Hong Kong West Drainage Tunnel
“Four Years of Challenges”

Norwegian Tunnelling Society
4 November 2019

Content

1. Project Background and Design
2. Western Portal, Eastern Portal and Main Tunnel
3. Adits
4. Dropshafts
5. Q&A

Flooding Problem on Northern Low-lying Areas

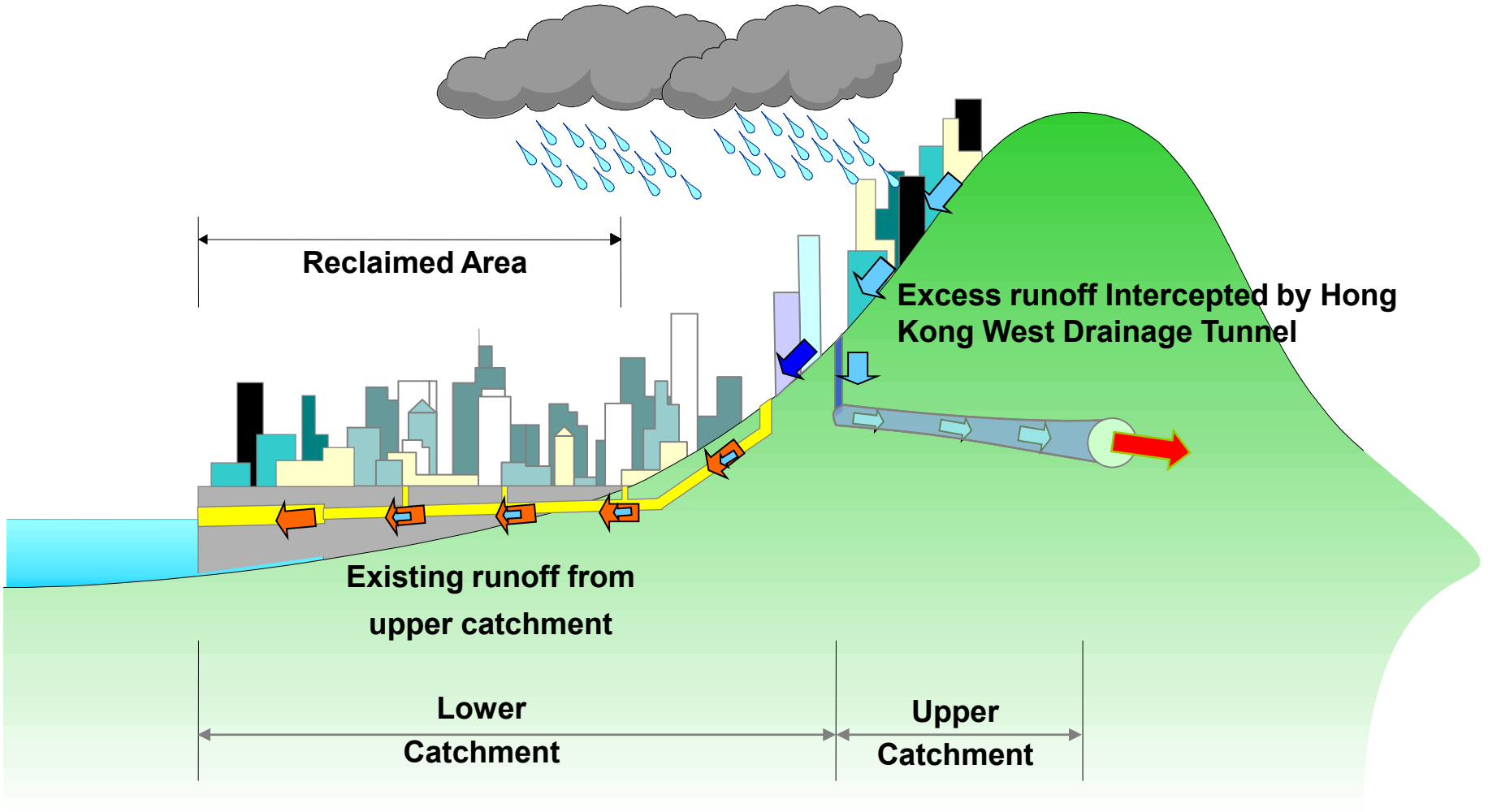
1992 - Admiralty

2005 – Eastern Street

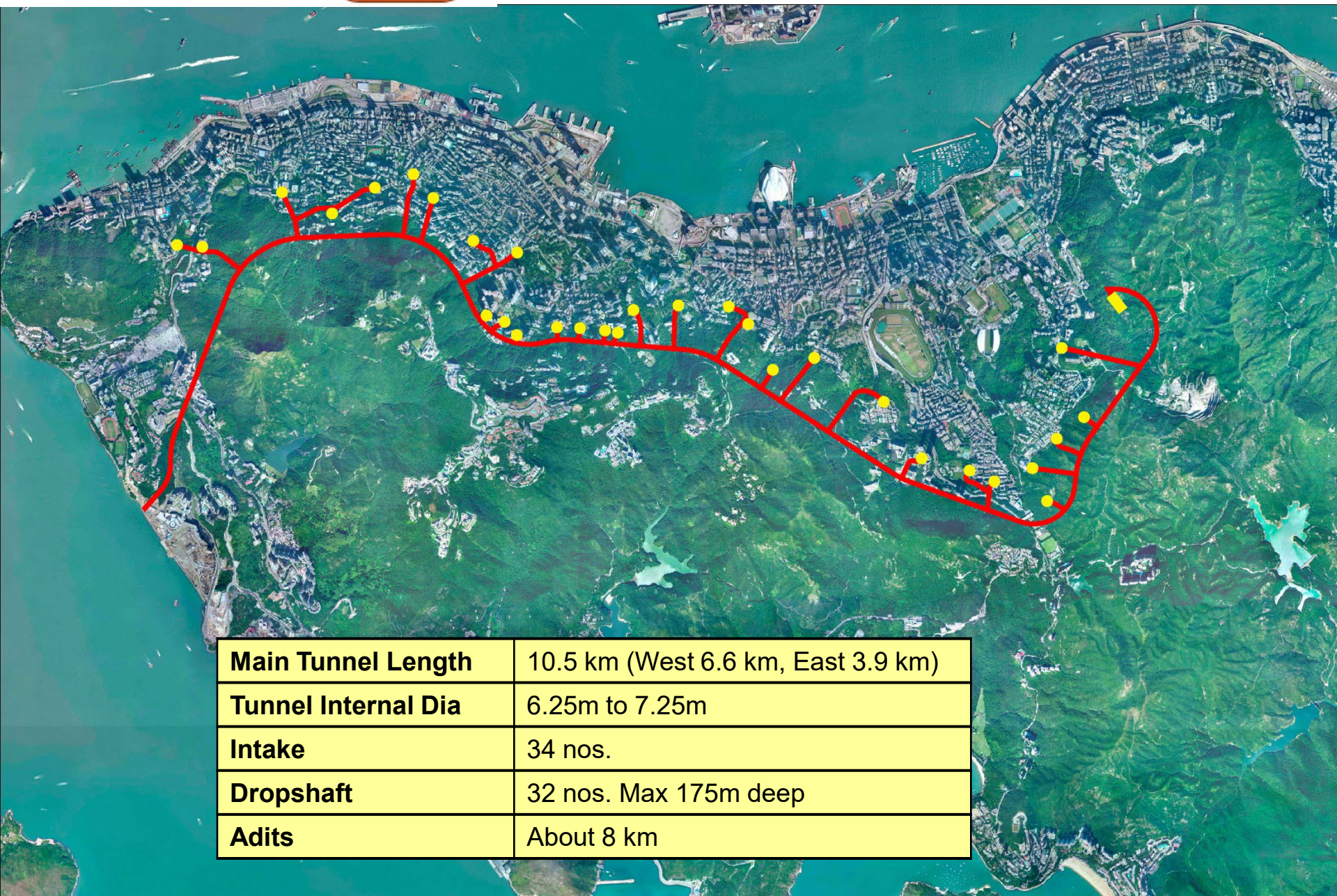
2005 – Connaught Road West

2008 - Sheung Wan
after Black Storm Signal

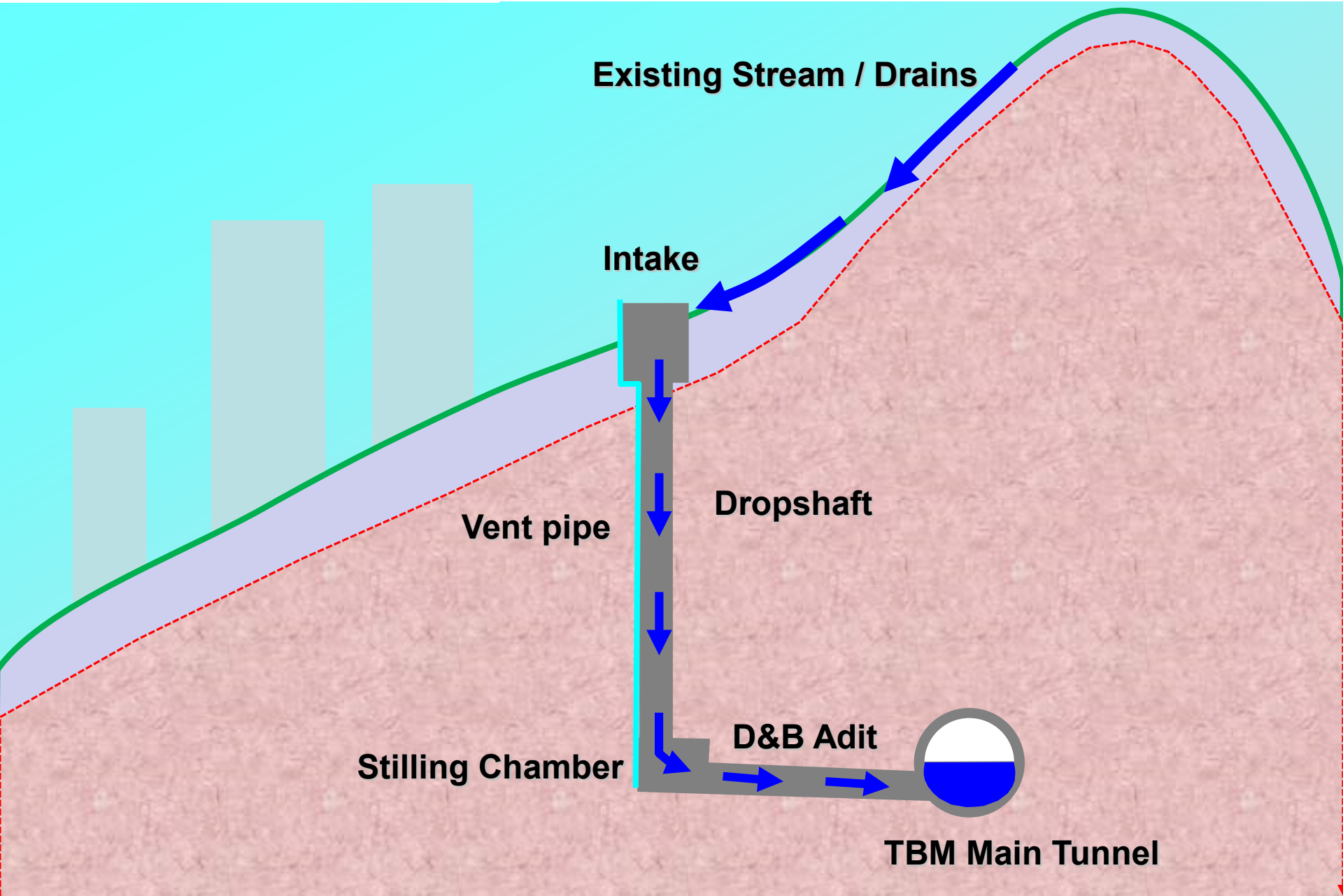
Interception Approach



Site Location Plan

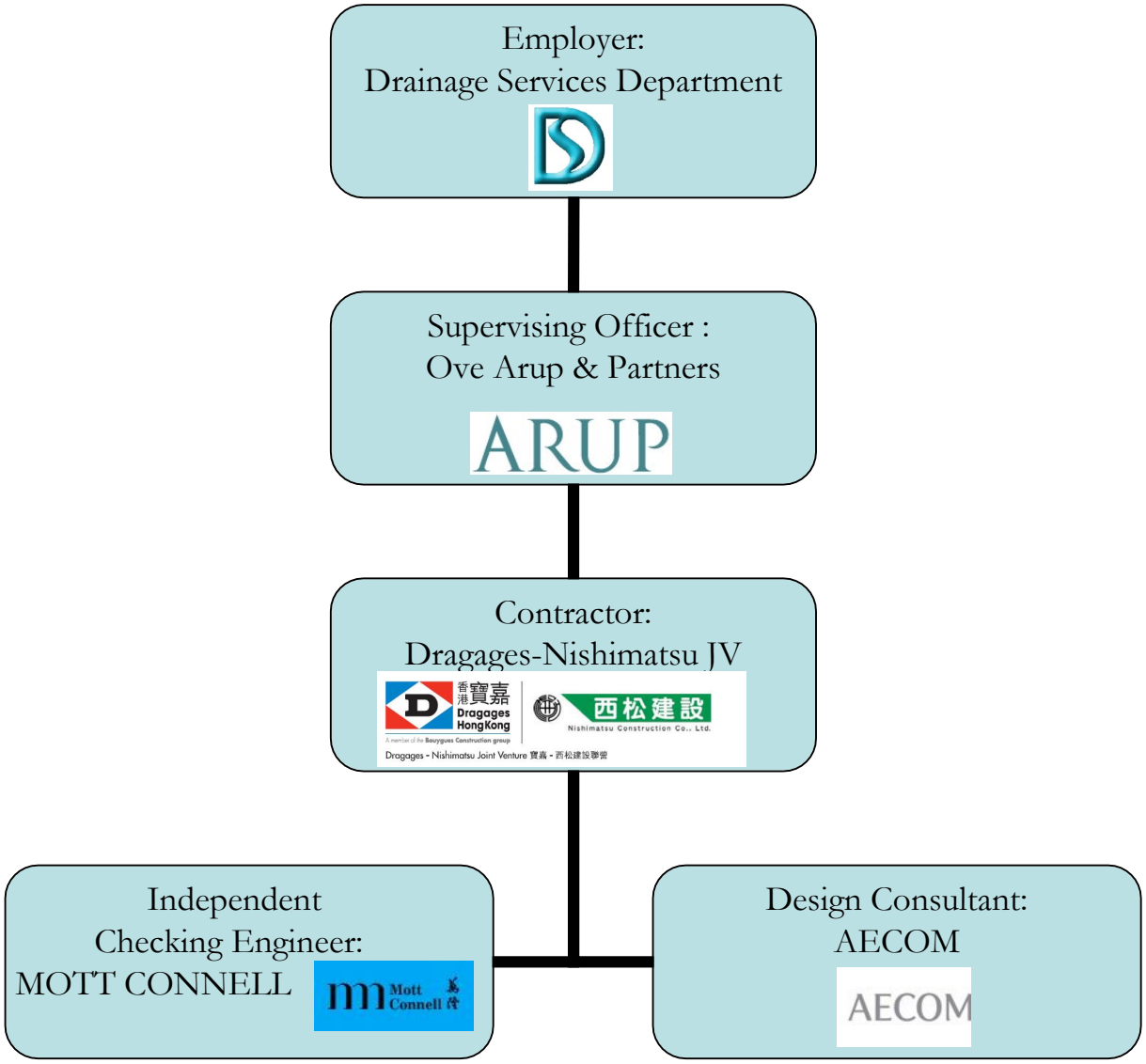


Main Tunnel Length	10.5 km (West 6.6 km, East 3.9 km)
Tunnel Internal Dia	6.25m to 7.25m
Intake	34 nos.
Dropshaft	32 nos. Max 175m deep
Adits	About 8 km


Existing Stream / Drains
Intake
Vent pipe
Dropshaft
Stilling Chamber
D&B Adit
TBM Main Tunnel

Contract Title	Contract No. DC/2007/10 – Design and Construction of Hong Kong West Drainage Tunnel
Client	Drainage Services Department / Project Management Division, HKSAR
Nature of Construction Contract	Design and Build
Client's Design Consultant	Ove Arup & Partners Hong Kong Ltd
Contractor	Dragages - Nishimatsu Joint Venture (DNJV)
Contractor's Designer	AECOM Asia Co. Ltd
Original Contract Estimate	HK$ 2.75 Billion
Contract Commencement Date	30 November 2007
Target Completion Date	2012

Project Organisation



Key Facts

West TBM Tunnel:

- 6.6km in length
- Total volume of excavated material ~ 360,000m^3
- Excavation Duration − 21.5 months

East TBM Tunnel:

- 3.9km in length
- Total volume of excavated material ~ 165,000m^3
- Excavation Duration − 16 months

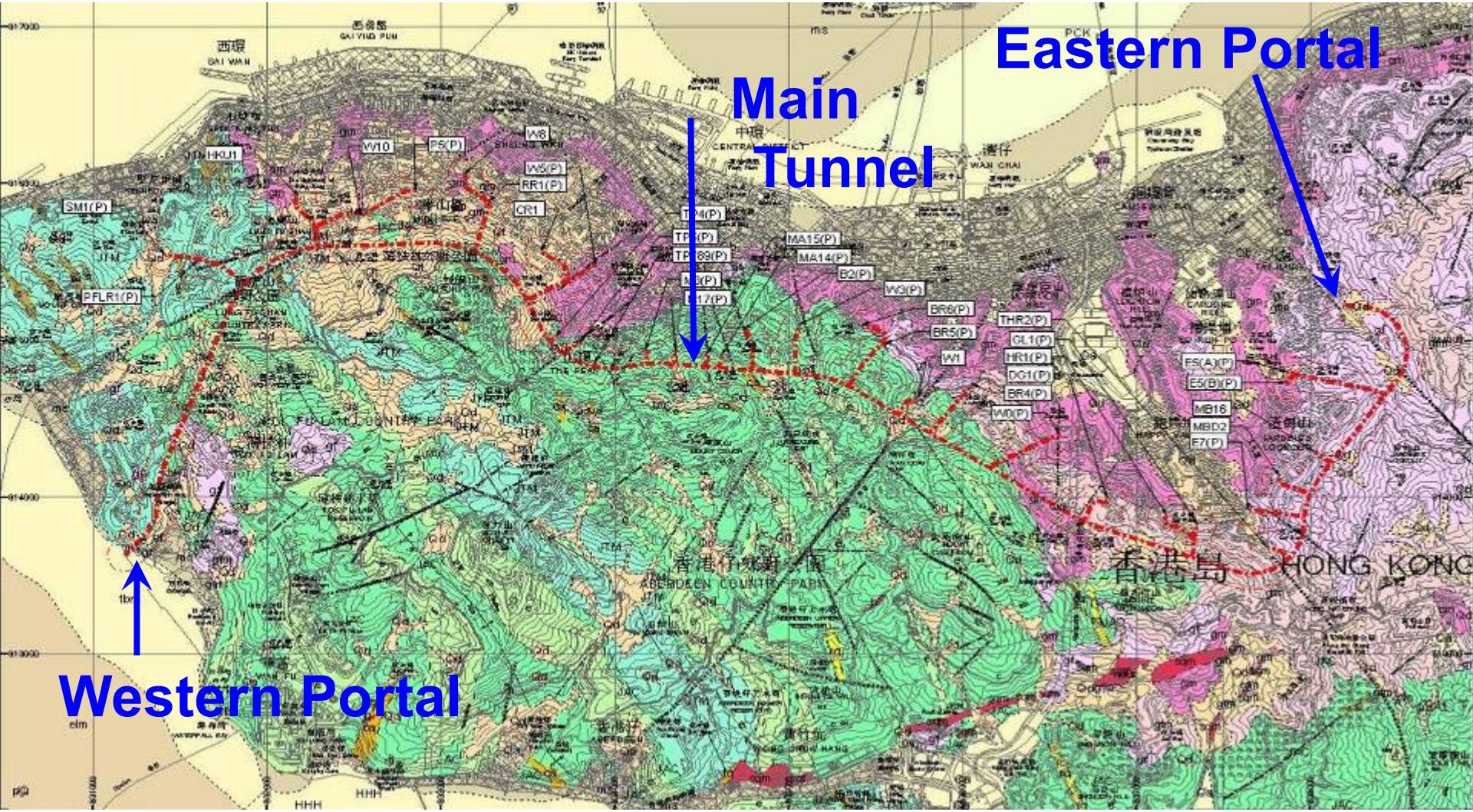
Adit Tunnels:

- 32 nos of Adits
- Total 7.9km in length
- ~3m excavation diameter, 2.3 to 3.5m completed diameter
- Total volume of excavated material ~ 60,000m^3
- Excavation Duration − 24 months

