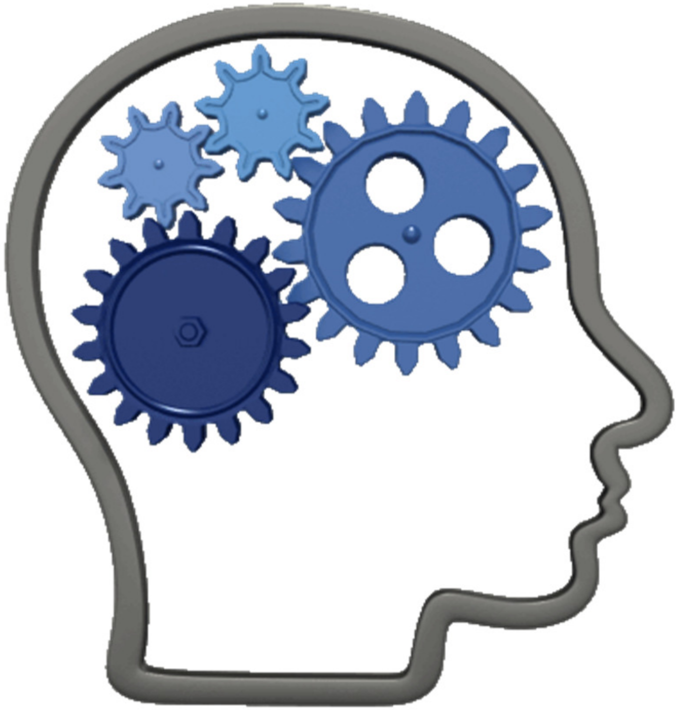
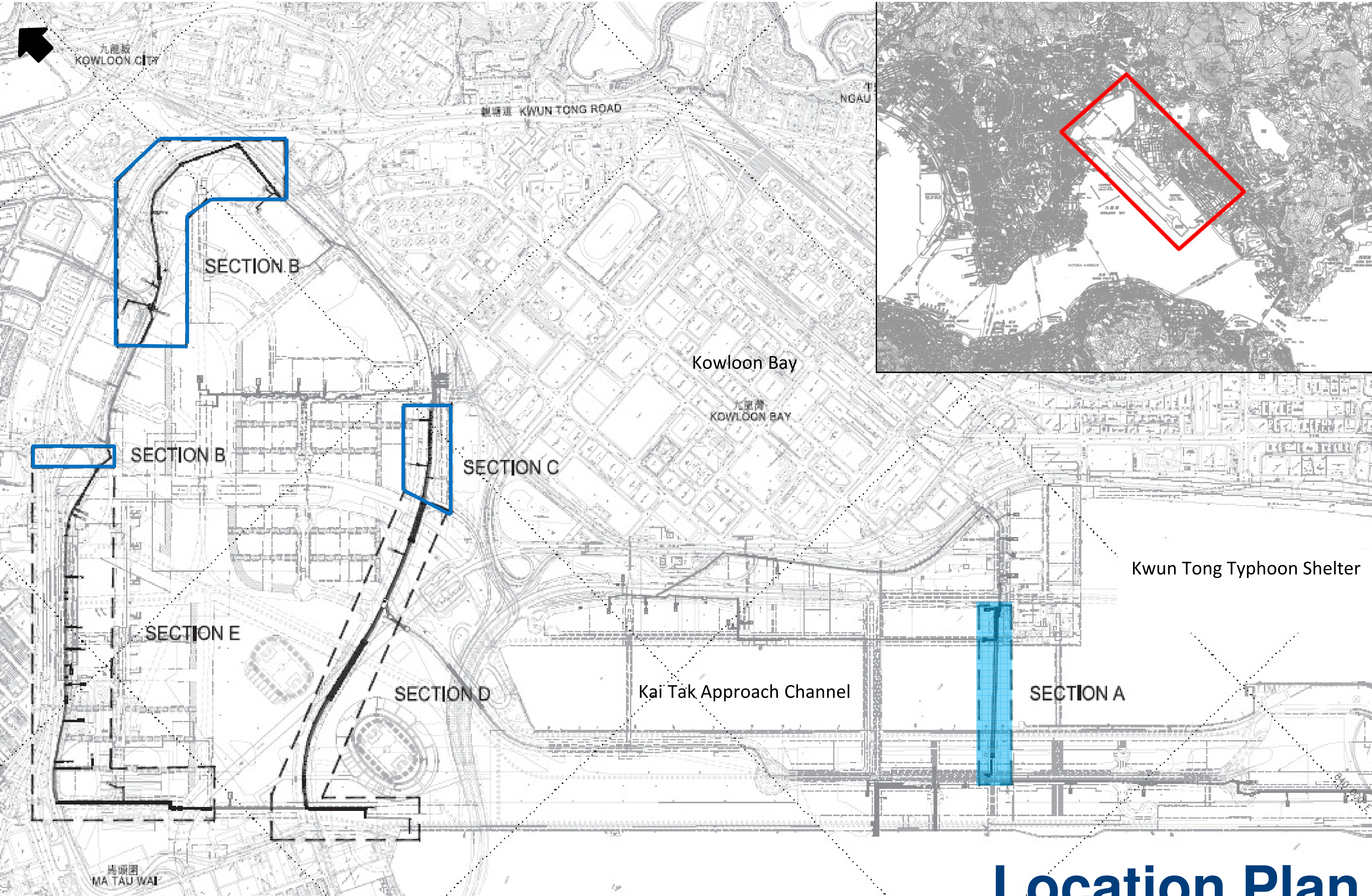
MEINHARDT

Trenchless Construction of Phase IIIA District Cooling System (DCS) By TBM Pipejacking on Kai Tak Development



26 October 2016

Presented by :
Ir Wilson W. S. Mok
FICE CEng FHKIE RPE(Civil and Geotechnical)

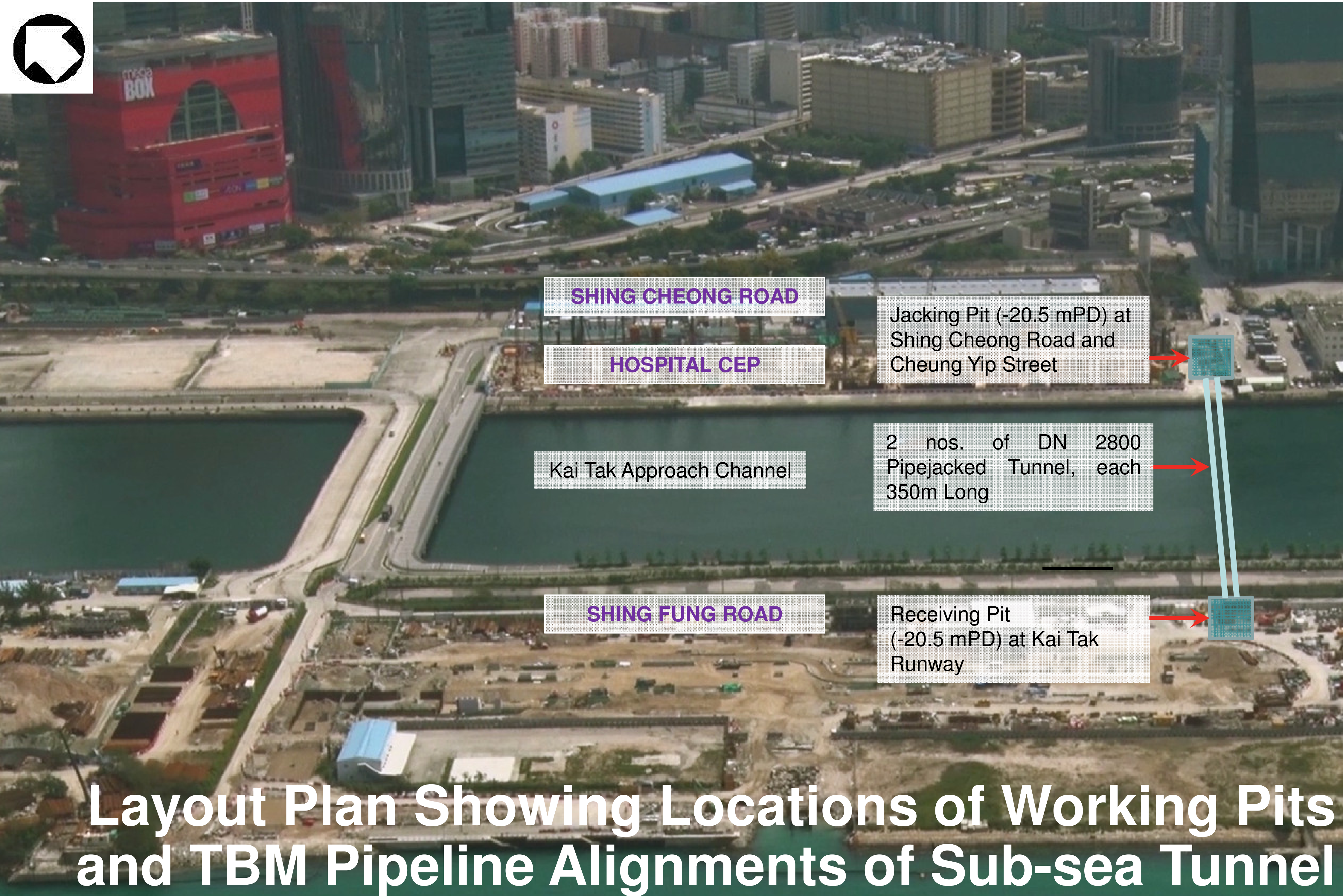


Location Plan

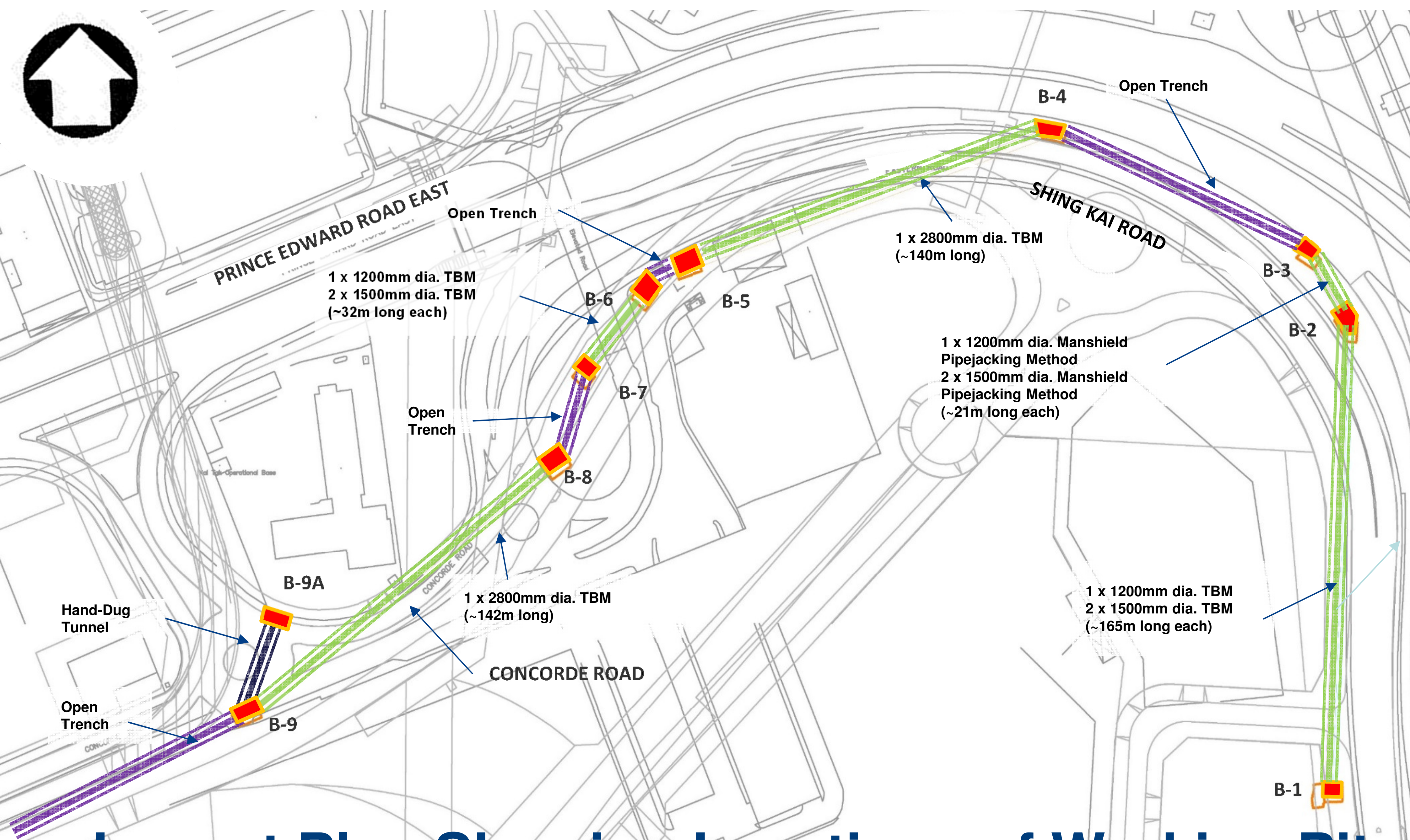
Scope of Works

- 2.5 km of Alignment Length of District Cooling System

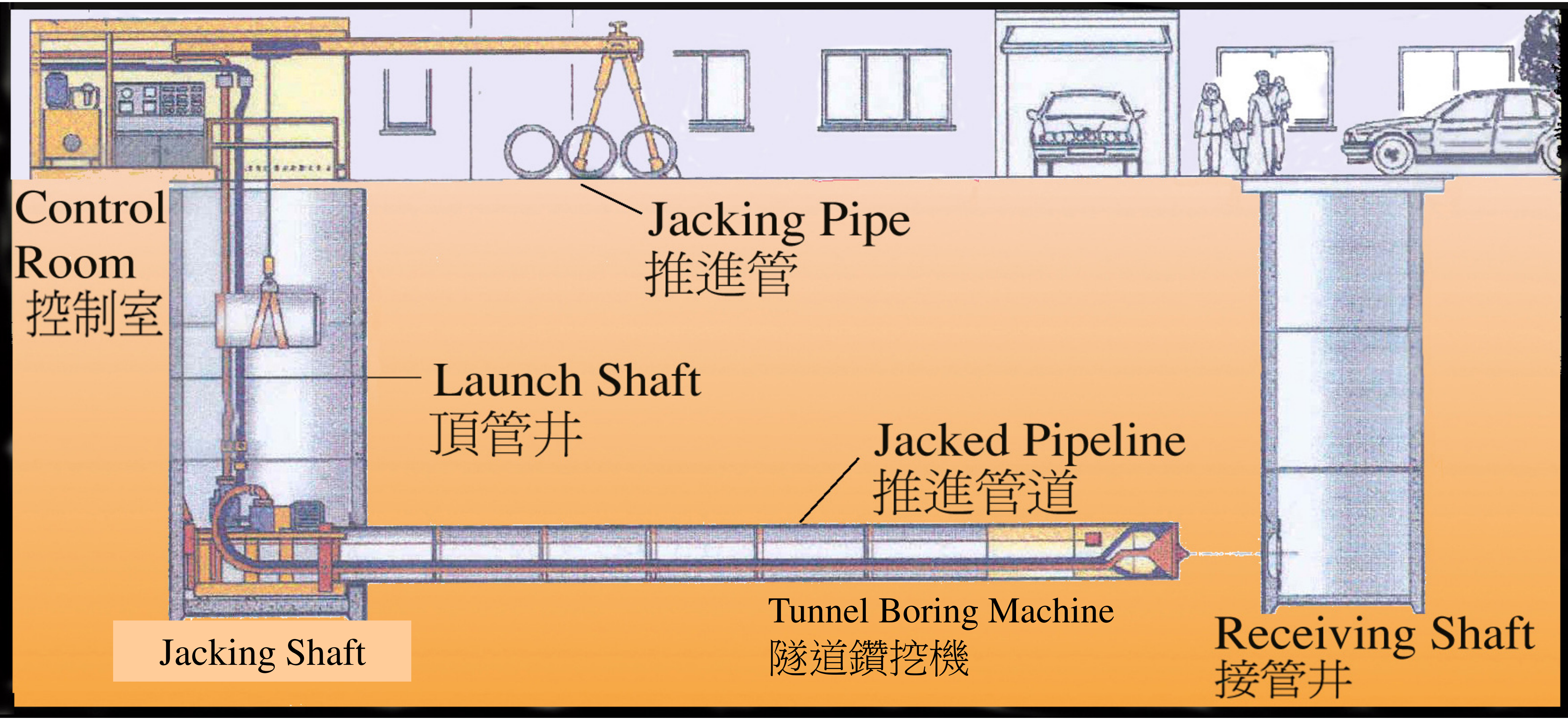
➢ 1.6 km by Open Trench
➢ 0.8 km by TBM Pipejacking Method
➢ 0.1 km by Hand-Dug Tunnelling Method



