

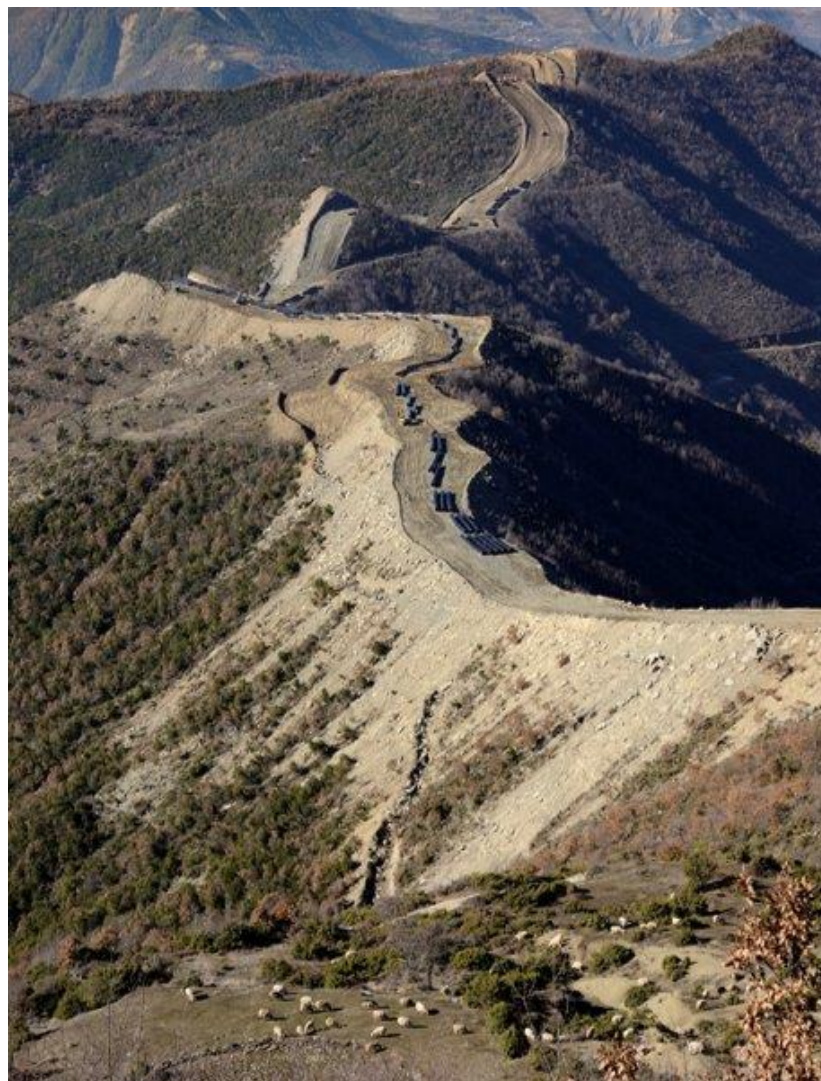


The feeder 9, River Humber

Replacement pipeline project, United Kingdom



IPLOCA's 54th Annual Convention
Prague 2022



Concurrently: Project Albania, 215km. 48"



Trans Adriatic
Pipeline





**Germany,
120km. 56"**



Israel, Direct Pipe 2 Landfalls,





**Germany,
Direct Pipe
2 River crossings,
650m. 56"**



Denmark, 70km. 40"





The presentation will include:

- Introduction
- Project Details
- Tunneling Challenges
- Pipe Installation

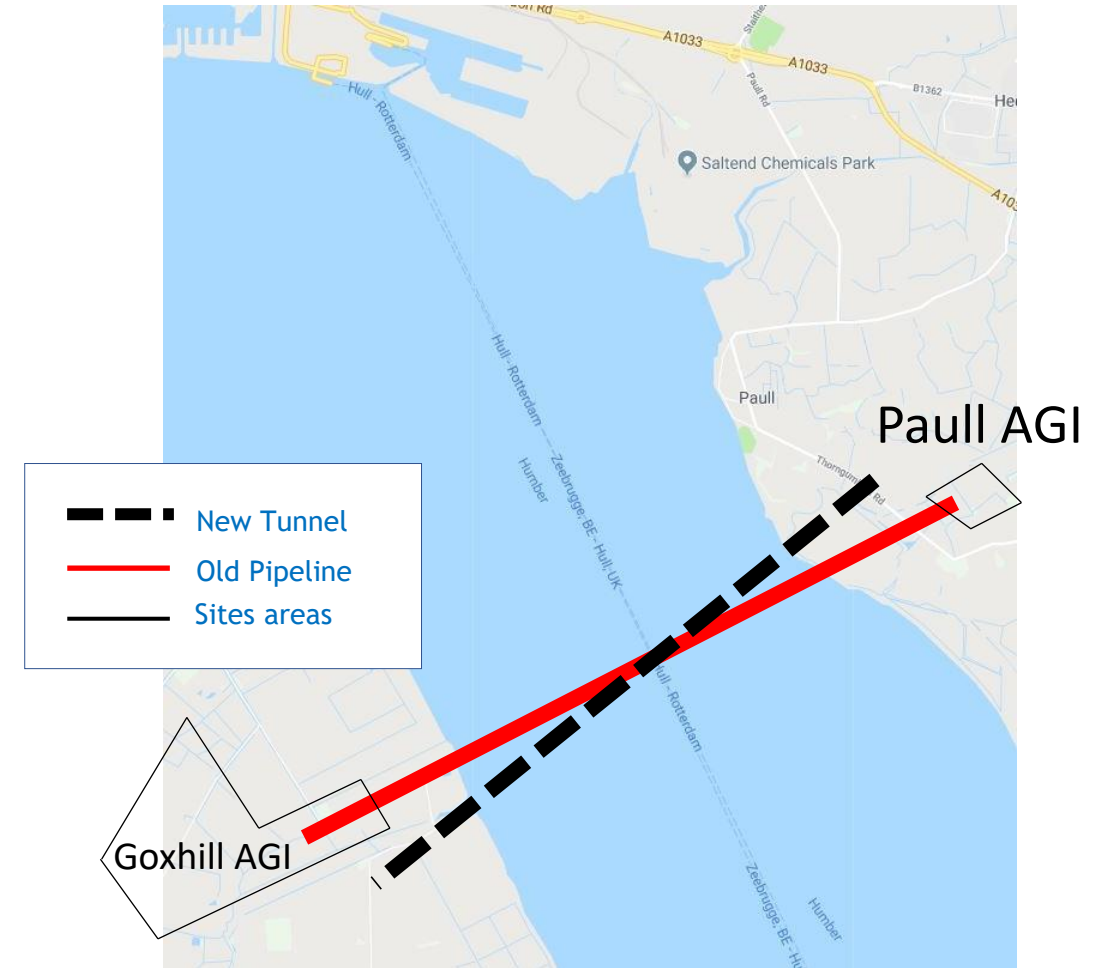




Overview

- Existing National Grid Feeder 9 Pipeline was originally constructed in 1984 in a trench below the River Humber bed
- This pipe transports 20% of the UK's natural gas supply
- Sections of pipeline at risk due to erosion of the riverbed
- Various short-term solutions were developed to protect pipeline
- Long term solution is the replacement of the 5km. existing Feeder 9 into a tunnel

KINGSTON UPON HULL





Overview

- Project awarded by National Grid in **May 2016**
- **Alternative bid** awarded
- 5.5 km of **pipeline Ø 42"** , 70 bar
- 4.86 km of **concrete lined tunnel** under the Humber estuary
- Connection works and modifications to the Goxhill and Paull Above Ground Installations (AGI's)



Above Ground - Environmental

Ramsar – an international treaty for the conservation and sustainable use of wetlands

Migrating Bird Wetlands



Special Area of Conservation - Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora

Water Voles



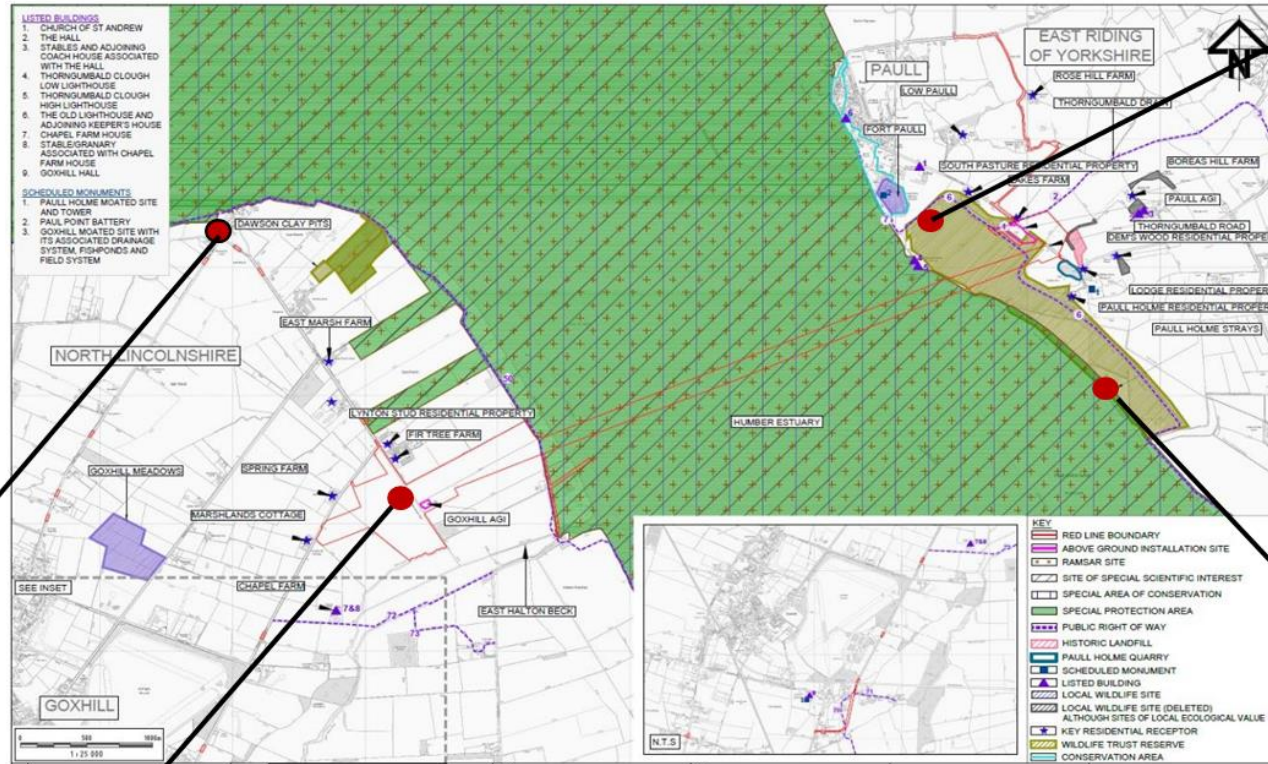
Sites of Special Scientific Interest – protection for flora, fauna, geological and physiographical features

Paull Holme Strays: RSPB



Special Protection Area – a designation under the European Union Directive on the Conservation of Wild Birds