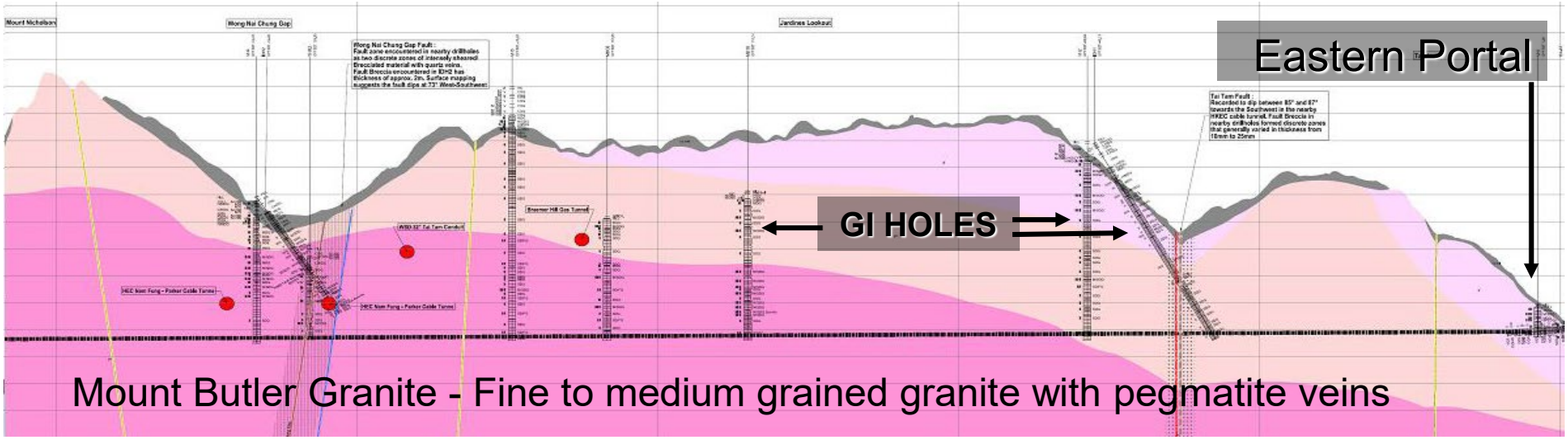
Drop Shafts:

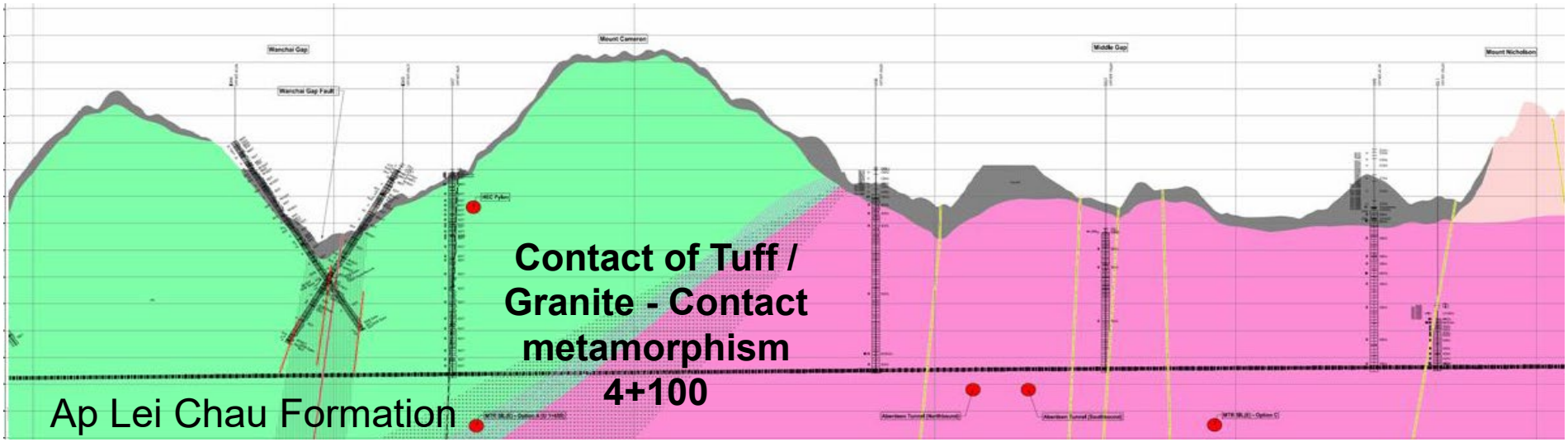
- 23 shafts totaling 2200m in depth excavated by RBM
- 2 constructed by RCD method
- 7 excavated by mechanical methods

Overview of the site geology (Geological Map of Hong Kong)

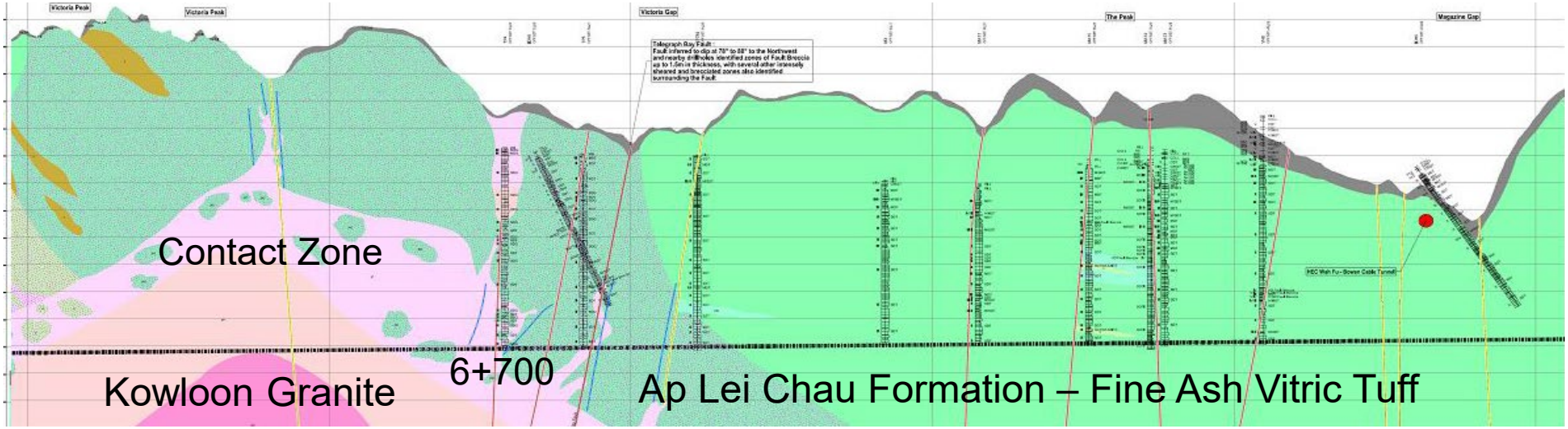


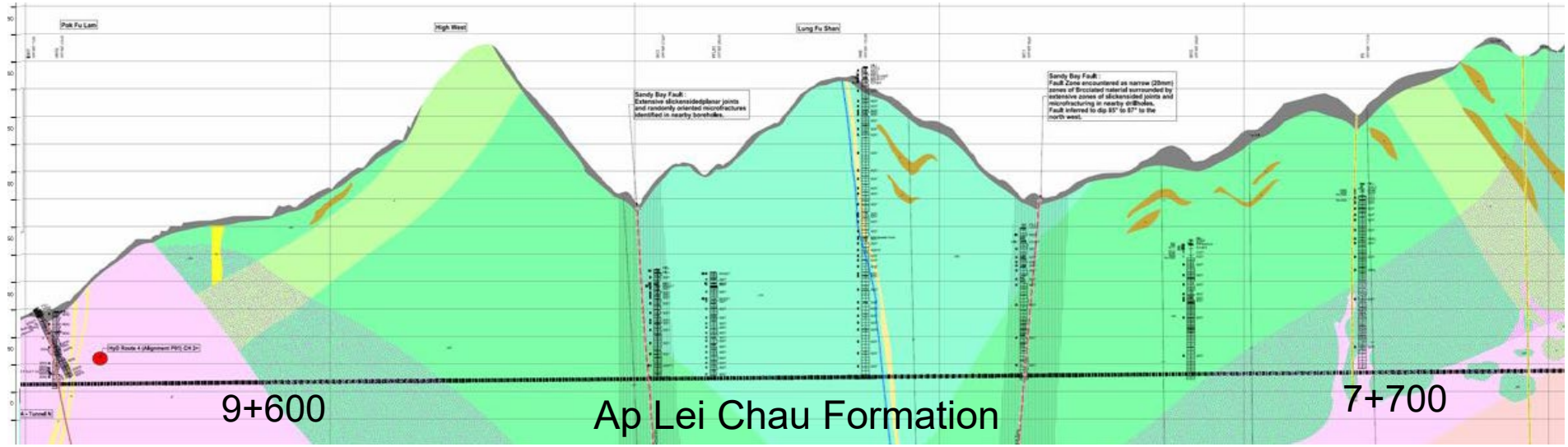
Longitudinal Section 1 of 3 (EP to Ch.5+000)





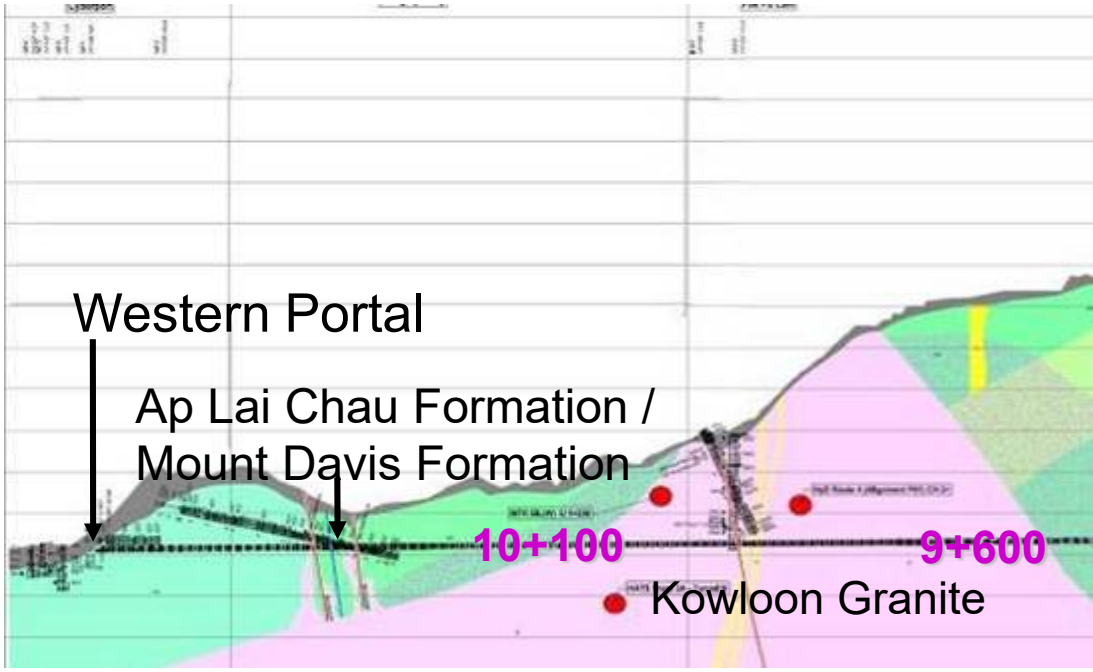
Longitudinal Section 2 of 3 (Ch.5+000 to Ch.9+600)





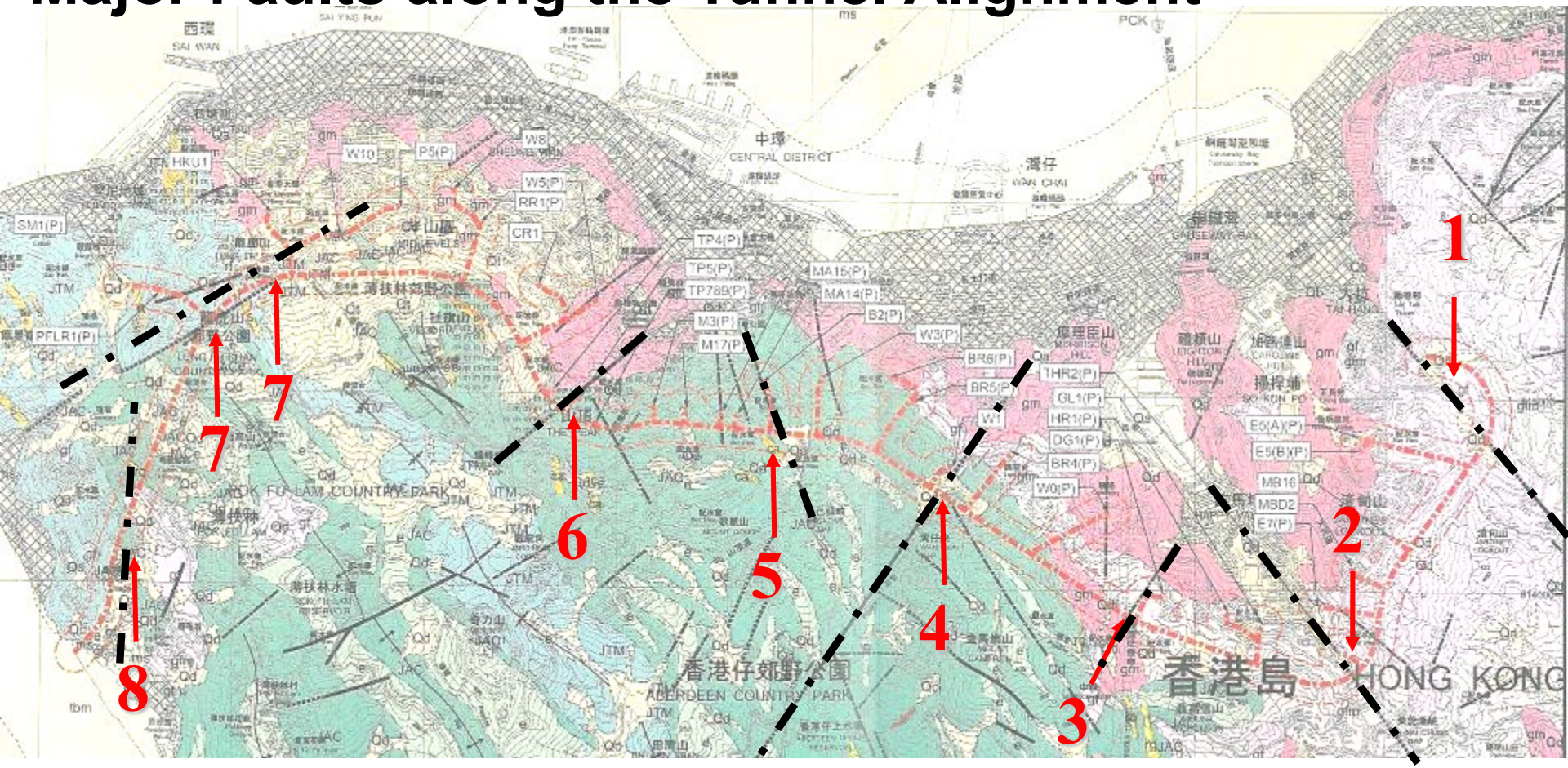
Longitudinal Section 3 of 3 (Ch.9+600 to WP)

- Granite and Volcanic Tuffs are in approximately equal proportion
- Metamorphosed Tuffs between Granite / Tuff Contact Zone



Mount Davis Formation – Coarse Ash Crystal Tuff

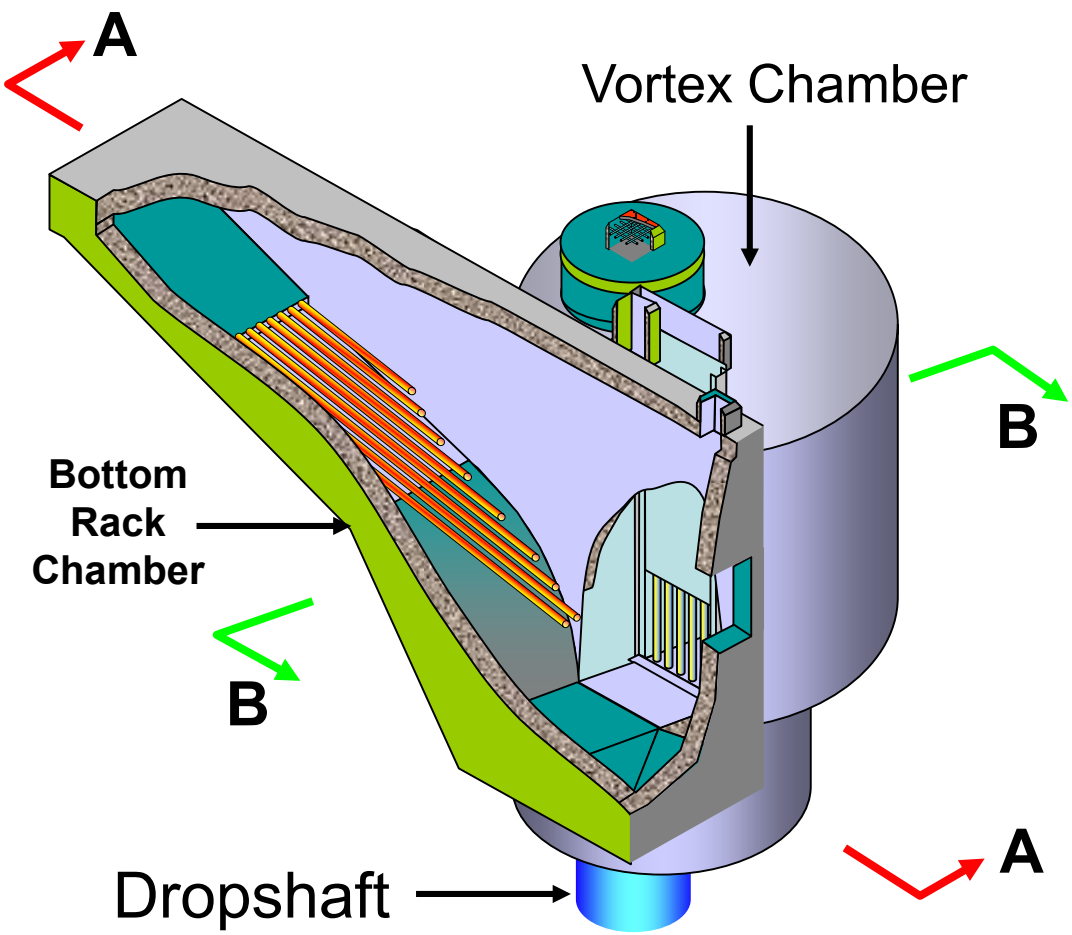
Major Faults along the Tunnel Alignment

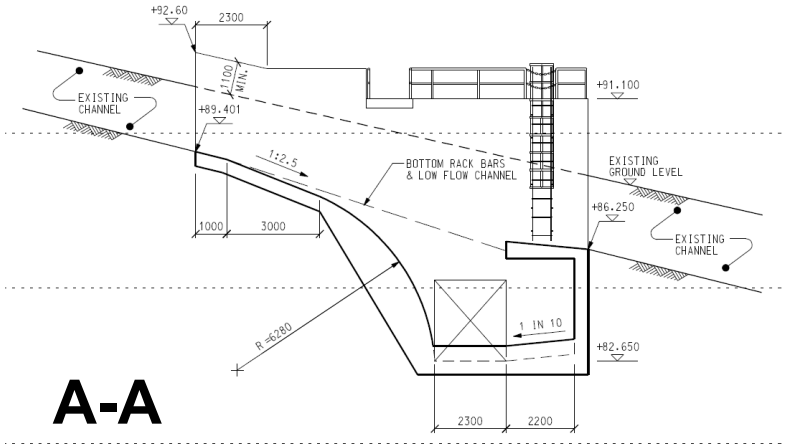


Eight Major Faults Anticipated (Approximate Chainage)

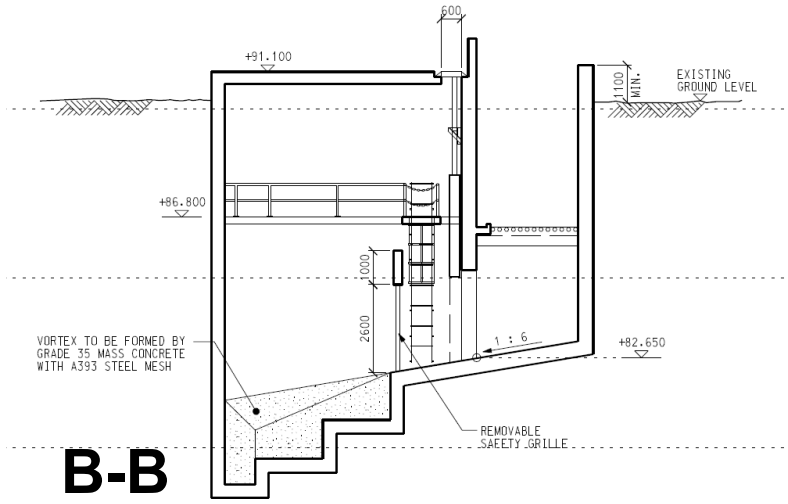
1) 0+645: Tai Tam Fault
2) 2+130: Wong Lai Chung Gap Fault
3) 3+270: Middle Gap Fault
4) 4+540: Wanchai Gap Fault
5) 5+080: Magazine Gap Fault
6) 6+570: Victoria Gap Fault
7) 8+360 & 8+960: Sandy Bay Fault
8) 10+160: Telegraph Bay Fault