Layout Plan Showing Locations of Working Pits and TBM Pipeline Alignments of Sub-sea Tunnel



Layout Plan Showing Locations of Working Pits and TBM Pipeline Alignments



Typical Arrangement for TBM Pipejacking Works

Advantages of Adopting Pipejacking Techniques
(in Comparison with Conventional Open-trench Method)

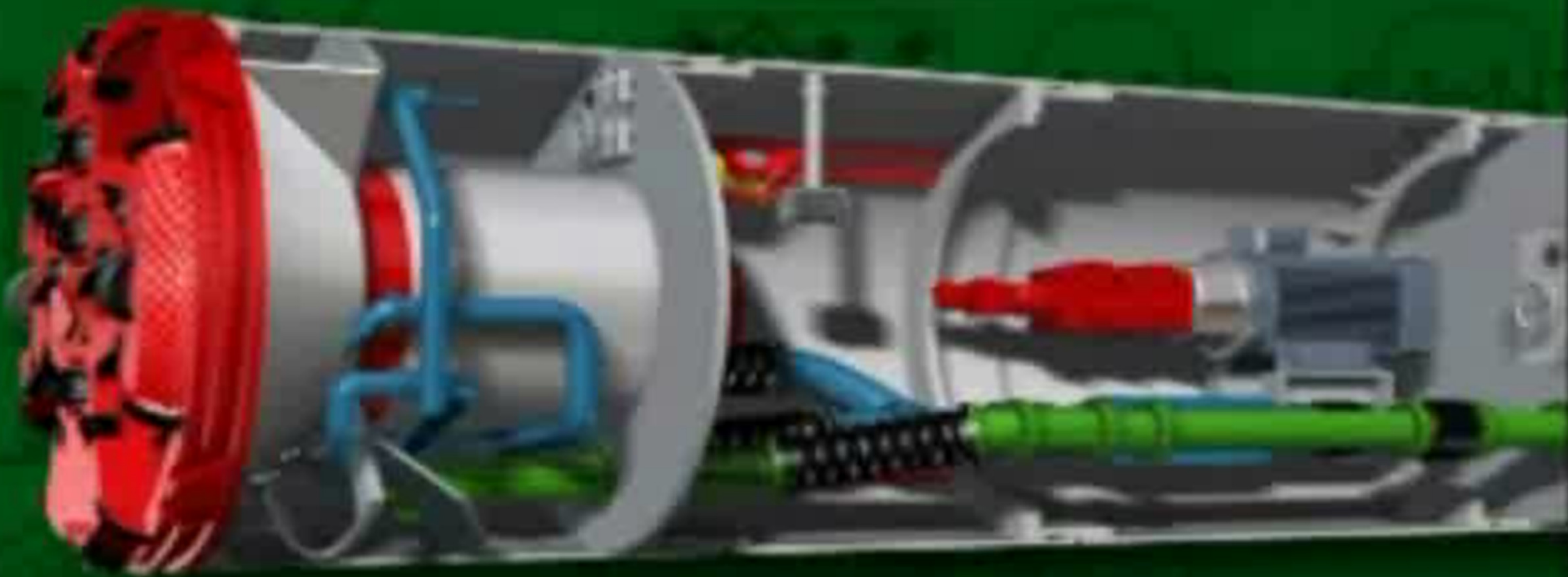
- Less disturbance to traffic
- Faster
- Less ground settlement
- Diversions of utilities limited to only the jacking and receiving shaft locations
- Less environmental problems
- Earth moving is reduced to a minimum
- Operational almost in all weathers
- Fully automatic operation, thus ensuring the safe and efficient completion of works on time

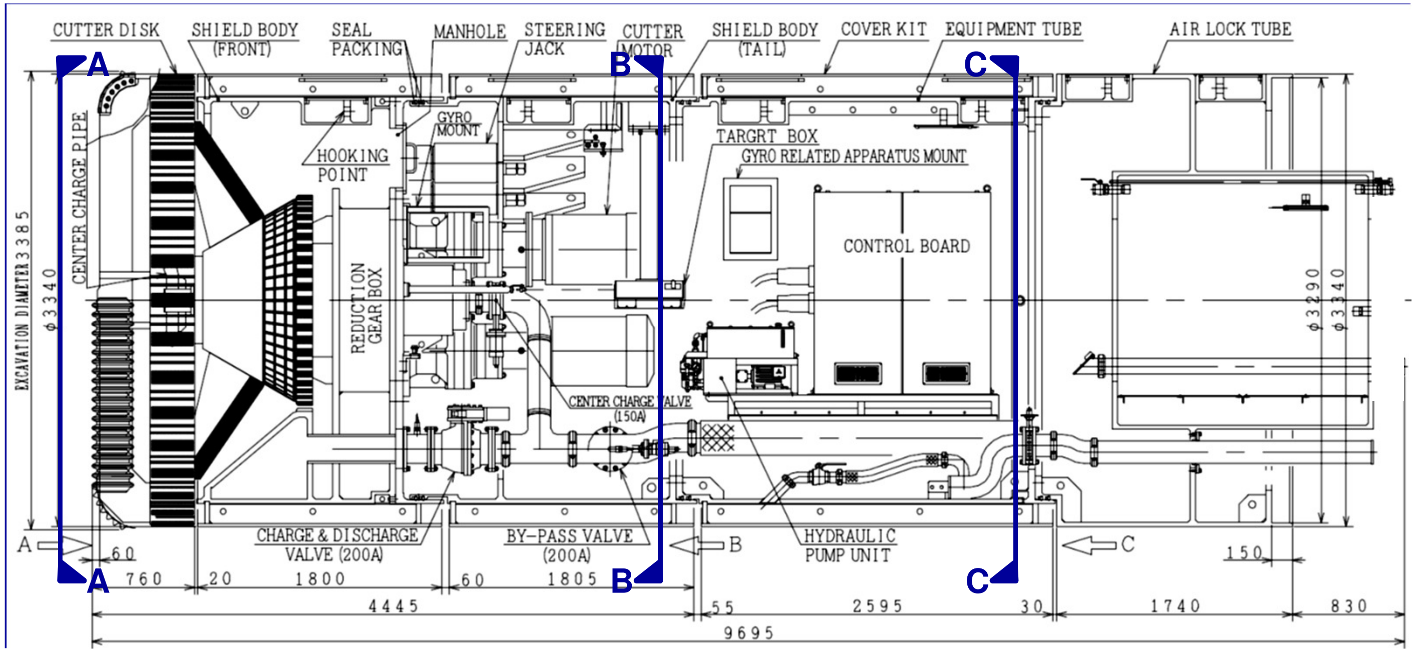
Method of TBM Pipejacking

- Earth Pressure Balance
- Slurry Pressure Balance

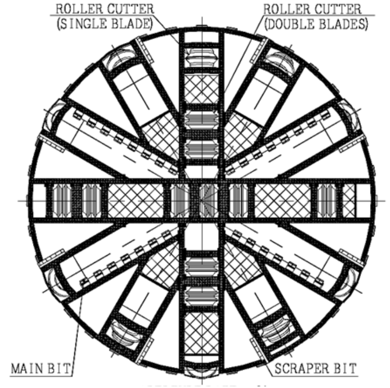
Choose Slurry Pressure Balance Method in the Project due to Highly Variable Ground Conditions