Intertidal Mudflats

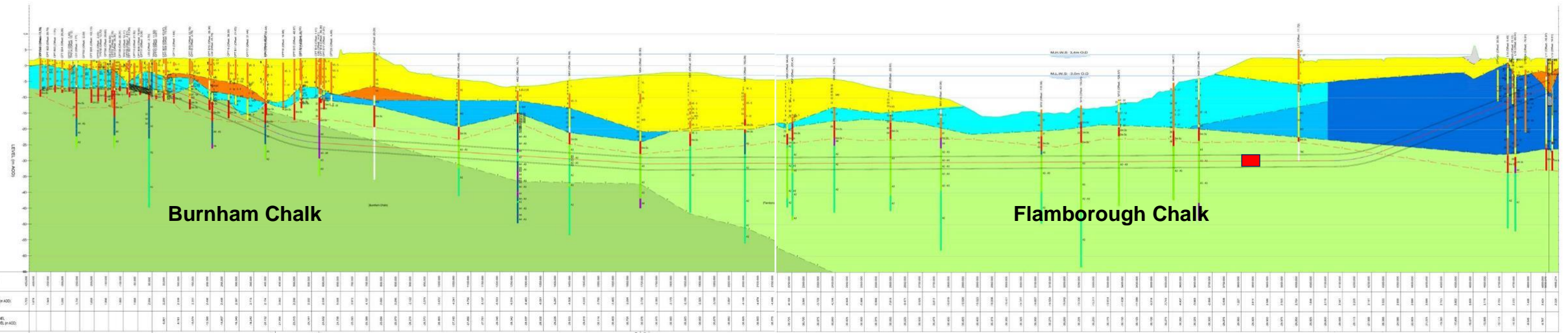




Underground - Geology

Goxhill

Paul





Challenges

Flooding:

A combination of **low-lying land**, **tidal flows**, and locked-in water leads to cumulative risks of **flooding from groundwater and surface water**

Measures:

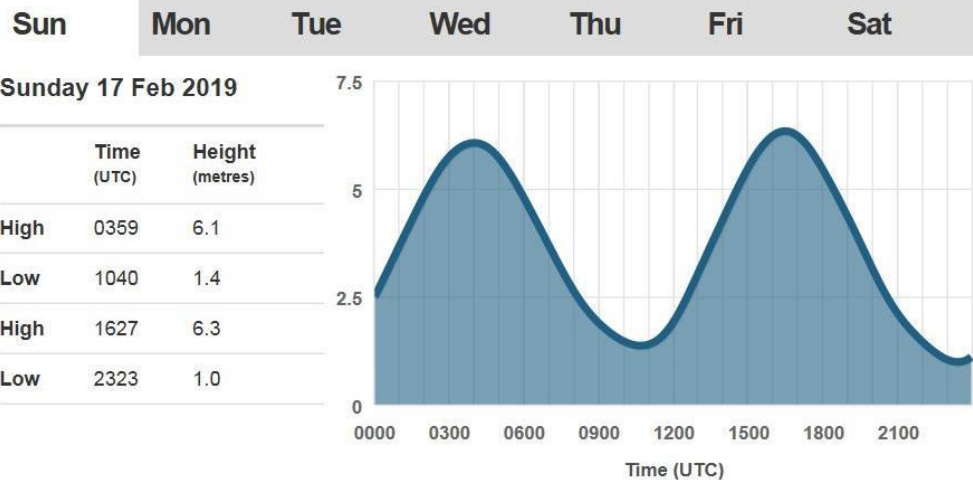
1. Elevated Vulnerable Infrastructure

- Offices
- Generators

2. Launch pit, STP and generators with bunds and **flood barriers**



Humber Bridge



Challenges

Tunneling:

- Tidal impact with up to **6.5m tidal variance**
- Up to **3.45 bar** working pressure for compressed air works
- Restricted space on TBM
- Very short working window
- Management of decompression regimes



Tunnel Facts

- ▶ Horizontal alignment: straight
- ▶ Overall tunnel length: 4,862 m
- ▶ Internal - Ext. Dia.: 3.65 – 4.10m.
- ▶ Min. overburden: 5 m (launch shaft)
6.5 m (reception shaft)
- ▶ Max. overburden: 33 m (under the estuary)
- ▶ Min. overburden to seabed: 10 m
- ▶ Tidal influence: up to 6.5 m

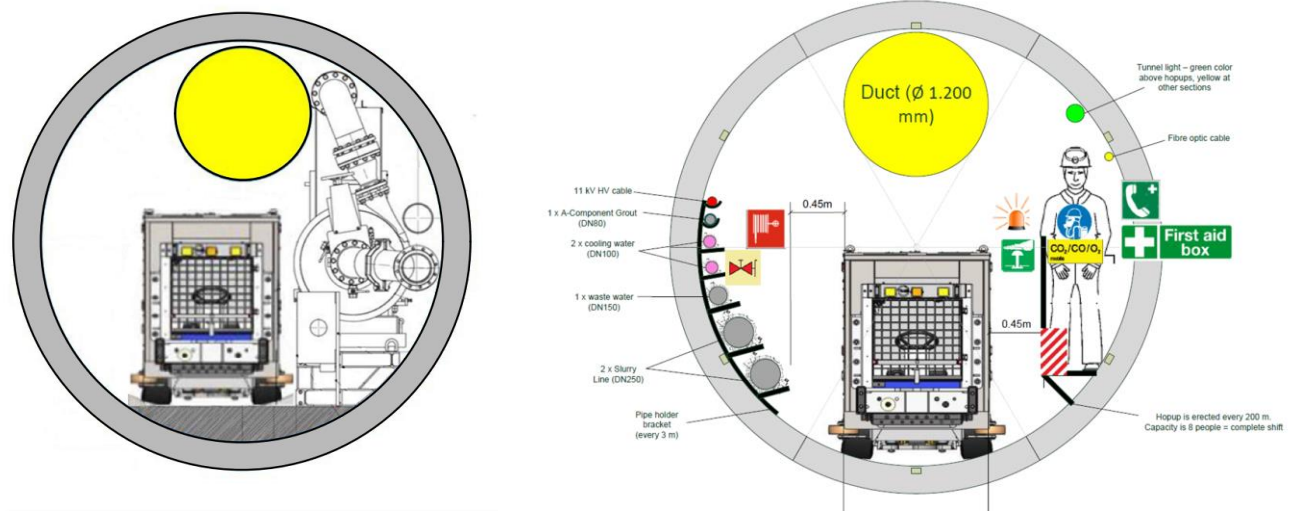




Challenges

Tunneling:

- Small tunnel diameter (4m) compared to length
- Long single tube tunnel without intermediate structures
- Pipe brackets (DoD left side) for slurry TBM operation including booster stations
 - Slurry lines
 - Cooling water
 - Waste water
 - Ventilation duct
 - 11kv HV supply and Communications





Multiple Service Vehicle:



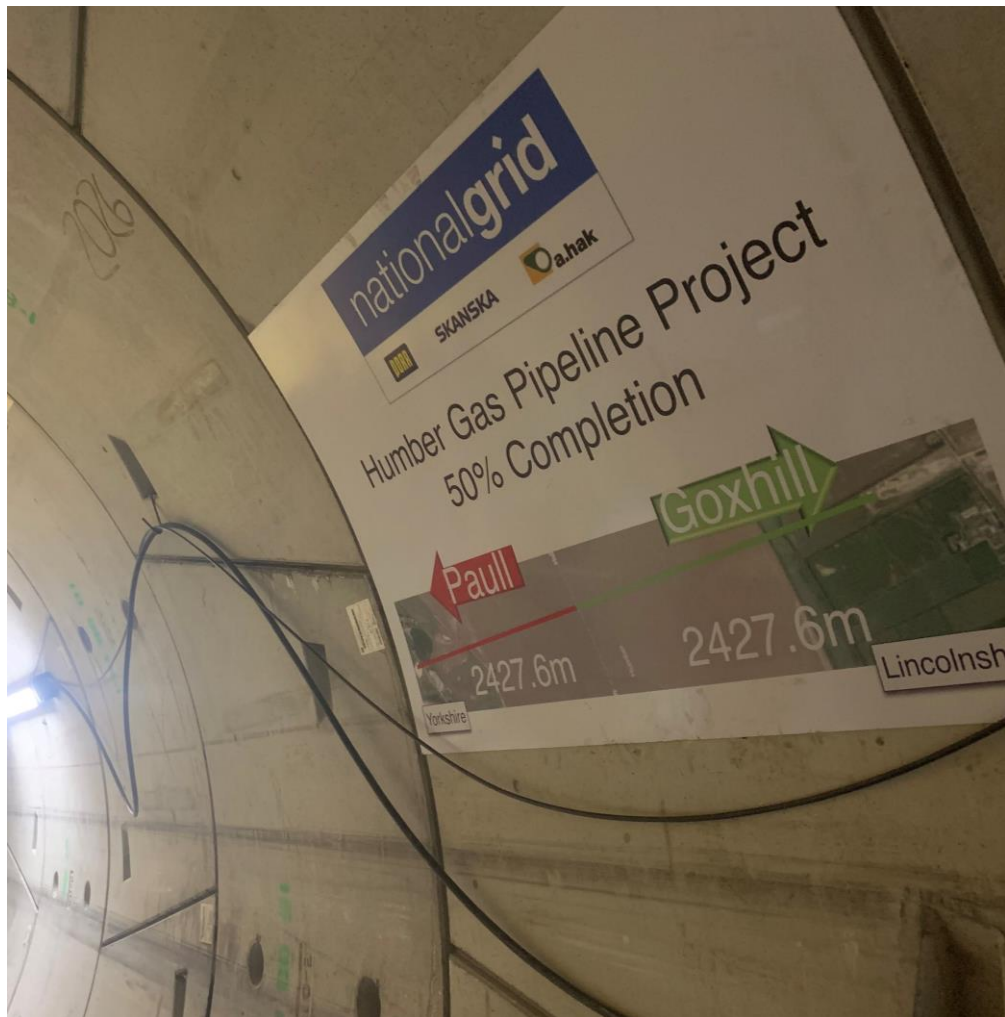
- length 17,150 mm
- width 1,260 mm
- maximum height 1,900 mm (loaded)
- weight 12 tons
- payload 20 tons
- design Speed 15 km/h
- operator cabins **on both ends** of the vehicle
- platform for transport of segments or pipes