Intake


A
Vortex Chamber
B
Bottom
Rack
Chamber
B
A
Dropshaft


+92.60
2300
EXISTING
CHANNEL
+89.401
1100
MIN.
+91.100
1:2.5
BOTTOM RACK BARS
& LOW FLOW CHANNEL
EXISTING
GROUND LEVEL
+86.250
EXISTING
CHANNEL
1000
3000
R=6280
1 IN 10
+82.650
2300
2200

A-A


600
+91.100
1100
MIN.
EXISTING
GROUND LEVEL
+86.800
1000
2600
1 : 6
+82.650
VORTEX TO BE FORMED BY
GRADE 35 MASS CONCRETE
WITH A393 STEEL MESH
REMOVABLE
SAFETY GRILLE

B-B

Hydraulic Physical Modelling

Intake

Typical completed intake

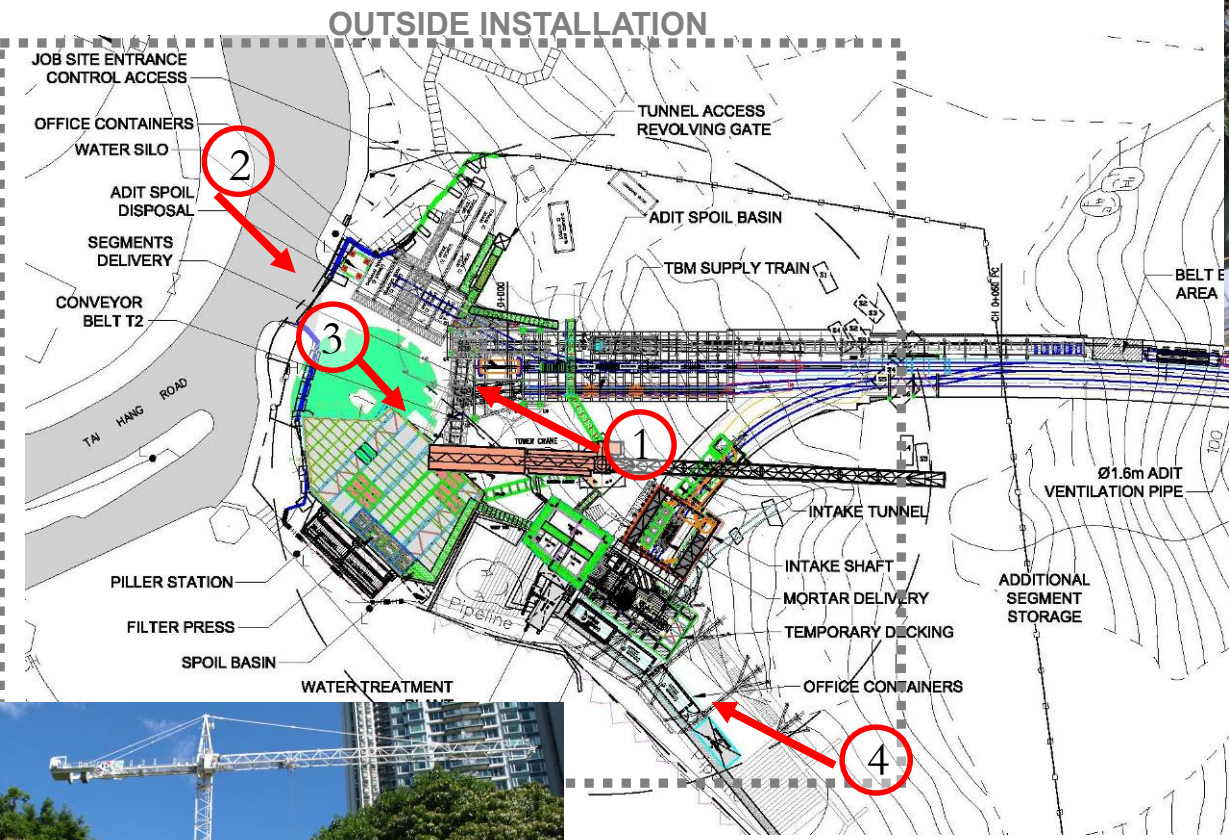
Portals

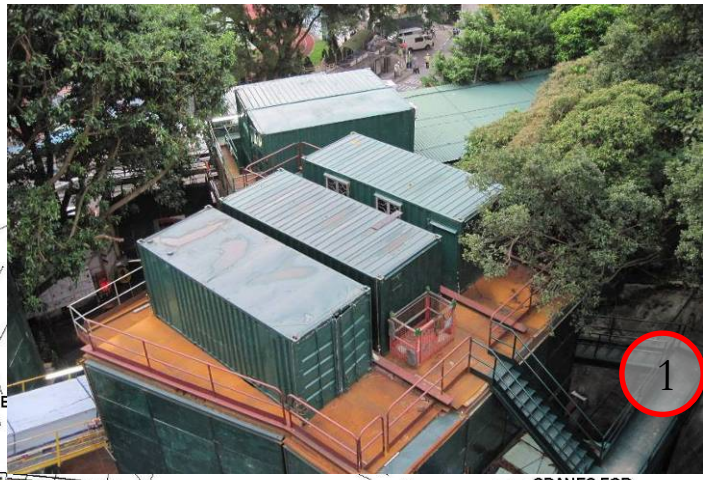

Eastern Portal
Portal:
Western Portal at Cyberport
Eastern Portal at Tai Hang
Western Portal

Eastern Portal

Eastern Portal

Site Layout at Eastern Portal



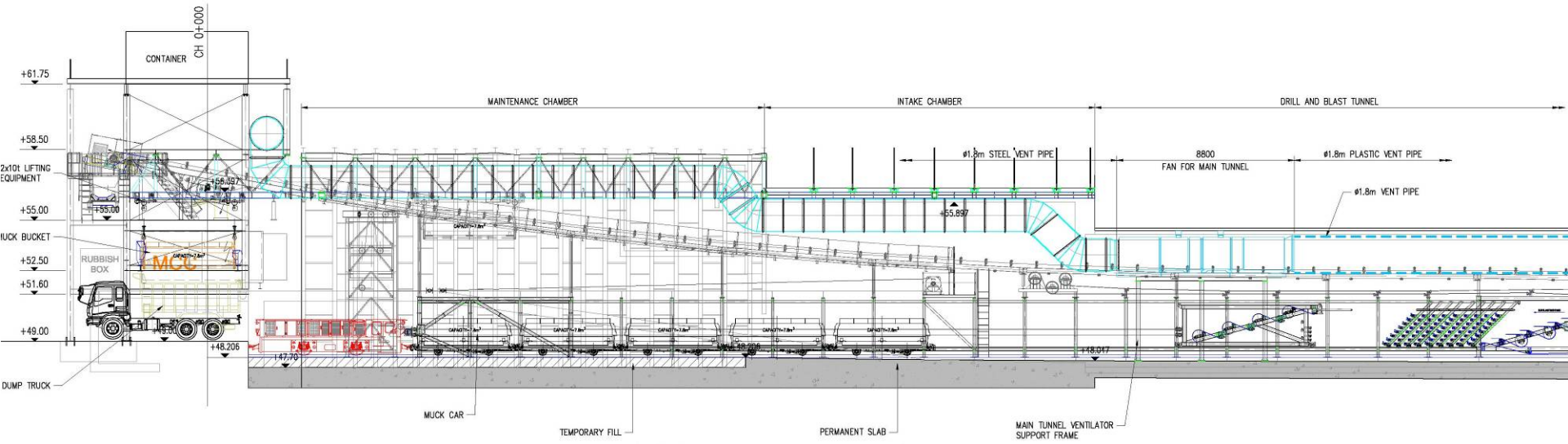


Major Works

Launching Tunnel Excavation (179ml: D&B)
Portal Structure & River Channel Structure
Intake Tunnel and Shaft

