the square-shaped well.
- The Giken silent piler method proposed is expected to have minimal impact in terms of vibration and ground movement to the surrounding areas.

Negative impact of Option 3:

- 20m long sheet piles will have to be installed. Discrete pockets of corestones have been identified in the site investigation at a level of approximately -15 mPD and below. Pre-boring or pile installation methods other than Giken silent piler will have to be used to overcome the corestones. These other methods will cause larger ground disturbance than the Giken silent piler method.
- Installation of longer sheet piles into stiffer ground will require higher operating force and increase the potential impact to T1 area.
- Installation of sheet piles north of the existing bored piled wall will decrease the working space available for TBM installation. Adequate access width to meet safety requirement can no longer be provided (see Fig. D2).

**OPTION 3 - PROTECTION OF T1 AREA BY INSTALLING SHEET PILES NORTH OF THE EXISTING BORED PILED WALL (Cont'd)**

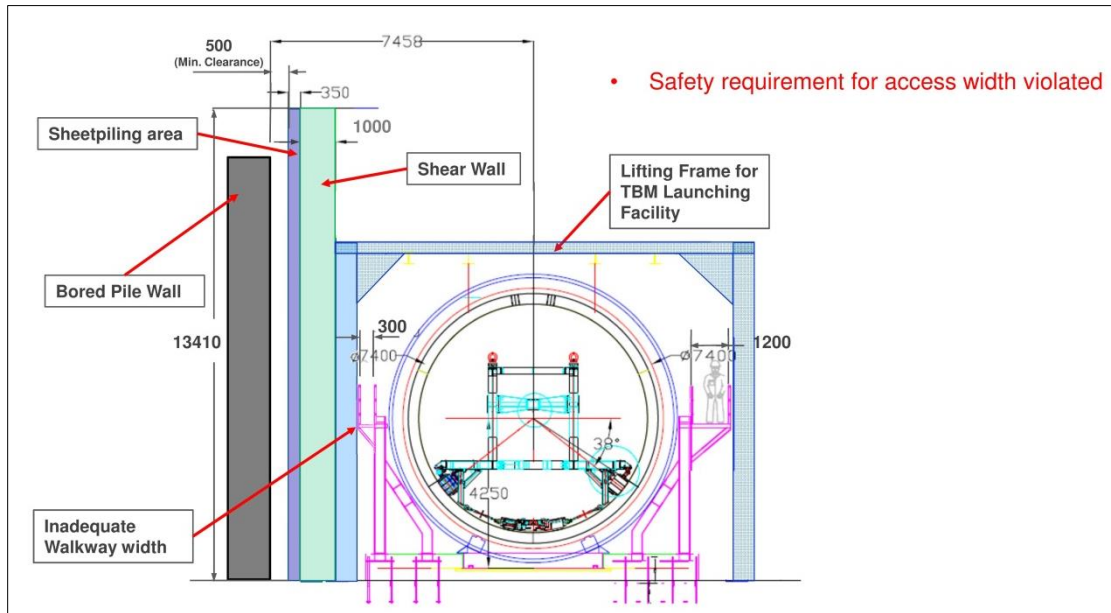


Figure D2 *Inadequate access width to meet safety requirement in Option 3*

Option 3 is considered undesirable as pre-boring or pile installation methods other than Giken silent piler will have to be used to overcome corestones during sheet pile installation. These other methods will cause larger ground disturbance that may have adverse impact to the archaeological features in T1 area.

**OPTION 4 - PROTECTION OF T1 AREA BY INSTALLING SHEET PILES SOUTH OF THE EXISTING BORED PILED WALL EXCEPT FOR THE 5m SECTION NEAREST TO THE ARCHAEOLOGICAL FEATURES**

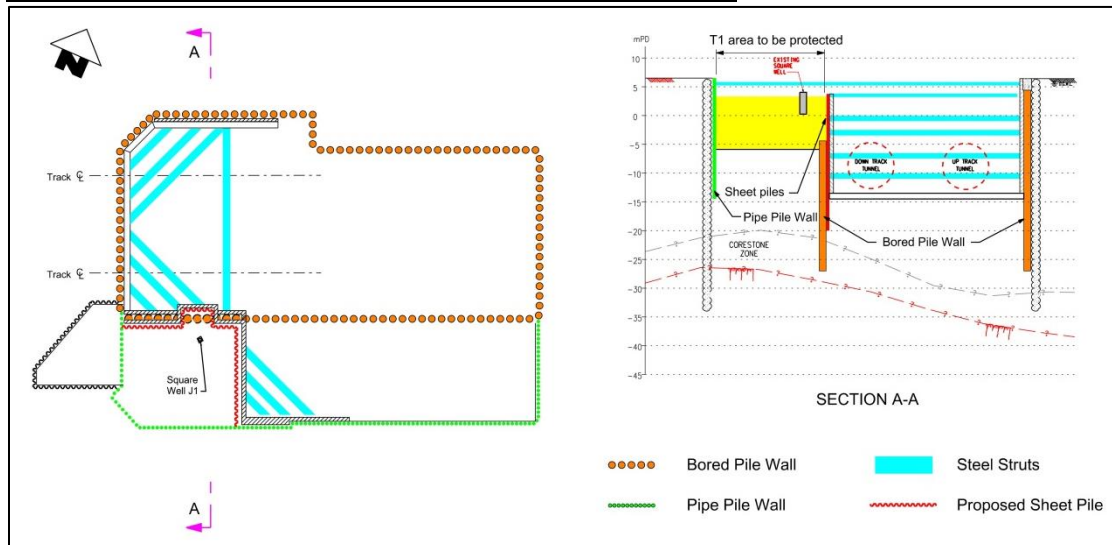


Figure E1 *Option 4 - Sheet pile south of bored piled wall except for the 5m section nearest to the archaeological features*

