PIPE JACKING

An introduction to pipe jacking prepared by the Pipe Jacking Association

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Pipe Jacking

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Pipe Jacking

Microtunnelling

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Pipe Jacking - General Arrangement

Pipe Jacking is an integrated system linking:

- soils
- jacking shafts
- pipes
- shields
- jacking loads
- engineering

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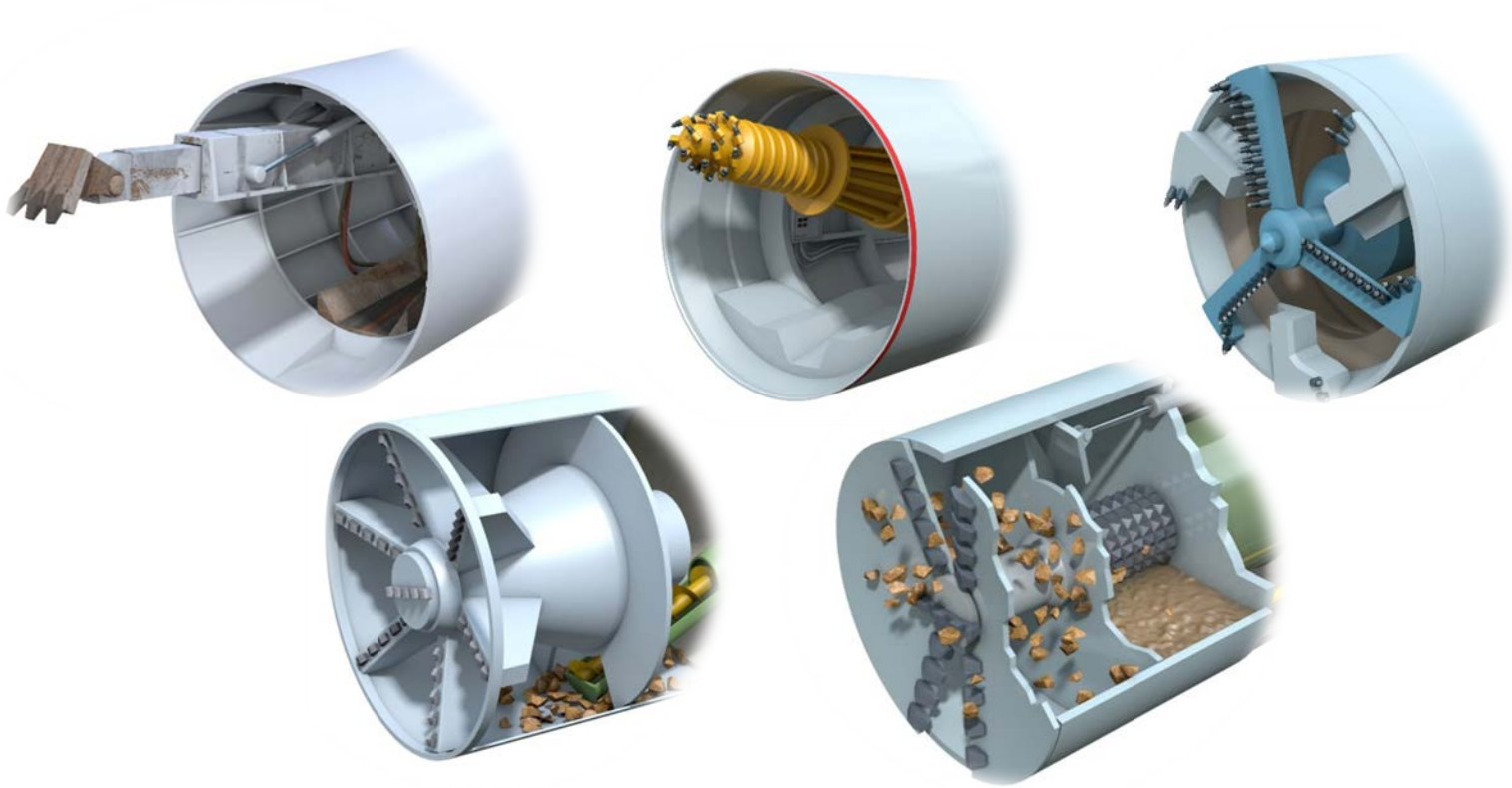
Machine Technology