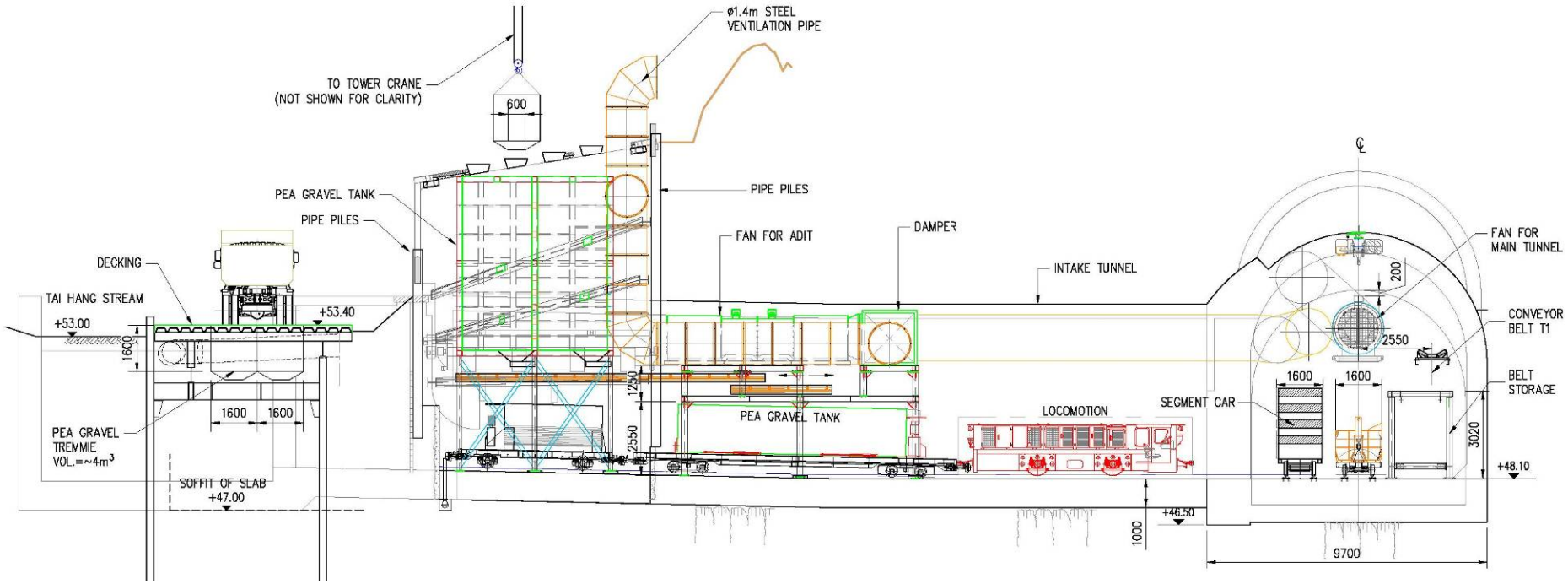
Eastern Portal

Eastern Portal



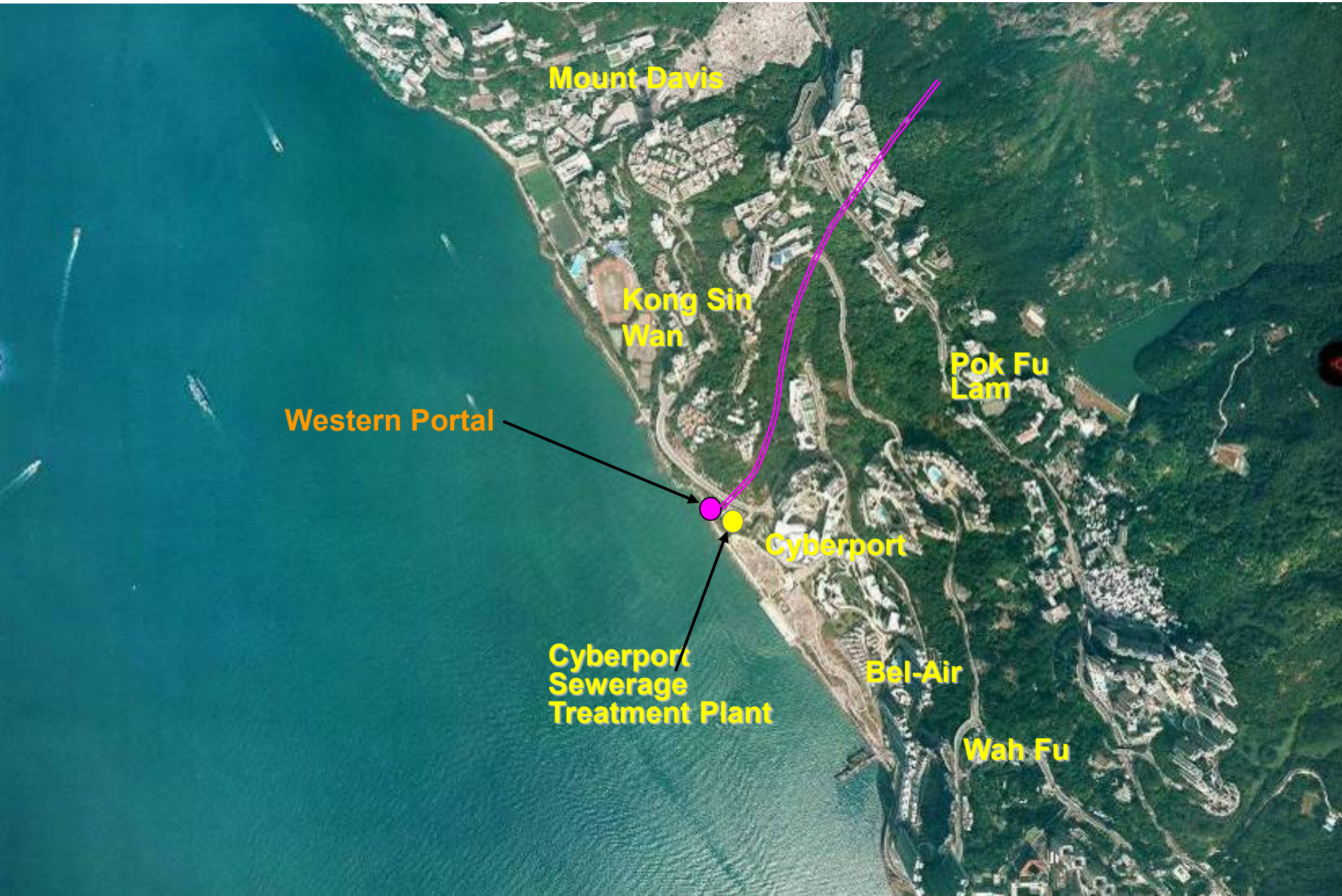
Launching Tunnel

Eastern Portal

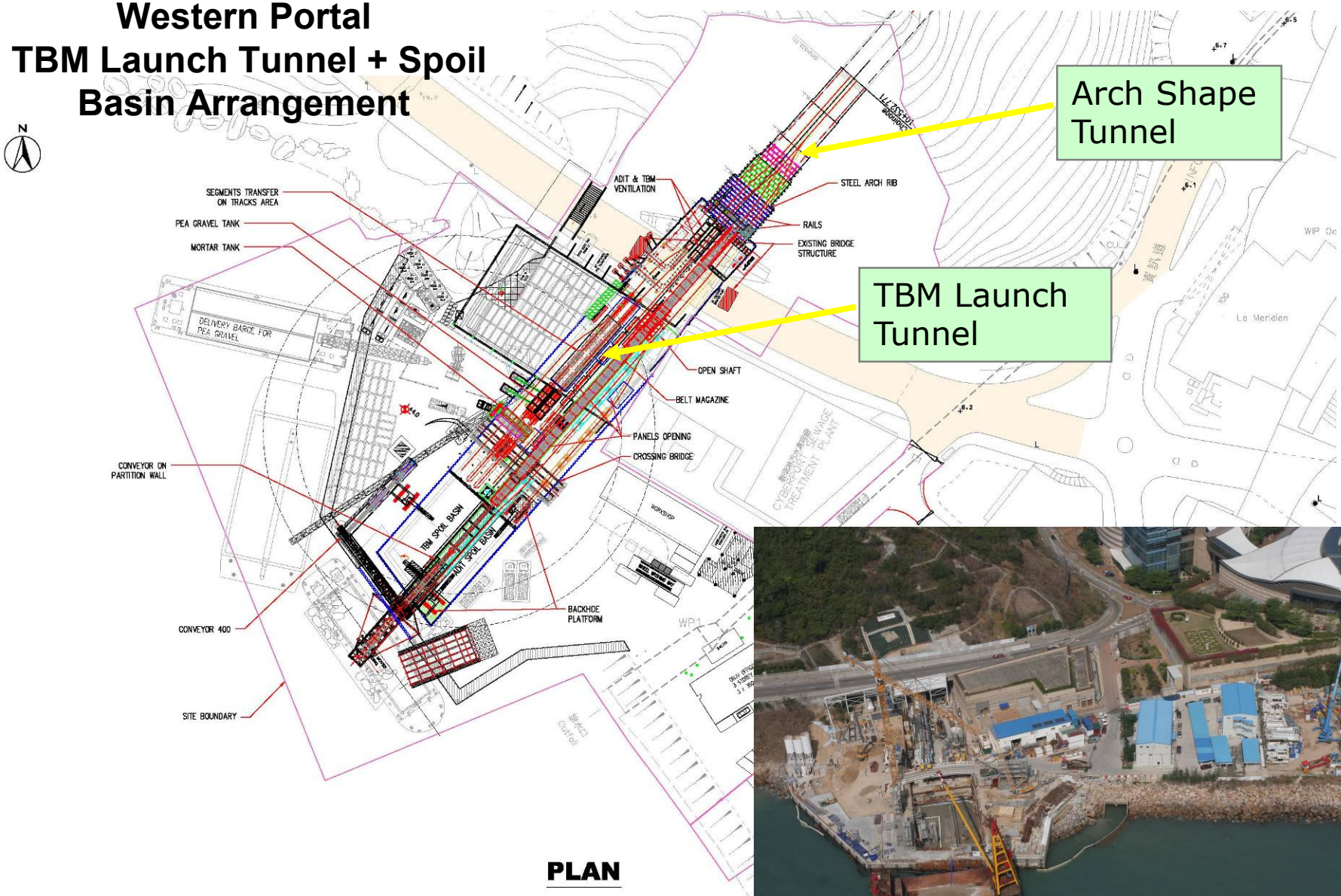


Intake Tunnel

Western Portal

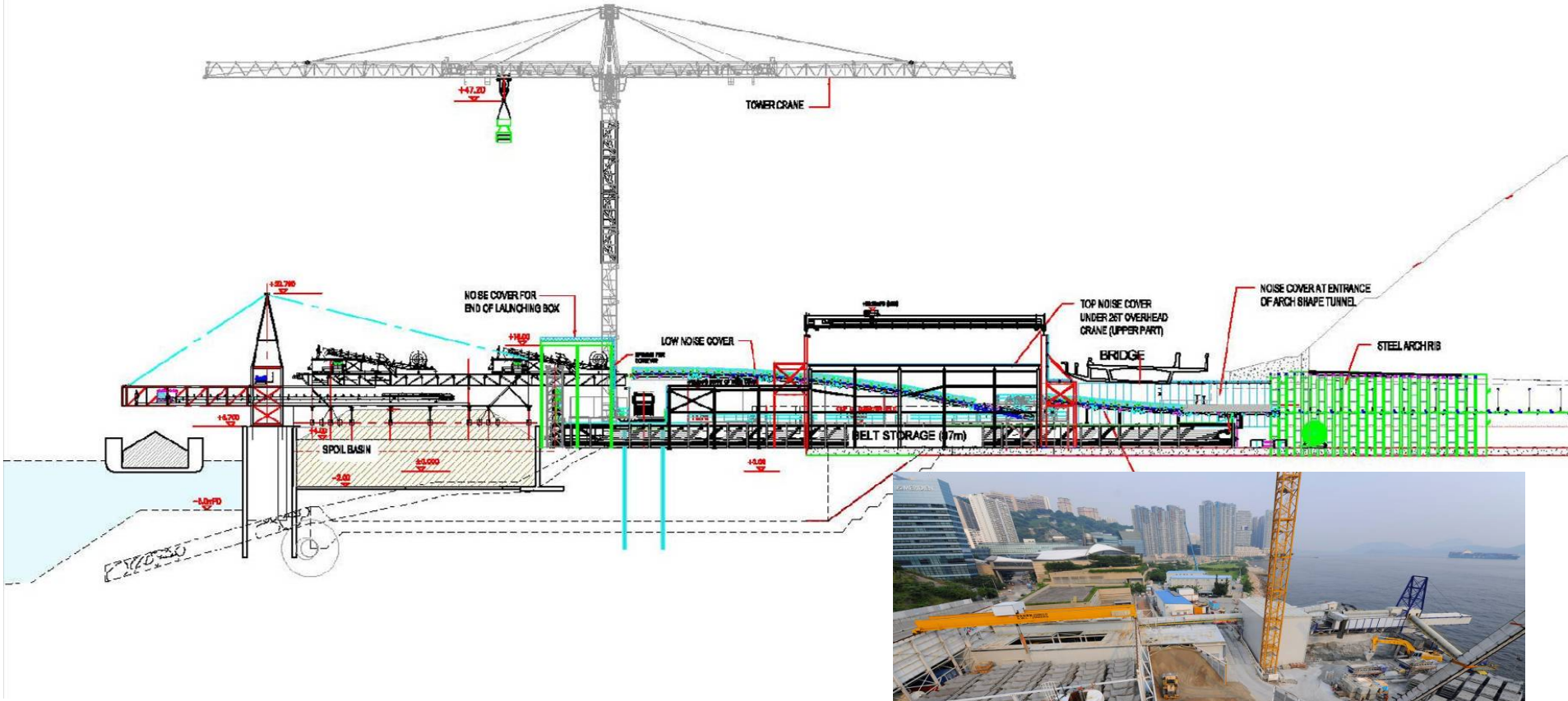


Western Portal
TBM Launch Tunnel + Spoil Basin Arrangement



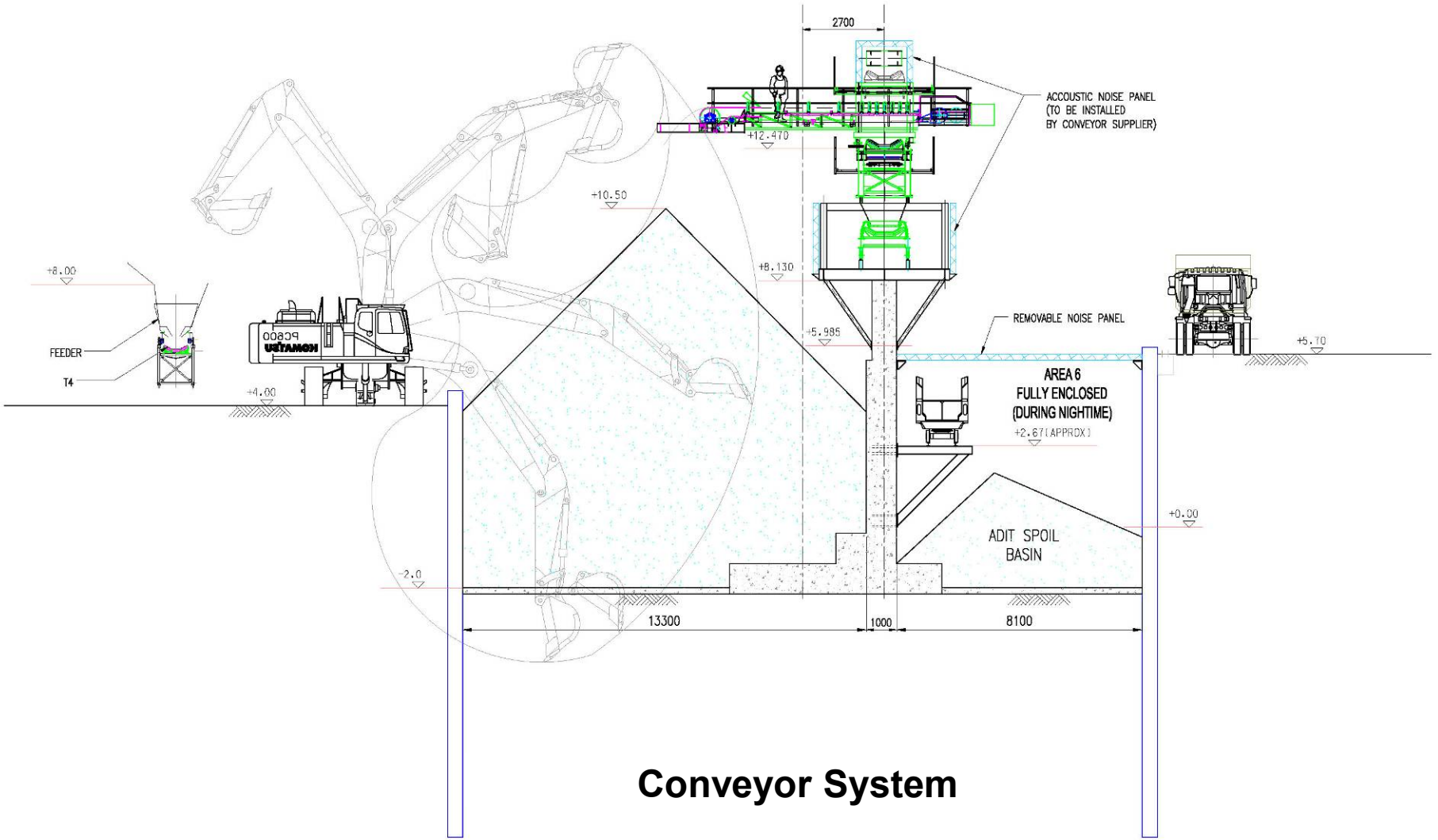
Western Portal

Western Portal



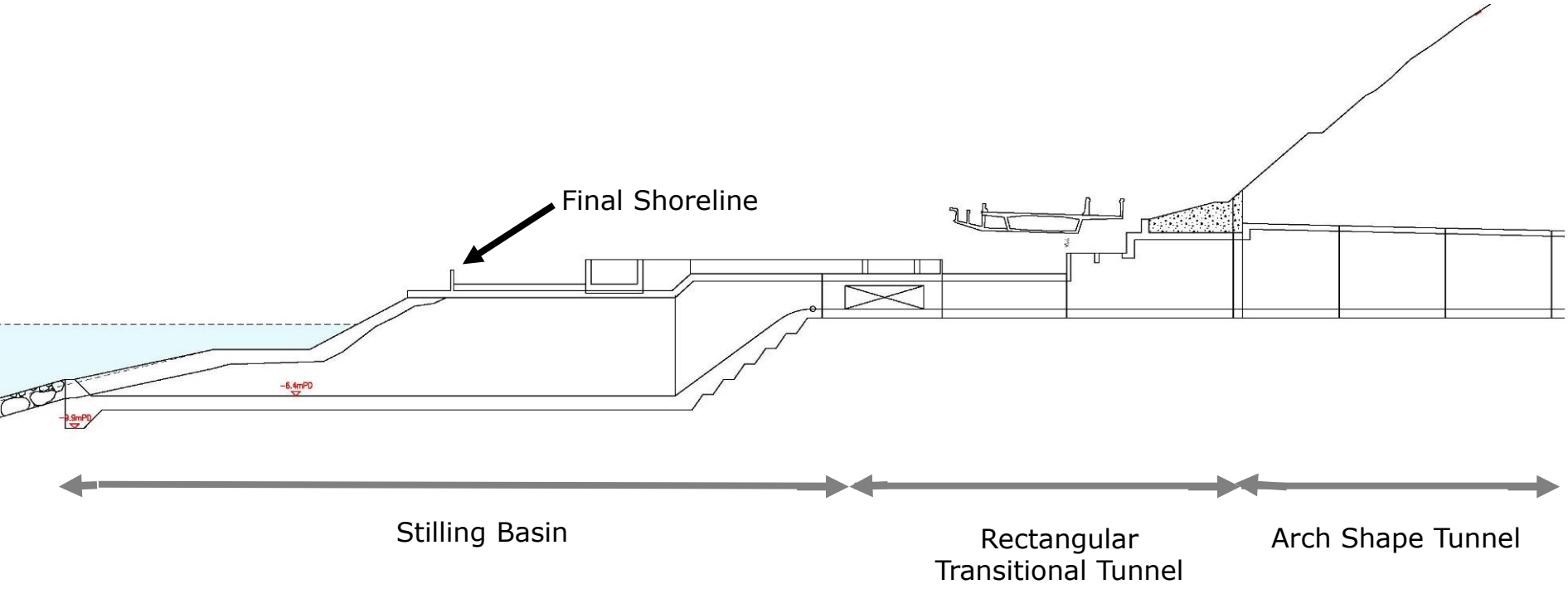
Western Portal

Western Portal



Conveyor System

Western Portal



Western Portal
Permanent Structure

Stilling Basin at Western Portal

Excavation

Completed Stilling Basin

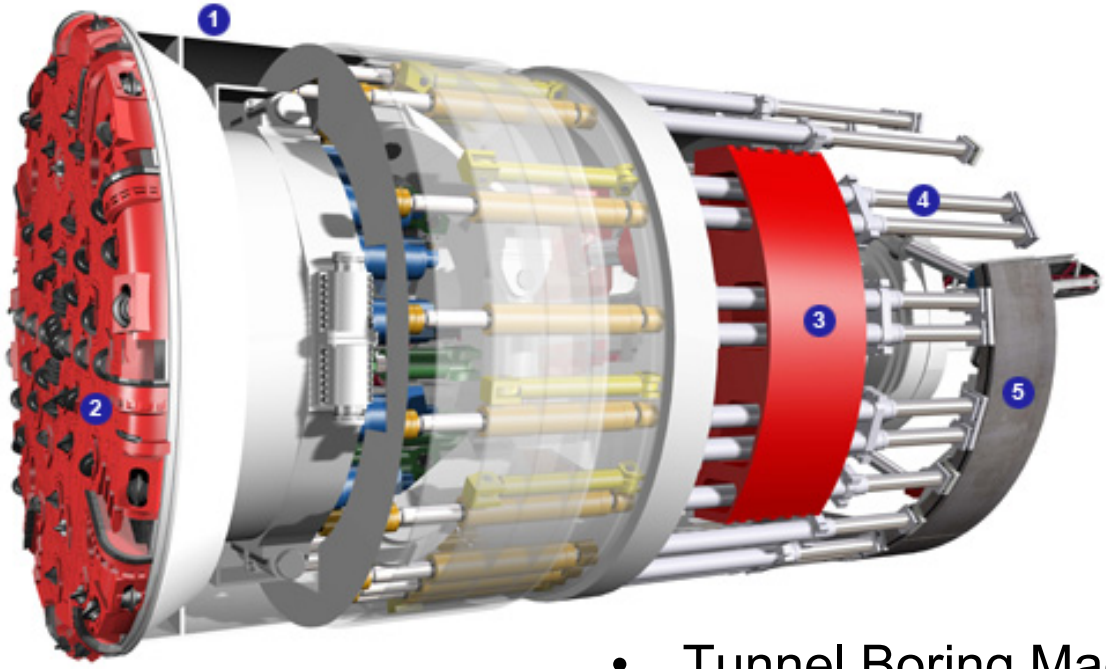
Main Tunnels

Methods of Construction :

- Two Hard Rock Double Shield TBM
  - Volcanic on West
  - Granite on East
- Launching from both portals
- External Diameters TBM
  - West TBM=8.3m
  - East TBM=7.2m
- Weight = 1,600t (Both TBM)
  - Cutter head = 160t
  - Remaining TBM Shield=530t
- Length= 230m (Both TBM)
- Delivery Date
  - West TBM : February 2009
  - East TBM : March 2009
- Factory in
  - Germany
  - Shanghai
  - Nansha

TBM Information

TBM Fabrication, Assembly and Testing in PRC



- Tunnel Boring Machine (TBM)
  - 1 – Front Shied
  - 2 – Cutterhead
  - 3 – Gripper System
  - 4 – Thrust Cylinder
  - 5 – Segment Erector

TBM Assembly at WP

12 –Feb-2009 - West TBM Arrival at West Portal

12 –Feb-2009 - West T Unloading Barge in position

18-Feb-2009 Main Bearing Installation

26-Feb-2009 – Forward Thrusters Testing

06-March-2009 – TBM Naming Ceremony

12-March-2008 – Connect Back Units

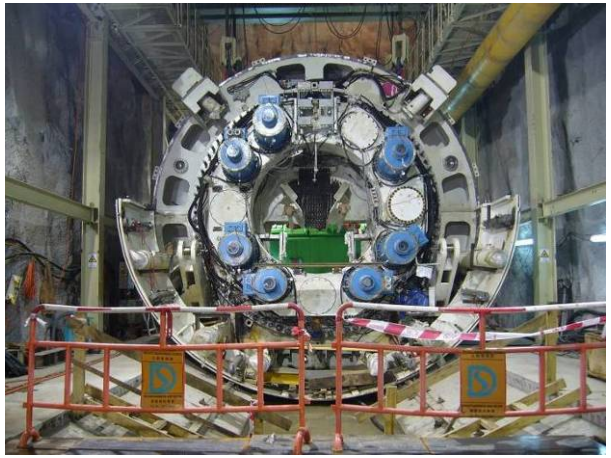
TBM Assembly from 12 February to 23 March 2009

TBM Assembly at EP

23 - March - Cutterhead Transport to Site

23-March-2009 – Unloading Cutterhead

31-Mar-2009 – Lifting Main Bearing for Installation



02-Apr-2009 – Main Bearing in Position

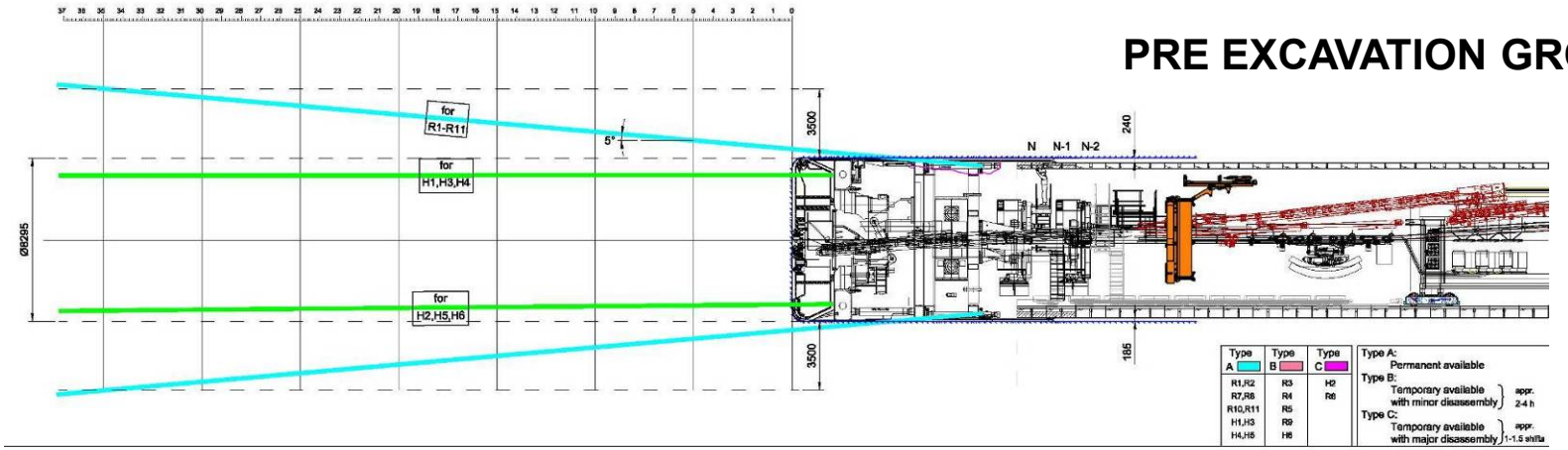
15-Apr-2009 - Cutterhead Installation

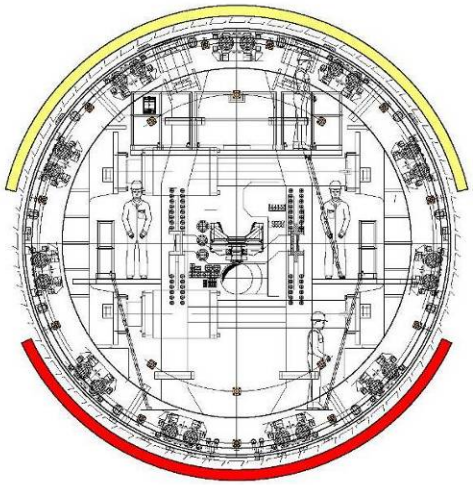
29-Apr-2009 – TBM Shield in Start Position Start Back Up Assembly

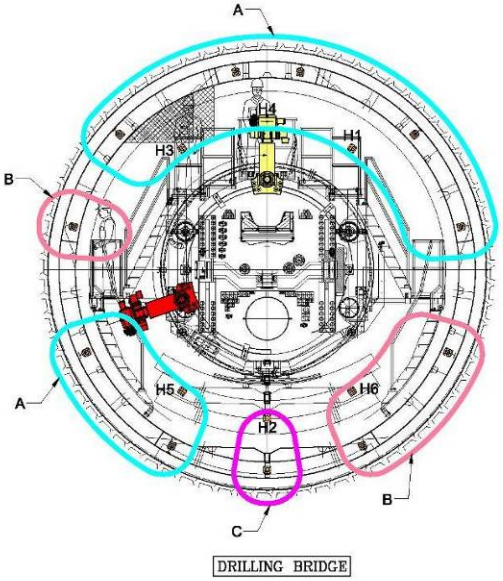
TBM Assembly from 23 March 2009 to 1 June 2009

Main Tunnel

PRE EXCAVATION GROUTING







Inflow Criteria:

- Not greater than 300 litres/minute from any portal
- Not exceeding 0.2 litres/minute/meter of any probe hole ahead of the excavation face and not more than 1 litre/minute from any 5m length

Main Tunnel

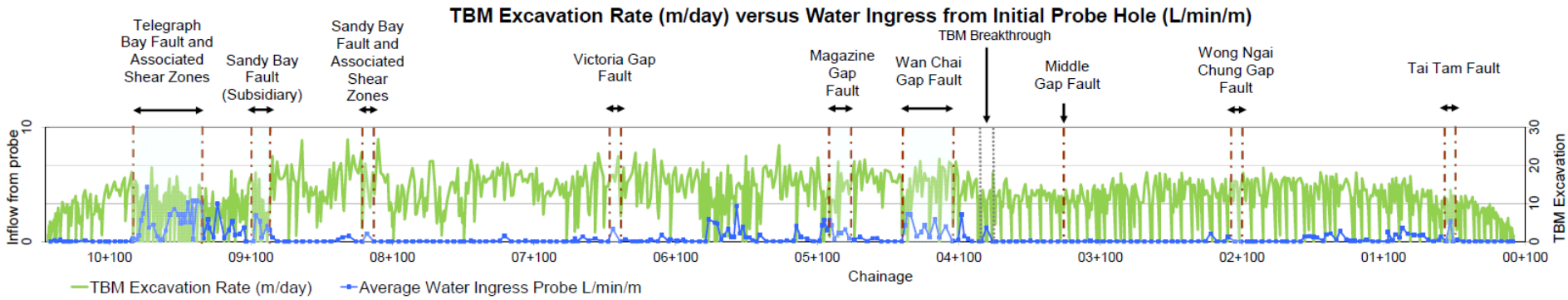
PRE EXCAVATION GROUTING

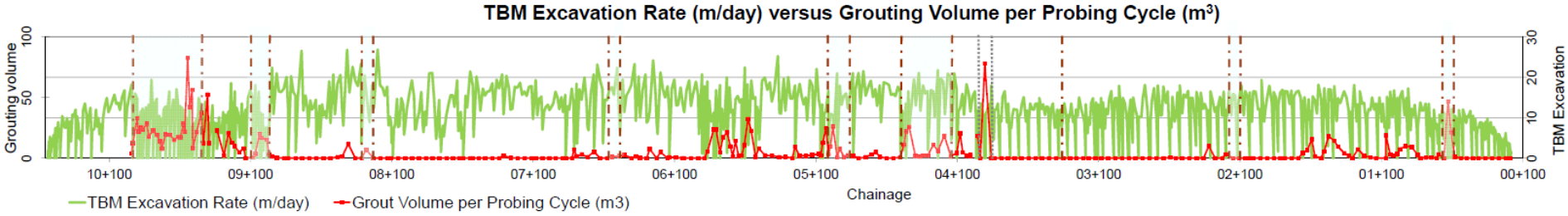
	Length of treated tunnel (m)	Number of probe cycles	Total length of probes (m)	Number of grout holes	Total length of grout holes (m)	Total volume of grout injected (m^3)
Eastern TBM	703	103	5,591	101	4,617	331
Western TBM	1,800	210	12,280	472	24,258	1,438