Under this option, it is proposed to install 12m long sheet piles south of the existing bored piled wall using Giken silent piler to provide the protection wall except for the 5m section nearest to the archaeological features, at which location 20m long sheet piles will be installed to the north of the existing bored piled wall.

Positive impact of Option 4:

- Sheet piles to be installed will be more than 3m away from the archaeological features in T1 area.
- Sheet piles to be installed south of the bored pile wall will be only 12m long, thus minimizing the chance of encountering corestones during installation.
- Sufficient working space can be maintained for TBM installation for more areas except for the 5m section nearest to the archaeological features.

Negative impact of Option 4:

- The chance of encountering corestones obstruction during installation of the 20m long sheet piles required along the 5m section north of the bored pile wall will still be significant.
- The shear wall required in front of the sheet pile protection wall to transfer the unbalanced overall lateral earth loads acting on the launching shaft will have an irregular pattern. The transfer of unbalanced overall lateral earth loads will thus be less effective, and may result in larger ground movement in T1 area.
- Adequate access width to meet safety requirement can still not be provided for TBM installation along the 5m section nearest to the archaeological features.

Option 4 is considered undesirable as similar to Option 3, pre-boring or pile installation methods other than Giken silent piler will have to be used to overcome corestones during installation of 20m long sheet piles.

## OPTION 5 - PROTECTION OF T1 AREA BY REDUCING THE SIZE OF THE LAUNCHING SHAFT

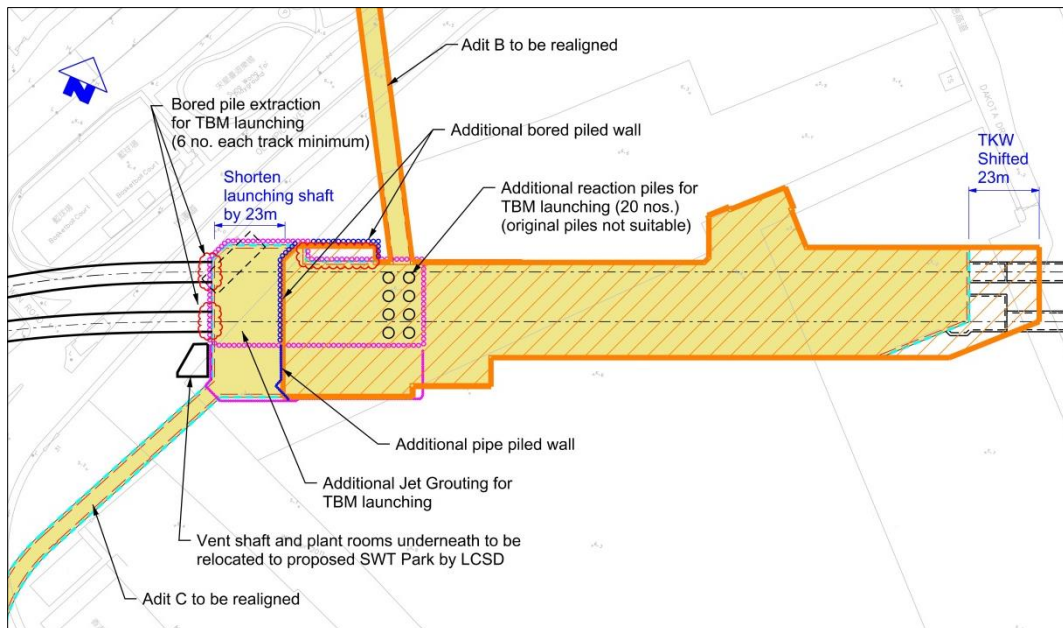


Figure F1 *Option 5 - Shaft size reduction*

Under this option, it is proposed to reduce the size of the launching shaft by 23m and to shift the entire To Kwa Wan Station eastwards by 23m. Additional construction activities required will include:

- a) Construct new bored piles and new reaction piles for TBM launching to suit the revised launching shaft configuration.
- b) Extract bored piles within the tunnel alignment.
- c) Install jet grouting for TBM launching.
- d) Remove abandoned bored piles during shaft bulk excavation.
- e) Modify large scale TBM installations that have already been completed on site, including slurry treatment plant, gantry crane and the associated foundations.
- f) Redesign platform and station.

Positive impact of Option 5:

- a) Station construction works will be shifted further away from Area T1.