Machines are available for pipe jacking in most ground conditions



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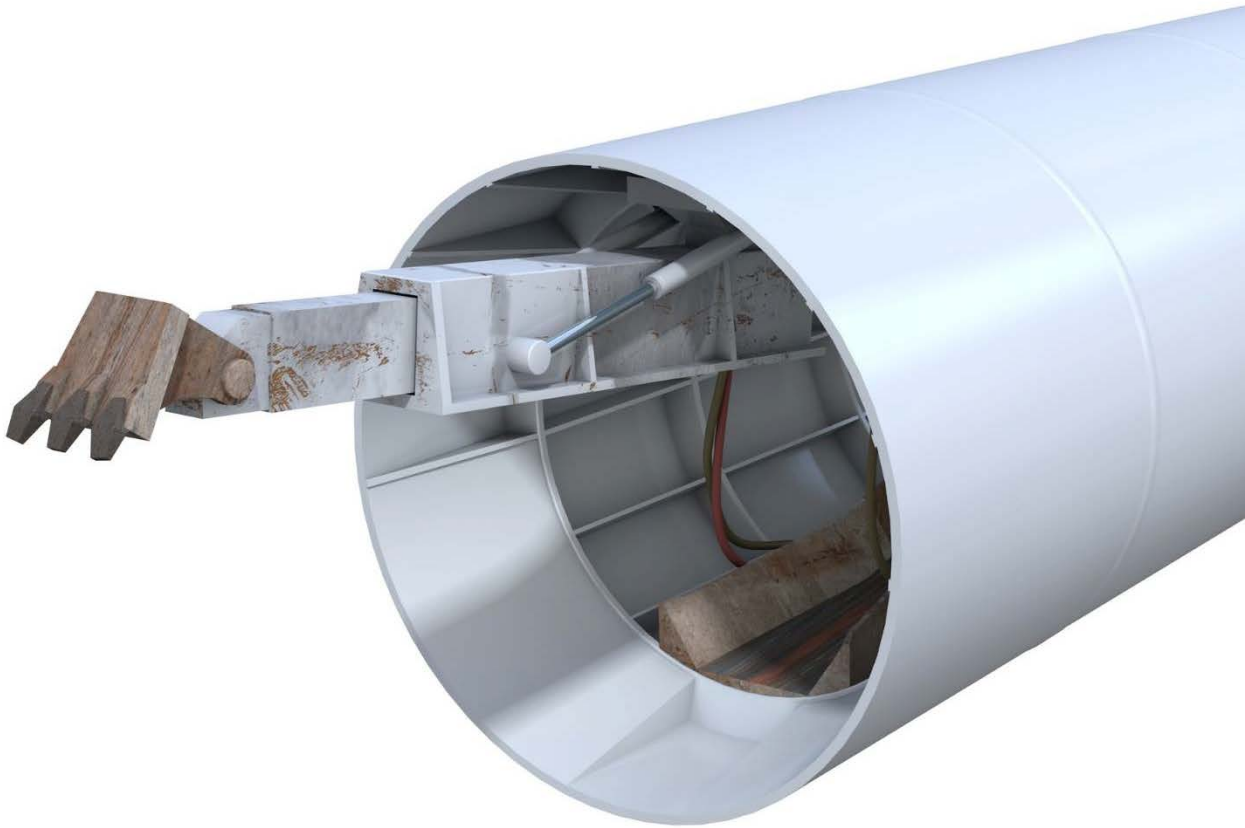
Machine Technology