Pipe Jacking and Microtunnelling

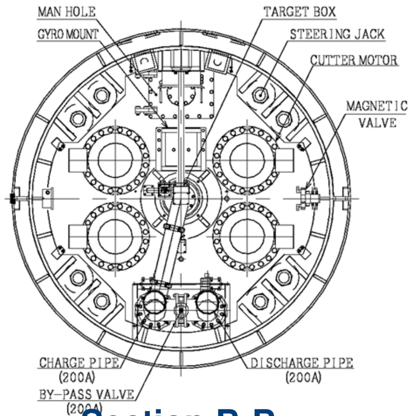




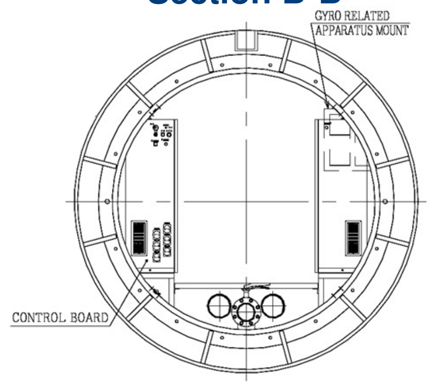
Side Elevation



Section A-A



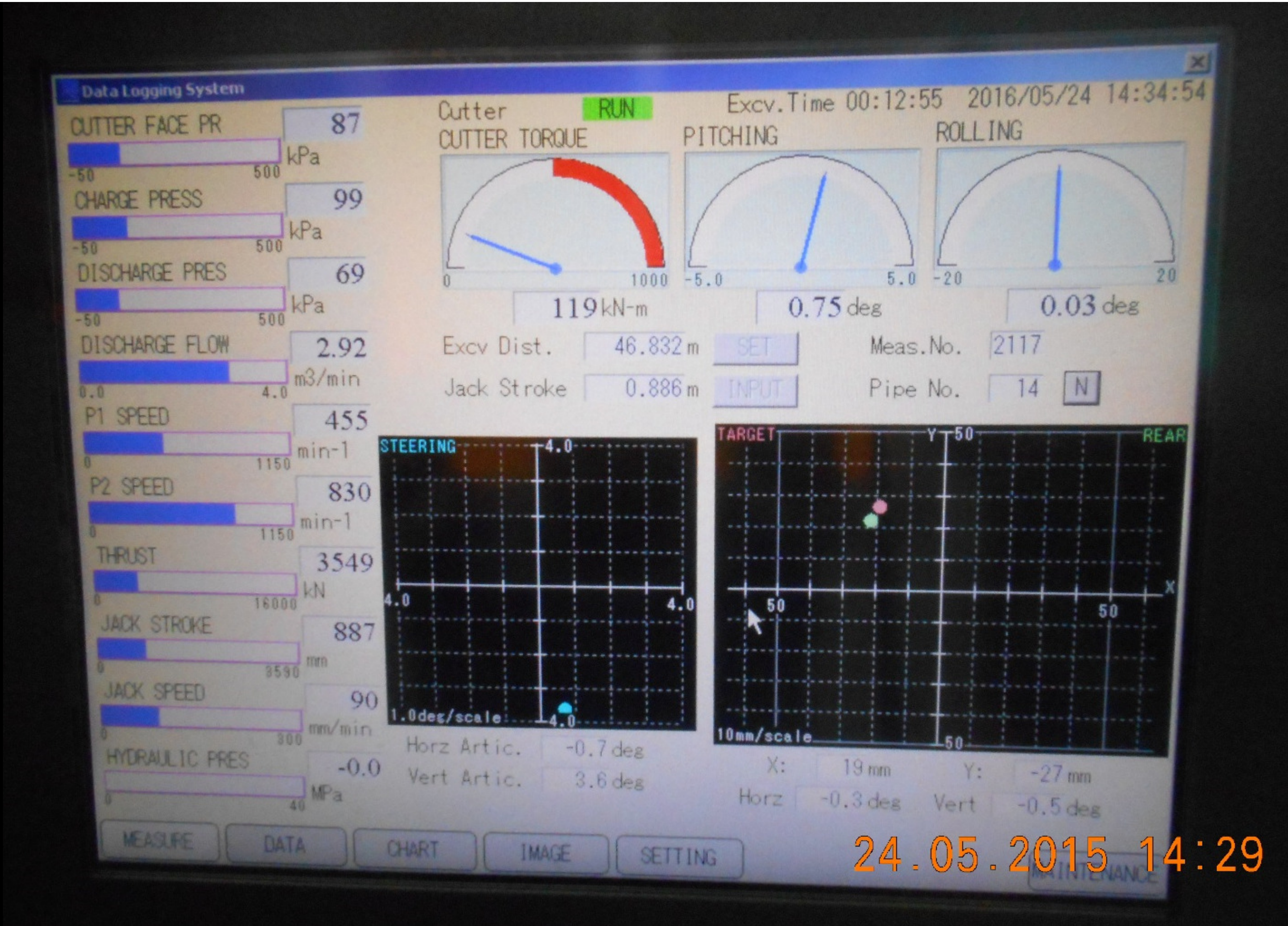
Section B-B



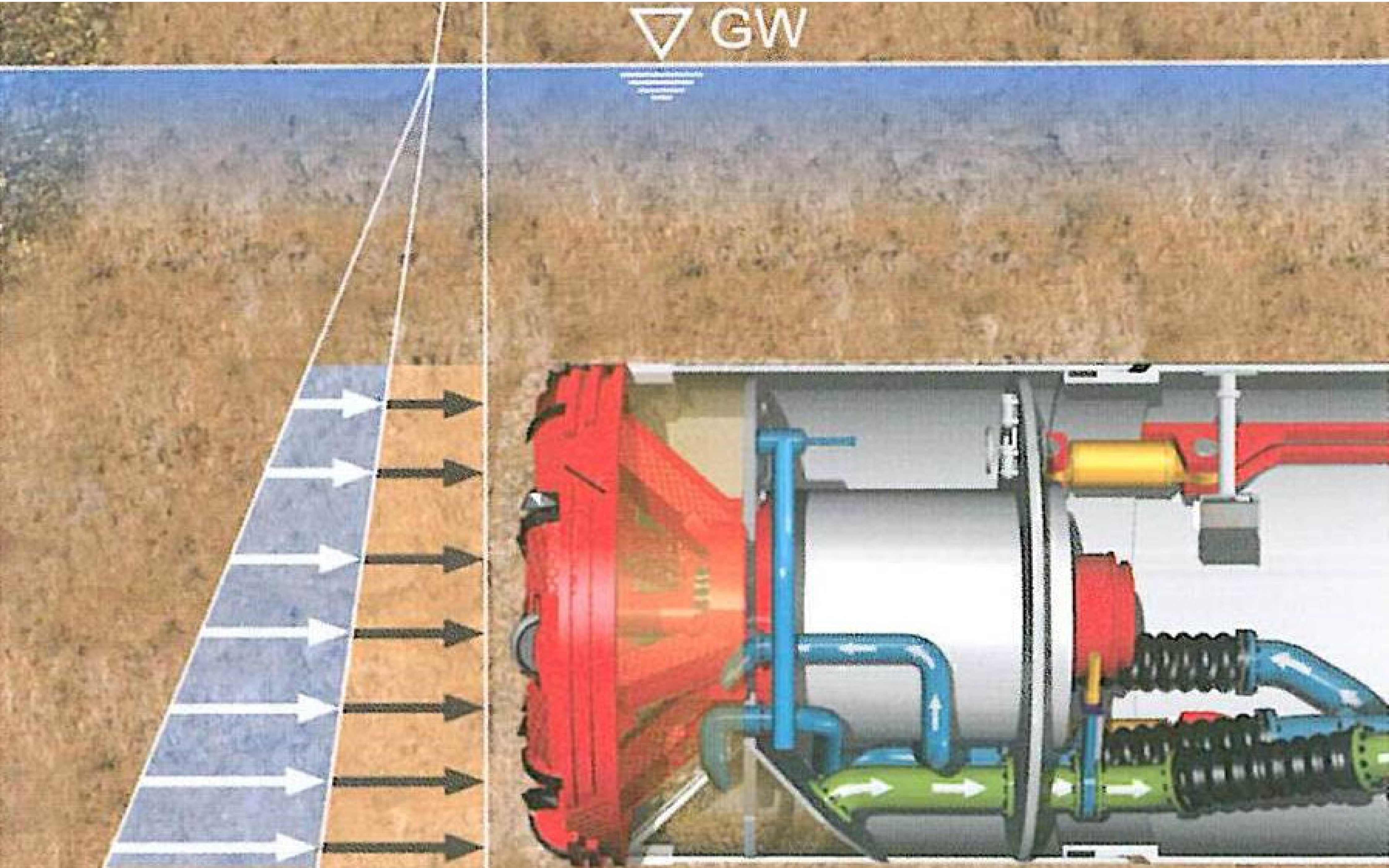
Front View and Side View

Section C-C

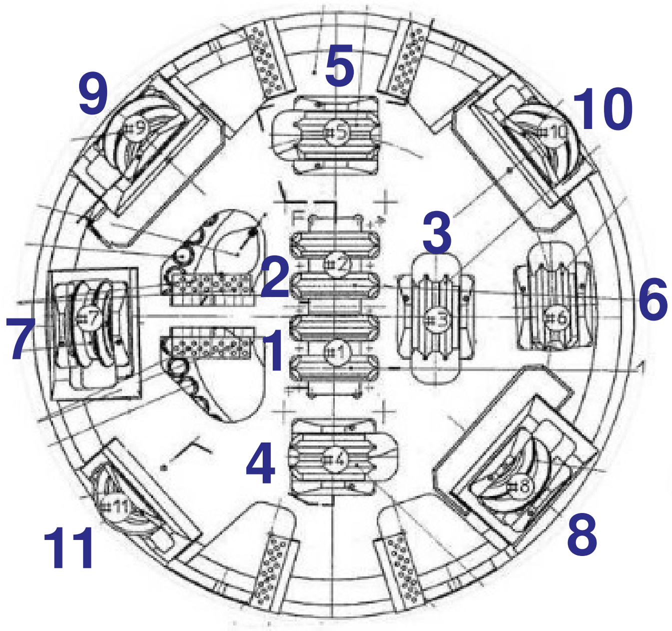
Configuration of 2800mm dia. TBM

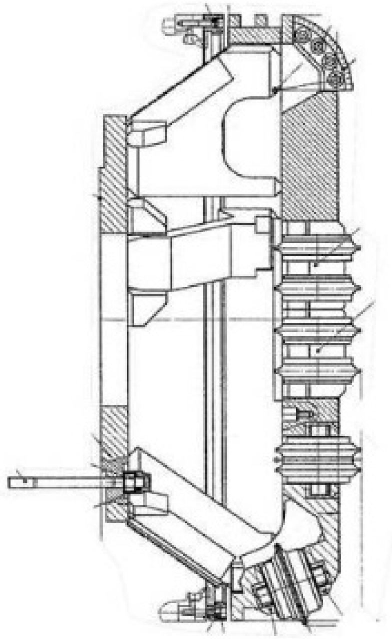


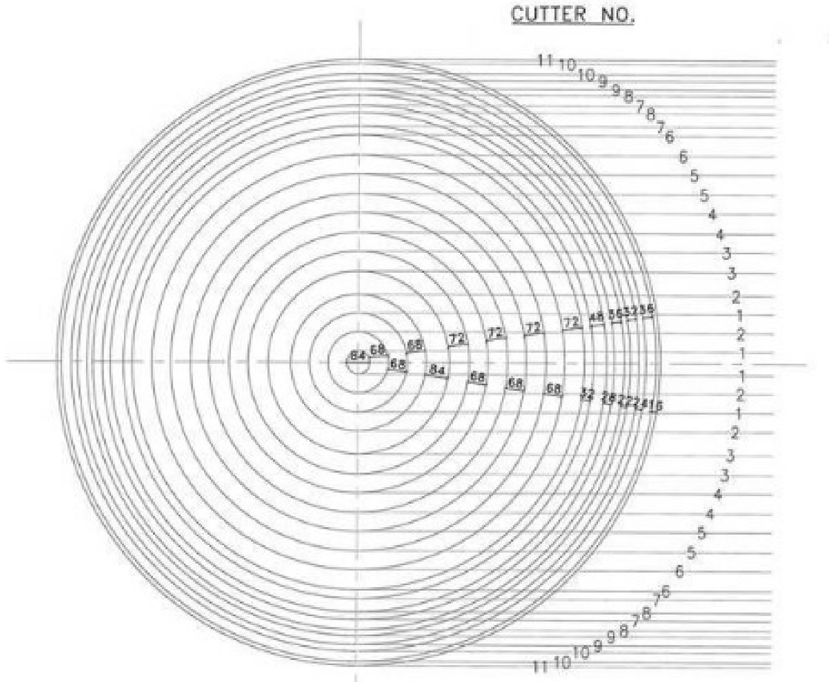
TBM Control Panel



Pipejacking by Slurry Pressure Balance Method

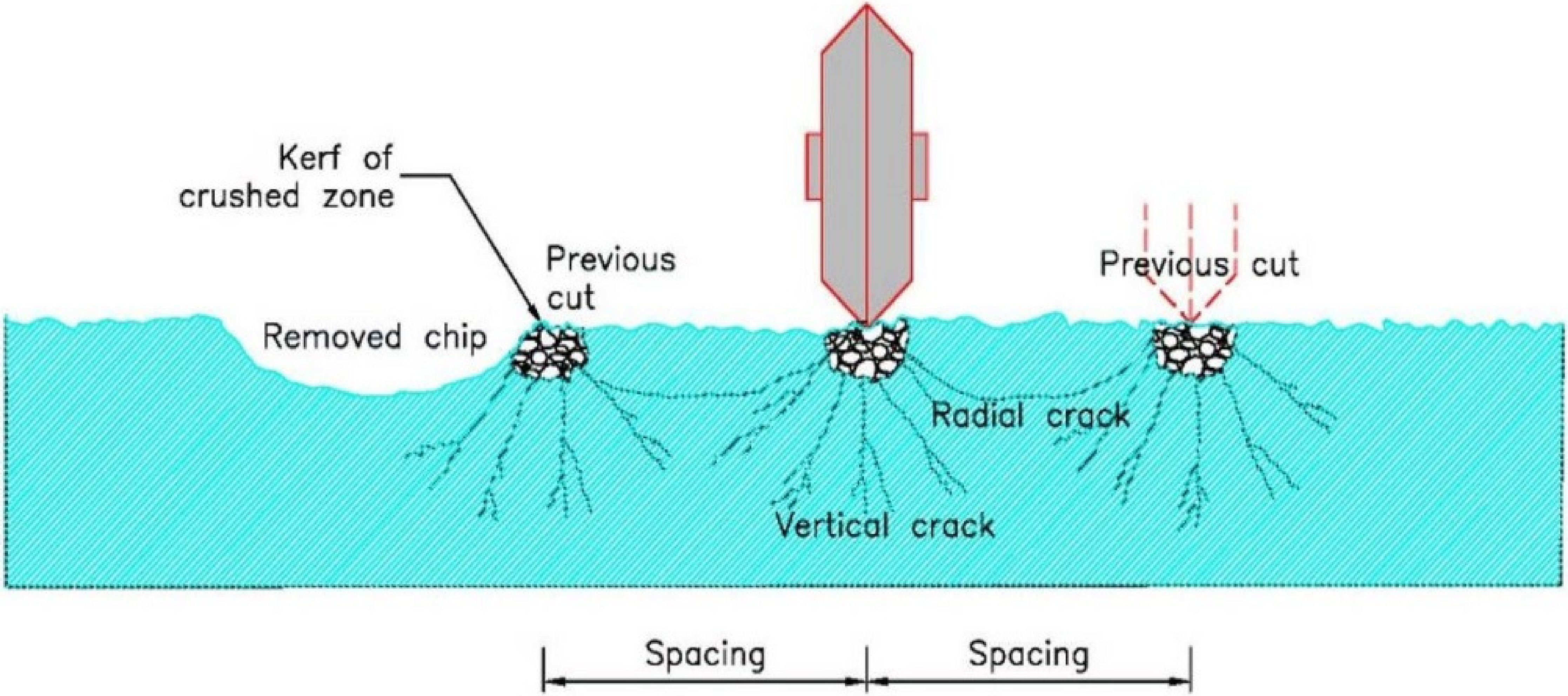






Circular Path in Rock Face
Formed by Cutting Discs

Pipejacking Operation –
Disc Cutters Cutting Analysis

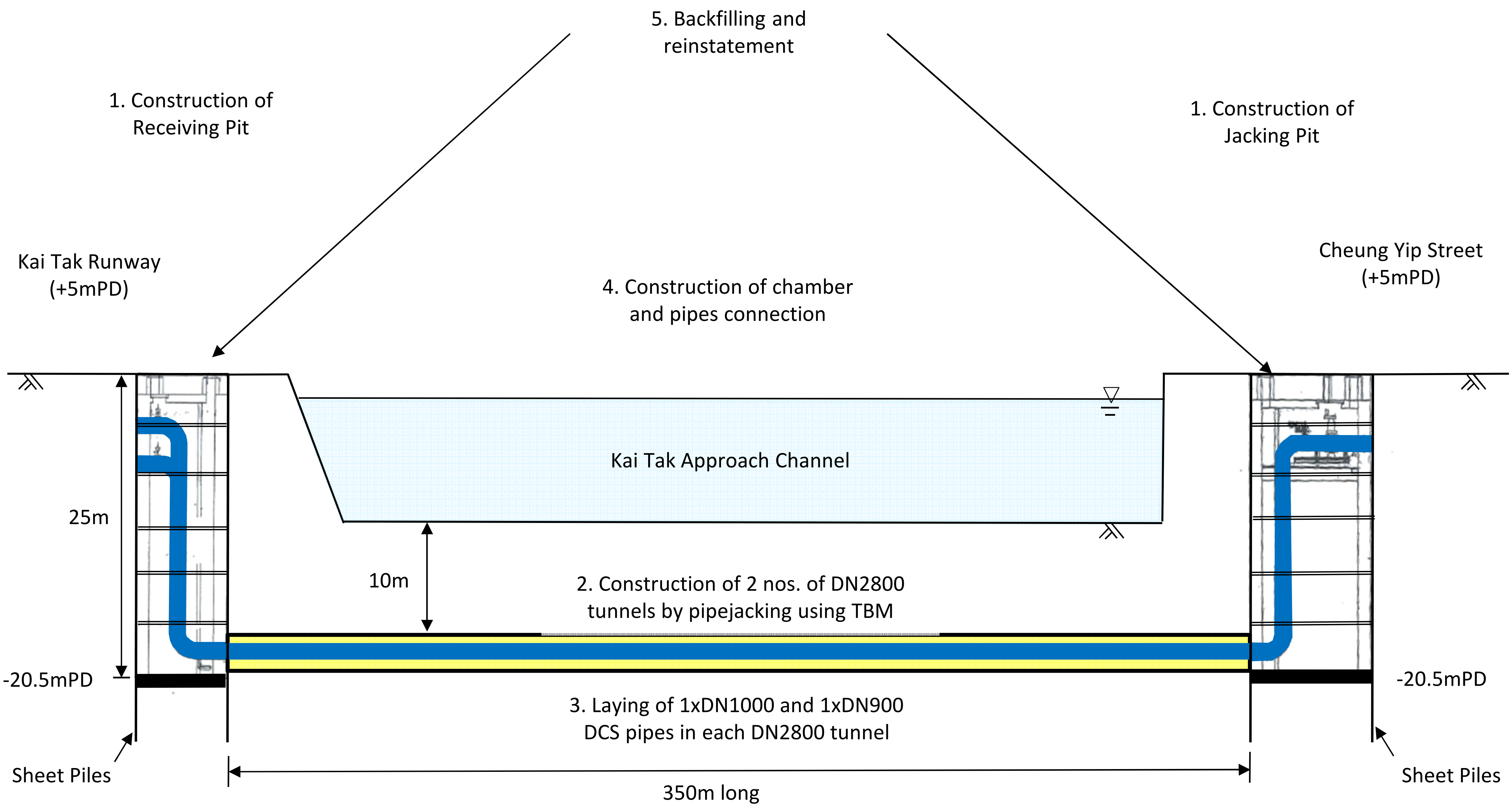


Mechanism of Rock Cutting by Disc Cutter

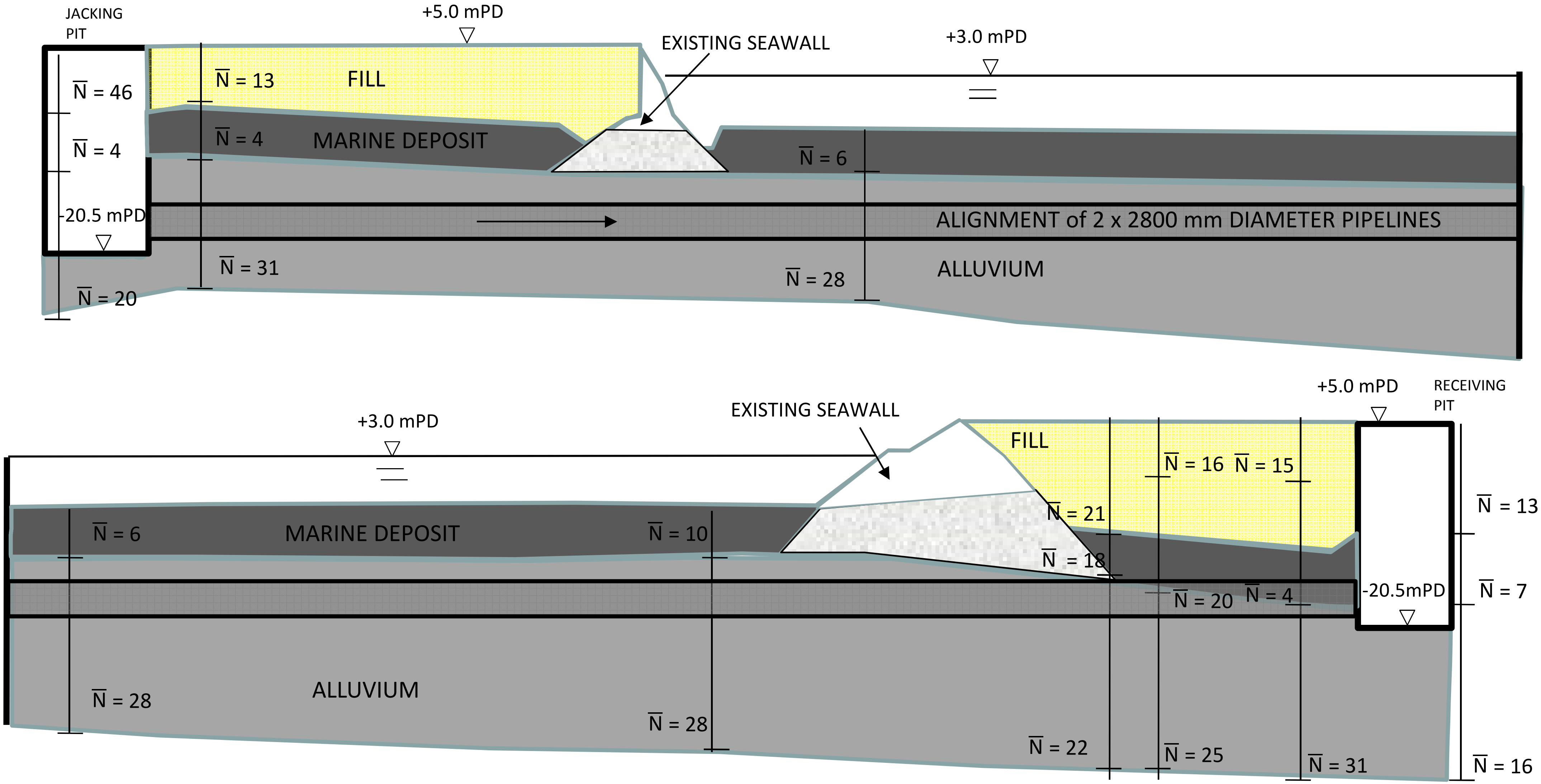
Circular Kerfs in Rock Face Formed by Disc Cutters