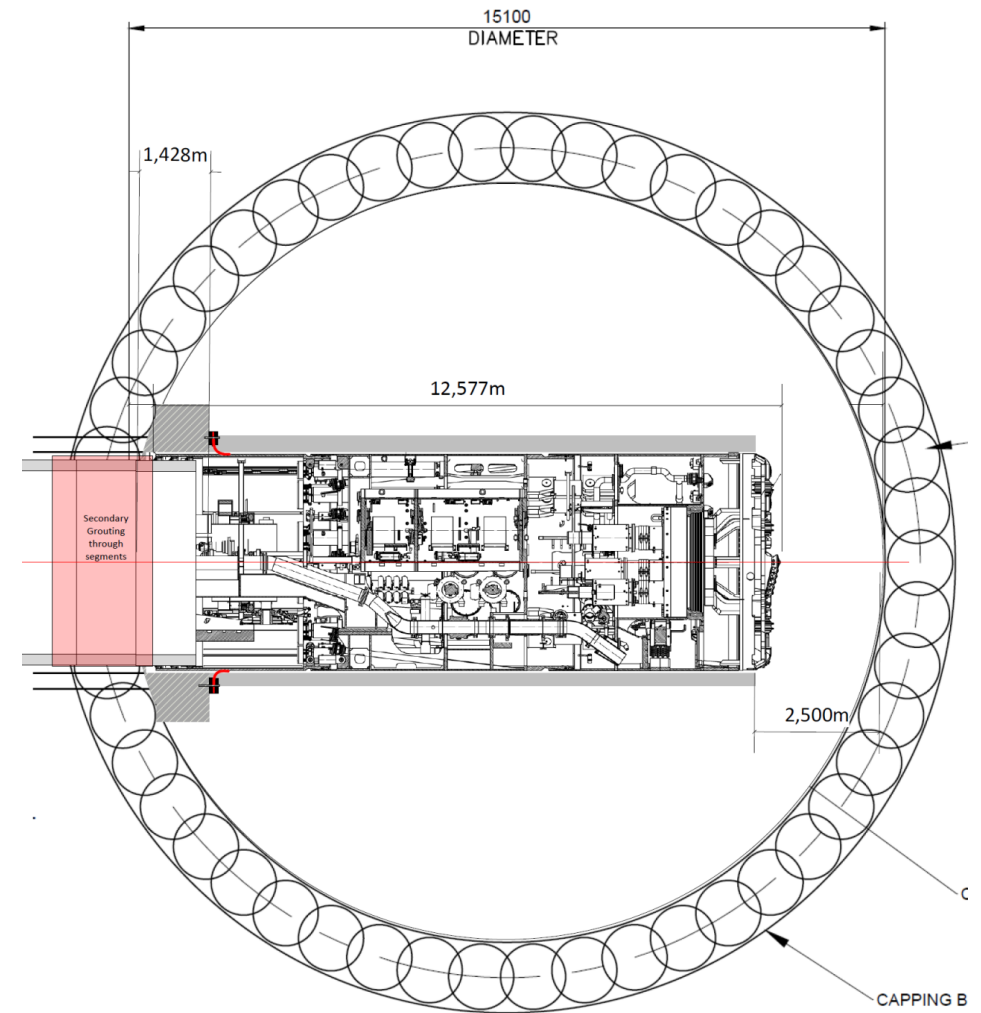
Safety & Training

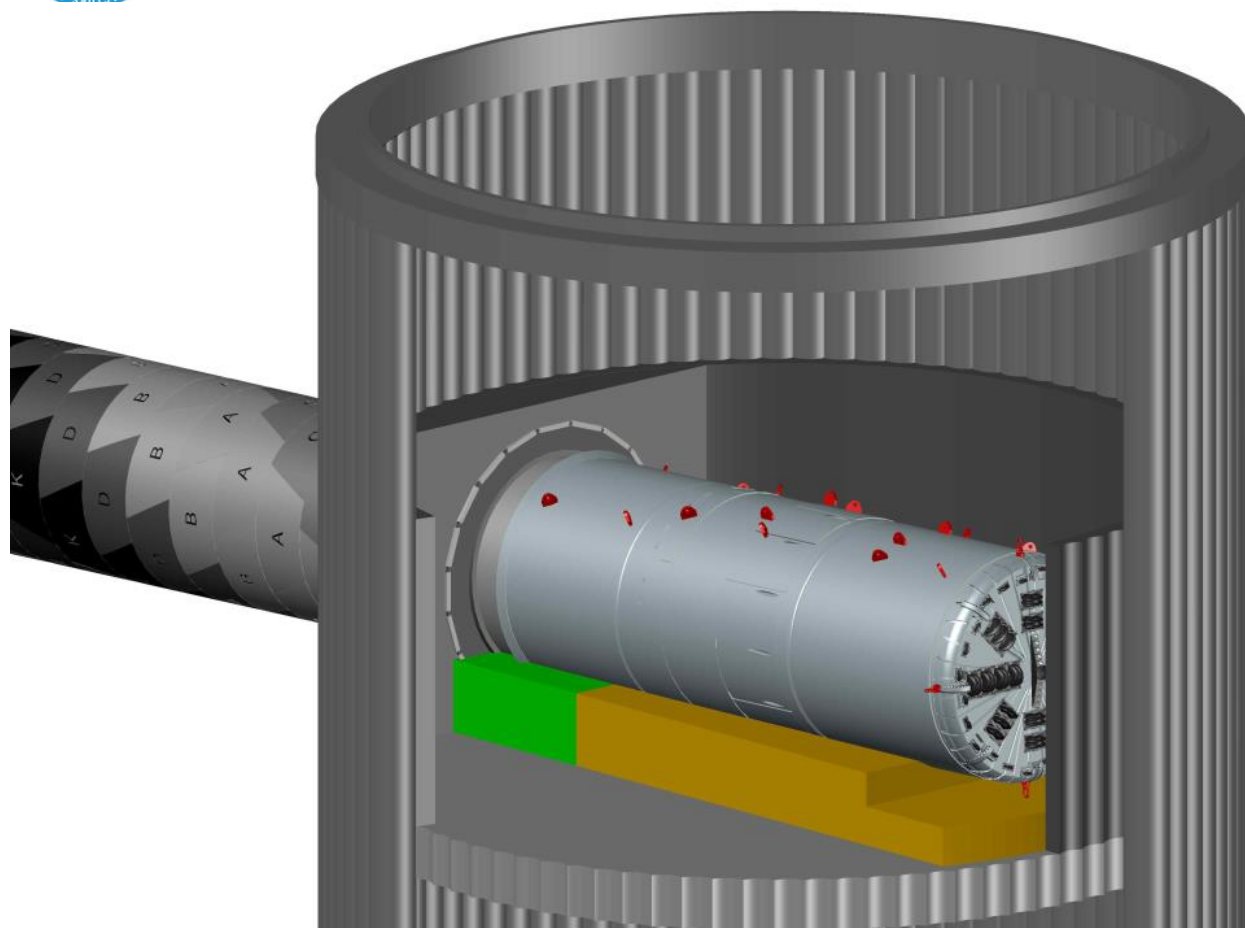




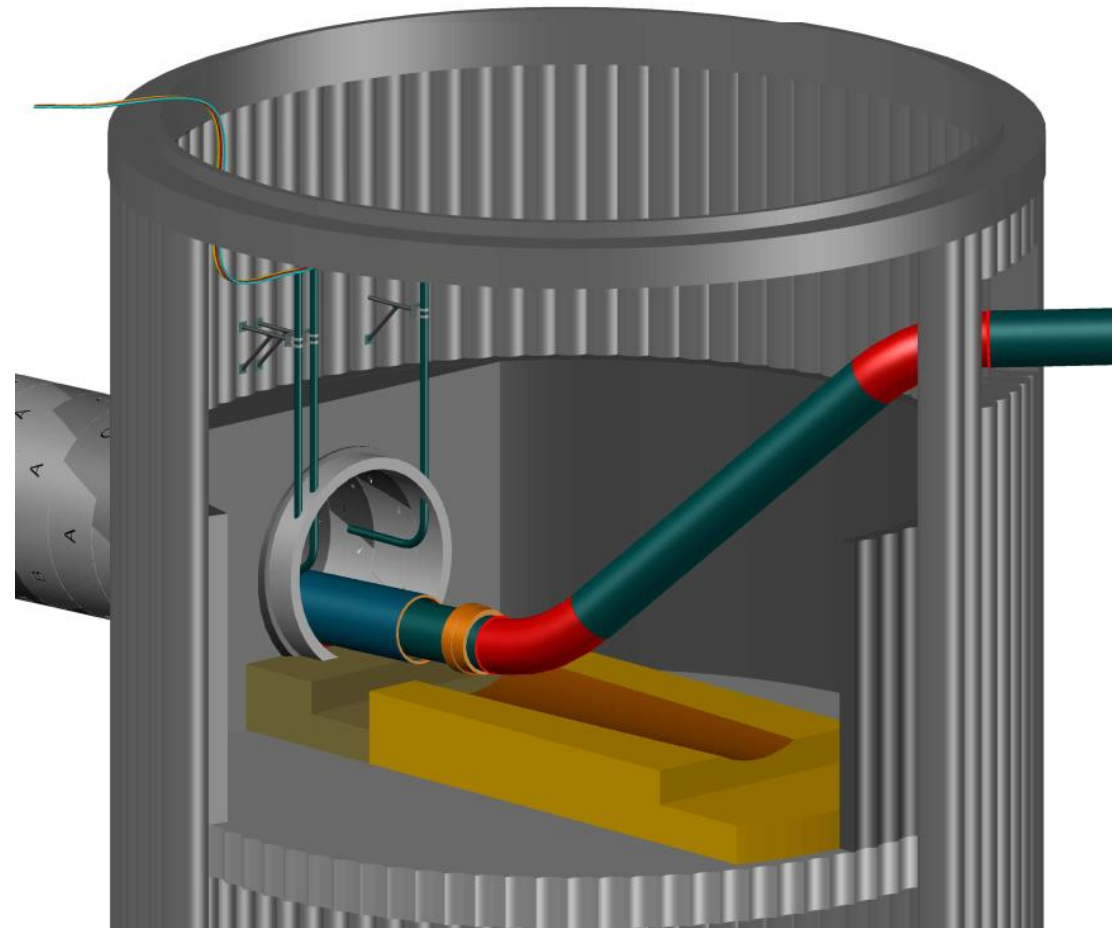








Receive TBM & drain shaft



Pipe insertion

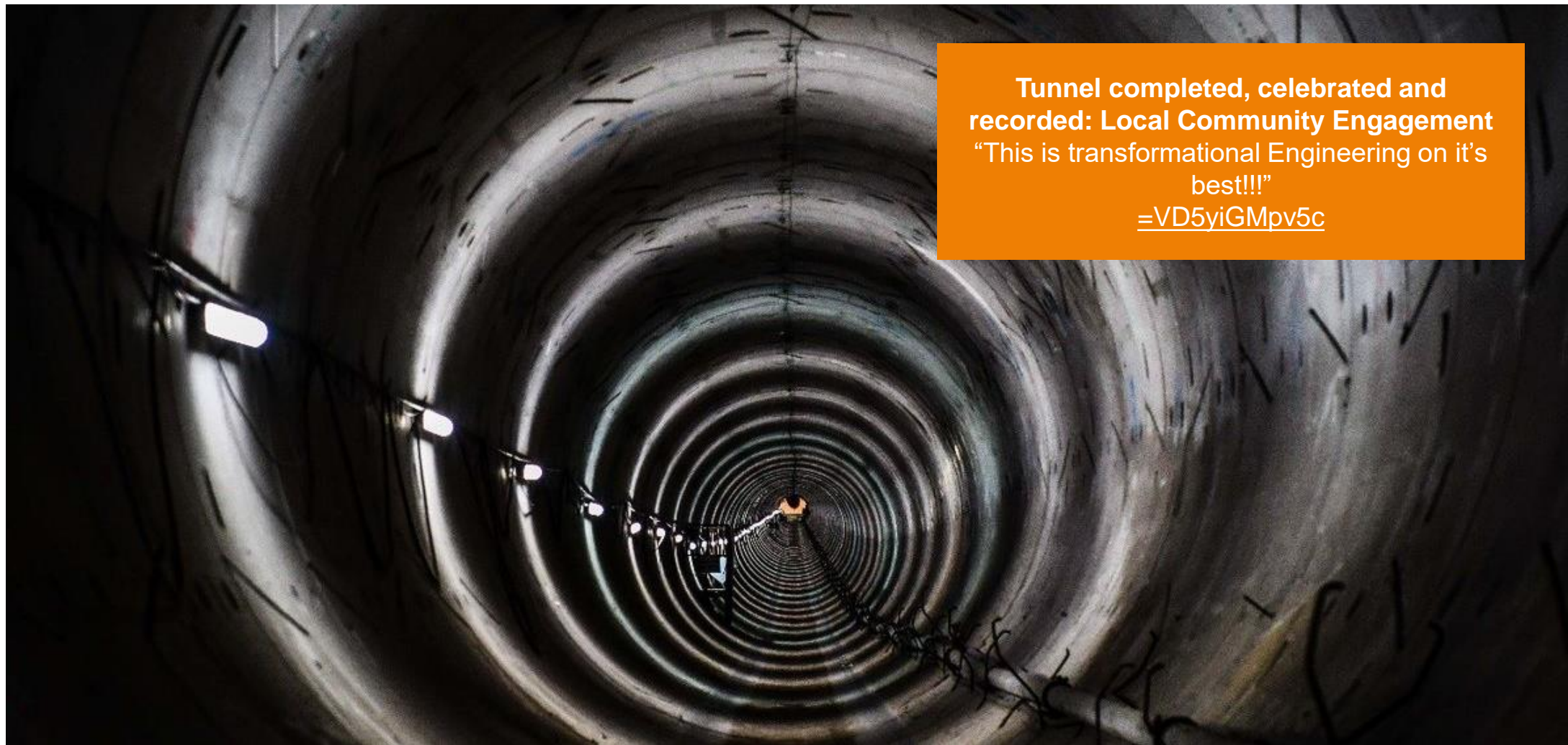


Take 5

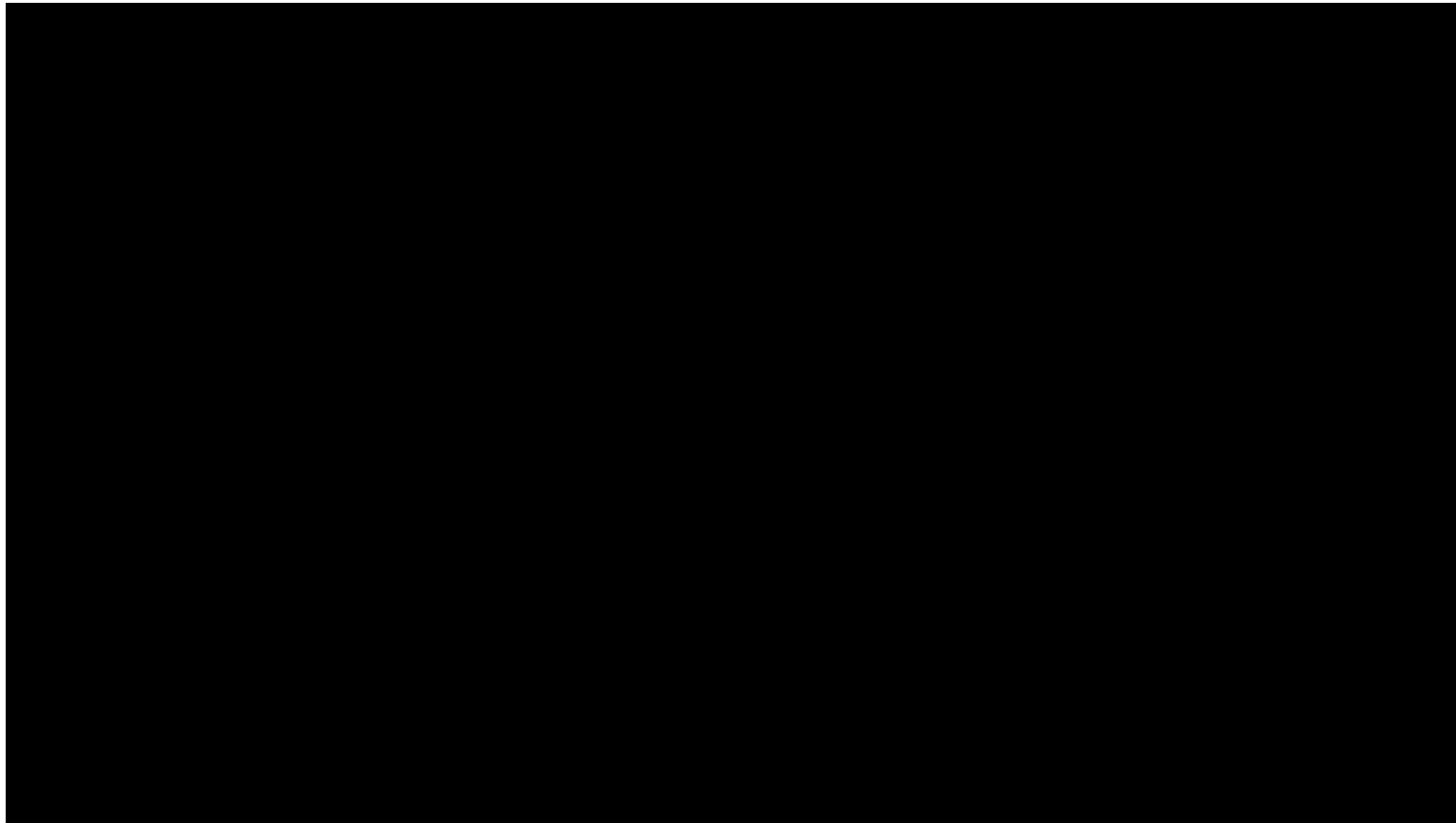
- Ensure everybody is fit for work.
- Always carry out task briefings before work starts.
- Make sure the work area is safe before the task begins.
- Stop work if anything changes and review how the changes will affect the task. Report unsafe conditions.