Machines are available for pipe jacking in most ground conditions

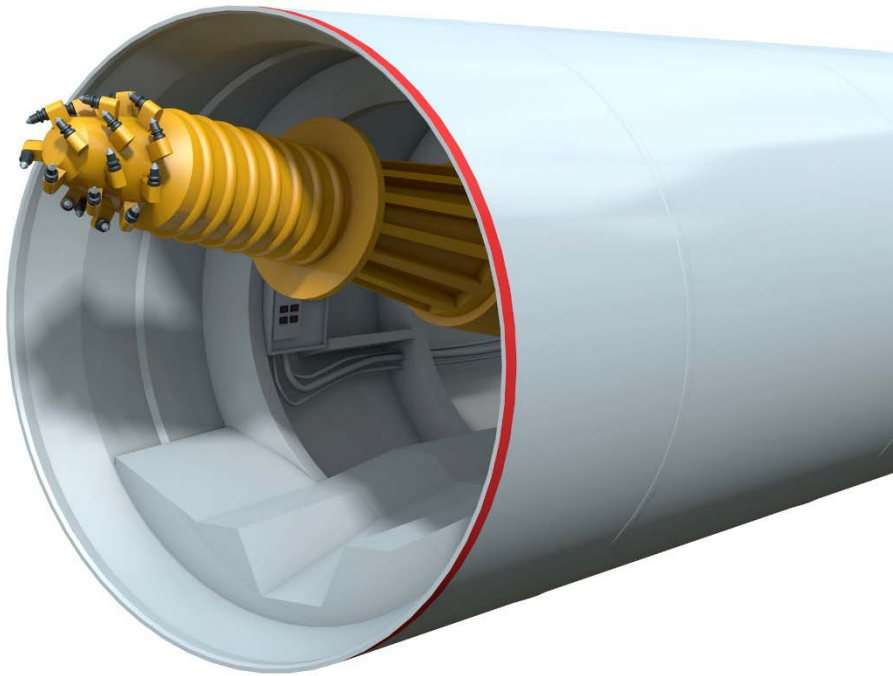
- Backacters



Machine Technology

Machines are available for pipe jacking in most ground conditions

- Backacters
- Open face cutter booms



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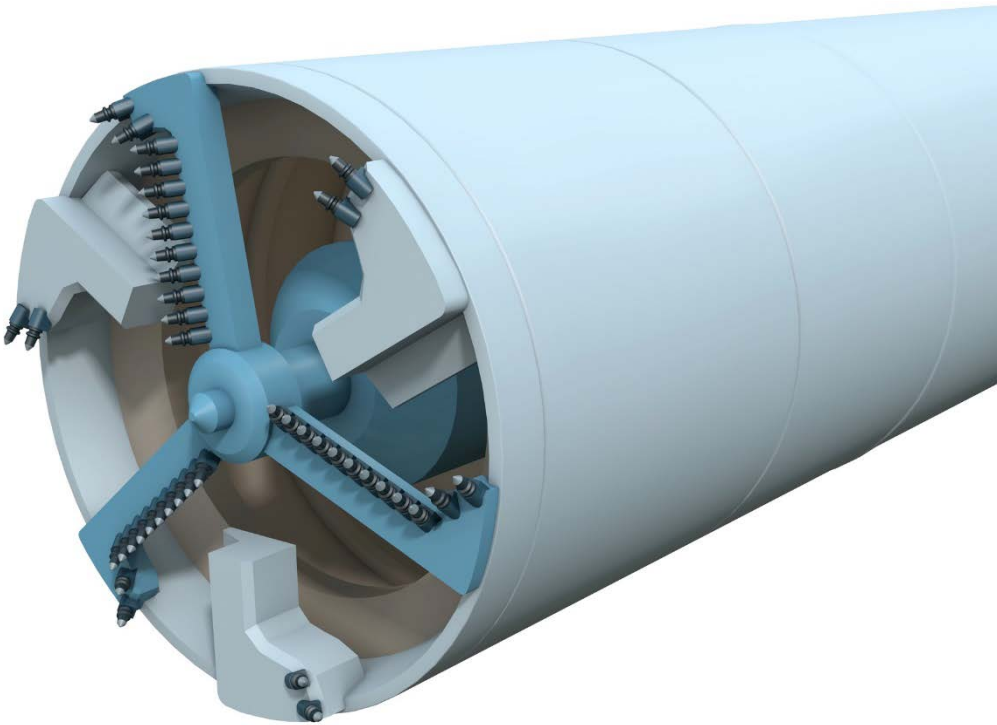
Machine Technology

Machines are available for pipe jacking in most ground conditions

- Backacters
- Open face cutter booms
- Tunnel boring machine



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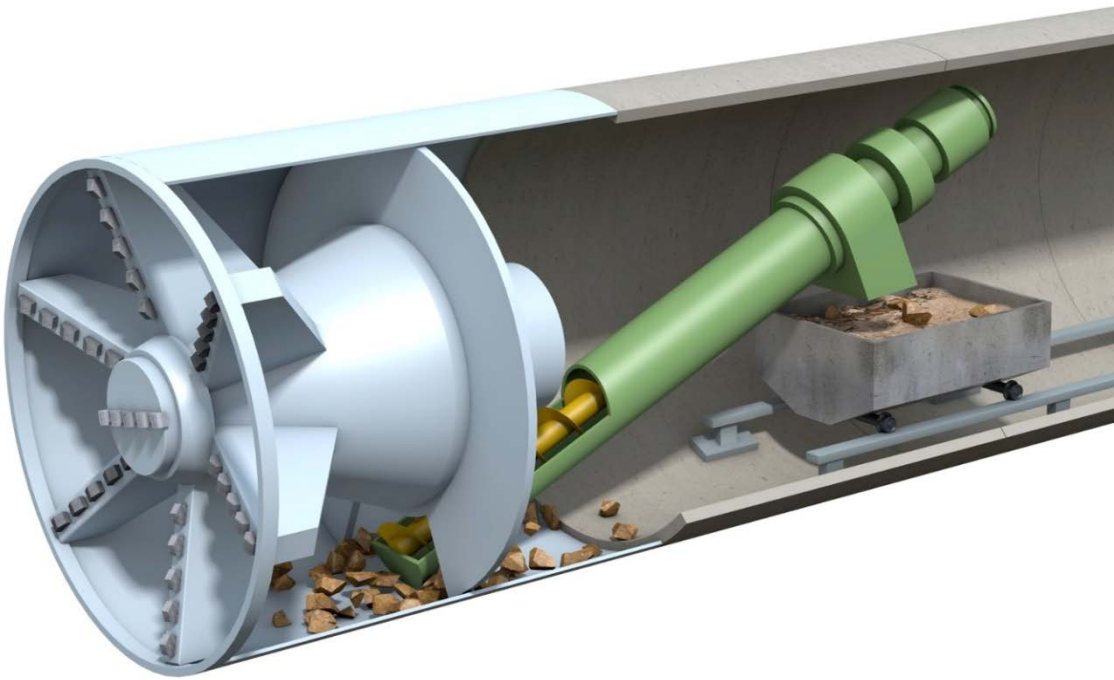
Machine Technology

Machines are available for pipe jacking in most ground conditions

- Backacters
- Open face cutter booms
- Tunnel boring machine
- Earth pressure balance



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Machine Technology

Machines are available for pipe jacking in most ground conditions

- Backacters
- Open face cutter booms
- Tunnel boring machine
- Earth pressure balance
- Pressurised slurry