Section A - Sub-sea Tunnel

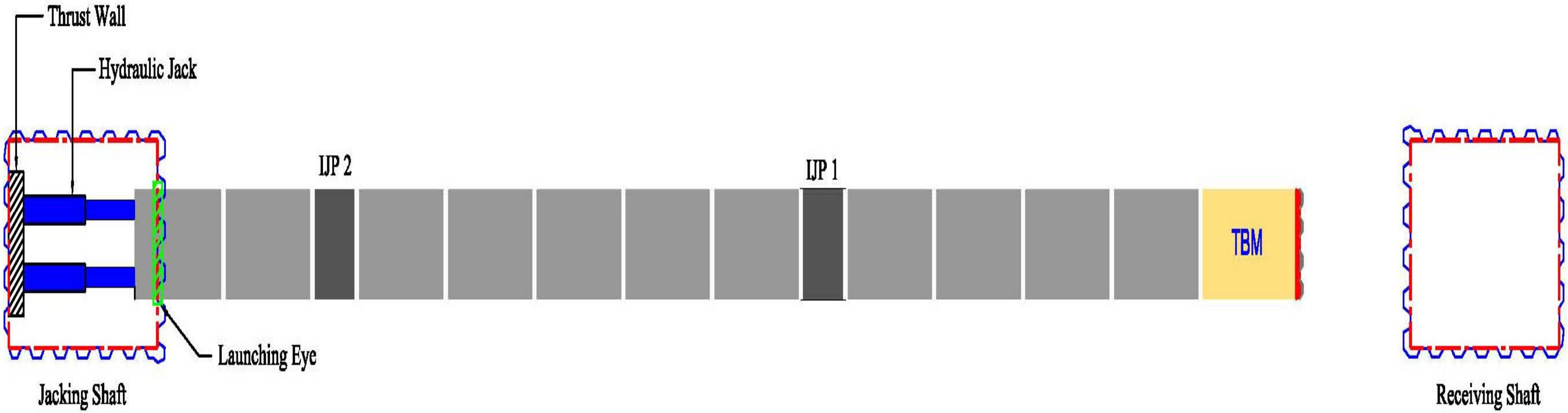
Construction Sequence



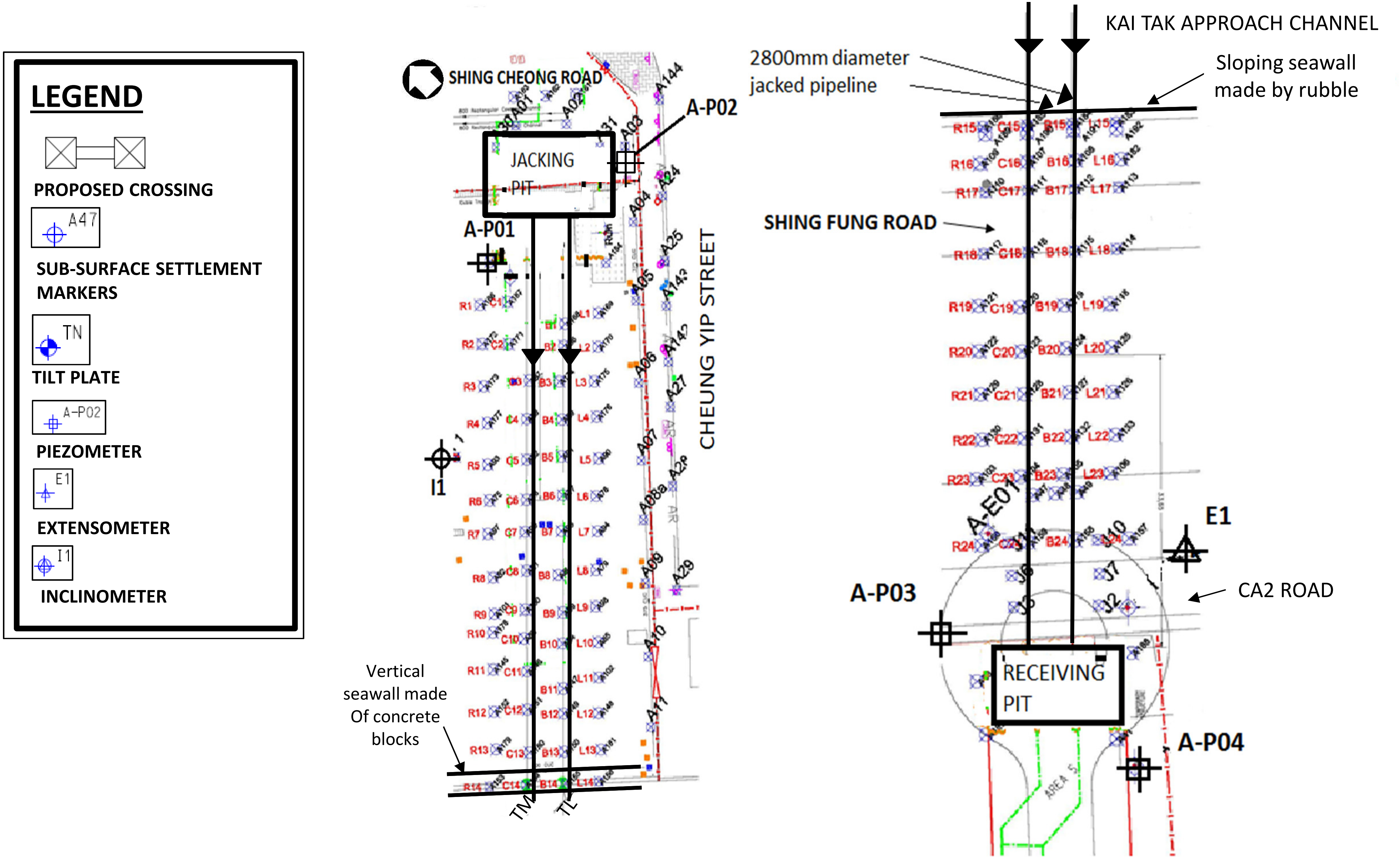
Site Investigation in Seabed



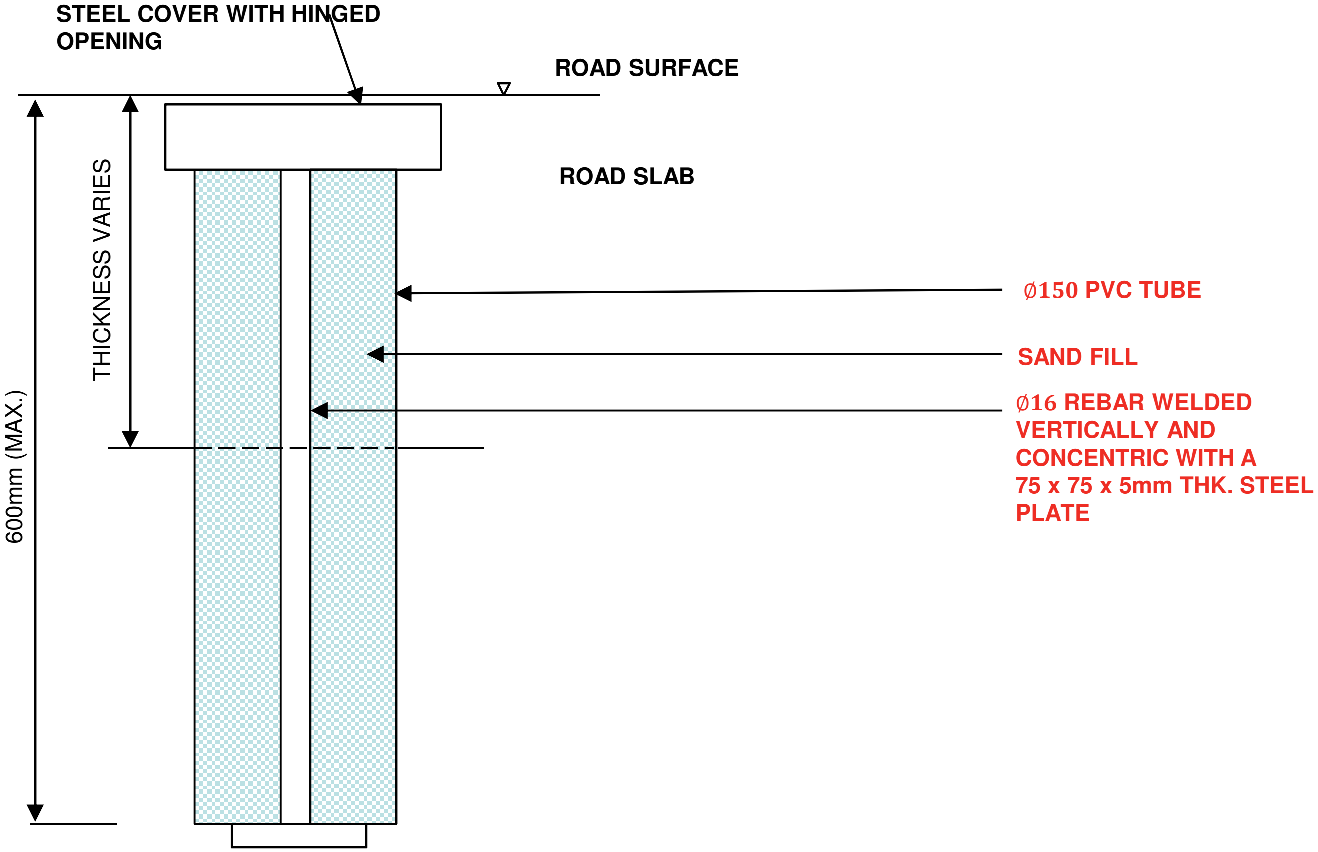
Inferred Geological Profile



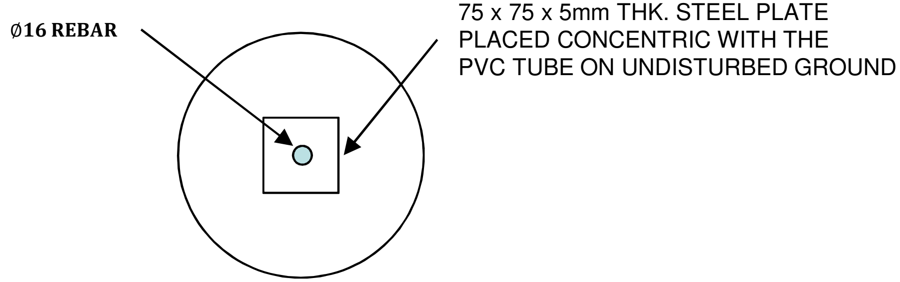
Typical Arrangement of Jacked Pipeline with Intermediate Jacking Stations



Geotechnical Instrument Plan



ELEVATION



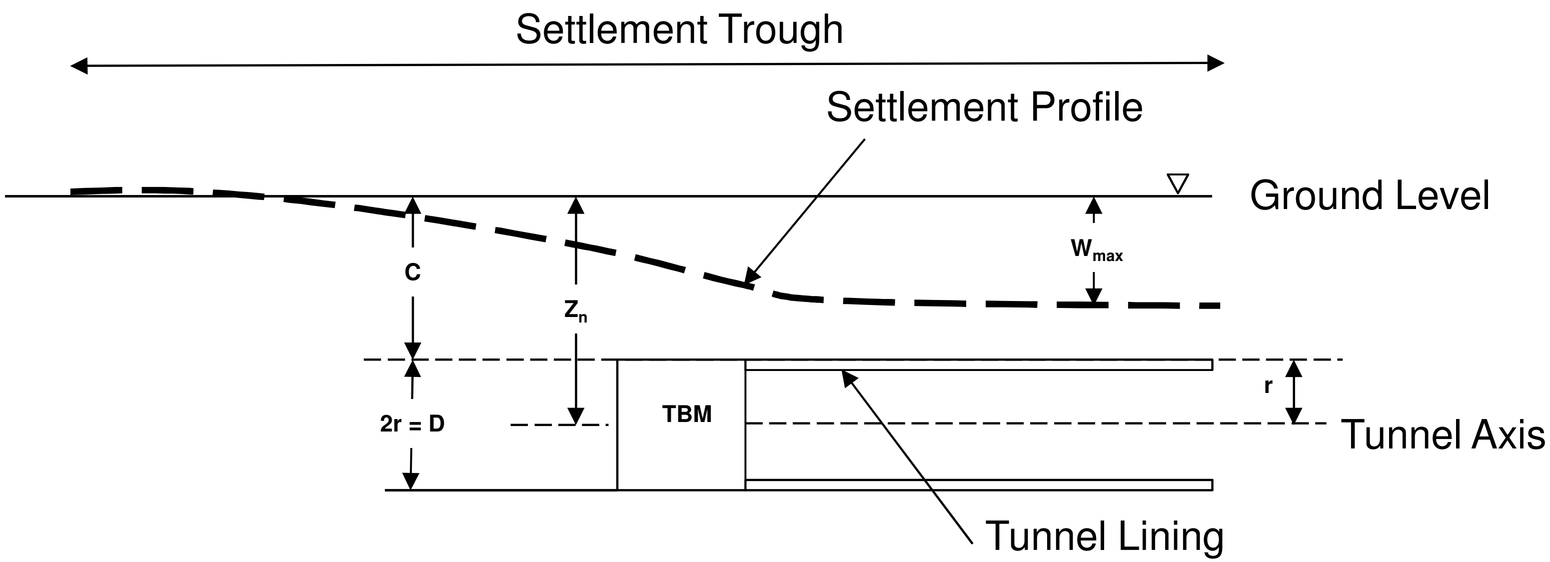
PLAN

Typical Details of Sub-surface Settlement Markers

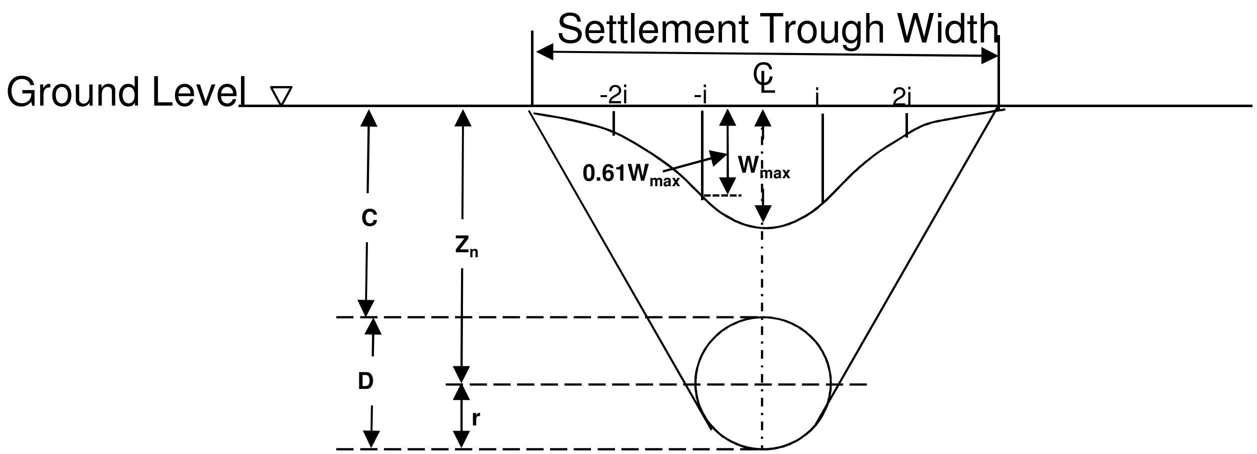
Settlement Marker

Installation of Settlement Marker

Completed Settlement Marker



Longitudinal Settlement Profile



Transverse Settlement Profile

From O'Reilly and News (1982)

$$W_{max} = \frac{V_s}{\sqrt{2\pi i}}$$

where i = 0.43Zn + 1.1 (cohesive soil)

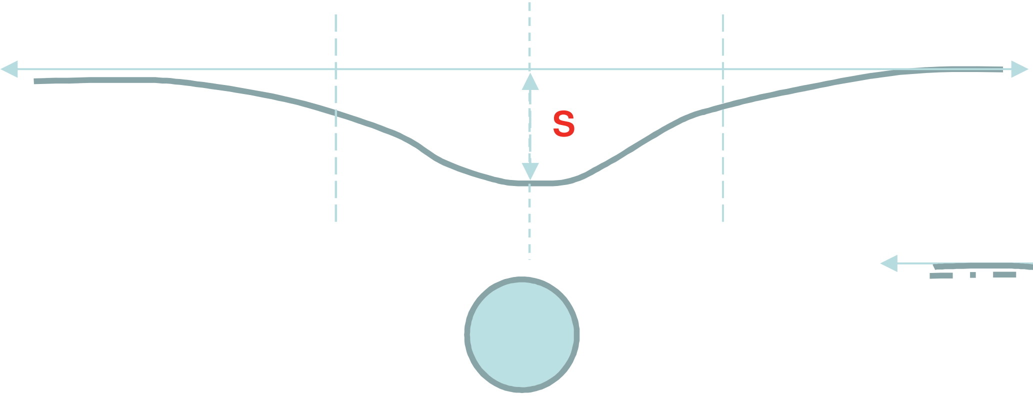
I = 0.28Zn – 0.12 (granular soil)