Negative impact of Option 5:

- a) A considerable amount of time will have to be spent in the redesign of temporary and permanent works including the platform and the station.
- b) A considerable amount of completed works including bored piles, reaction piles and heavy duty steel struts will become abortive and have to be removed.
- c) Removal of bored piles will involve chiselling in close proximity to T1 area and may have adverse impact to the archaeological features located there.

Option 5 is considered undesirable as removal of bored piles may have adverse impact to the archaeological features in T1 area. This option will also have significant cost and time impact.

## OPTION 6 - PROTECTION OF T1 AREA BY INSTALLING SHEET PILES SOUTH OF THE EXISTING BORED PILED WALL

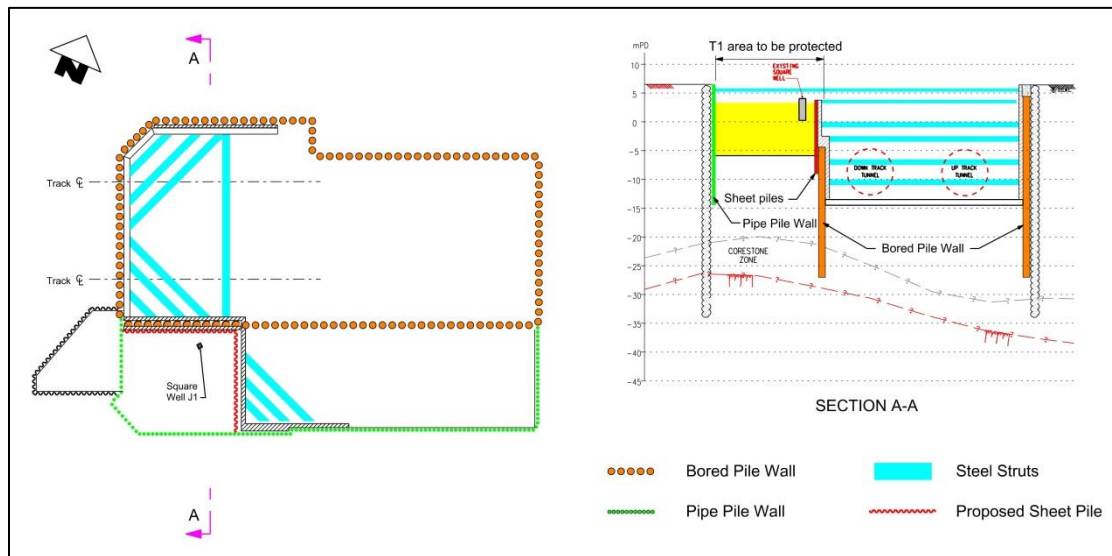


Figure G1 Option 6 - Sheet pile south of bored piled wall

Under this option, it is proposed to install 12m long sheet piles south of the existing bored piled wall using Giken silent piler to provide the protection wall.

Positive impact of Option 6:

- The Giken silent piler method proposed is expected to have minimal impact in terms of vibration and ground movement to the surrounding areas.
- The Giken silent piler method proposed will have a high chance of success as no obstruction is expected from site investigation records above the proposed toe level of the sheet piles which only need to be 12m long.
- Sufficient working space can be maintained for TBM installation. Adequate access width to meet safety requirement will not be compromised.

Negative impact of Option 6:

- Sheet piles will have to be installed at a clear distance of 1.8m from archaeological features at the nearest location, which may give a perception that they are too close.

Option 6 is considered the most desirable among all options considered as the Giken silent piler method proposed has been proven to be reliable when used in the same site before. The method is expected to have a high chance of success as no corestone is expected to be encountered during the installation of shorter (12m) sheet piles required. Recent measurements conducted in similar ground conditions and witnessed by Highways Department show that the vibration induced at a distance of 1.8m from the pile installation can be controlled to less than the admissible limit agreed with AMO.

**SUMMARY OF OPTIONS**

A summary of positive and negative impacts of the Option 2 to 6 described above is given in table form below for easy reference.

Option	Positive impact	Negative impact
2 - Install pipe piles into bored piled wall	a) Make good use of bored piles that are already in place	a) Technically not feasible
3 - Sheet pile north of bored piled wall	a) Giken method will have minimal impact to T1 b) Sheet piles more than 3m from T1	a) High chance of encountering obstructions during sheet pile installation b) TBM installation safety compromised
4 - Sheet pile north of bored piled wall except for the 5m section nearest to the archaeological features	a) Giken method will have minimal impact to T1 b) Sheet piles more than 3m from the archaeological features	a) Chance of encountering obstructions during sheet pile installation still high b) TBM installation safety compromised c) Larger ground movement due to irregular pattern of shear wall
5 - Shaft size reduction	a) Construction works will be shifted further away	a) Removal of bored piles will involve chiselling in close proximity to T1, which may cause further impact to the stability of T1 area b) Time consuming and costly
6 - Sheet pile south of bored piled wall	a) Giken method will have minimal impact to T1 b) Low chance of encountering obstructions during sheet pile installation c) TBM installation safety not compromised	a) Sheet piles only 1.8m from archaeological features at the nearest location