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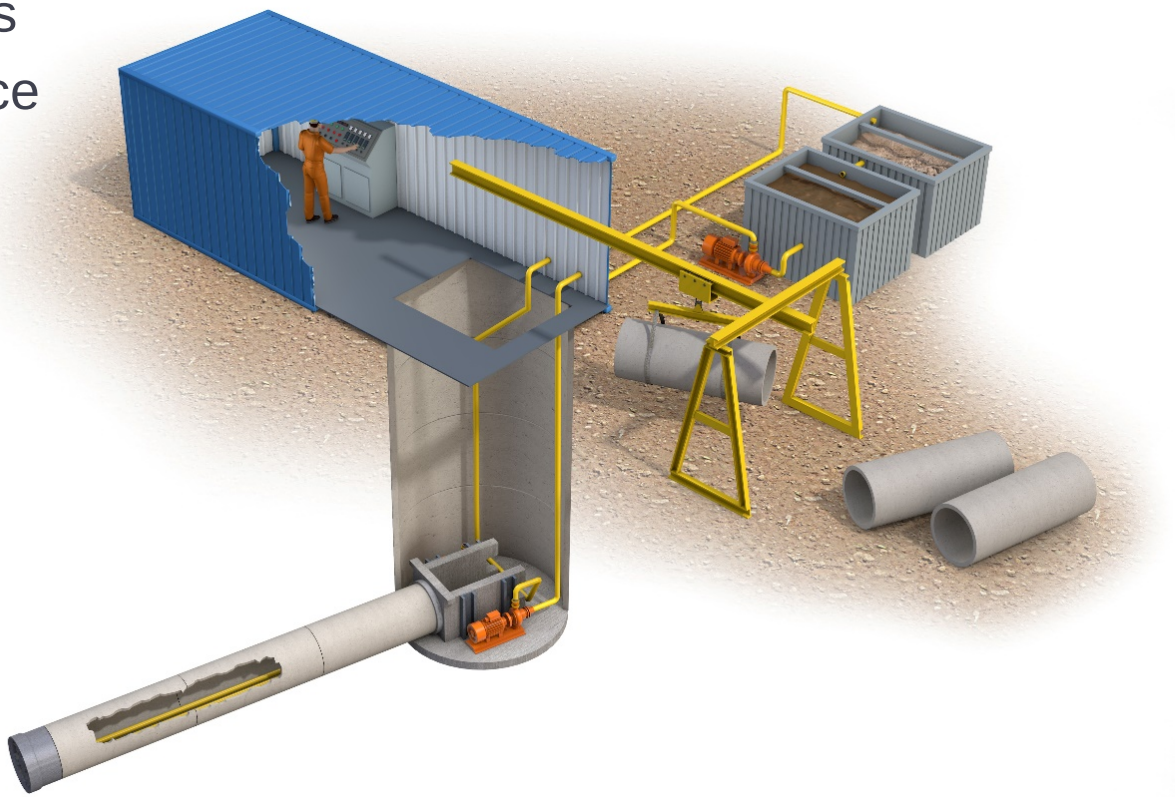
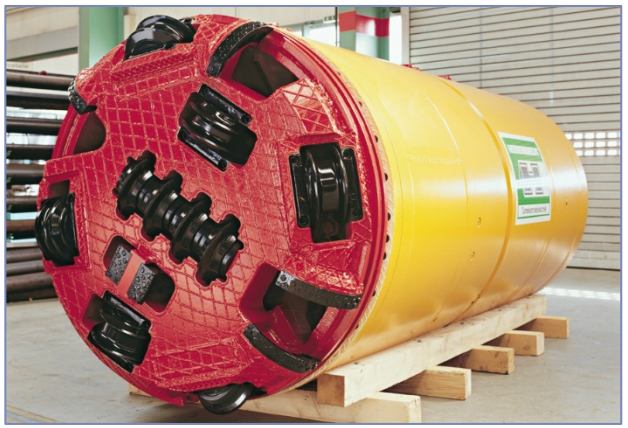
Microtunnelling

- Fully guided machines
- Controlled from surface
- Non man entry
- Two options:
  - Pressurised slurry
  - Screw auger



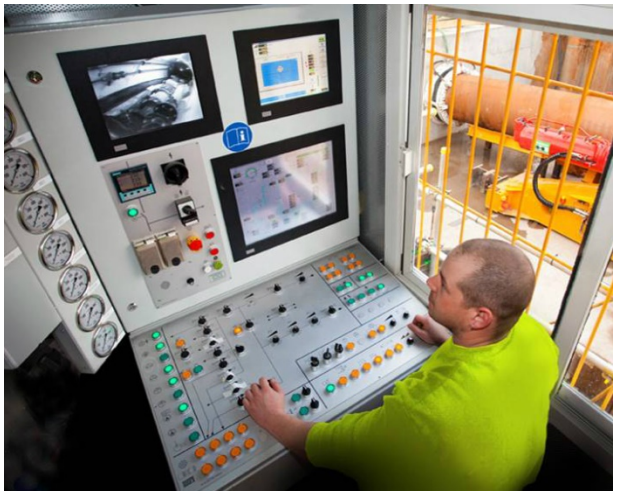
Benefits of Mechanisation

- Significantly safer working
- Efficient
- Hand arm vibration eliminated
- Quicker installation
- Ground support
- Remote control
- Risks mitigated



Computer Guidance

- Real-time line and level checks
- Maintains accuracy in difficult ground
- Allows remote operations



Drive Lengths, Diameter and Accuracy

Indicative jacking lengths achievable between shafts for mechanised drives, based on PJA members' experience and lengths being achieved internationally for both straight and curved drives appear below:

Diameter (m)	<0.9	0.9	1.0	1.2	1.35	1.5	1.8	1.9	2.1	2.4
Lengths (m)	150	200	250	450	550	700	900	1000	1000	2000

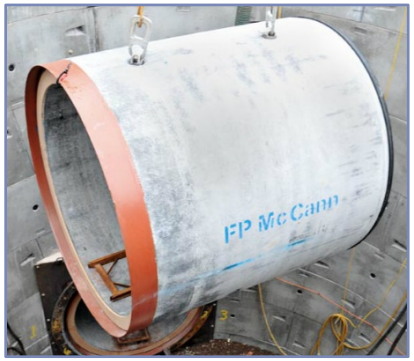
Accuracy:

In stable self-supporting homogenous ground typical tolerances for pipe installation are ±50mm for line and level at any point in the drive.