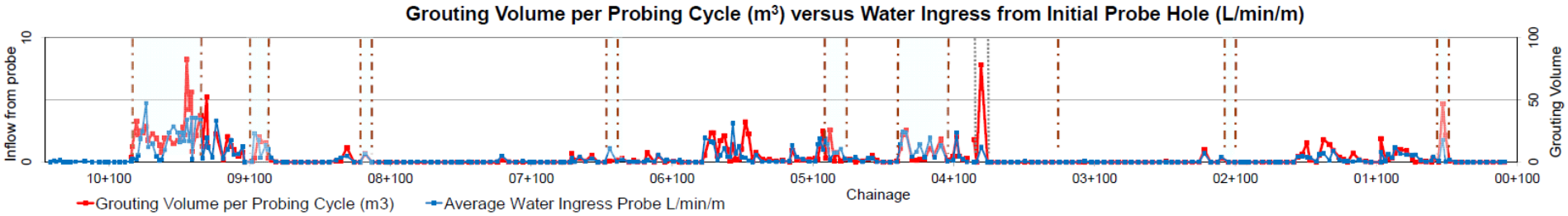
Summary of Grout Quantities

Main Tunnel

PRE EXCAVATION GROUTING

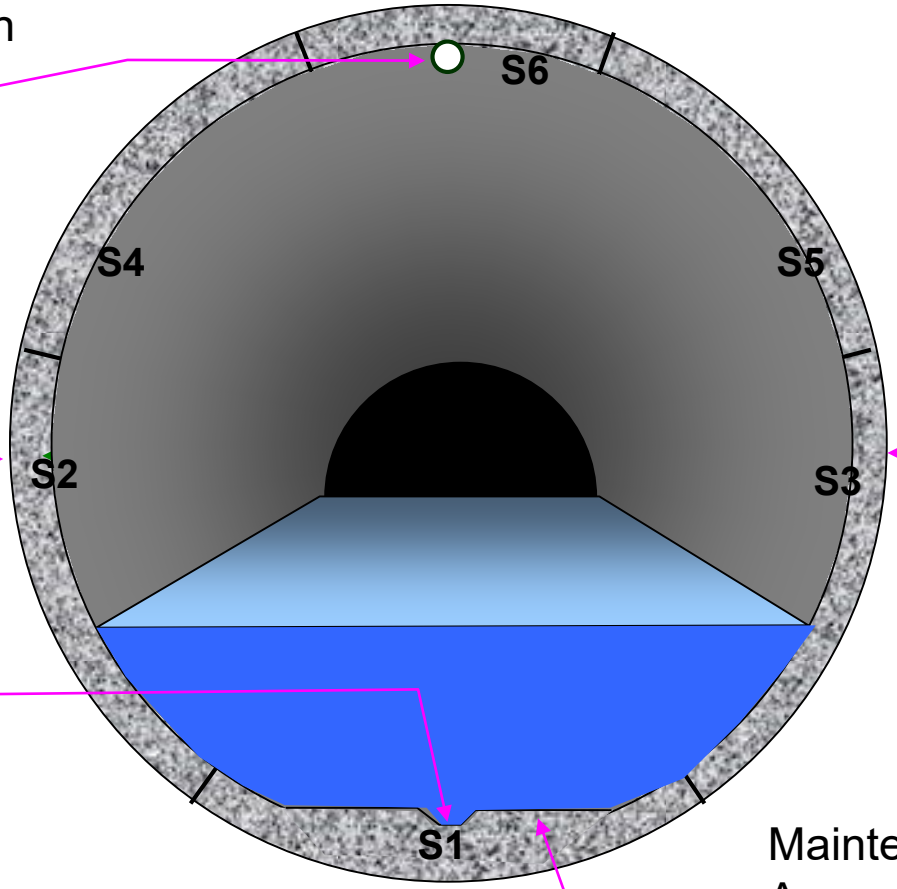






Comparison of Water Inflow, Grout Quantities & TBM Excavation Rate

Tunnel Lining



Designed for 1:200 Year Flow

Precast Segments

Storage on Segment Precast in mainland China

Supplier: Redland
Delivery: By Barge from China to Western Portal
By Truck from Western Portal to Eastern Portal

Total Segments casted : 41292 u

Segments cast: 504 u per week
(6 segments per ring)

Typical turning radius between 300m to 930m

Main Tunnels

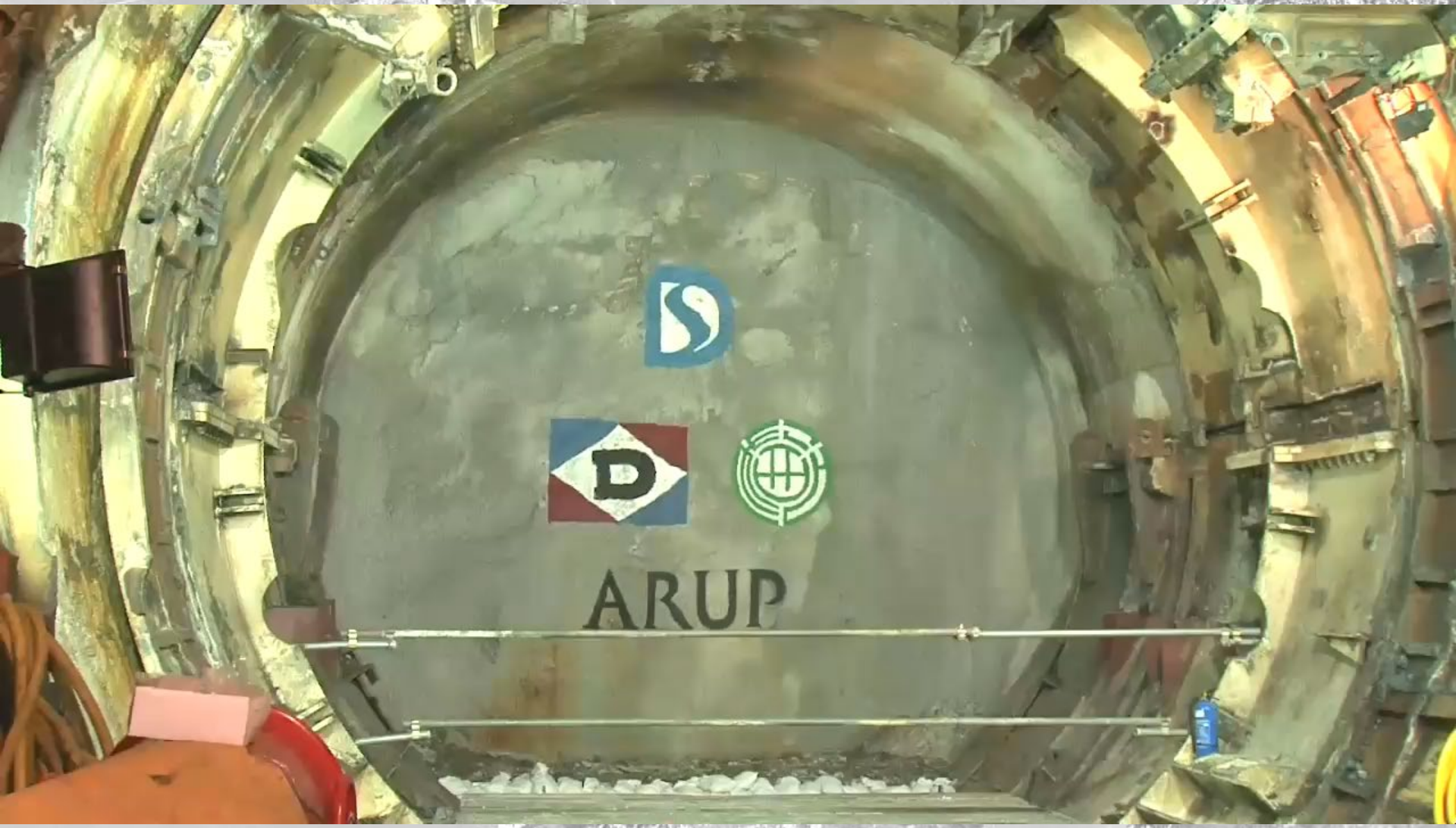
Western TBM Tunnel

- 6.6Km length in 21.5 Months
- 7.25m I.D.
- Start from Western Portal on 23rd March 2009
- Breakthrough on 17th January 2011

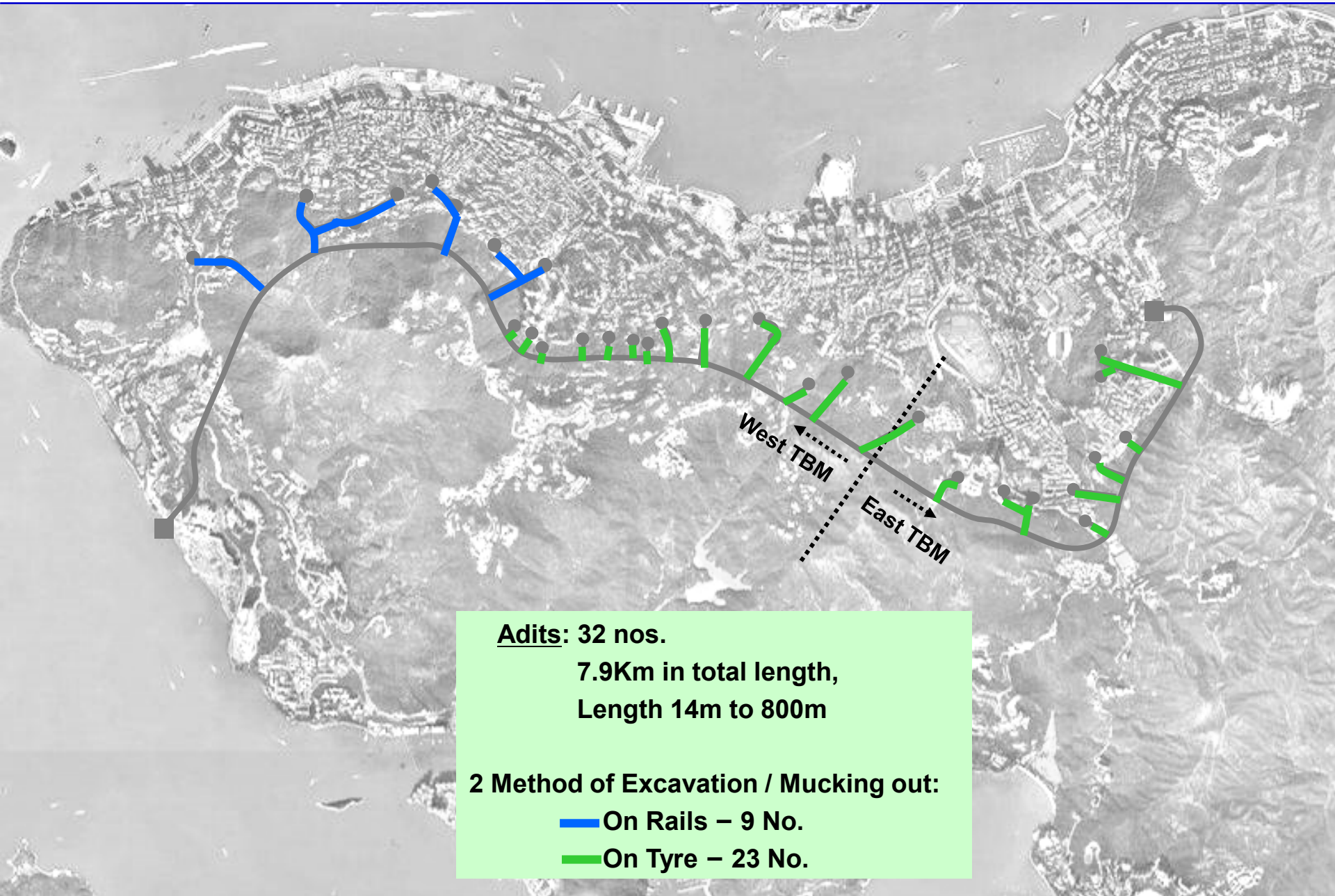
Eastern TBM Tunnel

- 3.9Km length in 16 Months
- 6.25m I.D.
- Start from Eastern Portal on 1st June 2009
- Breakthrough on 6th October 2010

Main Tunnels



Adits



Adits: 32 nos.
7.9Km in total length,
Length 14m to 800m

2 Method of Excavation / Mucking out:
On Rails – 9 No.
On Tyre – 23 No.

Adits

Methods of Construction :

- Adit Tunnel in Horse-Shoe Shape by Drill & Blast Method
- Initial 5m length by Mechanical Excavation
- Micro blast technique used in later adit junctions
- Maximum 12 concurrent blasting faces
- 2 blast cycles per day on longer adits
- Typical 3m pull per blast

Mechanical Excavation

Drilling for Blasting

Adits

Micro Blasting :

- Carried out for the initial 5m length of adit
- Pull length range between 300mm to 1m
- MIC range from 0.2kg to 1kg
- Custom made blast door

Preparation for Blasting

Custom Blast Door

Adits

Concurrent Blasting :

Blast Door

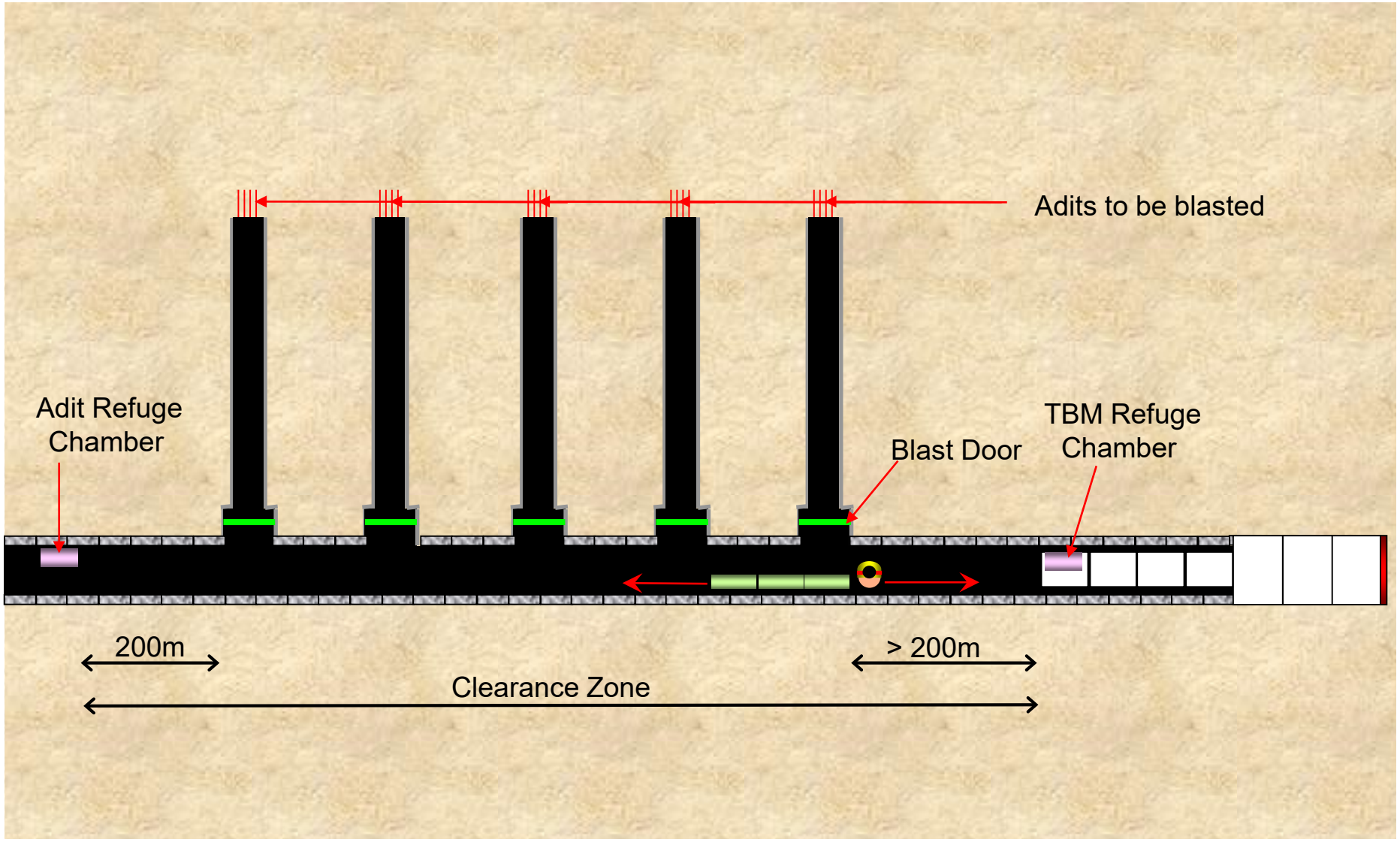
Adit Refuge Chamber

Explosive Delivery Truck

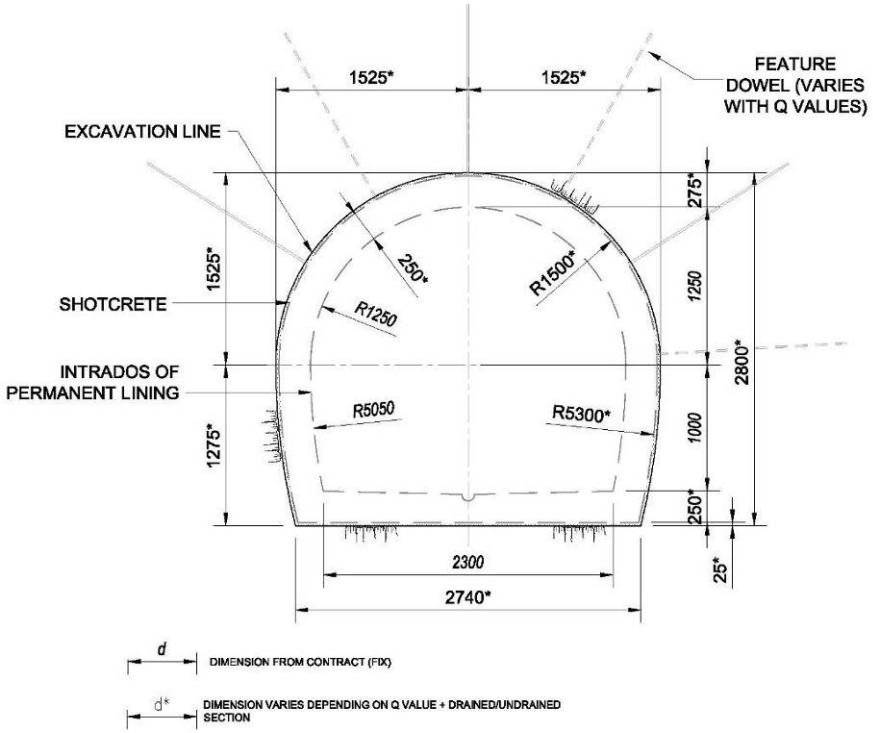
TBM Refuge Chamber

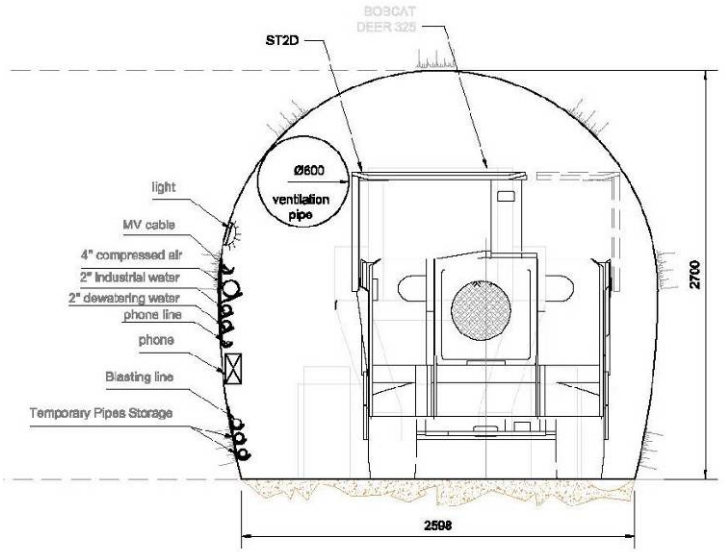
Adits

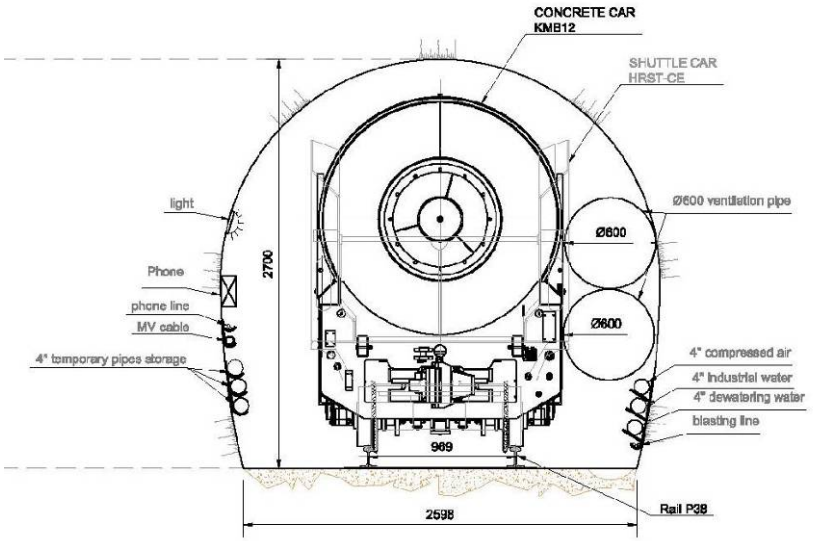
Concurrent Blasting :