- Does your workforce understand what they need to do to get the job done safely?

**Safety Award 2020,
Most Improved
Contractor**





Tunnel completed, celebrated and recorded: Local Community Engagement
“This is transformational Engineering on it’s best!!!”
[=VD5yiGMpv5c](https://www.youtube.com/watch?v=VD5yiGMpv5c)





Pipe Insertion

1. Design
2. Testing, moduling
3. Execution



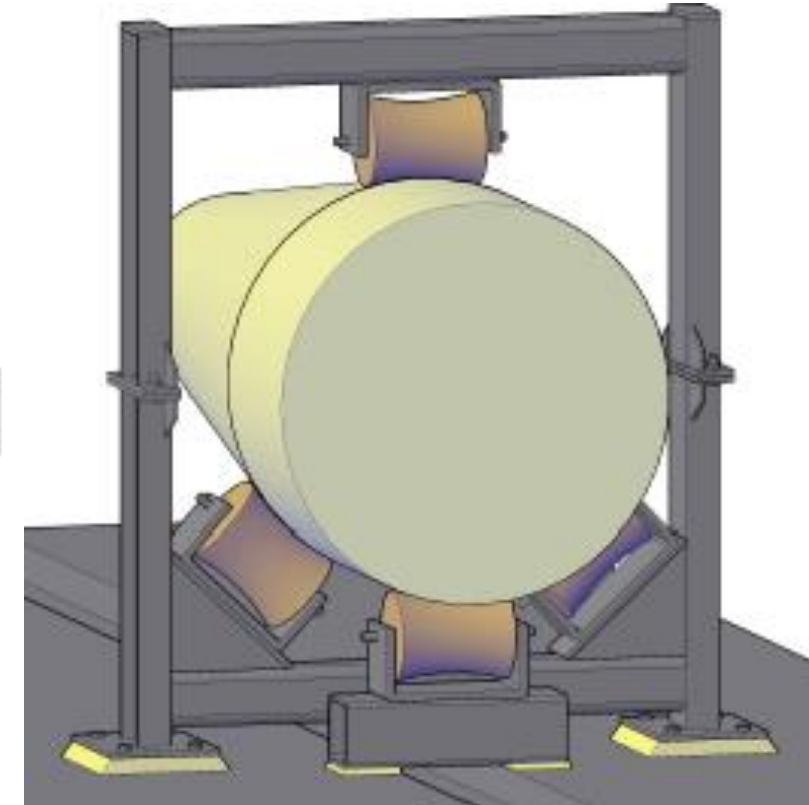
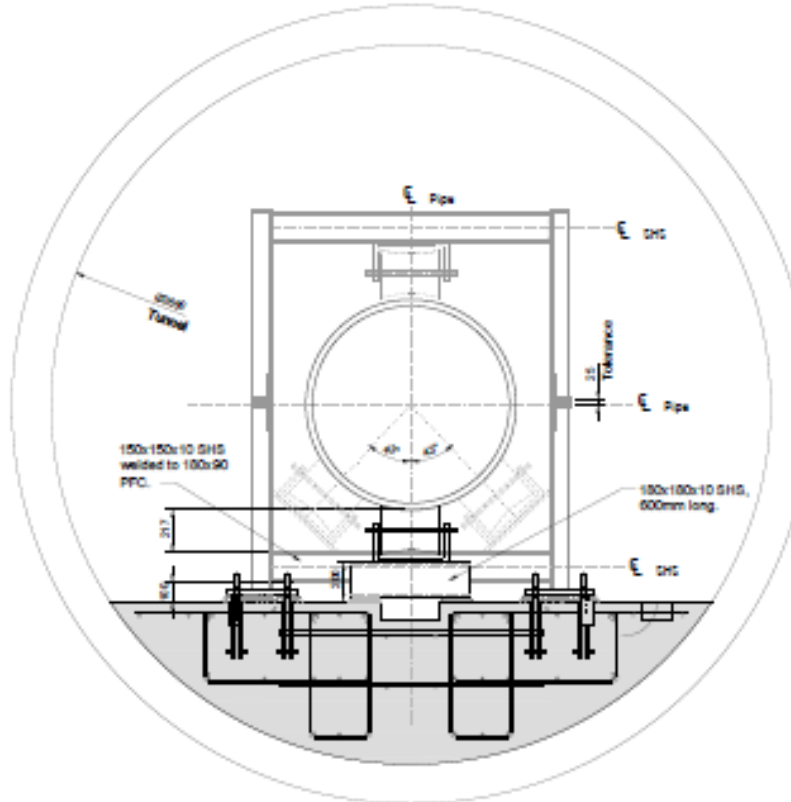