A risk analysis should be undertaken on all drives to ensure all foreseeable hazards to include access and egress of operatives and any other risks are adequately considered.

Pipe Jacking Pipes

- Concrete jacking pipes: BS EN 1916
- Clay pipes: BS EN 296-7 and BS EN 12899: 2000
- Installation forces are key
- Follow manufacturers recommendations
- Steel pipes: sleeves for pressure mains



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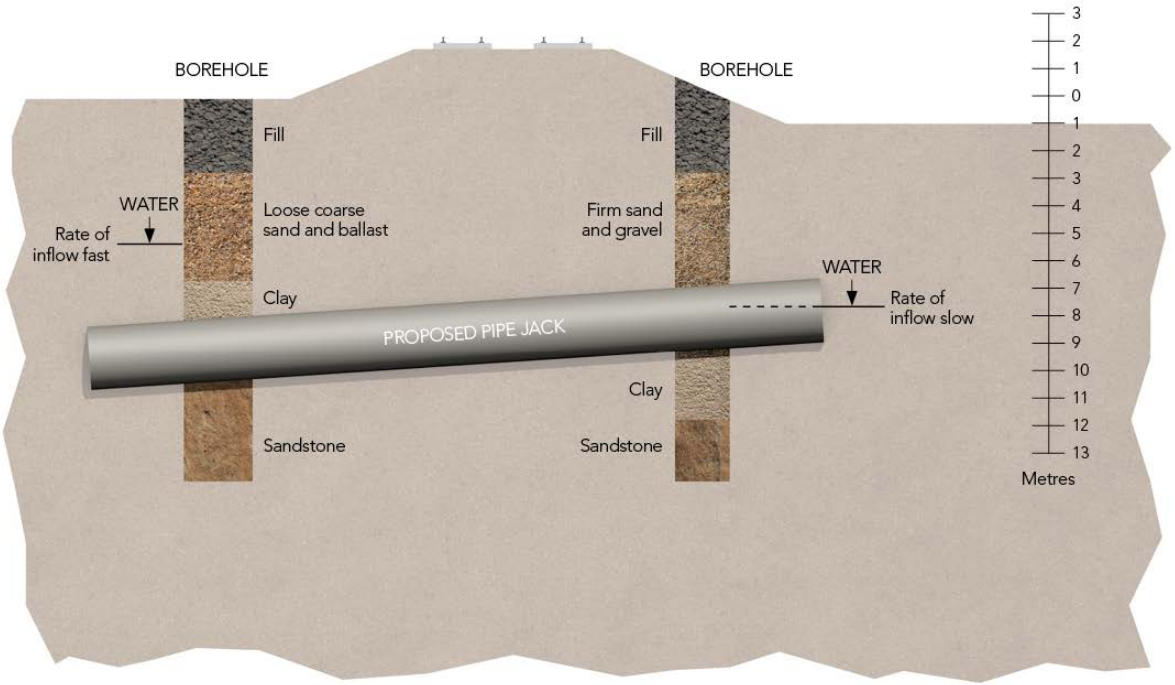
Site Investigation



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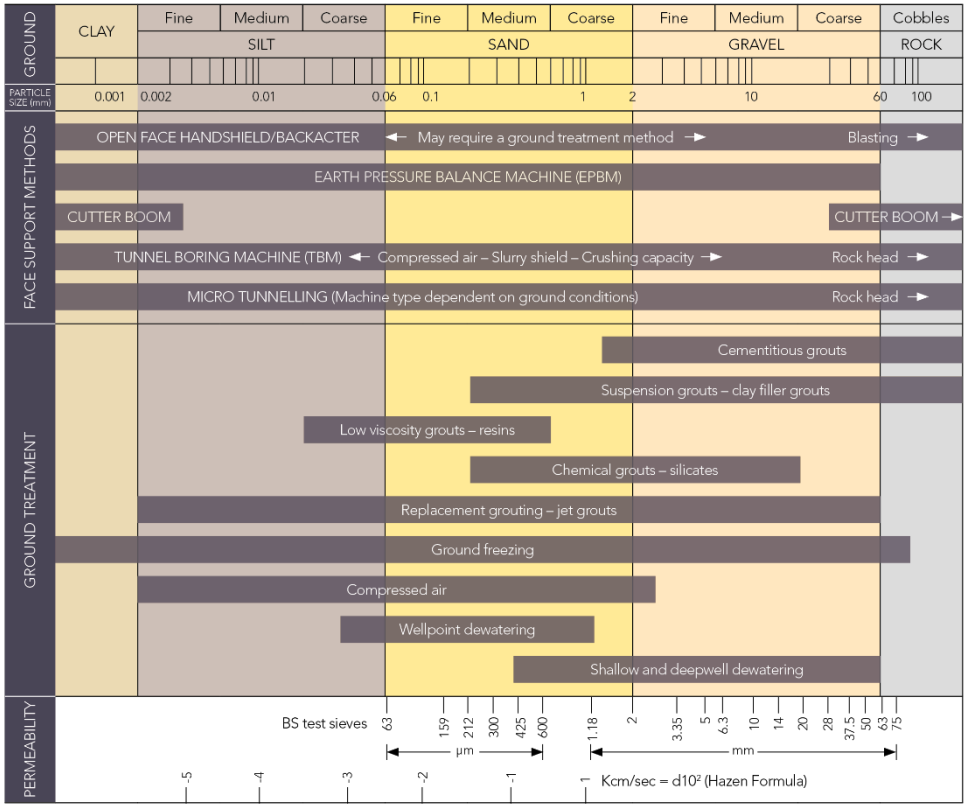
Soil Conditions