Adits





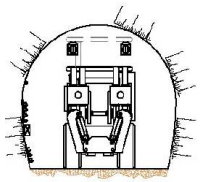


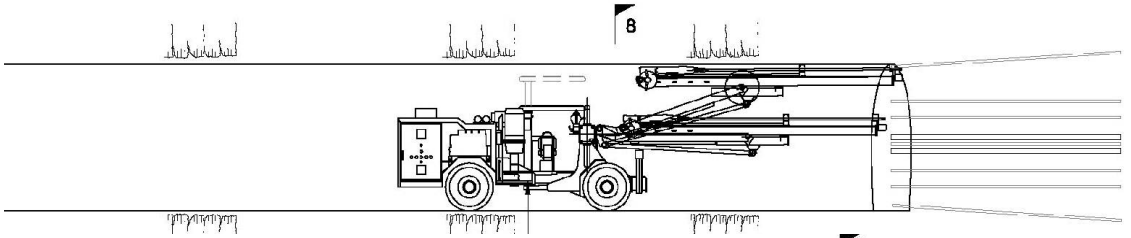
Adits Typical Section

Adit Excavation by Drill & Blast Method – Tyre

STAGE 1 :

Drilling

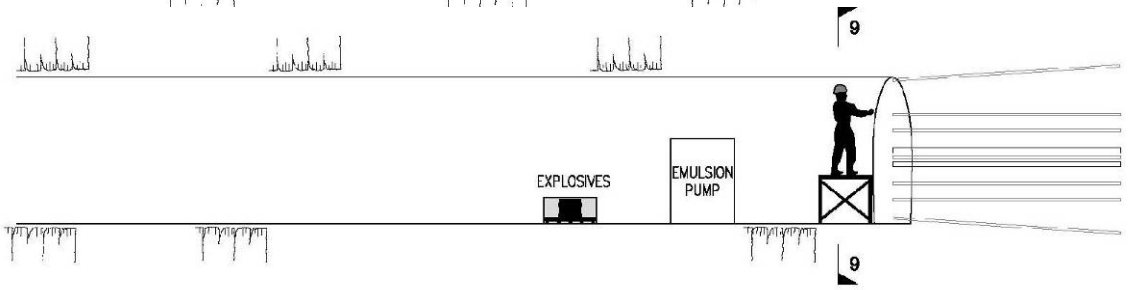




STAGE 2 :

Charging

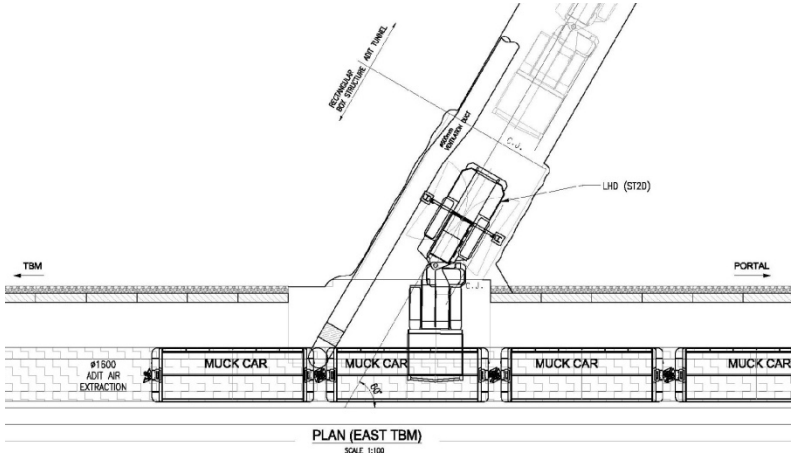
SECTION 9 - 9

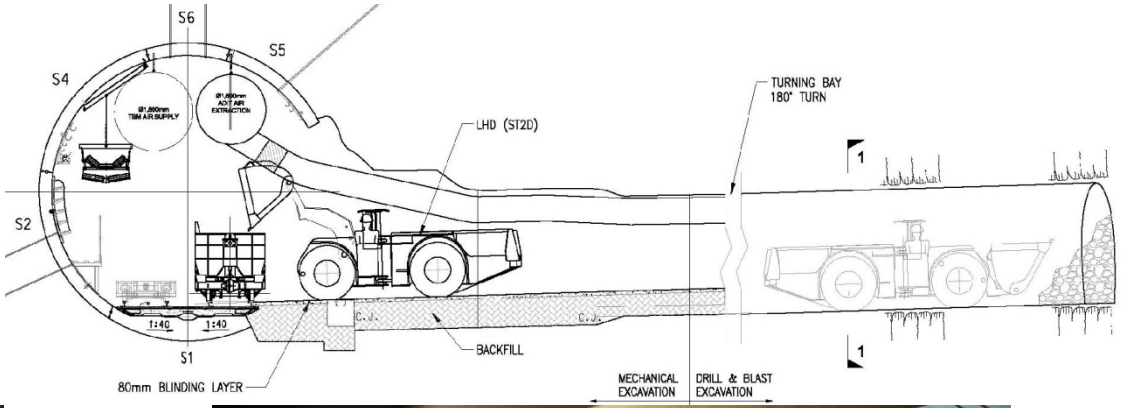


Adit Excavation by Drill & Blast Method – Tyre

After blasting and ventilation

STAGE 3 : Mucking out

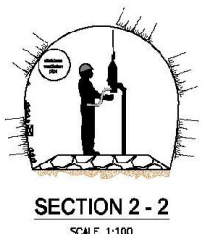


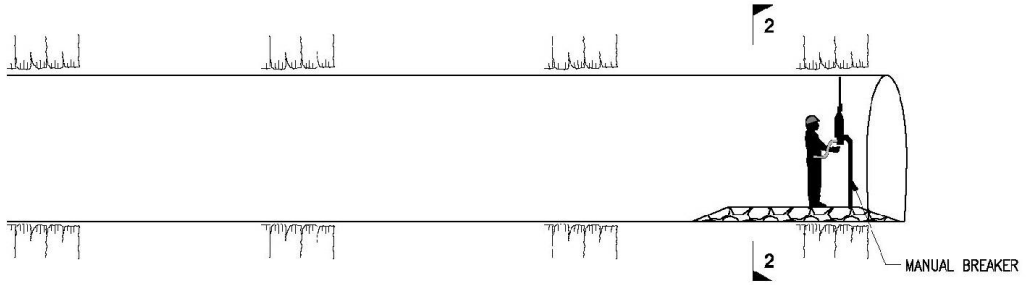


Adits

STAGE 4 :

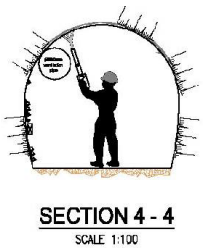
Scaling

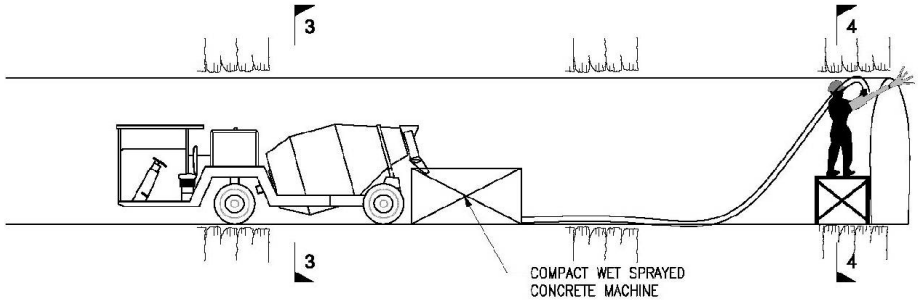




STAGE 5 :

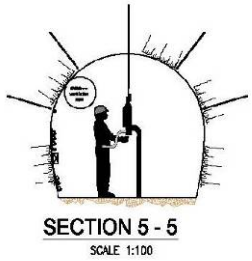
Shotcreting

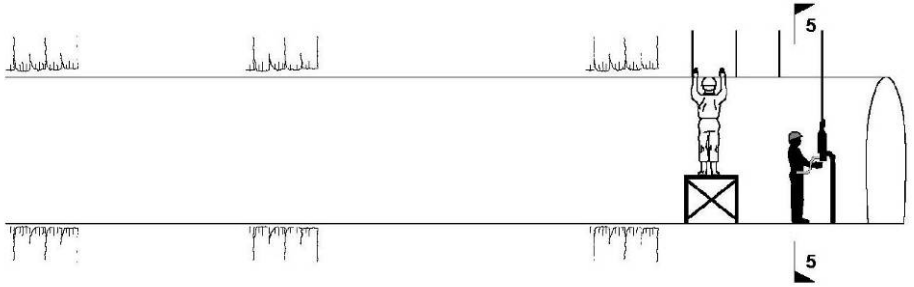




STAGE 6 :

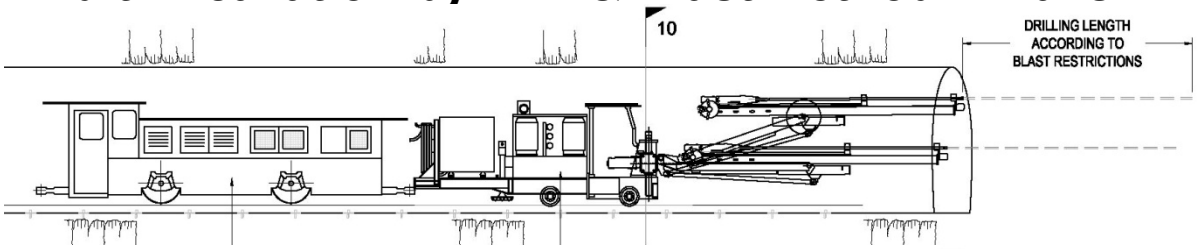
Rockbolting

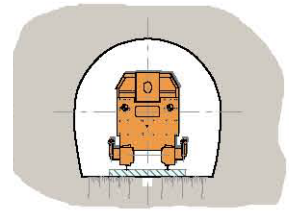




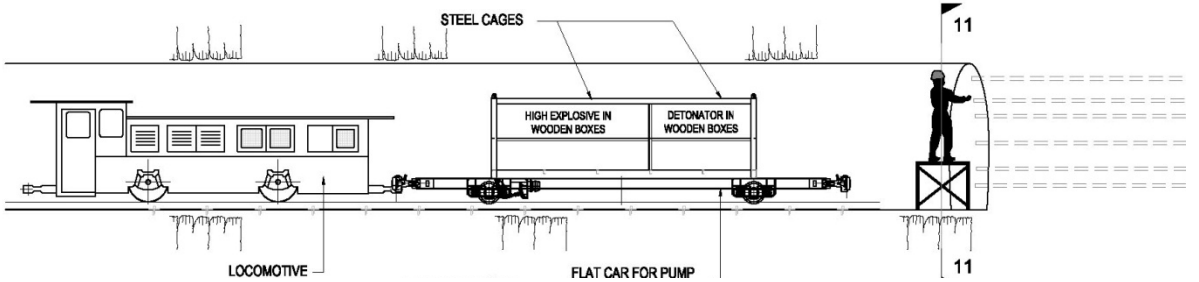
Adit Excavation by Drill & Blast Method – Rails

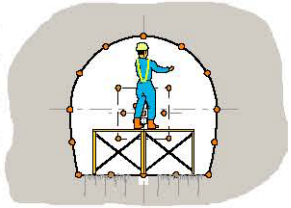
Face Drilling



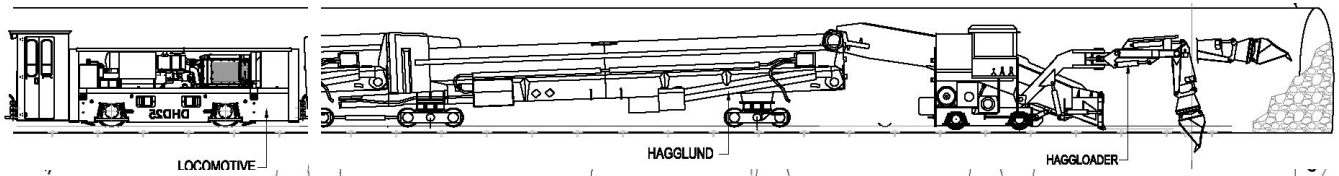


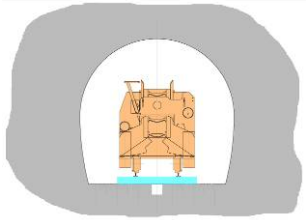
Explosive charging



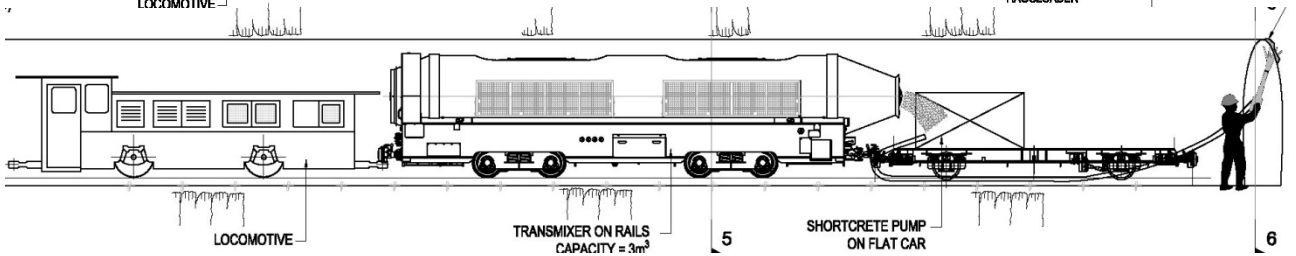


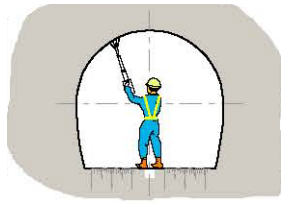
Mucking Out& Scaling



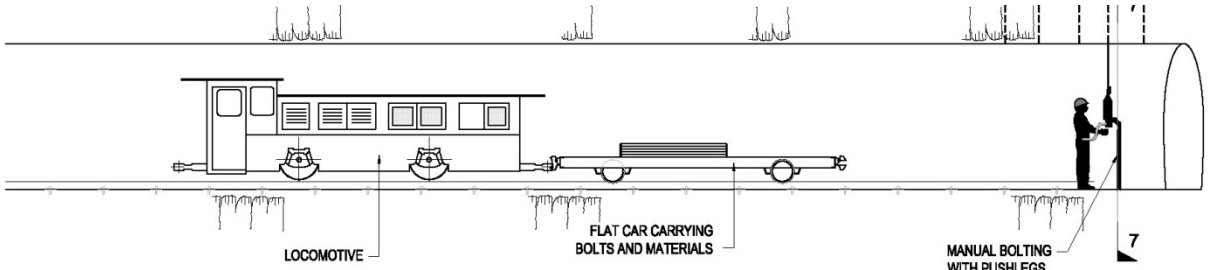


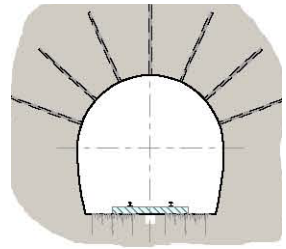
Shotcrete





Rock Bolt





Adits

Concreting :

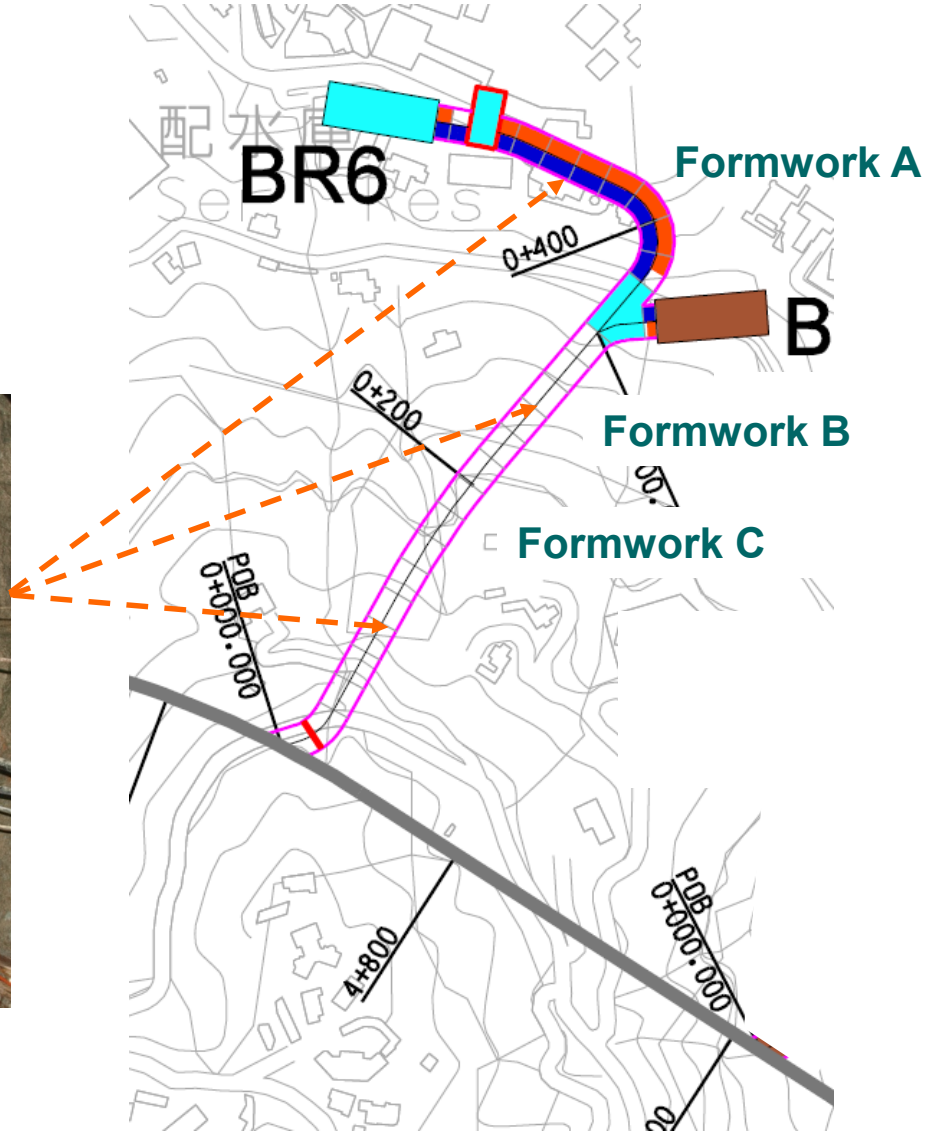
- Permanent Lining by In-situ Casting Method
- Total of 26 sets of formwork
- Total volume of concrete required;
  - ~26000m^3
- Maximum concrete volume cast per day;
  - East Adit = 220m^3
  - West Adit = 370m^3

Adits

Challenges

Tight Programme

- Up to 4 sets of formworks operating concurrently in individual adit



Challenges

Concrete Delivery Logistics

- Delivery distance of up to 7Km
- Multiple delivery points using intake locations

Adits

Formwork Erection at Stilling Chamber

Typical Lining Formwork

Formwork Erection at Turning Bay

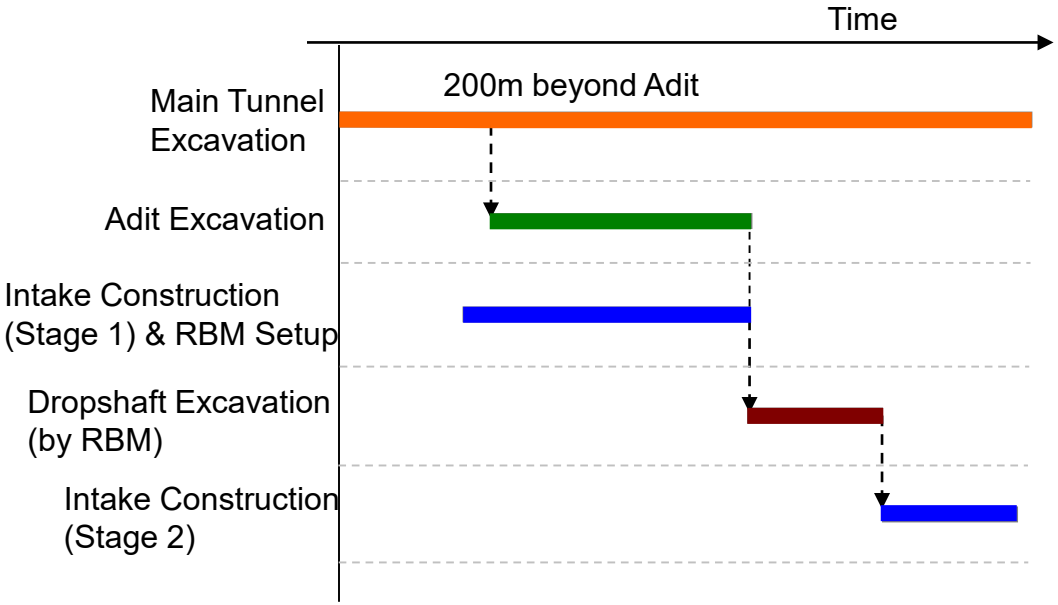
Formwork Erection at Adit / Main Tunnel Junction