Overview original FEED design

Pipeline details

- *Diameter* 1067 mm
- *Wall thickness* 19.1 mm
- *Coating* 3.5 mm FBE

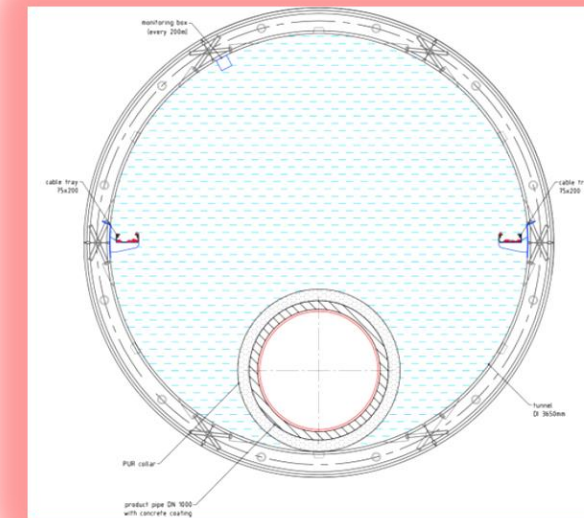
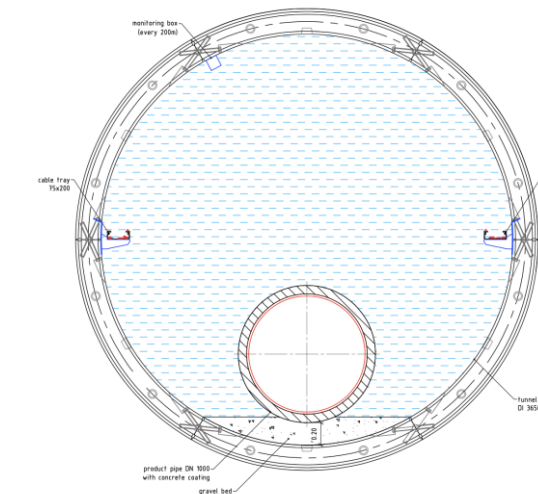
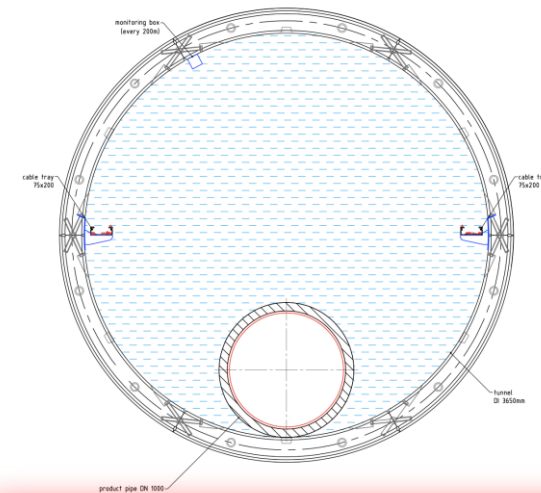
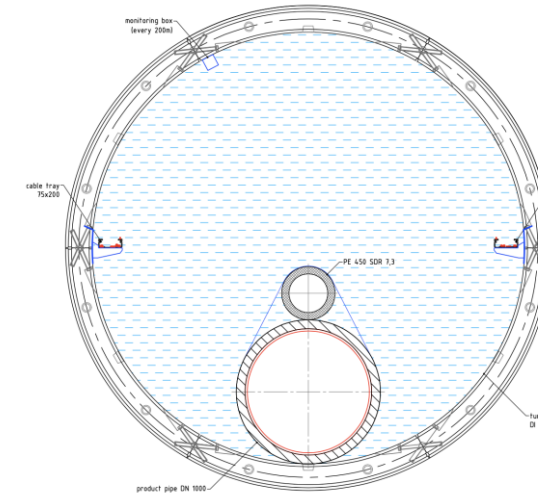
- Pipeline installation
 - Pipe on roller supports
 - Tunnel to remain water filled
- Impressed current CP system





Alternative options pipe installation:

1. Flotation pipe
 - Minimize weight
 - Poor symmetry
2. 'Bare' pipe (CWC coated)
 - High friction expected
 - Possible wear of concrete coating
3. Pipe on gravel/sand bed
 - Optimum pipe support
 - High construction effort
4. **Pipe with PUR Collars**
 - **Lower friction**
 - **Prevent CWC abrasion**

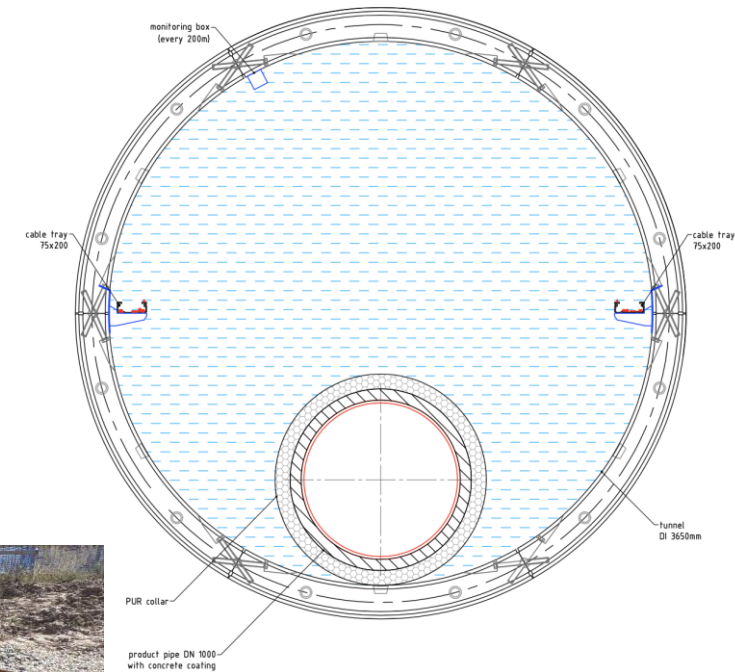
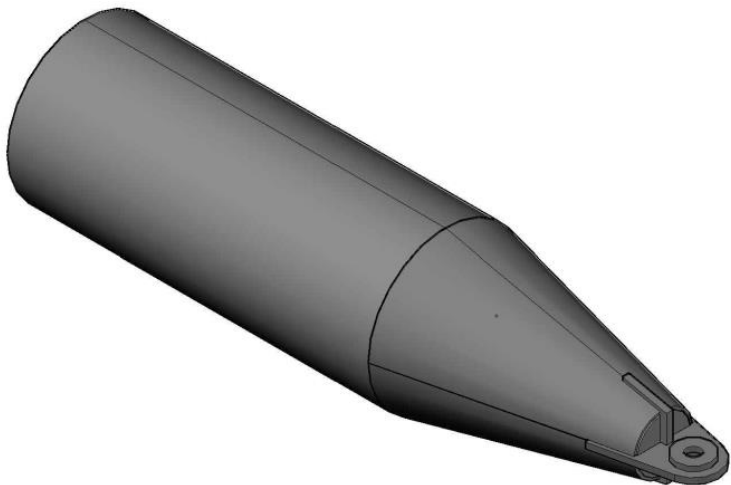




Final installation method

Concrete weight coating

- **PUR collars**
 - 450 mm x 60 mm
 - 6 m spacing
- **Field Joints**
 - FBE Coating
 - Concrete infill