Assume overcut = x mm

$$V_s = \frac{\pi}{4}((2r + x)^2 - (2r)^2)$$

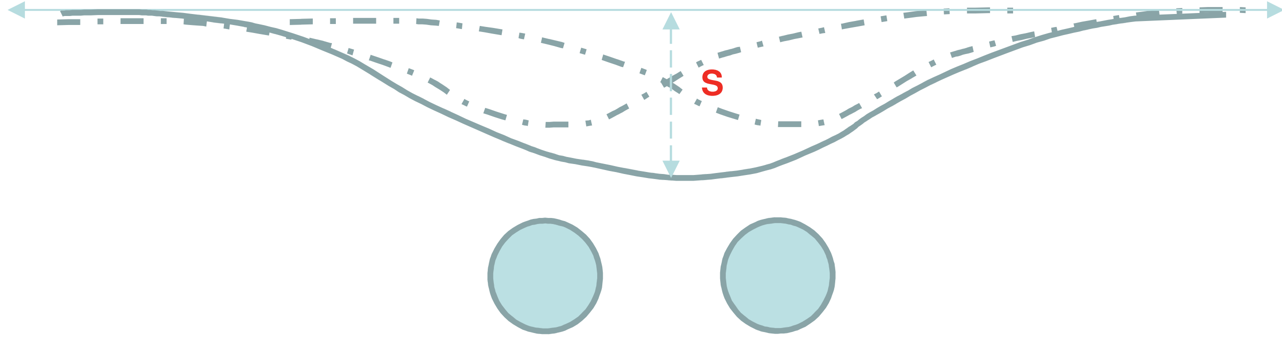
i = Point of inflexion or maximum gradient

V_S = Volume of Settlement Trough

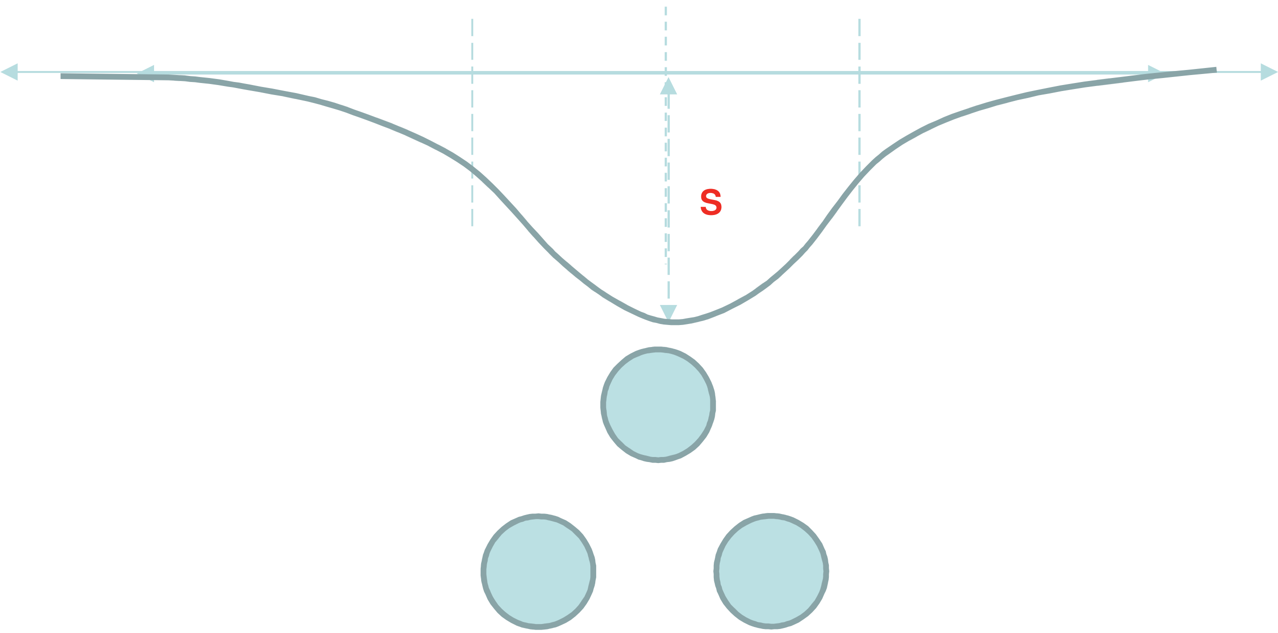


Settlement Trough for One Tunnel

S = Maximum settlement at Centre Line of Tunnel



Settlement Trough for Two Tunnels

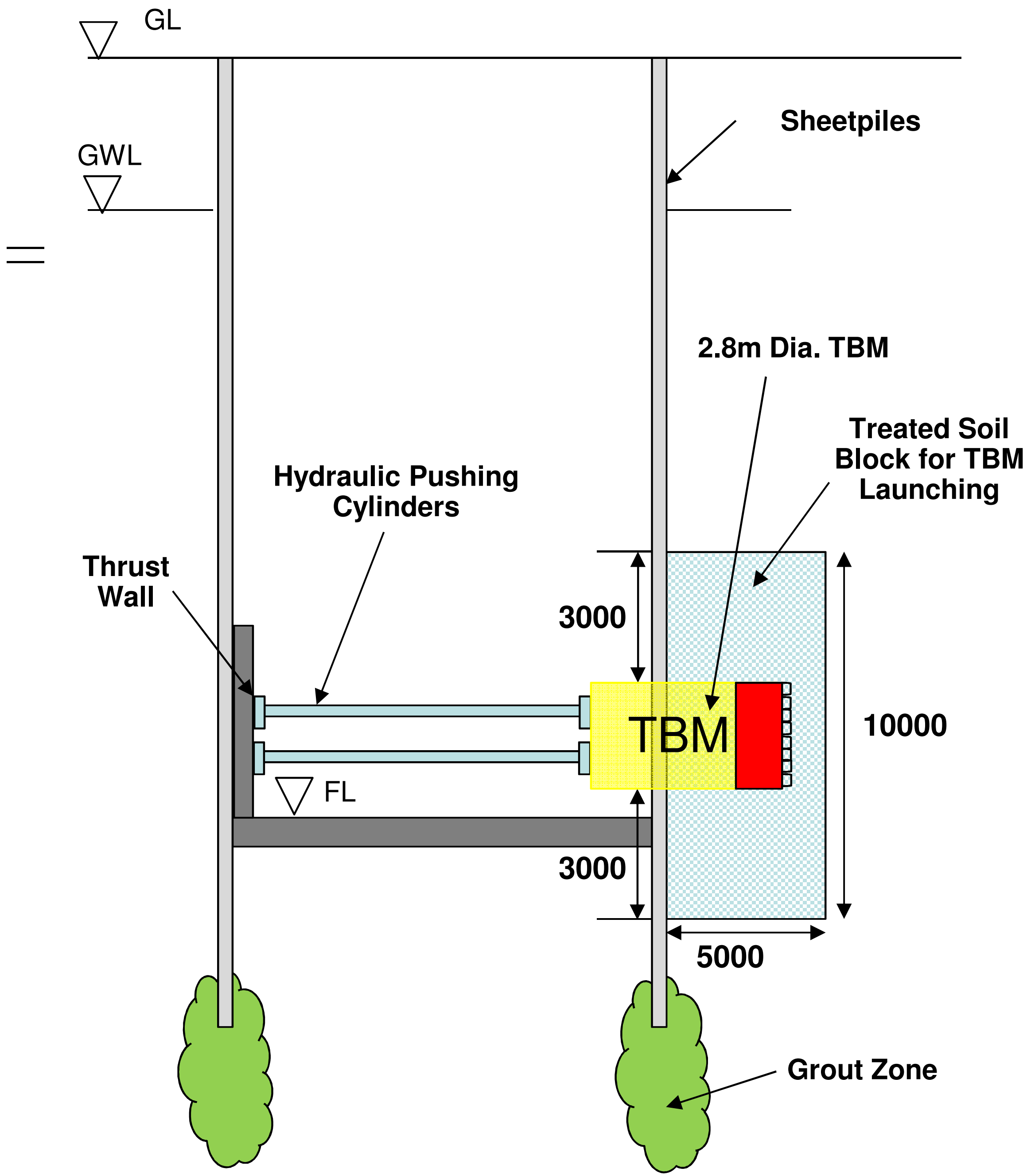


Settlement Trough for Three Tunnels

Typical Shape of Settlement Trough

General View of Jacking Pit at Cheung Yip Street and Shing Cheong Road

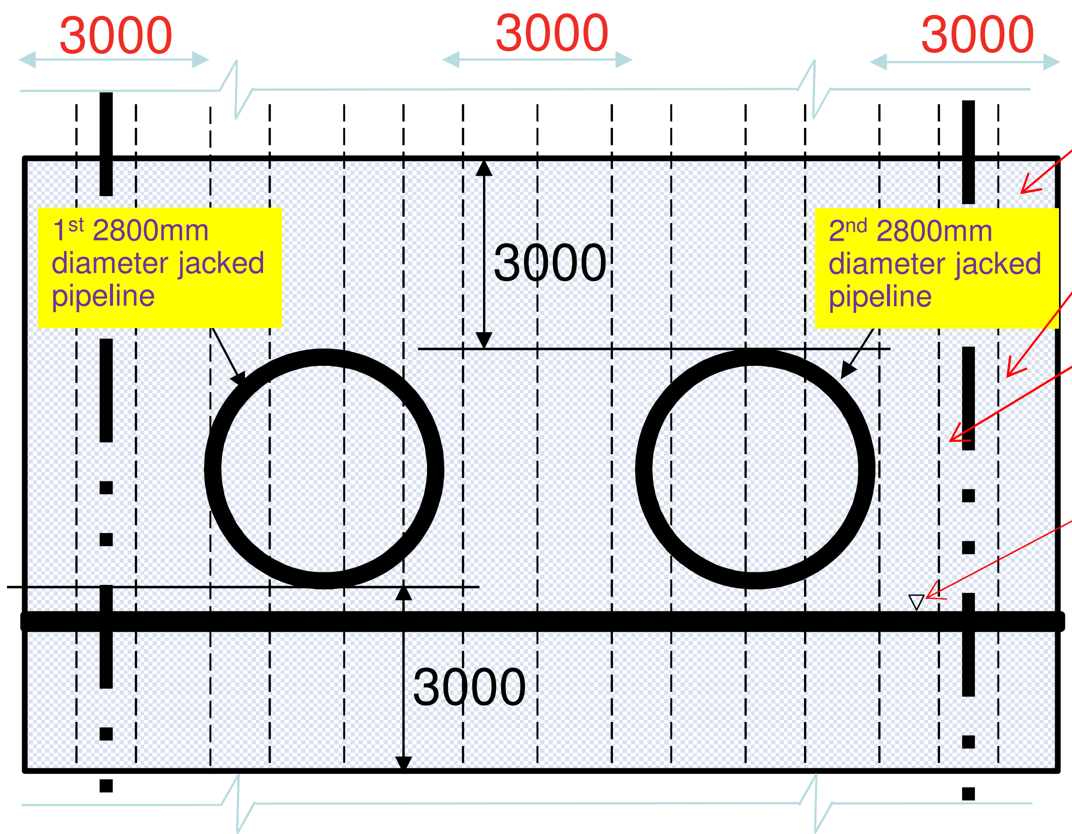
Excavation with Lateral Support for Jacking Pit