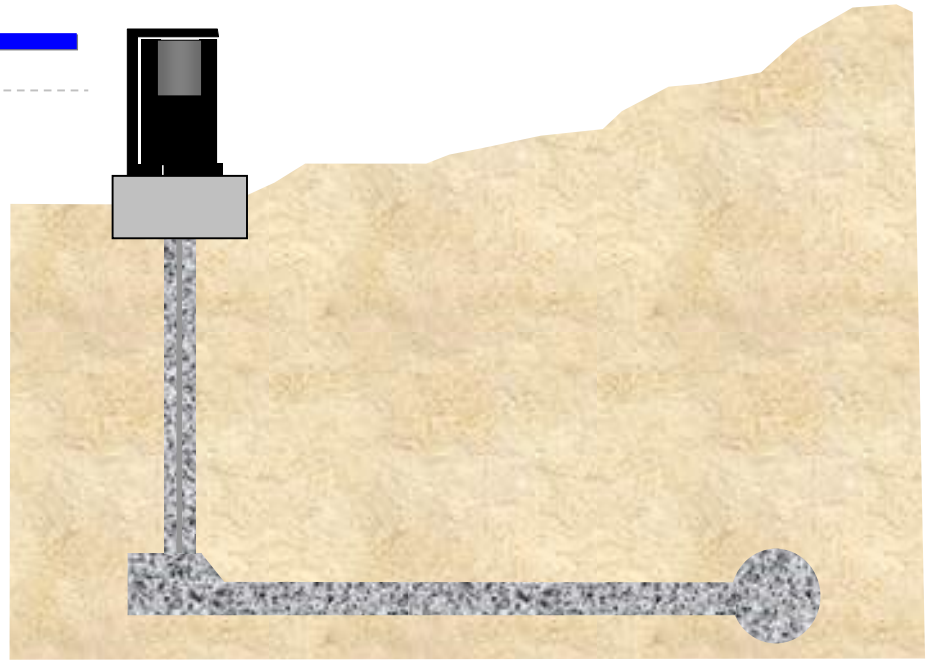
Concreting Arrangement

Concrete Delivery

Typical Details of In-Situ Concrete Lining Works

Construction Sequences

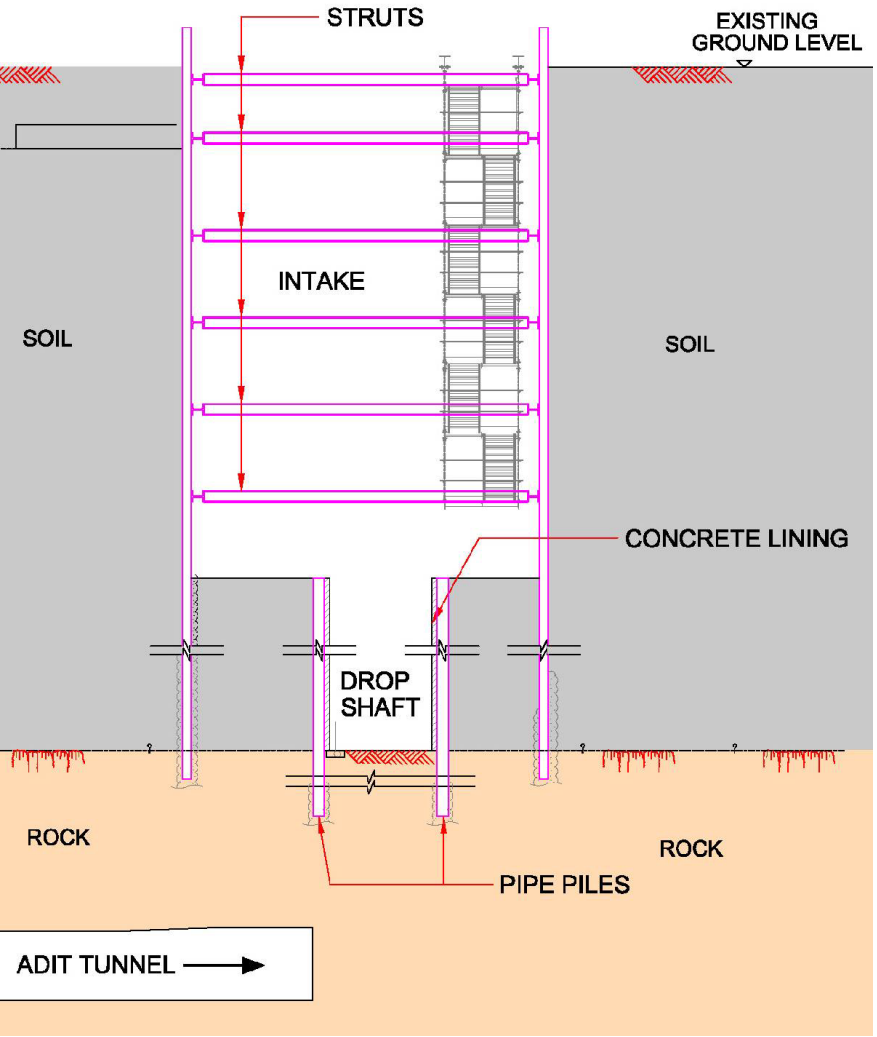


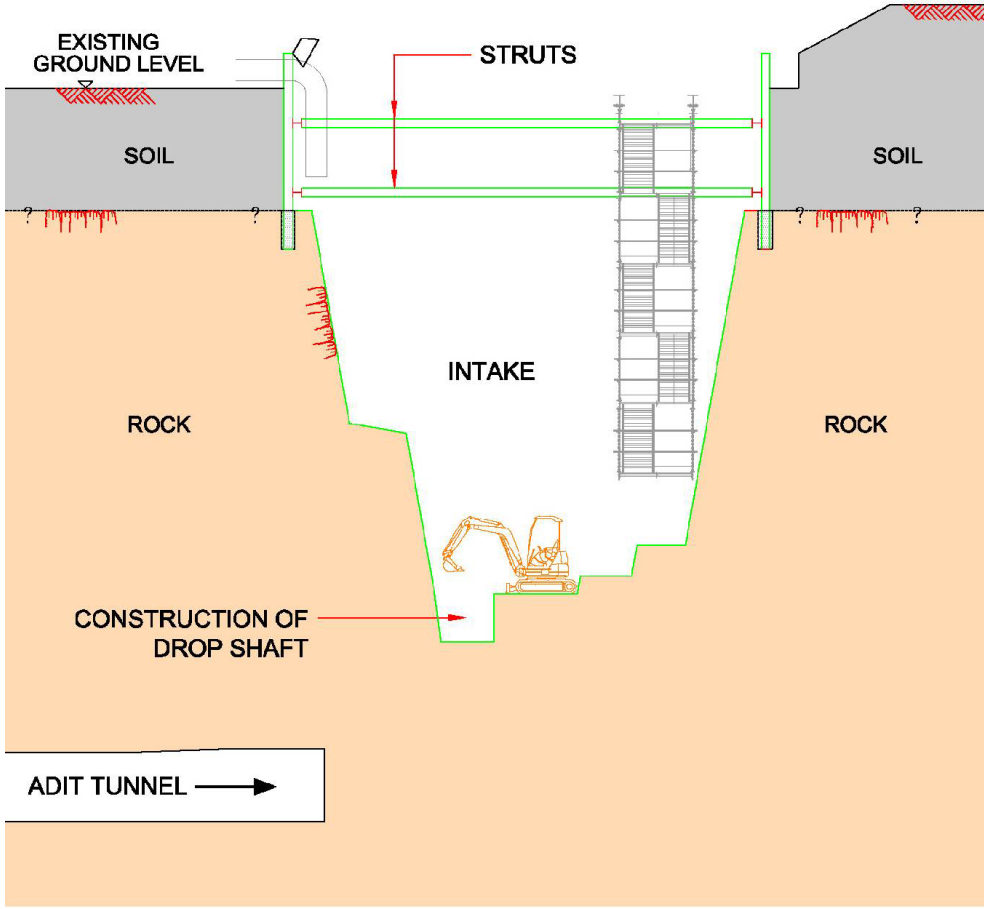


Site Constraints

Drop Shafts

Methods of Construction



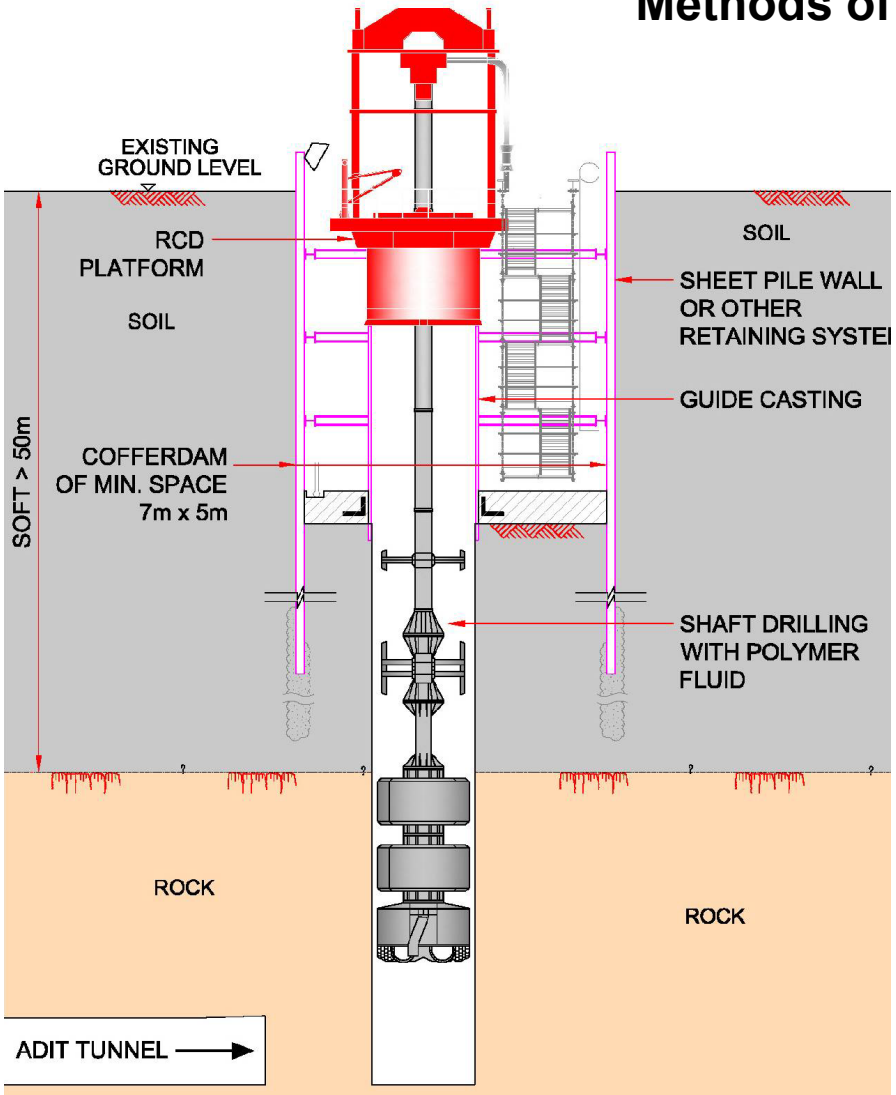


Open Excavation - 7 nos.

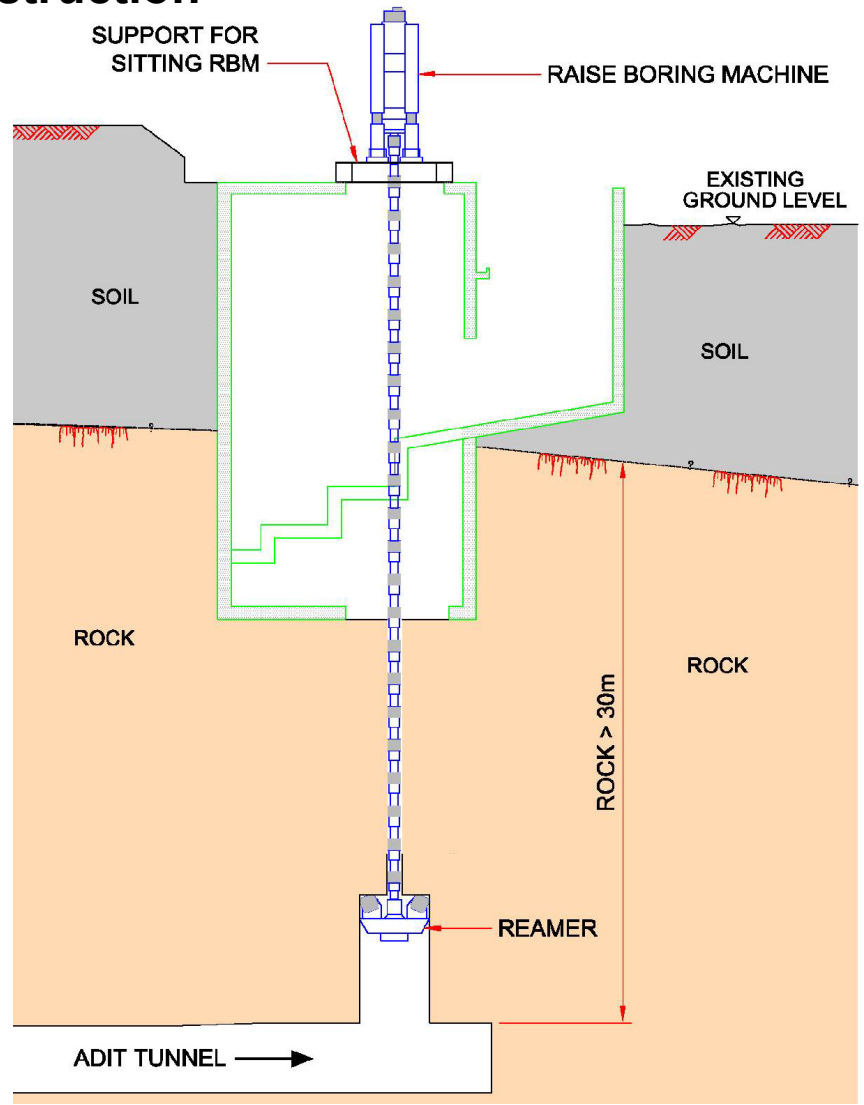
2 types of open excavation

Drop Shafts

Methods of Construction

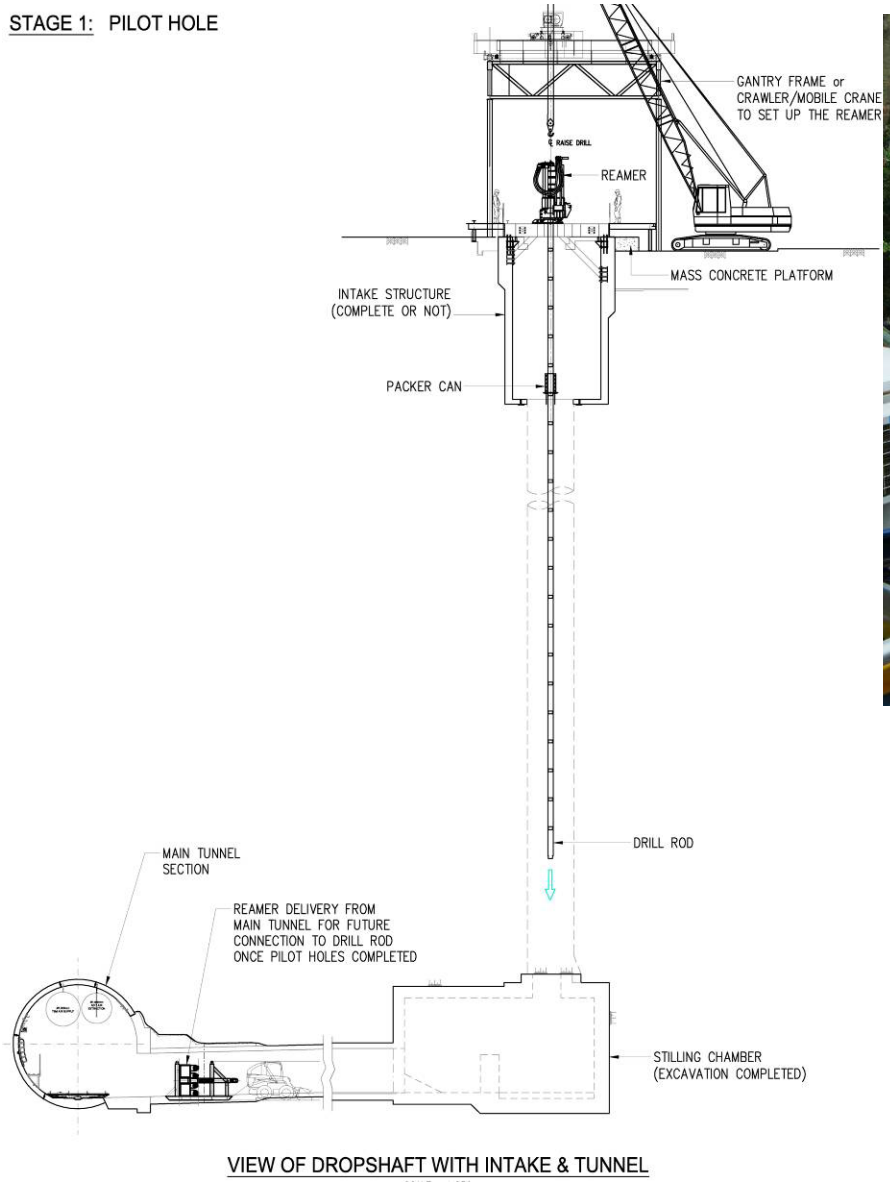


Reverse Circular Drilling Machine (RCD) - 2 nos. – Diameter =2.45m / 3.05m

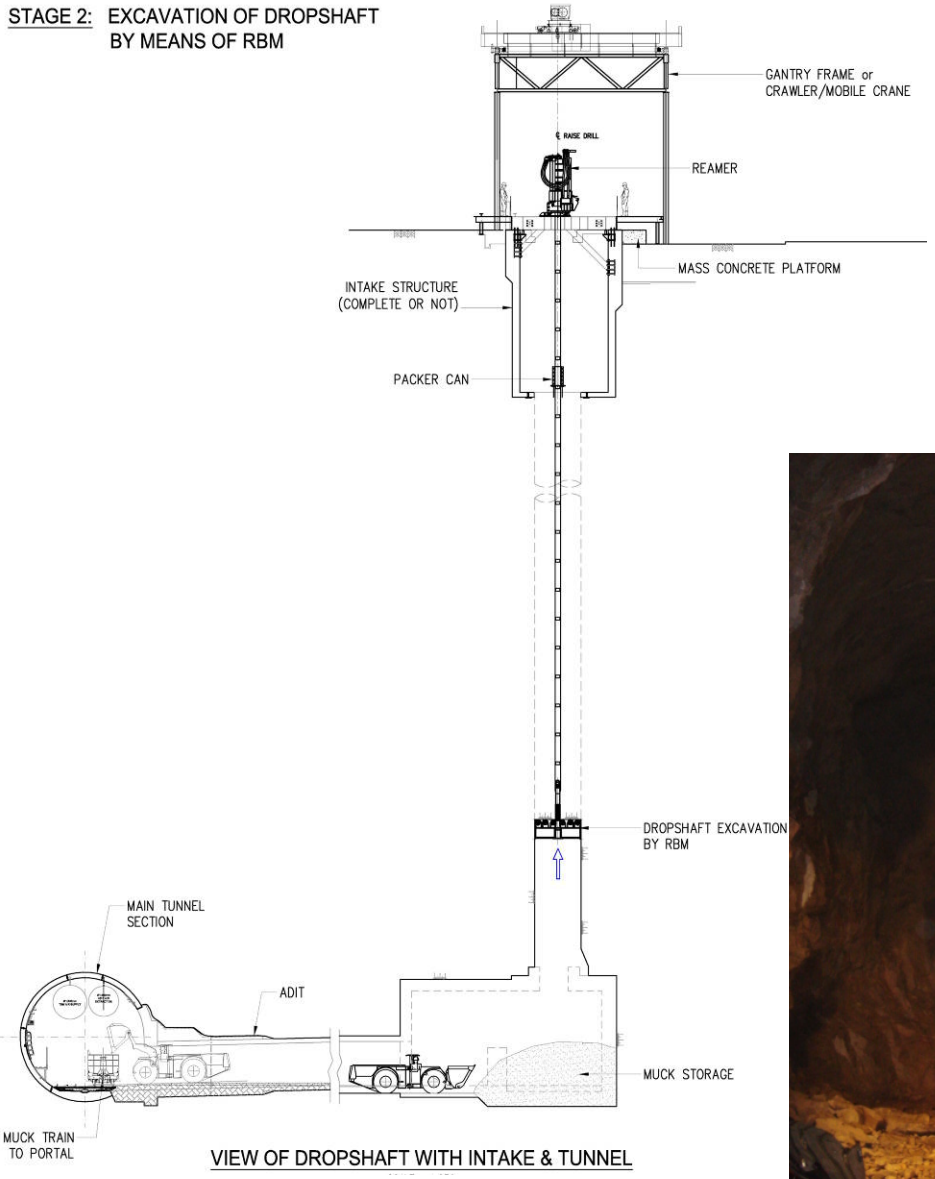


Raise Boring Method 23 nos.