TEST	Non-cohesive	Cohesive	Mixed Soils	Fill Material	Rock
Unit weight and moisture content	●	●	●	●	●
Angle of friction	●		●	●	
Particle size distribution	●	●	●	●	
Abrasivity	●	●	●	●	●
Cohesion		●	●	●	
Types and proportions of minerals	●	●	●	●	●
Standard penetration tests	●	●	●	●	
Permeability and nature of ground water flows (seasonal/tidal changes)	●		●	●	●
Toxic/hazardous constituents in the ground/groundwater	●	●	●	●	●
Frequency and physical properties of boulders, cobbles or flints	●	●	●	●	●
Pump down tests	●		●	●	●
Presence of gases				●	●
Compressive strength					●
Rock quality designation (RQD)					●
Core logging (TCR, SCR, FI)					●
Tensile strength					●
Specific energy (excavatability)					●
Slake durability					●
Geological description	●	●	●		●
Plasticity indicees (SL, PL, PI)		●	●		
Disaggregation mixing test*		●	●		
RF (x-ray fluorescence) mixing test		●	●		

*See N. S. Phillips 2016 on www.pipejacking.org/research

Tunnelling in Unstable Ground



Note: Whilst open face handshield and compressed air are referred to above, these are only used in special circumstances

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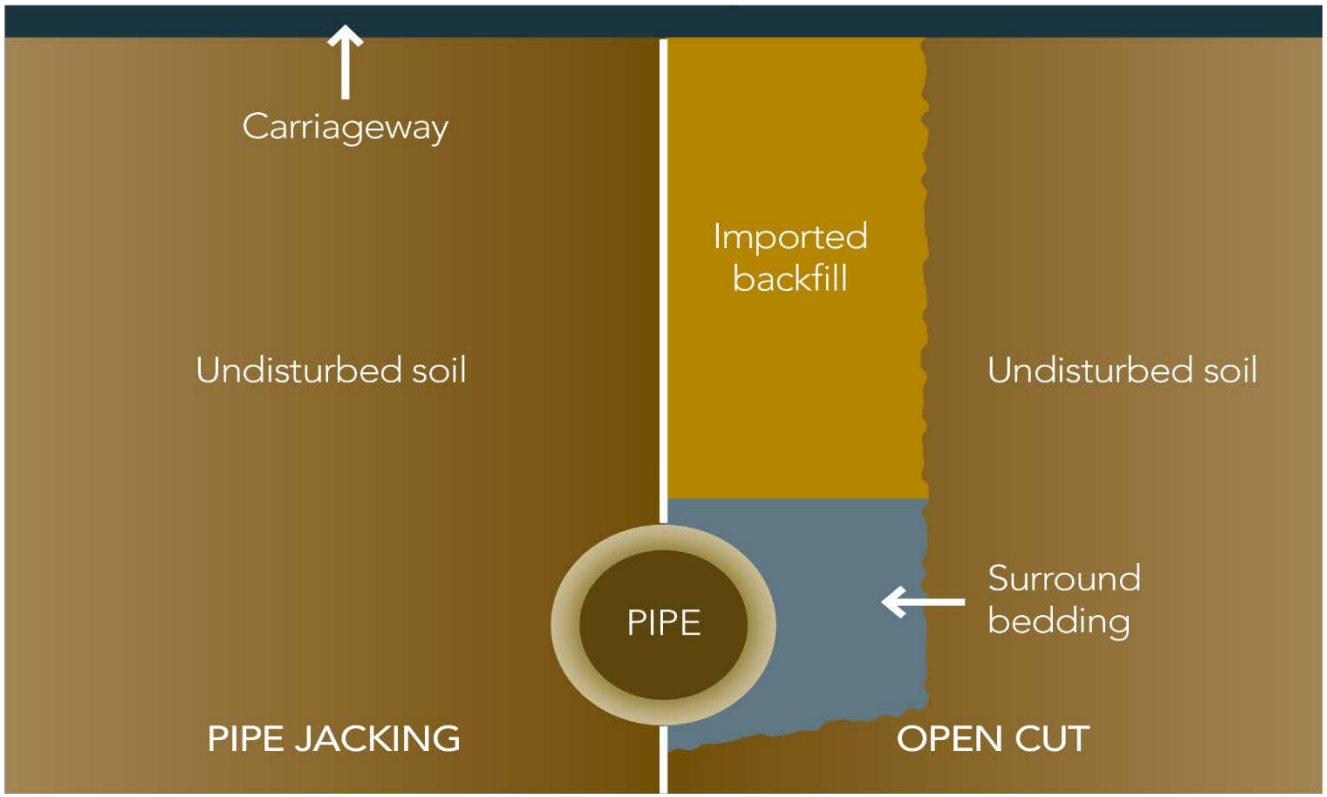
Open Trench vs Pipejacking