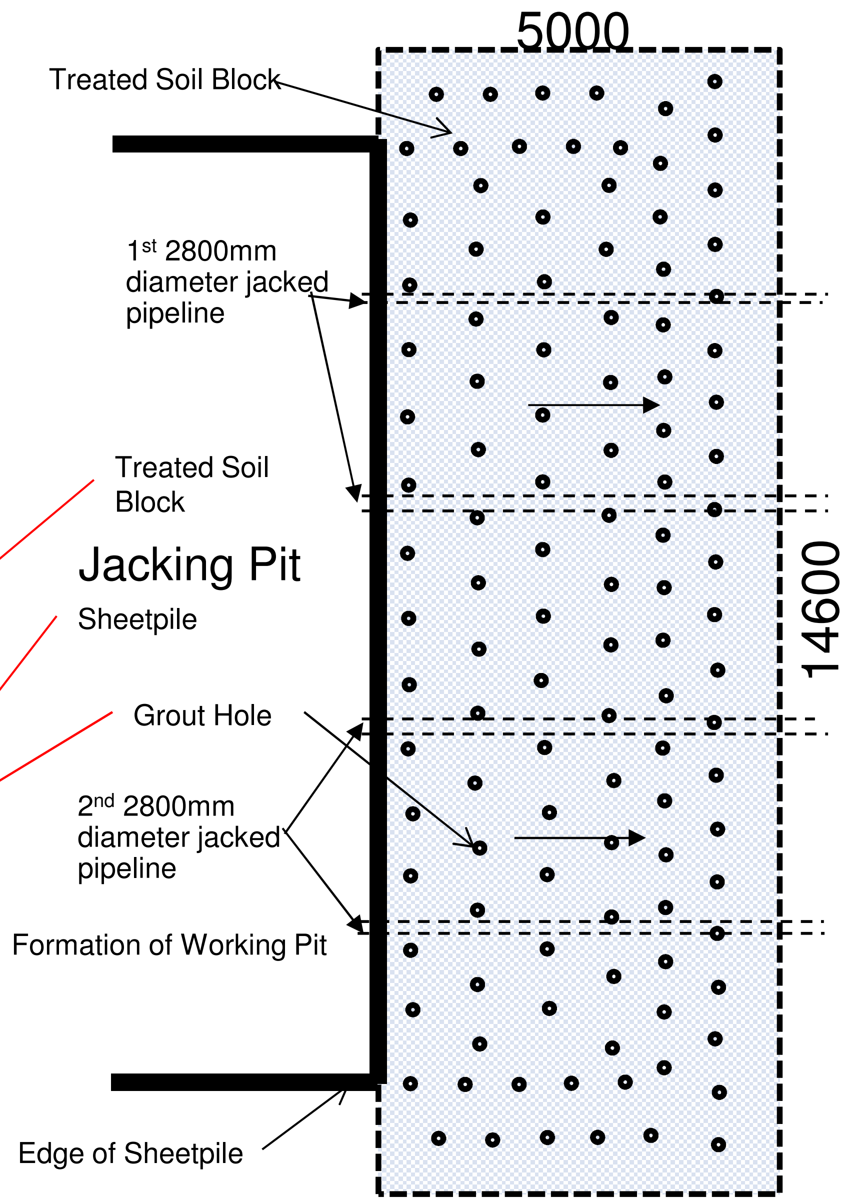


Typical Arrangement of Jacking Pit

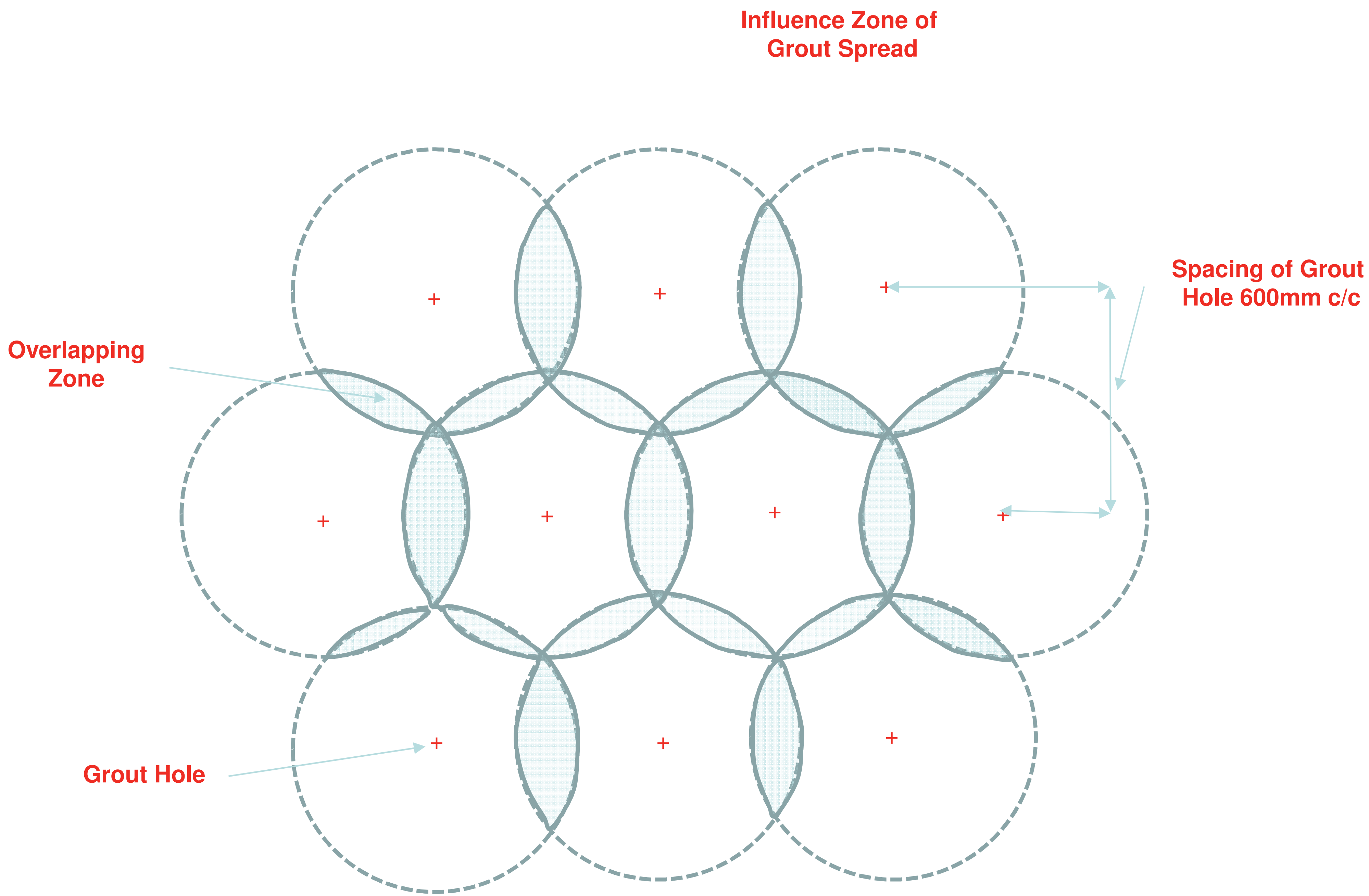
Note: Treated soil block formed by BC grout followed by chemical grout

Treated Soil Block



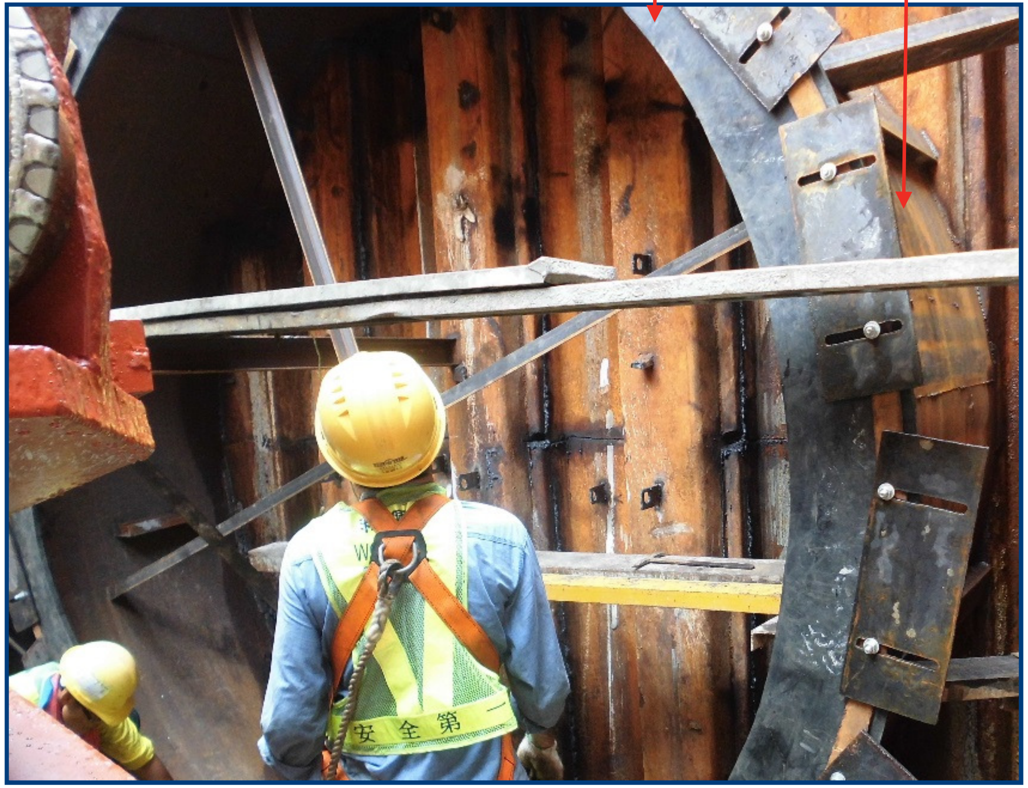


Grout Pattern for Treated Soil Block outside Launching Eye in Jacking Pit



Typical Details of Treated Soil Block

Operation in Jacking Pit



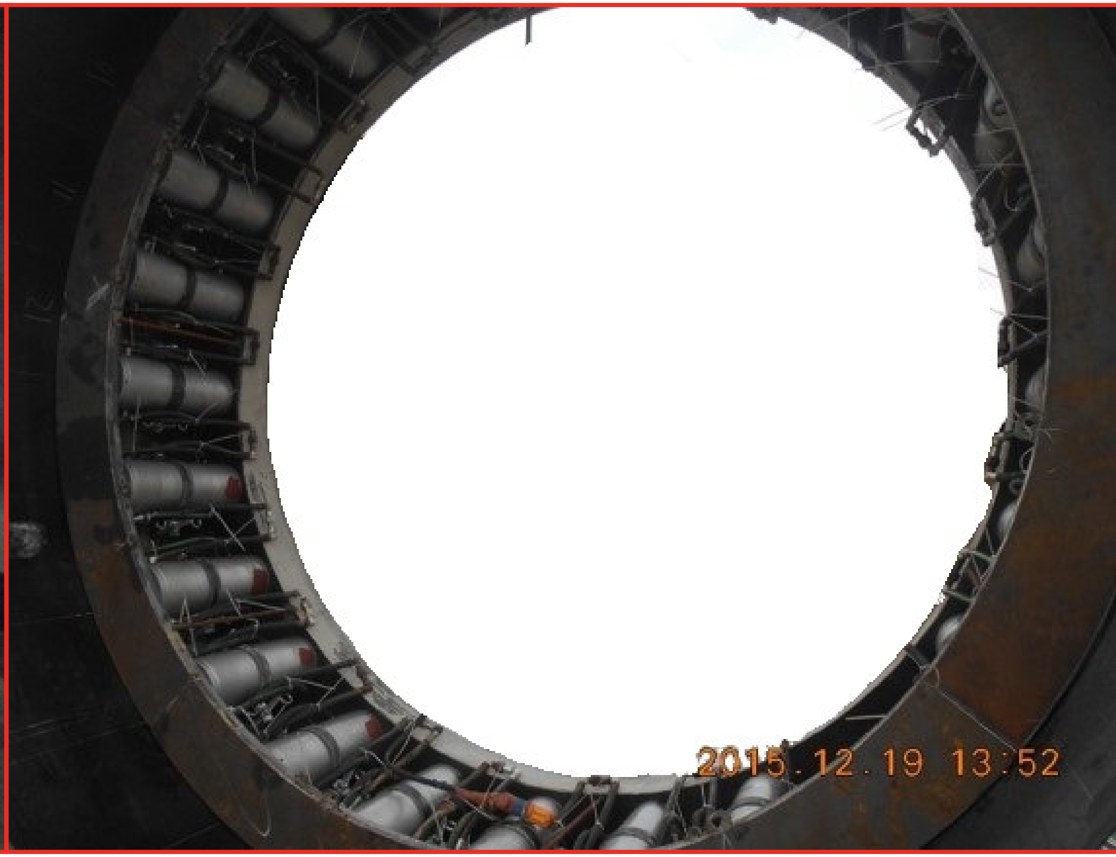
Installation of Entrance Ring

Pushing First Can of TBM to Entrance Ring

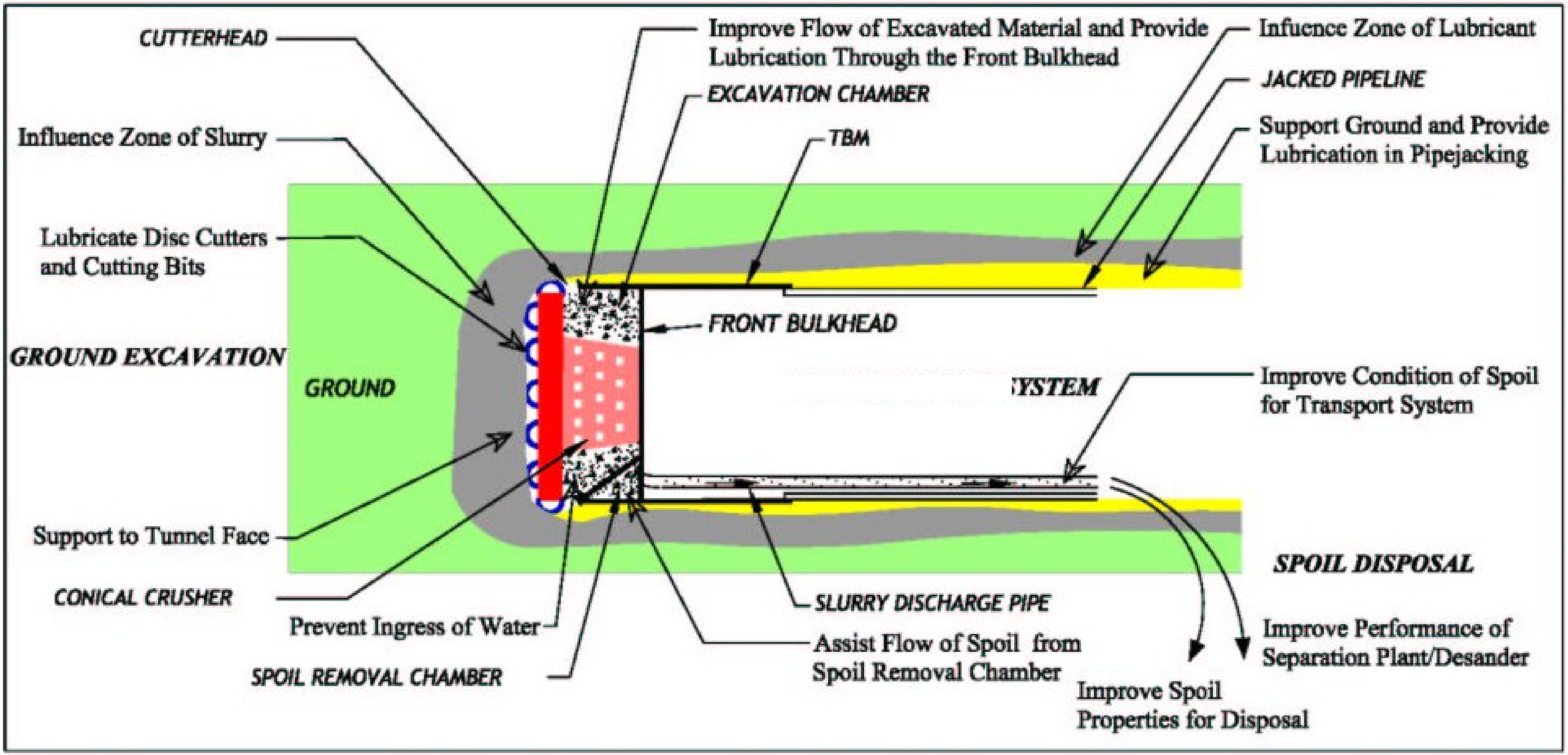
Positioning of TBM Machine Cans in Jacking Pit

Jacking Pipe

- Precast Concrete Pipe with a Strength of 50MPa
- 18mm Thick Soft Wood Packer Provided for Each Pipe
- Grout Holes Provided at Crown Level, and at Axis Level (for Every Fifth Pipe), for Lubrication and Grouting



Appearance of Intermediate Jacking Station



Spoil Handling System

Sodium-based Bentonite

Bentonite After Mixing

Bentonite Being Pumped to Jacked Pipeline for Lubrication

Nature of Ground	Foreseen Difficulties	Suggested Viscosity of Lubricant (Marsh sec)
Soft Clay	Increasing jacking force	30-40
Hard Clay	Increasing jacking force, Loss of lubricant	35-45
Clayey sand and fine sand	Increasing jacking force, Loss of lubricant	40-50
Coarse sand, gravel and cobbles	Increasing jacking force, Loss of lubricant	60-120

Automatic Lubrication Station

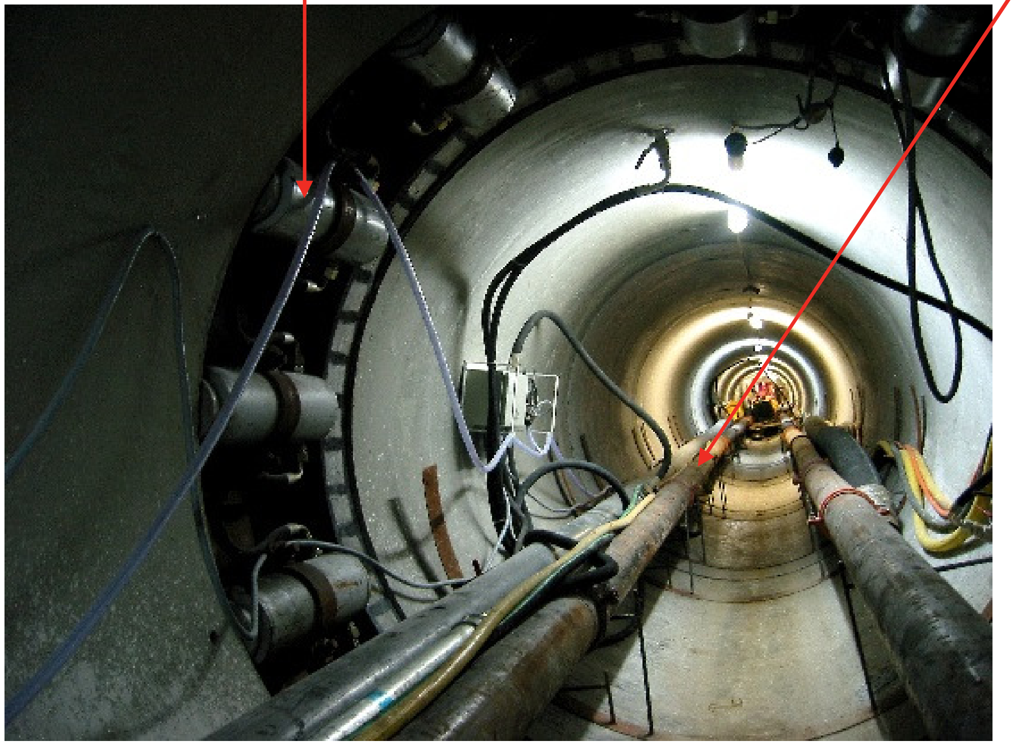
Separation of Excavated Materials in Desander