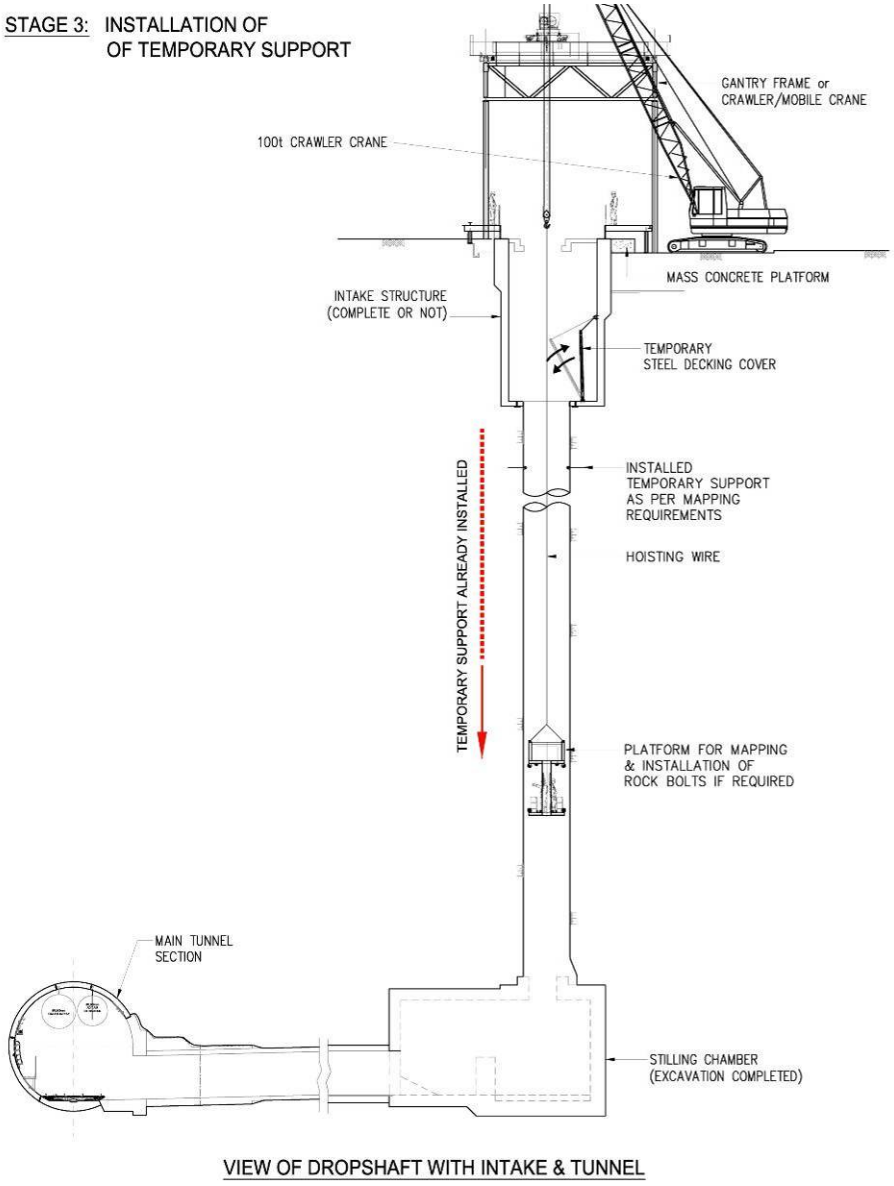
Drop Shafts by RBM

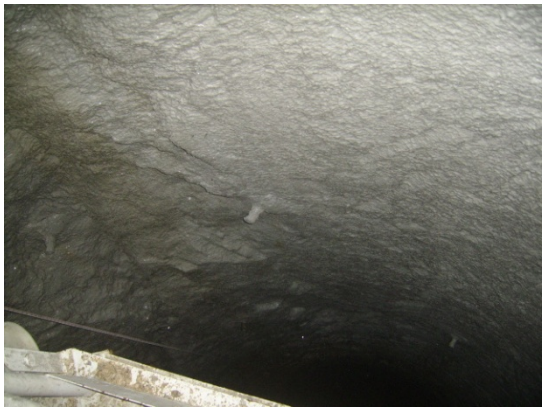


Drop Shafts by RBM

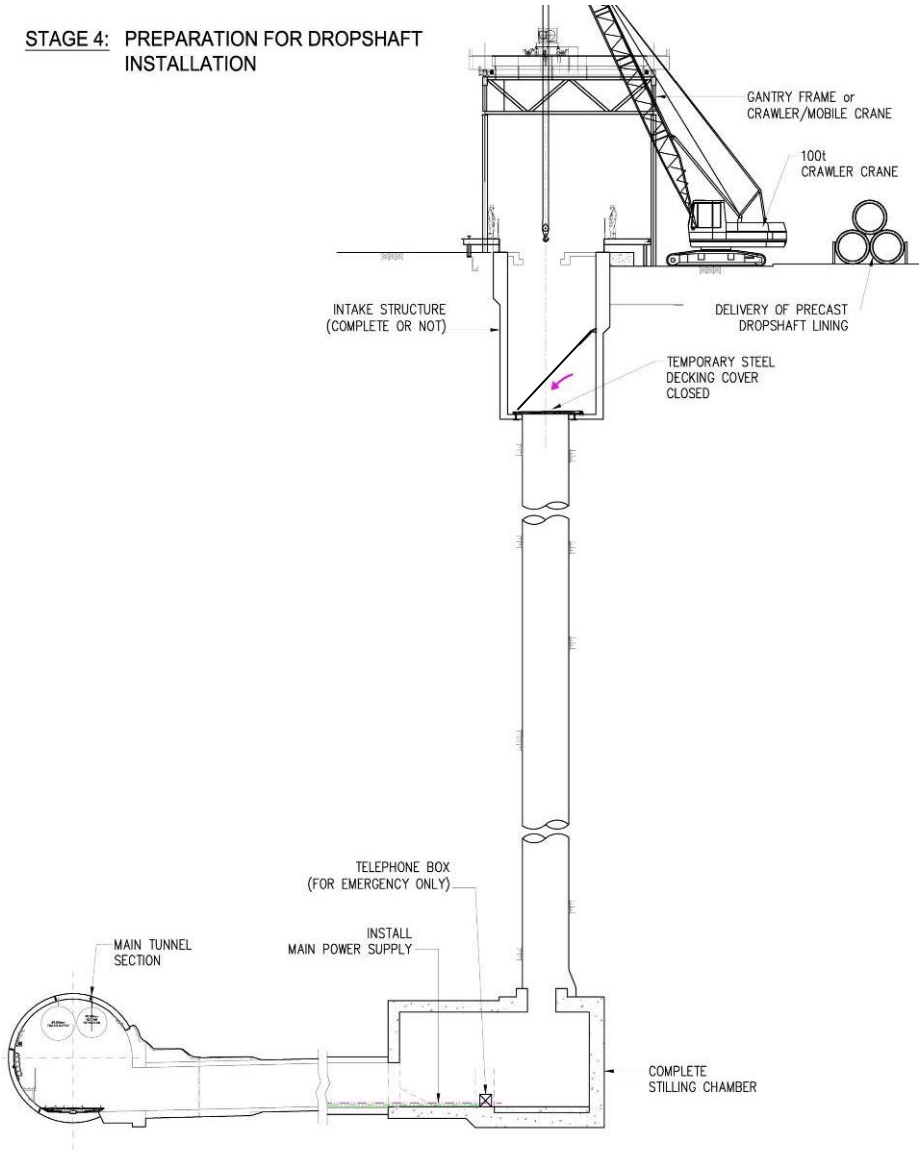


Drop Shafts by RBM

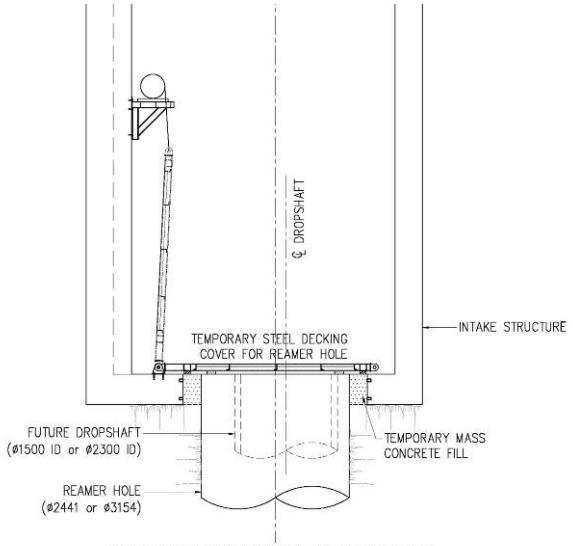




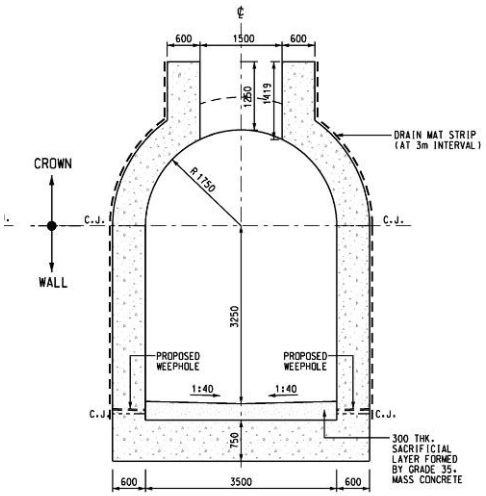
Drop Shafts by RBM



VIEW OF DROPSHAFT WITH INTAKE & TUNNEL

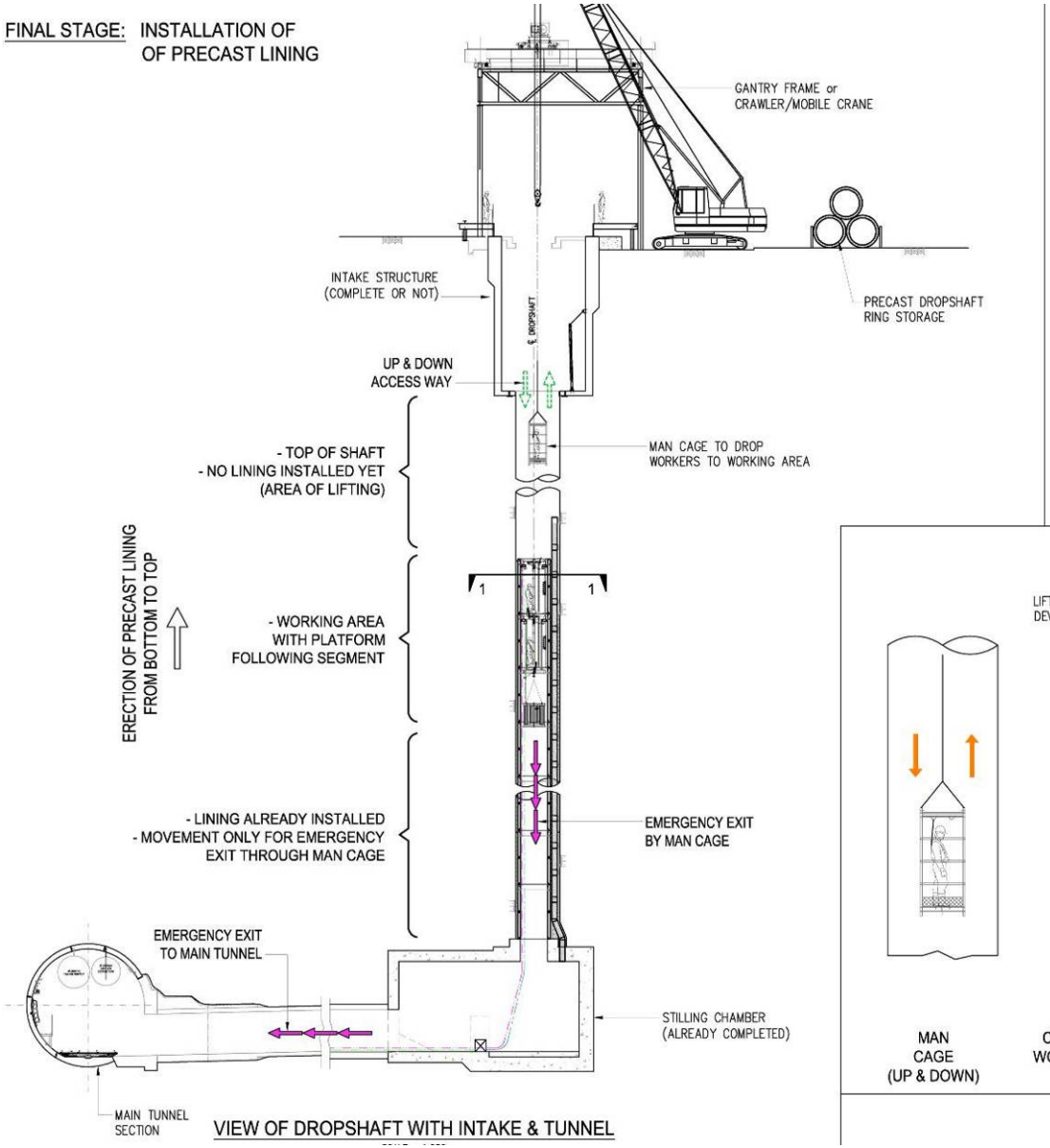


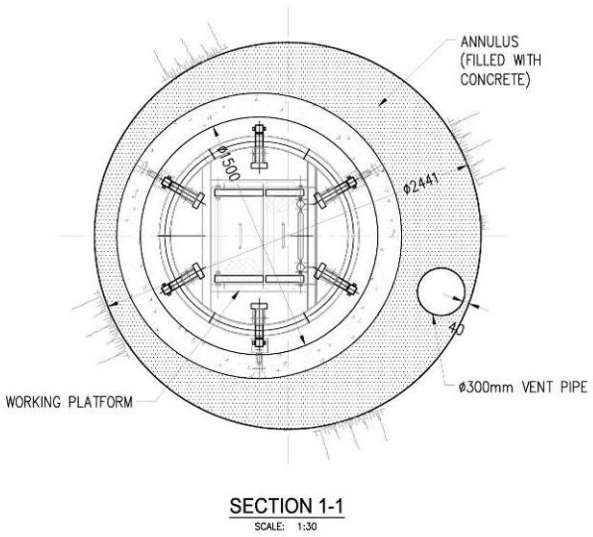
TEMPORARY DECKING OVER REAMER HOLE AT BASE SLAB LEVEL

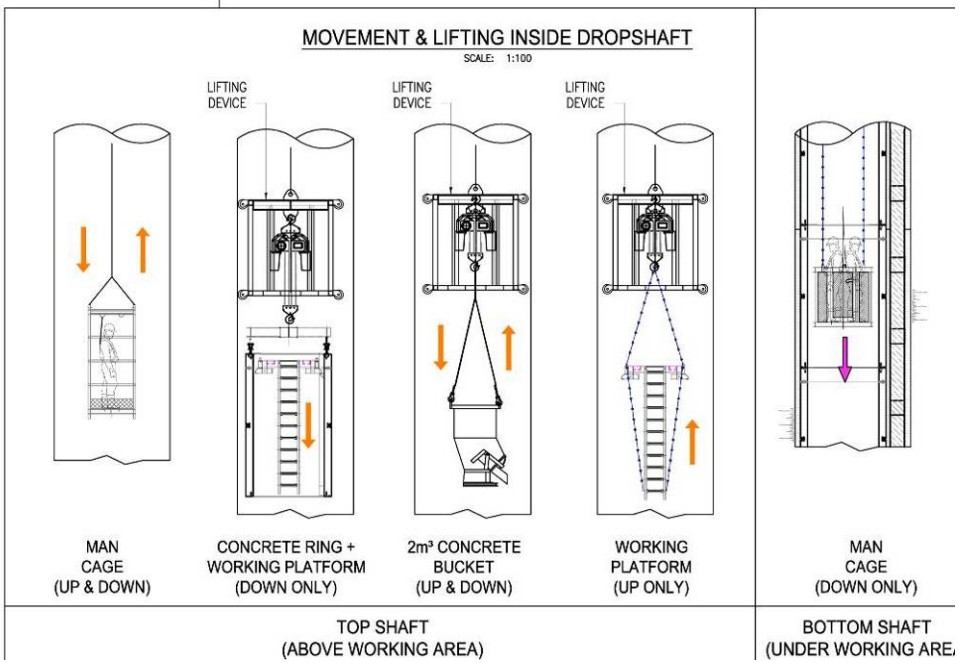


TYPICAL CONNECTION FOR DROPSHAFT TO STILLING CHAMBER

Drop Shafts Lining

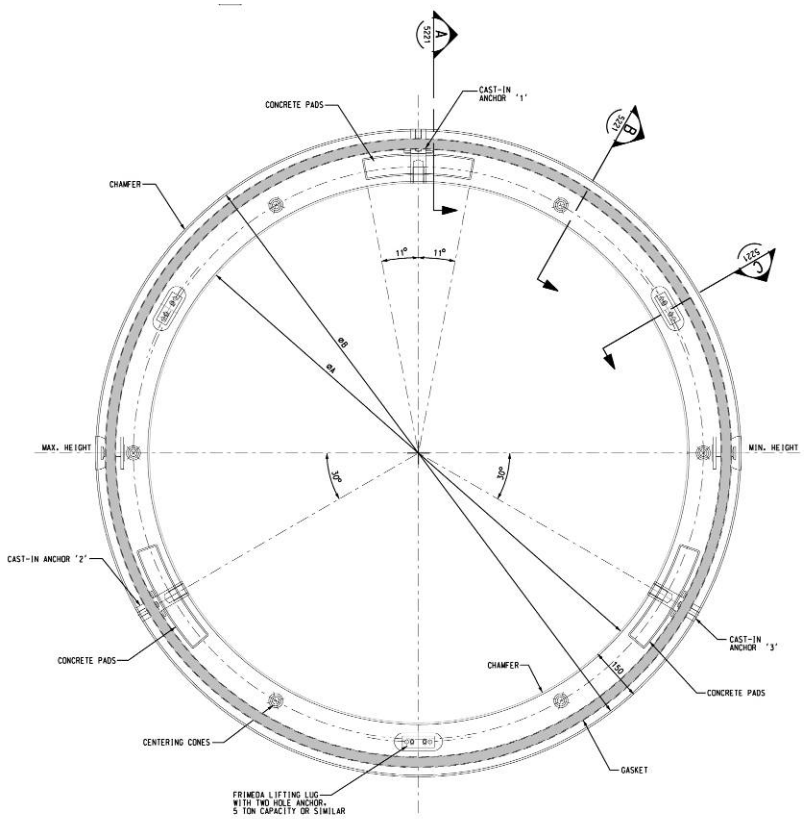






Drop Shafts Lining

- Detailed Design (DDA) for precast ring completed
- 4 Types of Precast Concrete Rings:
  - 1.5m Internal Diameter & 3m High
  - 1.5m Internal Diameter & 1.5m High (Loading restriction on Intake roads)
  - 2.3m Internal Diameter & 2m High
  - 2.3m Internal Diameter & 1m High (Loading restriction on Intake roads)



Lay shear shape into centering cone recess at upper face

Blow up shear shape

Drop Shafts Lining

Install ring clutch to lifting lug

Blow up lifting lug and ring clutch

Ring clutch
Lifting Lug

Drop Shafts Lining

Challenges

Restrictions at Intakes on Bowen Road

- 5 Ton weight restriction
- Raise Boring Machine dismantled into ~2 Ton Parts
- Special 1m and 1.5m pre-cast lining used
- Concreting delivered using $1m^3$ chutes

Drop Shafts Lining

Dropshaft MB 16 Completed

THANK YOU

Q&A

DSD Hong Kong West Drainage Tunnel Project Website

http://www.dsd.gov.hk/others/HKWDT