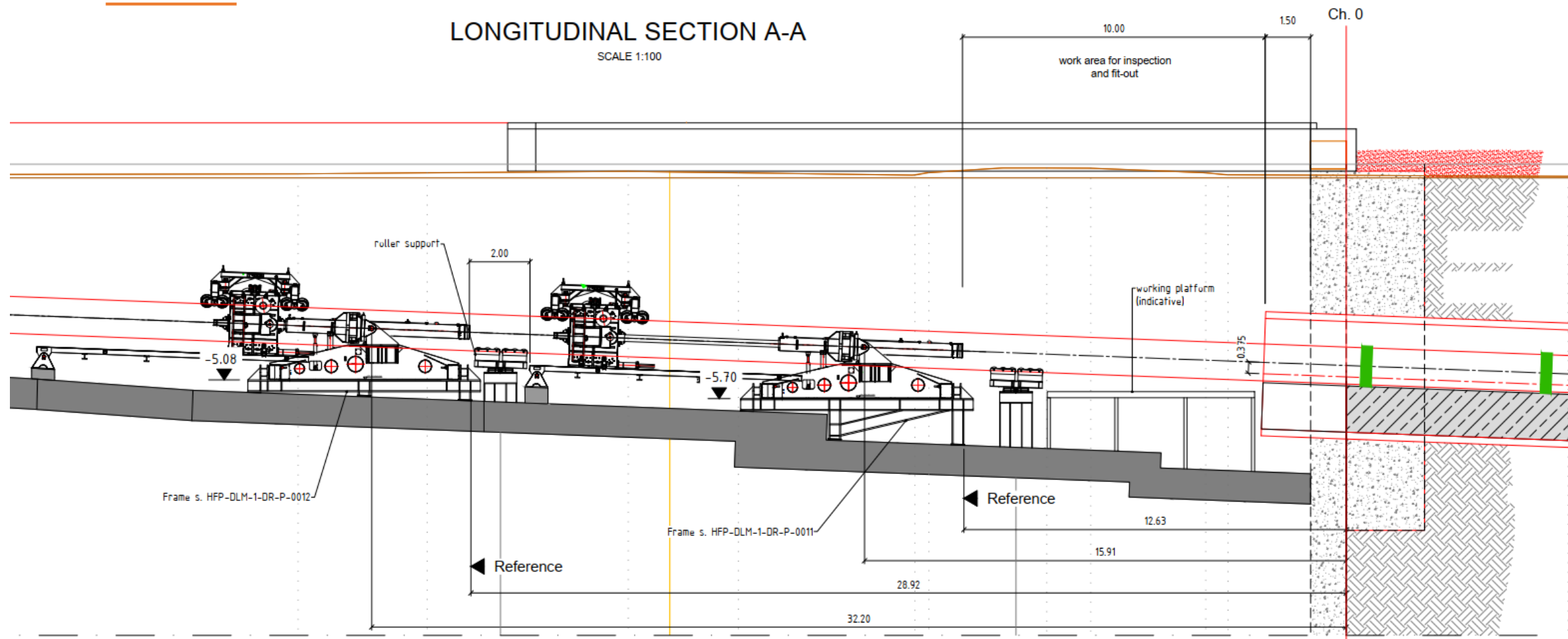




Push installation

LONGITUDINAL SECTION A-A

SCALE 1:100

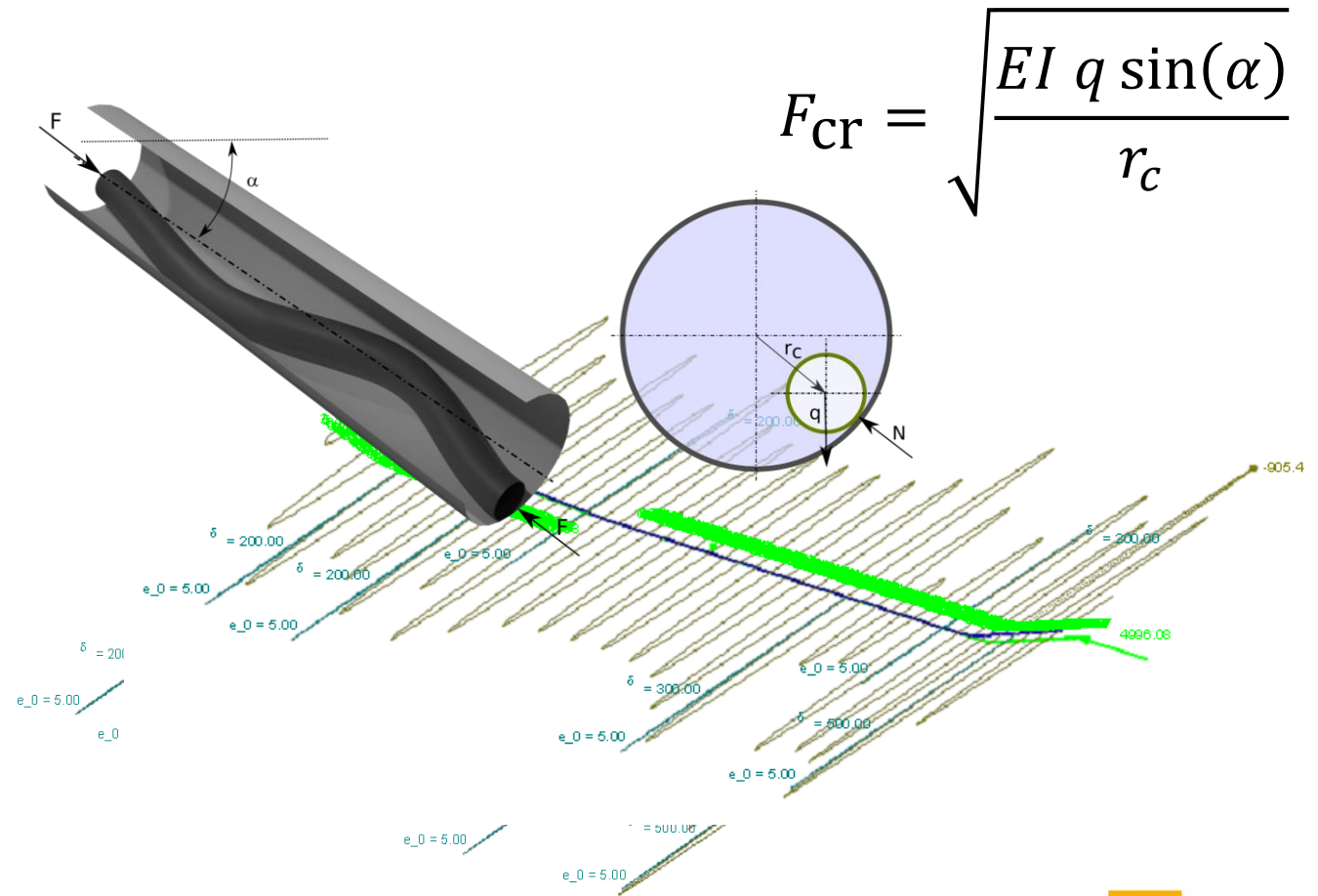


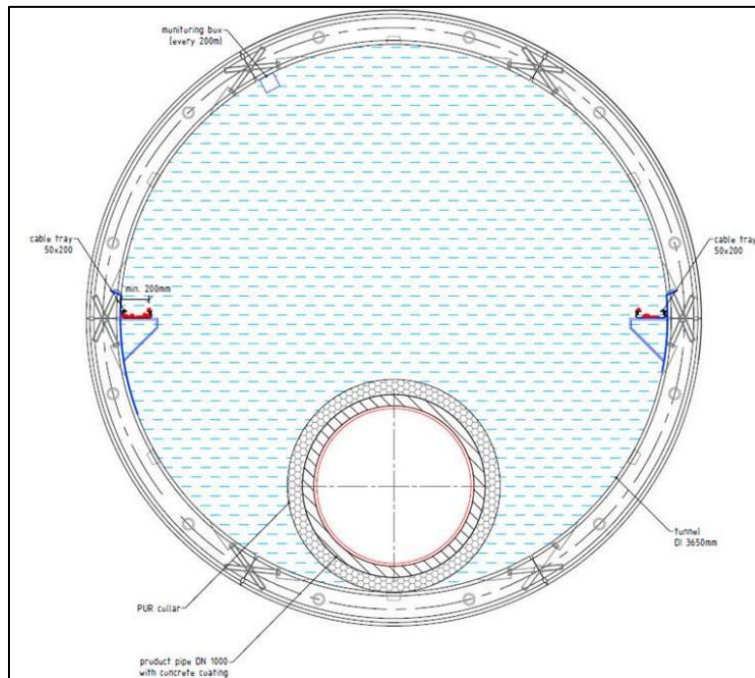


Push installation – limiting factors

- Risk of sinusoidal pipe string **buckling** during installation
- Critical buckling loads are determined by
 - Radii of tunnel / pipe
 - Pipeline stiffness
 - Pipeline weight
 - Friction
- FE-Model to assess pipe deformation / buckling
- Comparison with analytic approach

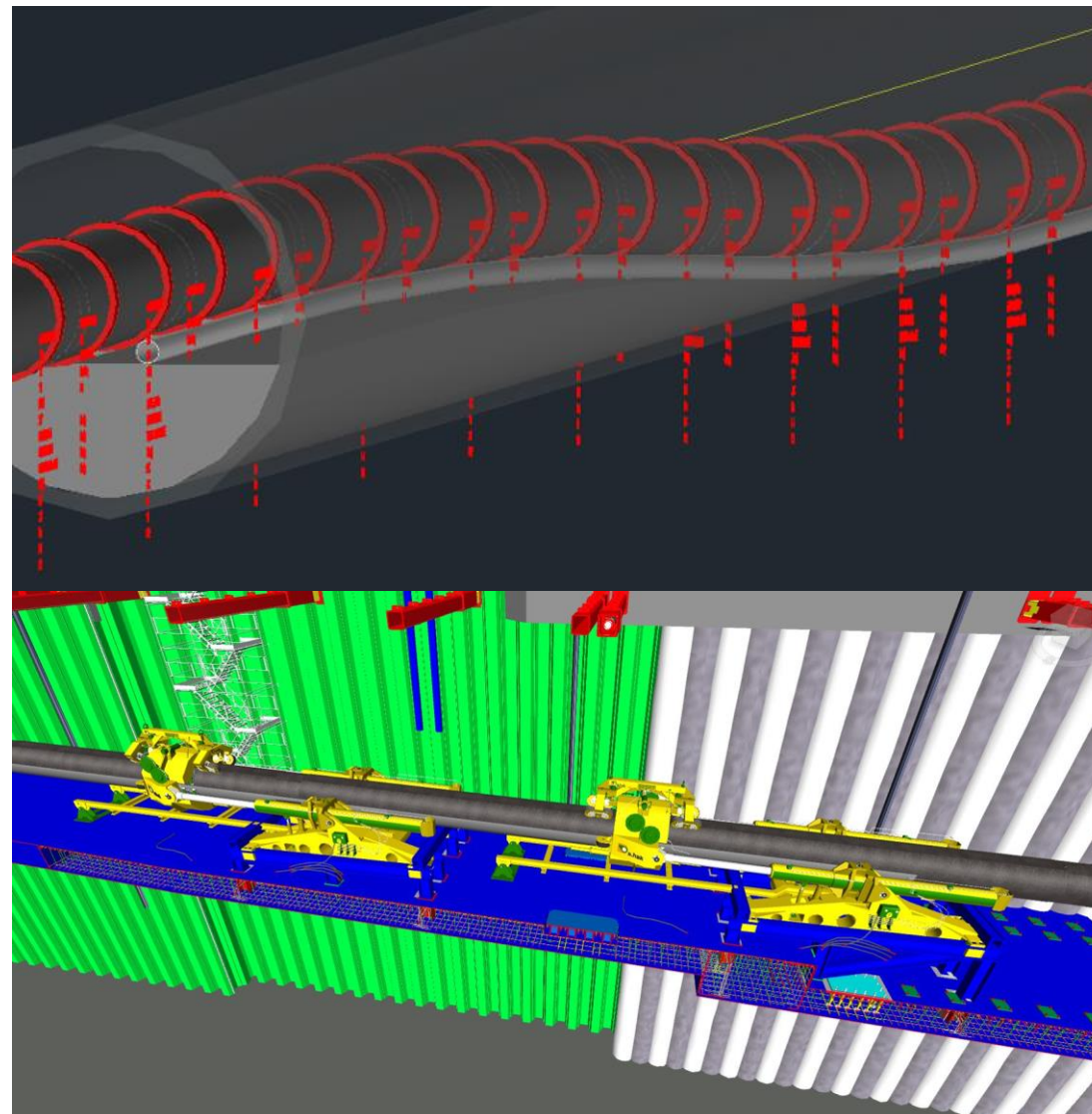
→ Critical load approx. **700 T**





Inserted Pipe into flooded Tunnel

**Stress calculations,
simulation**





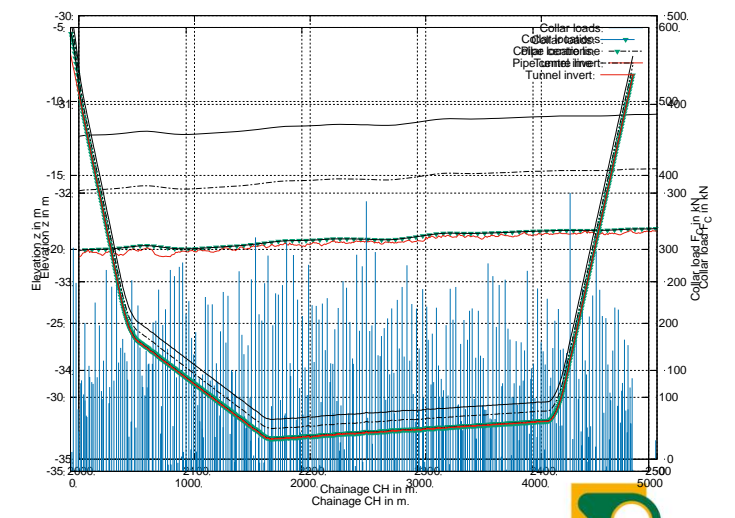
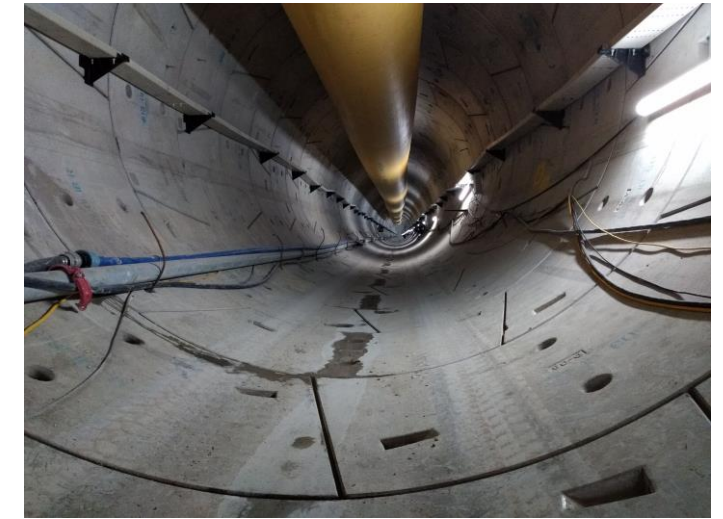
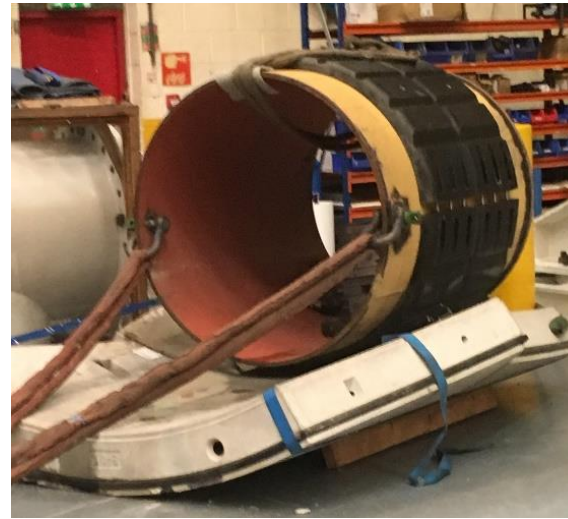
Tests and trials