Appearance of TBM after being pushed into Receiving Pit

Intermediate Jack

Slurry Pipes and Electric Cables

Lifting eye / Grout Hole

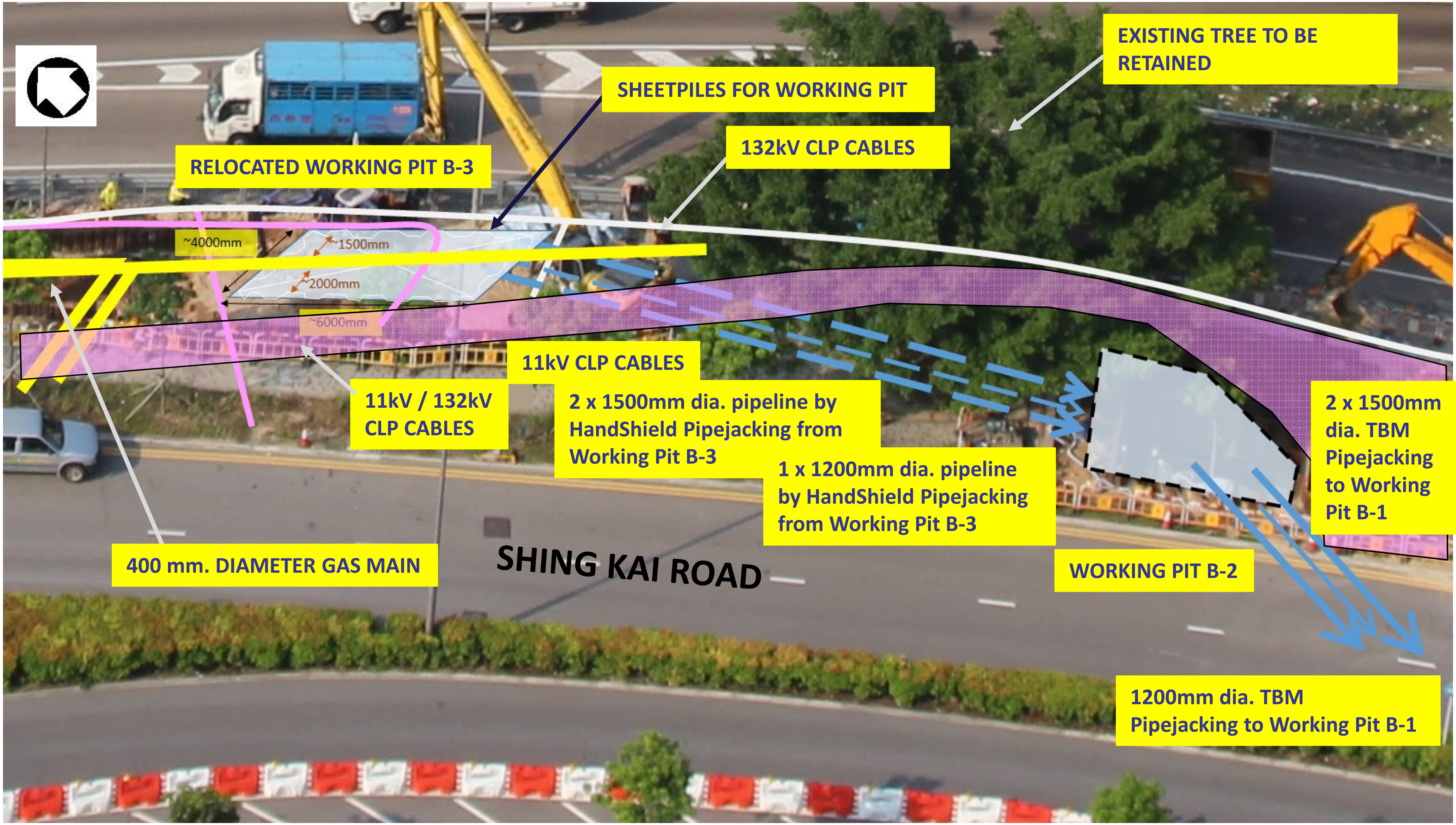


Tunnel Formed by Precast Concrete Pipes

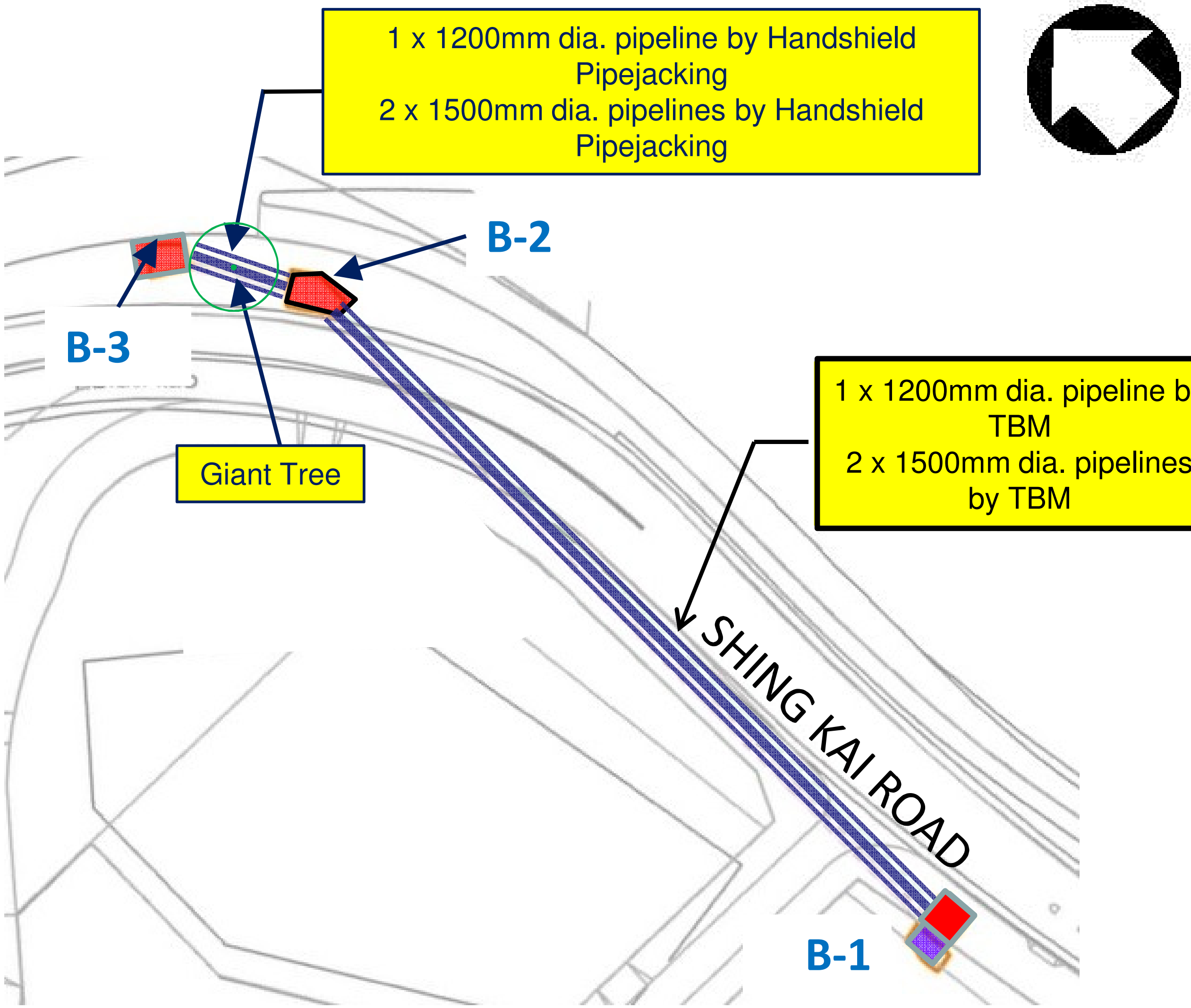
Condition of Completed Tunnel

Tunnel Formed by TBM Pipejacking

TBM Pipejacking in Triangular Configuration



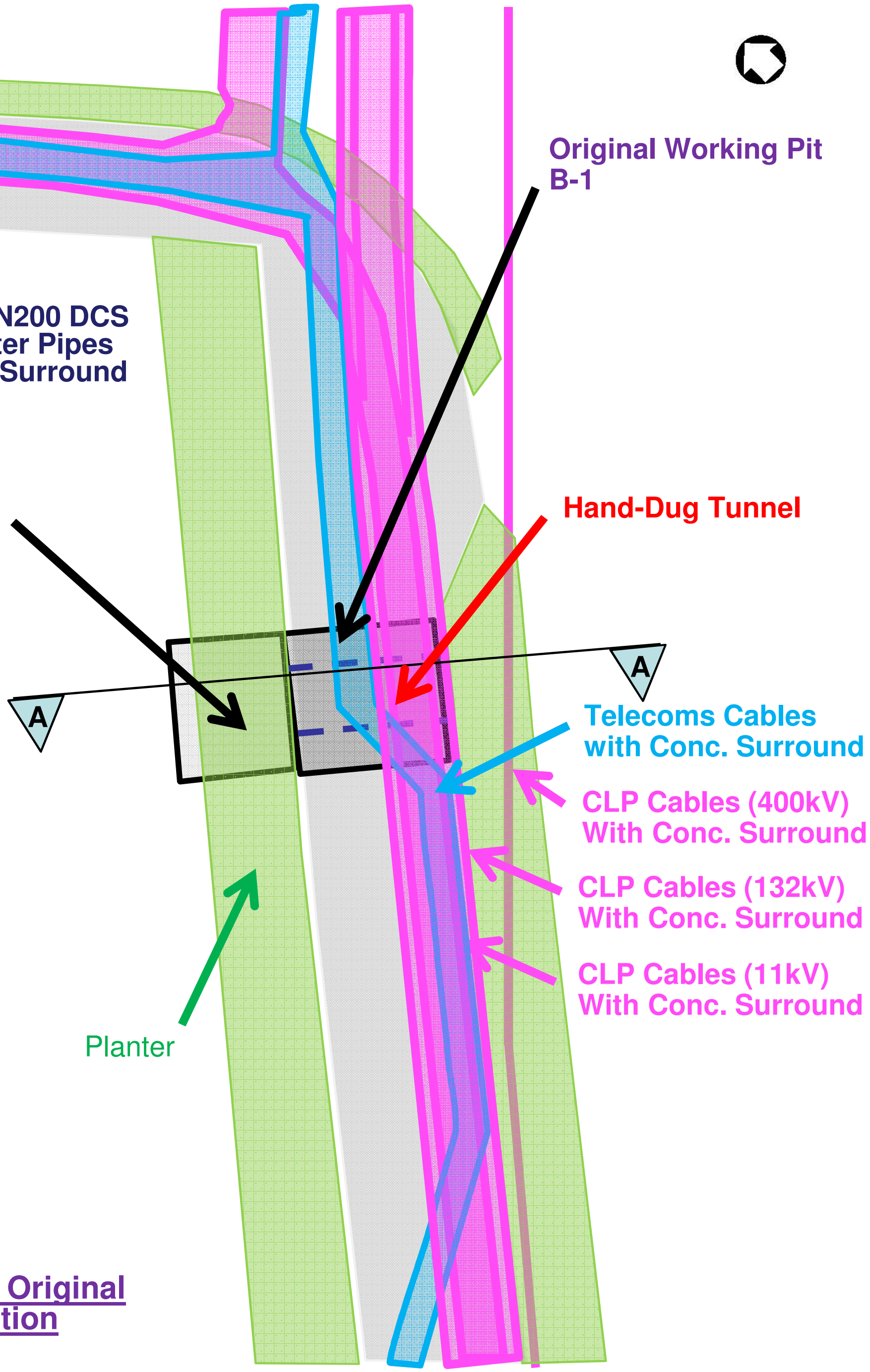
Jacked Pipeline Arrangement in Working Pit B-2



Giant Tree

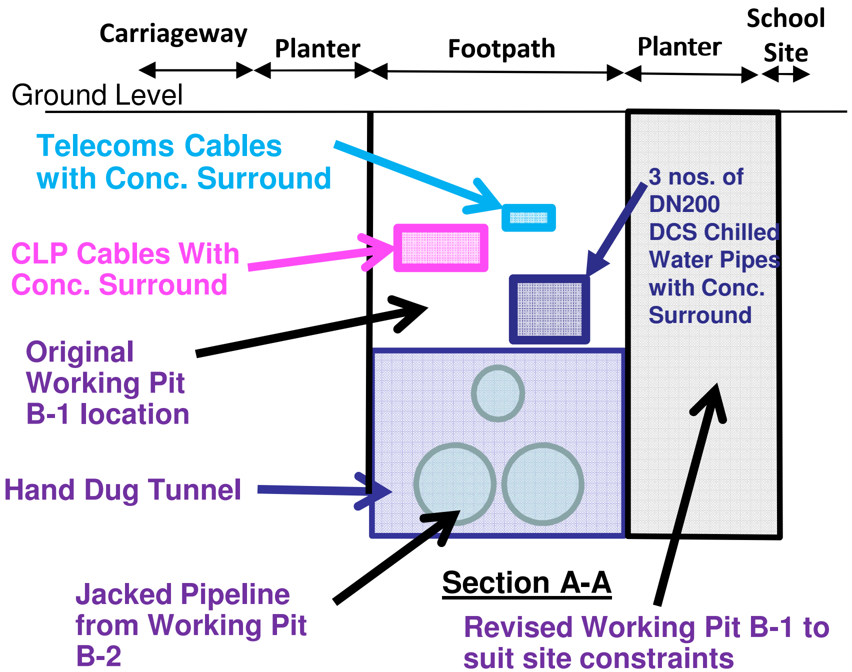
Plan Showing Locations of Working Pits B-1, B-2, B-3 and the Pipeline Alignment in Between