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Open Trench vs Pipejacking

Lorry Movements

	600mm ID pipeline 4m deep, 100m length		1200mm ID pipeline 4m deep, 100m length	
Aspect	Open trench	Trenchless	Open trench	Trenchless
Excavated width	1400mm (trench width)	760mm (OD of jacking pipe)	2350mm (trench width)	1450mm (OD of jacking pipe)
Reinstatement width	1700mm	None	2650mm	None
Excavated volume per metre of pipeline	6.1m^3	0.5m^3	10.28m^3	1.65m^3
Imported stone fill and coated stone per metre of pipeline	11.9 tonnes	None	18.27 tonnes	None
Number of 20 tonne lorry loads per 100m pipeline (muck away and imported stone)	136	8	220	21

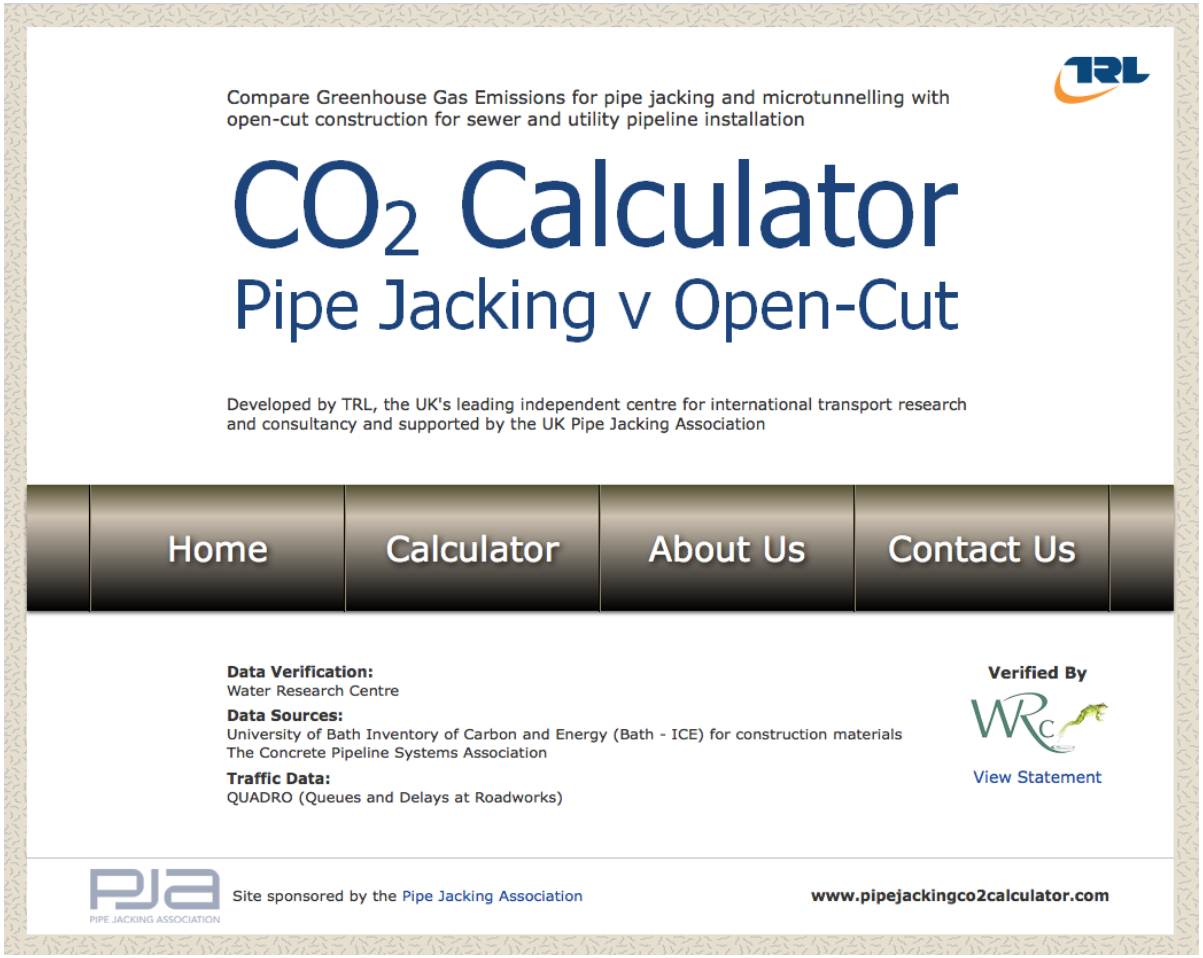
Carbon Calculator

- Easy to use
- Options:

  - Feasibility

  - As designed

  - As built



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Carbon Calculator

CO_2 Savings – 500 metres

Project Data **4m** depth to invert	**600mm diameter pipeline 500m length x 4m deep**		**1200mm diameter pipeline 500m length x 4m deep**	
Method	Open cut	Pipejacking	Open cut	Pipejacking
Tonnes CO_2	351.4	113.3	570.6	301.8
CO_2 saving	238.1 tonnes = **68% saving**		268.8 tonnes = **47% saving**	

Project Data **6m** depth to invert	**600mm diameter pipeline 500m length x 6m deep**		**1200mm diameter pipeline 500m length x 6m deep**	
Method	Open cut	Pipejacking	Open cut	Pipejacking
Tonnes CO_2	492.4	124.6	765.5	328.3
CO_2 saving	367.8 tonnes = **75% saving**		437.2 tonnes = **57% saving**	