Verification of design assumptions

- Friction tests
- CWC shear test
- Tunnel as-built survey

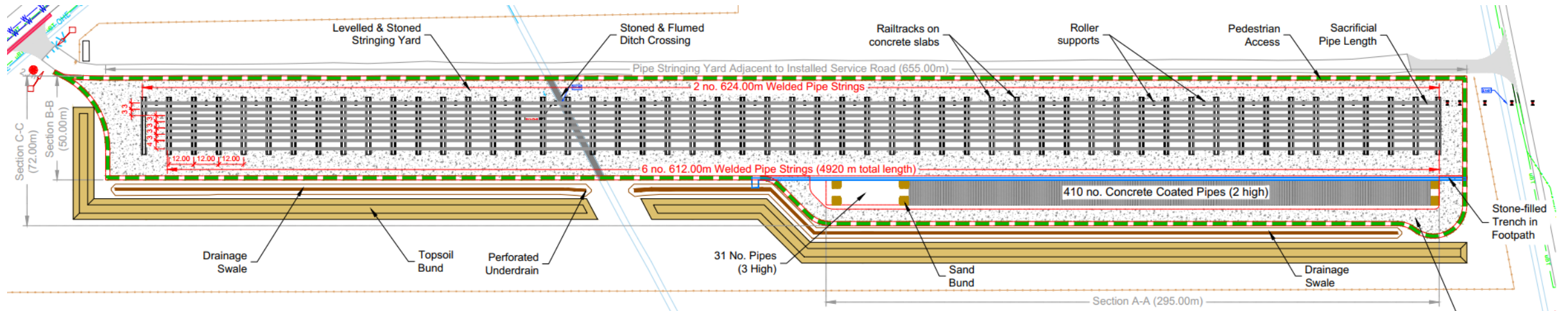
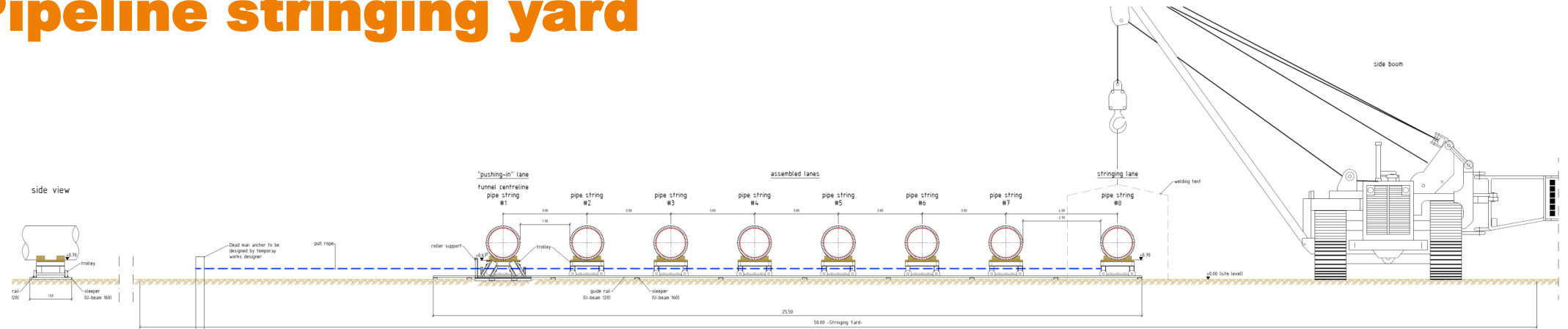
Further:

- CWC water absorption
- FPE impingement from CWC application
- Water density (tunnel flooding)
- Assessment of segment steps (resistance to push installation)
- Pipe string movement / roller friction



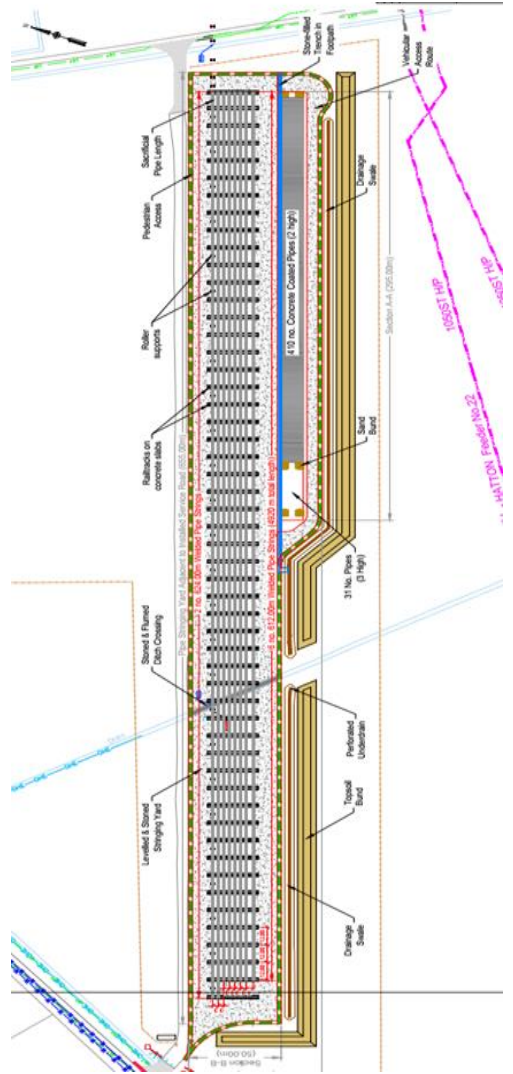


Pipeline stringing yard





Firing Line String Setup





Firing Line String Setup

Move pipe string:

- from stringing yard to the **pipe thruster (400m)**
- across to **firing line**.