Construction of Hand-dug Tunnel from Receiving Pit

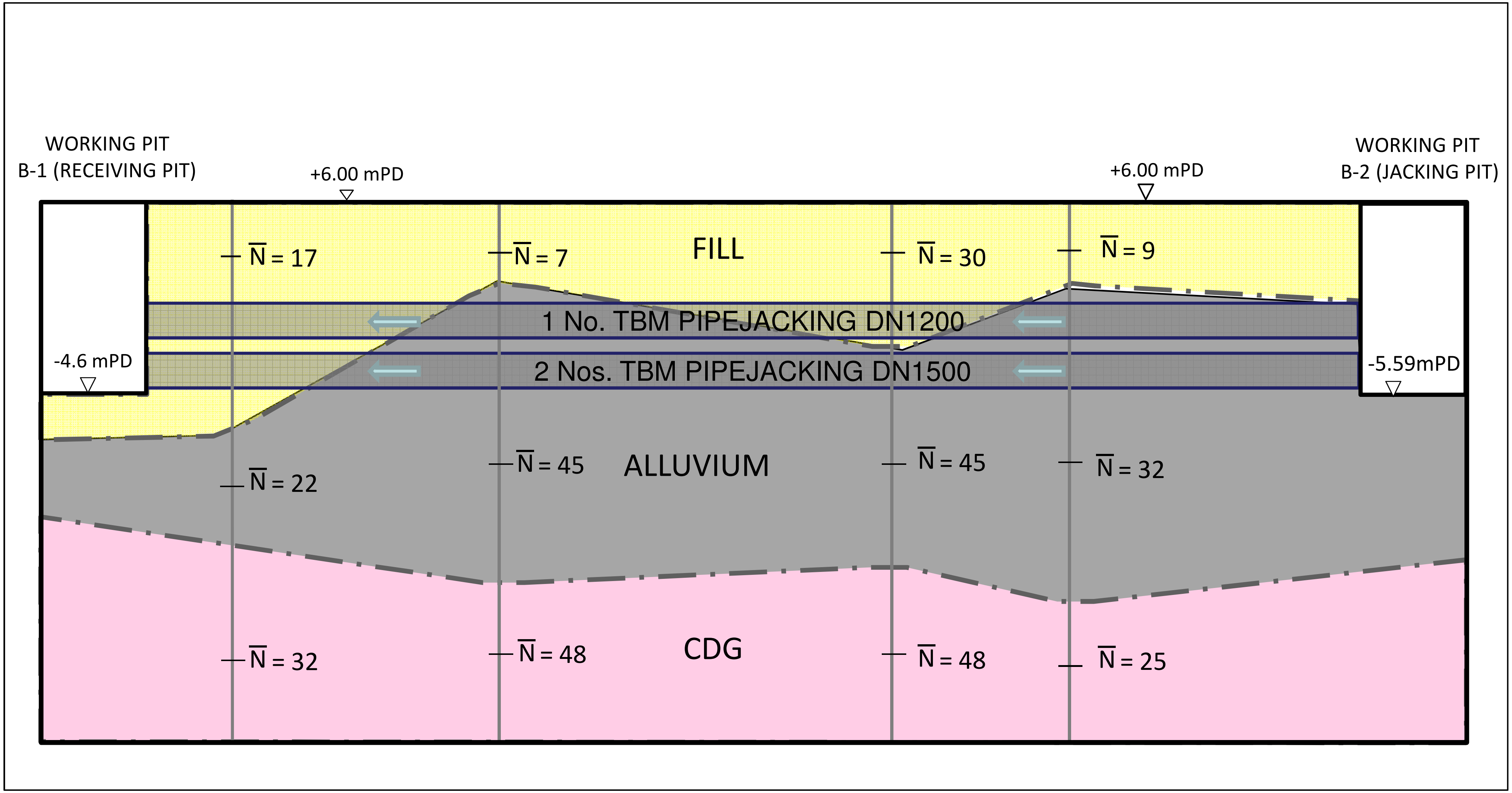


Hand-dug Tunnel Excavation from Working Pit

Utilities Congested at Original Working Pit Location



Location of Working Pit B-1 and Hand-dug Tunnel



Inferred Geological Profile

Manual Excavation in Upper Bench of Hand-dug Tunnel

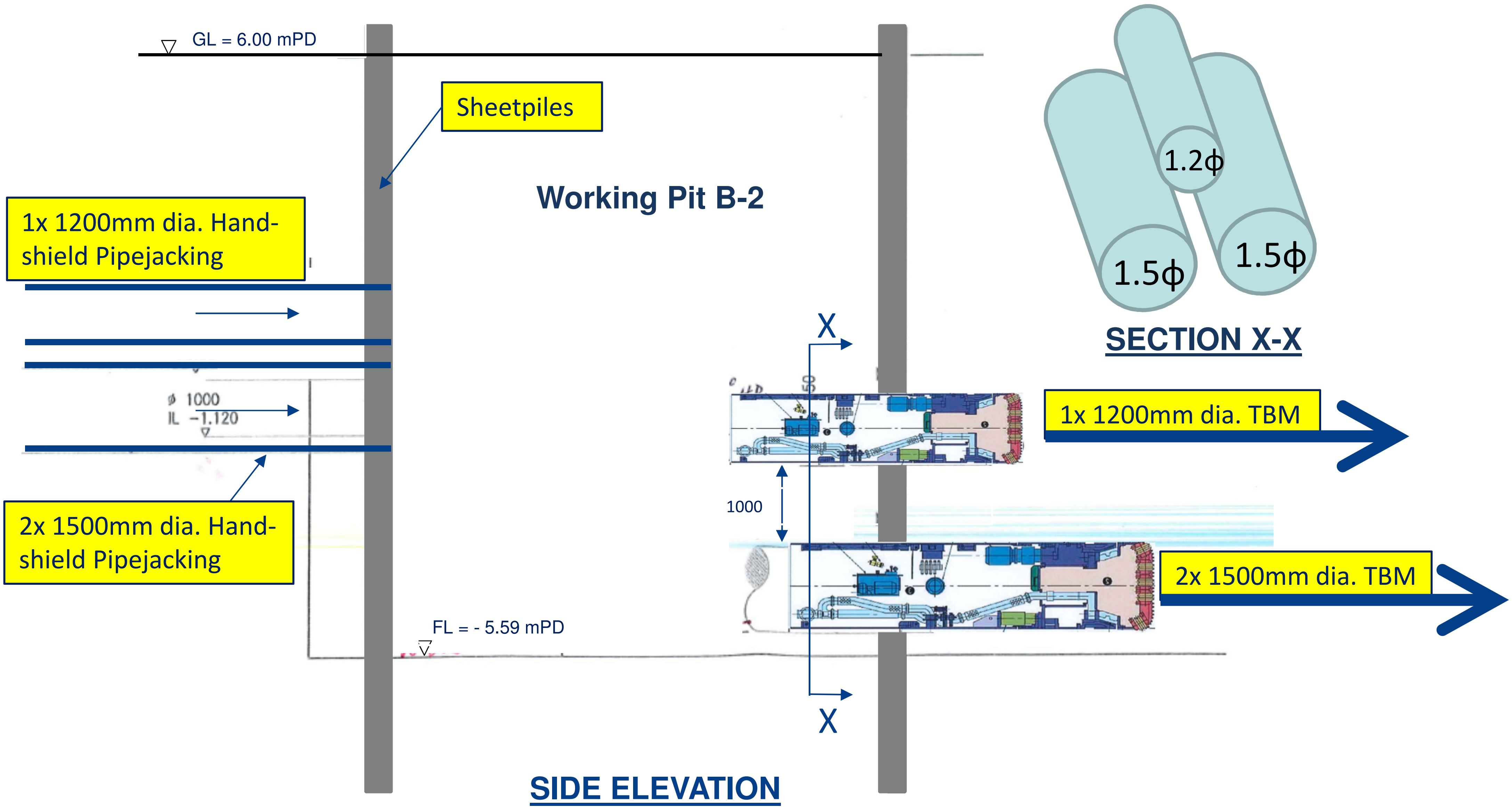
Lower Bench Excavation in Hand-dug Tunnel by Mini-excavator

Hand-dug Tunnel Excavation from Receiving Pit

Hand-dug Tunnel Excavation from Receiving Pit

Parallel Running of 2 Nos. of 1.5m Diameter TBM

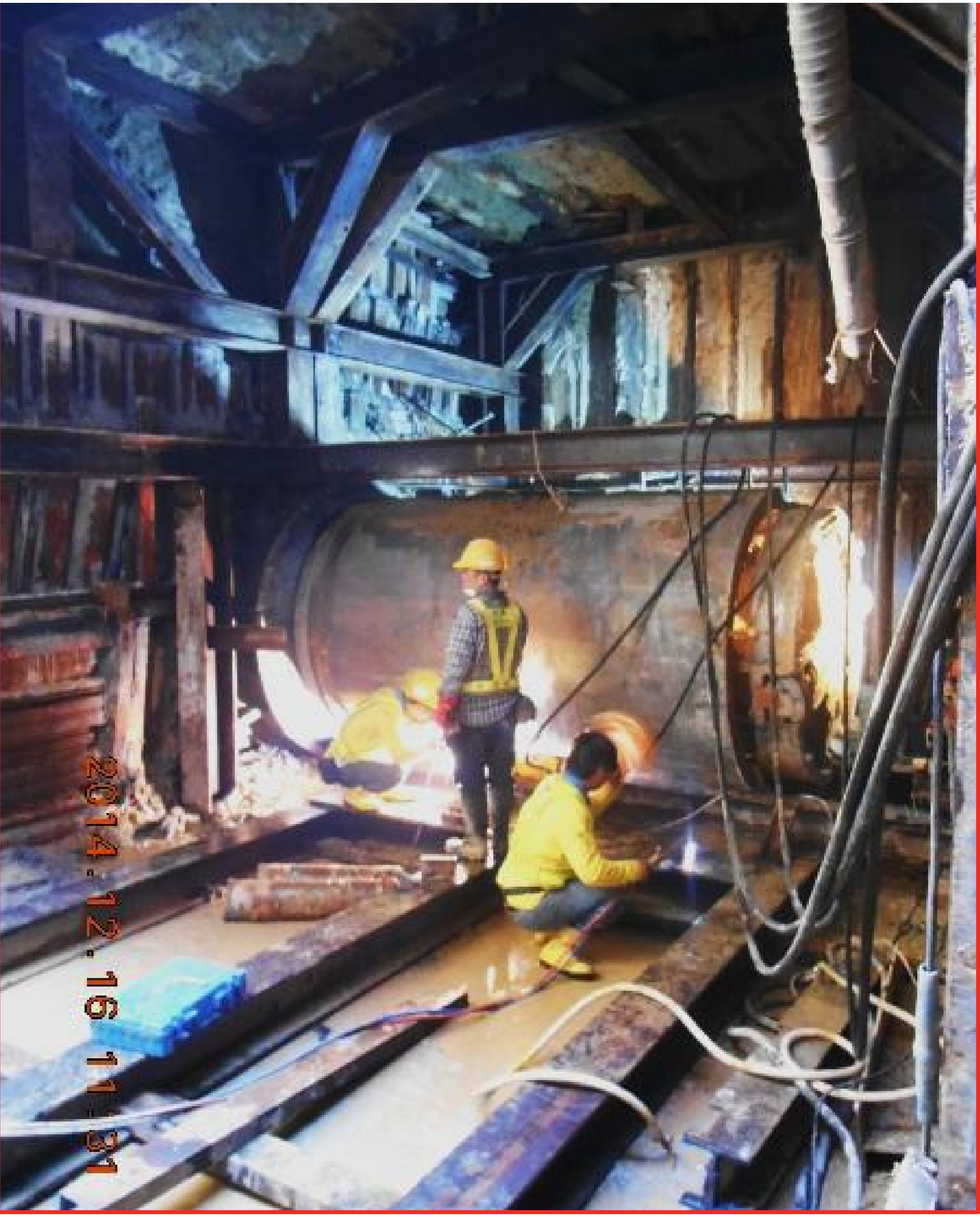
Note: 2 nos. of 1500 mm dia. TBM advanced simultaneously at a distance of 40m apart.



Pipejacking in Working Pit B-2

Parallel Running of 2 nos. of 1.5m Dia. TBM Pipejacking in Jacking Pit

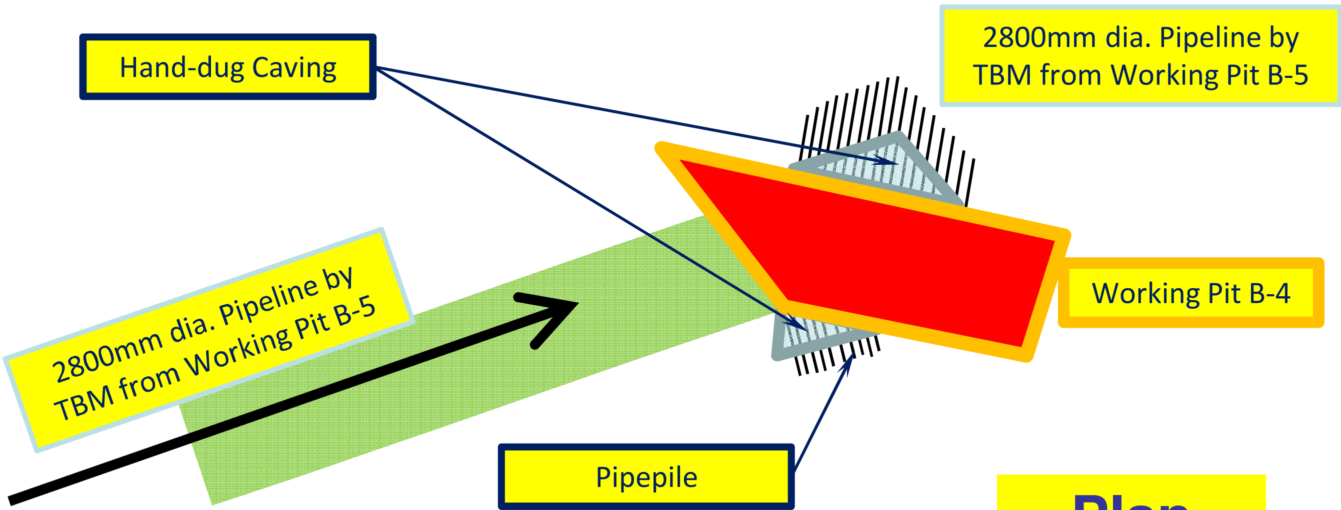
TBM Breakthrough in Hand-dug Tunnel from Receiving Pit



Lifting Up of TBM from Receiving Pit to Ground Surface

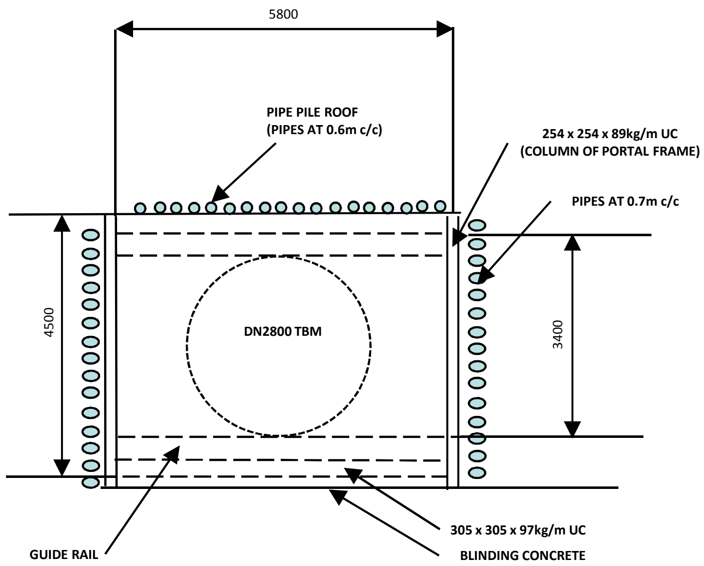
Preparation of Receiving Eye for TBM Entry

Caving Construction in the Lower Portion of Receiving Pit for Receiving 2.8m Diameter TBM



Plan

Construction of Hand-dug Caving in Working Pit B-4



Front Elevation of the Caving

As-Constructed Caving in Working Pit B-4

Working Pit B-4 - Change of Construction Methodology for Receiving Tunnel Boring Machine due to Constraints by Existing Utilities

TBM Entry in Caving of Working Pit B-4

Skin-off of 2.8m Diameter TBM for Lifting up to Ground Surface

TBM Entry in Caving and Skin-off of TBM at Working Pitp for Lifting up to Ground Surface

Skin-off of TBM at Working Pit for Lifting up to Ground Surface

Installation of DCS Pipelines in the Completed Jacked Pipelines

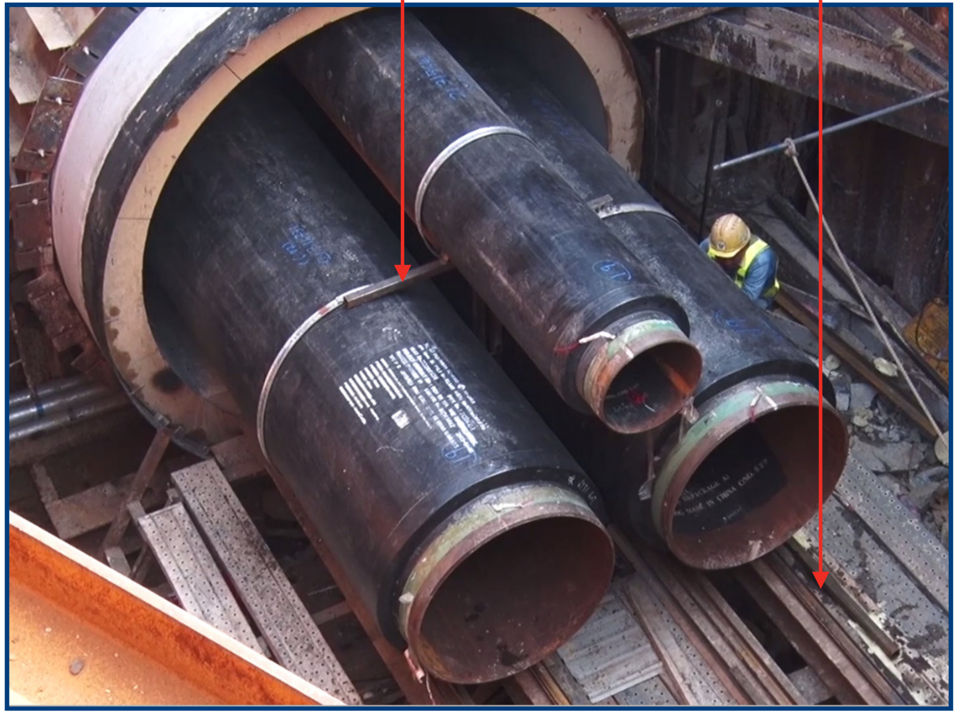
Concrete platform for placing guide rails

Railing

Installation of guide rails in Concrete Platform

Tailored made steel trolley for transportation of DCS pipes in Pipejacked Tunnel

Railing



Installation of DCS Pipes

DCS Pipes Installation in Jacked Pipeline

DCS Pipelines Installation in Jacked Pipeline

Problems Commonly Encountered by TBM Pipejacking

- **Alignment Control**
- **Ground Settlement**
- **Obstruction**
- **Damage of Jacking Pipes**

THANK YOU