Major Applications

- New sewerage and drainage construction
- Sewer replacement and lining
- Gas and water mains
- Oil pipelines
- Electricity and telecoms cable ducts
- Subways

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Technical Benefits

- Inherent strength
- Smooth internal finish
- No secondary lining
- Fewer joints
- Watertight
- Inverts for combined systems
- Less settlement
- Minimal surface impact
- Fewer utility diversions

Safety Benefits

- Inherently safer method
- Quicker installation
- Reduced labour input
- Utility strikes minimised
- Public interface reduced
- Reduced confined space man hours

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Sustainability:

Environmental and socio-economic benefits

- Reduces disruption
- Reduces damage to services
- Maintains highway integrity
- 90% fewer vehicle movements
- Less spoil
- Less quarried material
- Reduced CO_2 emissions
- No secondary lining
- Economic alternative to deep open cut
- Socially acceptable

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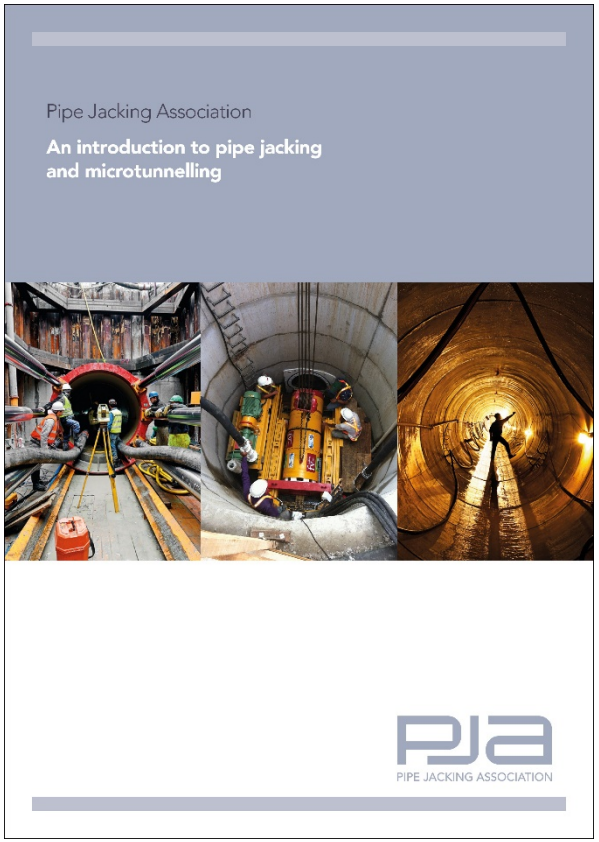
Research Projects at Leading Universities

University research programme initiated in 1986 – projects include:

- Laboratory testing of model jacked pipes
- Field testing of performance of pipes
- Finite element analysis of concrete jacking pipes
- Full scale testing of concrete pipes
- Soil conditioning and lubrication materials
- Field testing of soil conditioning and lubrication methods
- Slurry management and soil disaggregation

PJA Publications and Design Advice

- Introduction to pipe jacking
- Detailed design guide
- Videos and presentations
- Preferred pipe sizes
- Case studies
- Research
- Carbon calculator
- Contractors, pipe and other suppliers
- Safety guidance
- Downloadable from website



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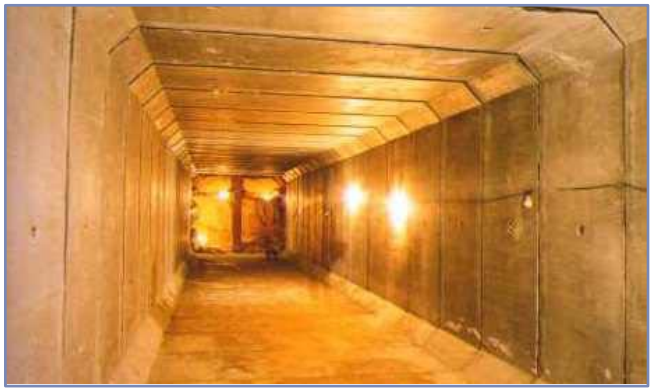
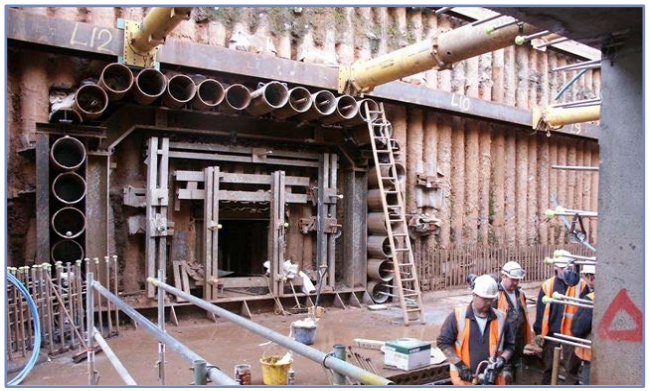
Additional Applications



Box Sections

- Subways
- Roadways



Other uses

- Jacked arches
- Bridge slide foundations

Summary

- Engineering integrity
- Low capital costs
- Low maintenance
- Cost-effective
- Safe installation
- Environmental benefits
- Reduced CO_2 emissions
- Extensively used
- 150mm to 2.4/3m diameters
- Long drive lengths
- Straight or curved drives

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