Thruster set up

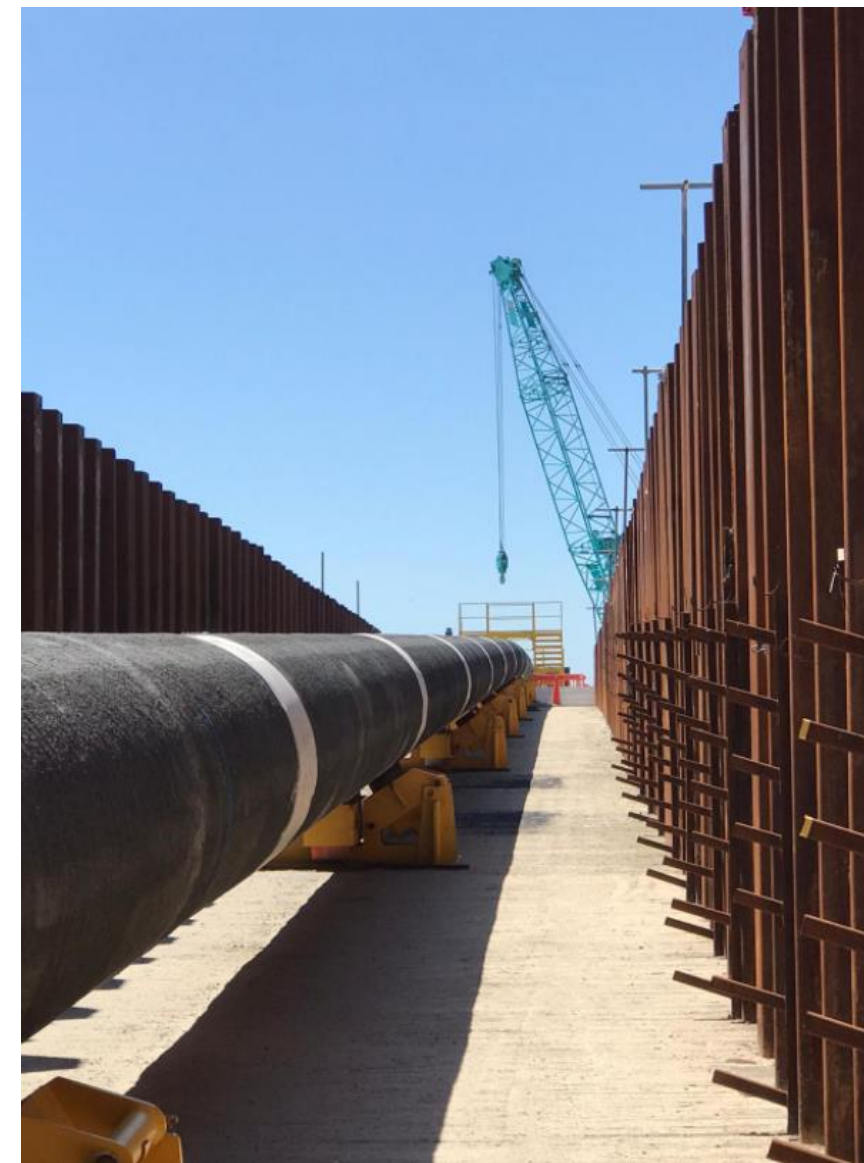






Shaft installation – pipe thruster setup

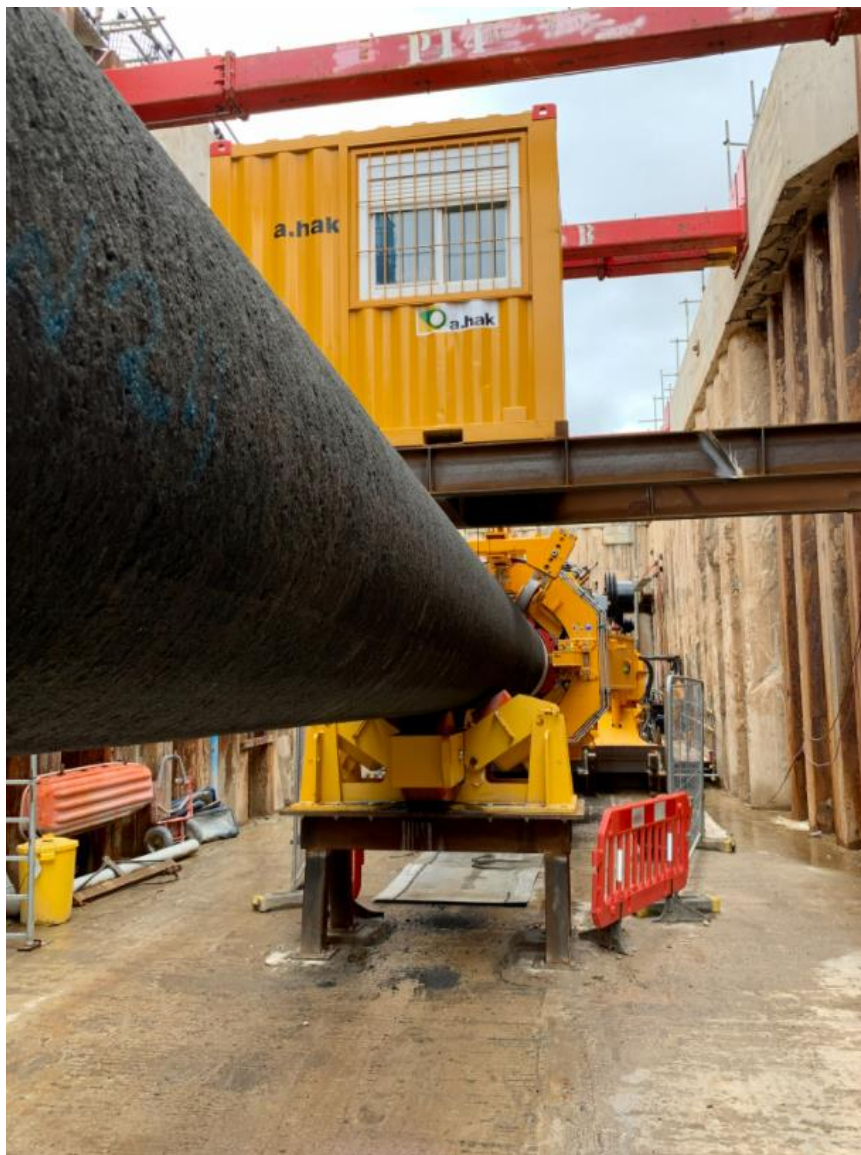


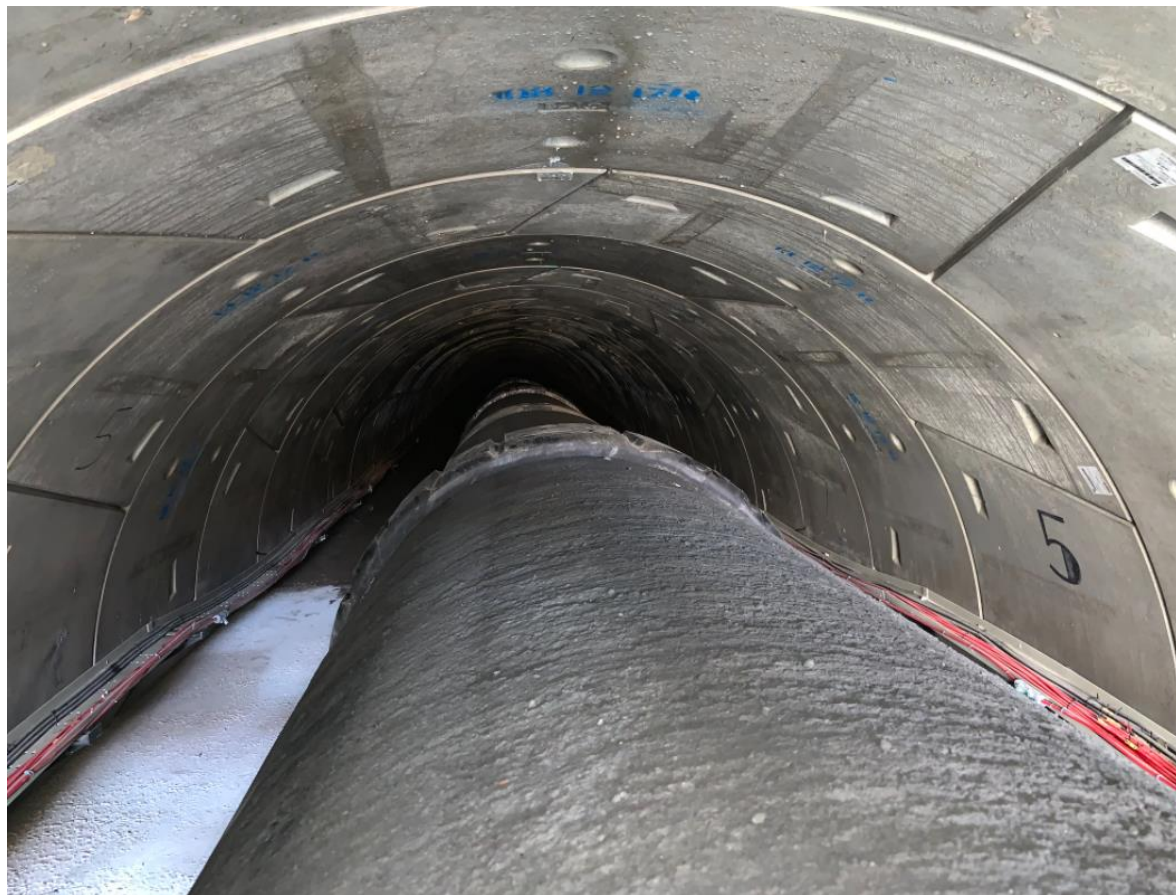








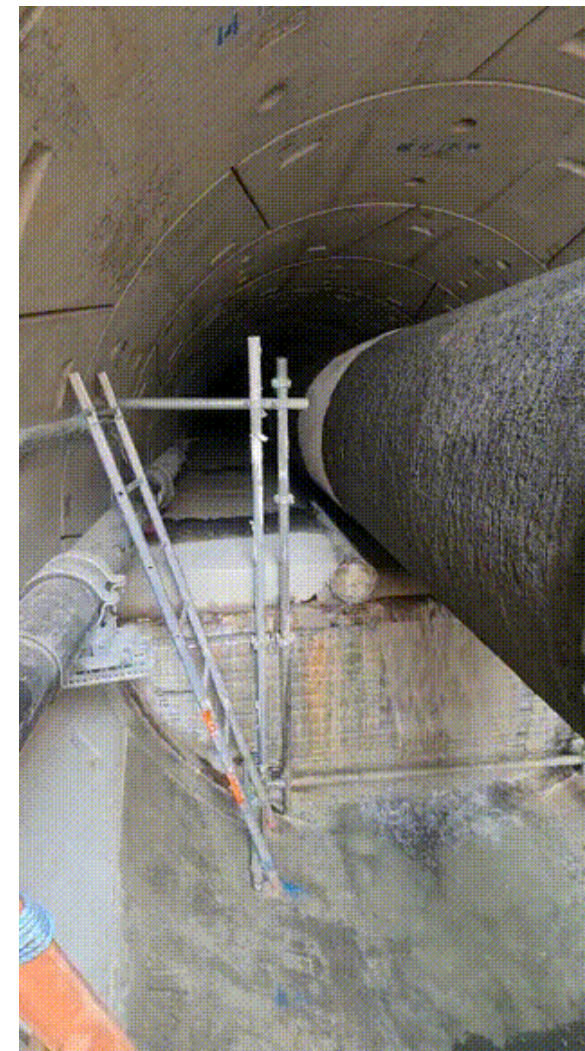
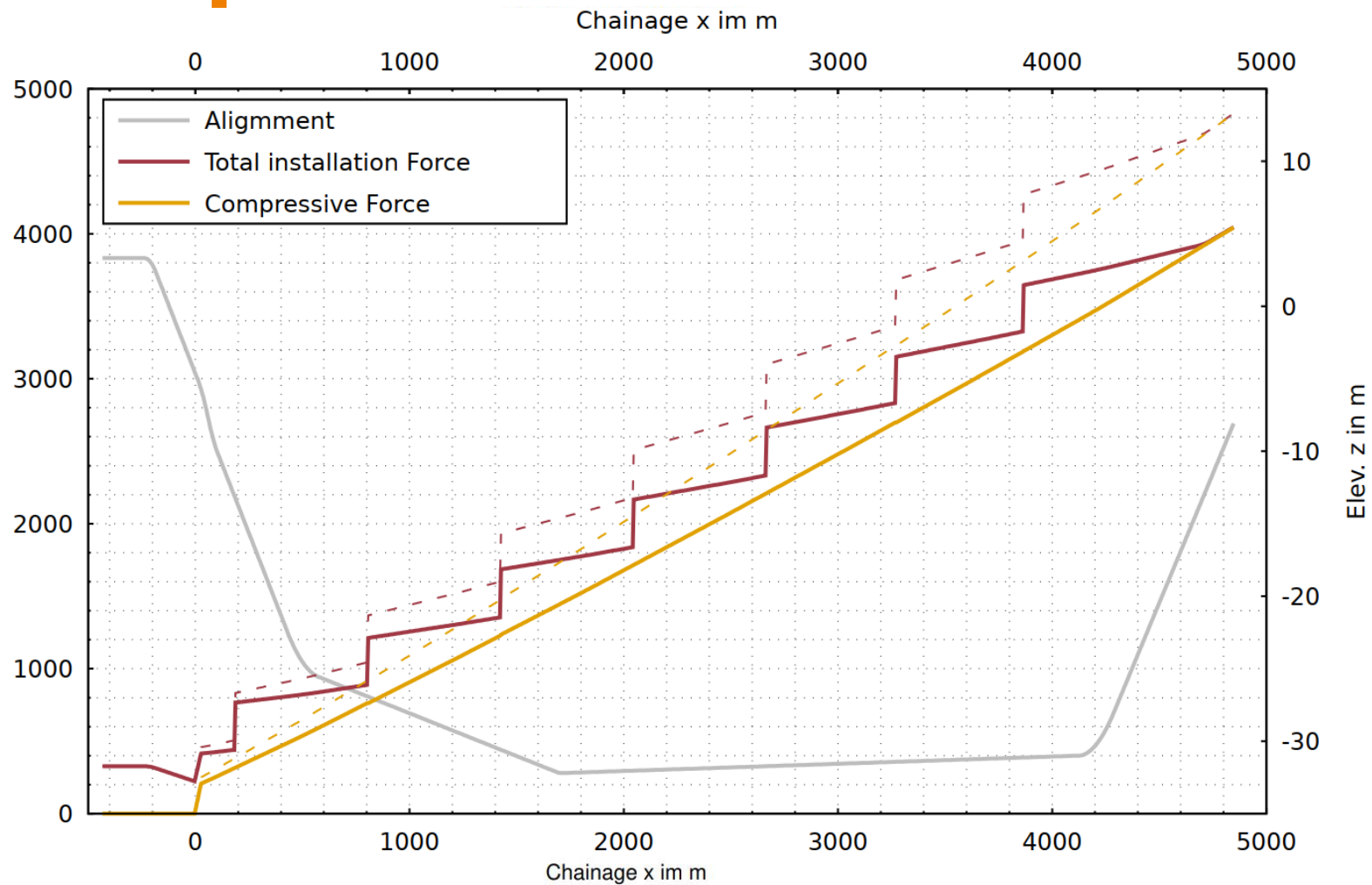








Pipeline installation







Announcement
[officially amazing](#)

<https://youtube/Qskk4PKSZsQ>





Iploca members involved

- Herrenknecht
- Volvo
- CRC Evans / Pipeline Induction Heat (PIH)
- Shawcor



PIPELINE INDUCTION HEAT



“I have been massively impressed with how the whole insertion operation has been managed”

- Steve Ellison, National Grid



Paul Hammond looks back

https://youtu.be/FfJqaH_kh-E



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Replacement pipeline project, United Kingdom



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