Trenchless World Congress
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Pipe Bursting Techniques and Considerations for Successful Pipe Replacement

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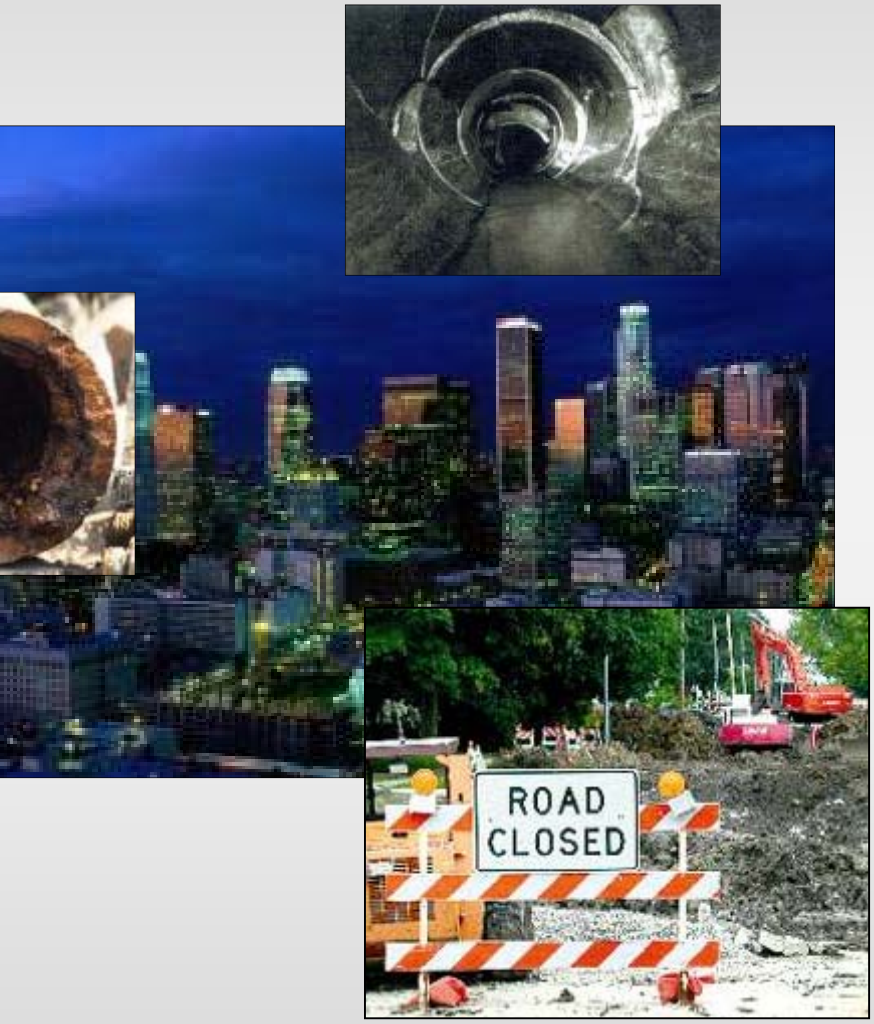
Ex-Chair, International Pipe Bursting Association. IPBA Division of NASSCO, USA

hy Trenchless?

- Minimal disruption of traffic
- Year round construction
- Improved safety
- Reduced landscape damage
- Minimal disturbance to local business
- Improved construction productivity
- Can access otherwise inaccessible areas

e State of the Infrastructure



- Universal deterioration
  - Water lines
  - Sewer lines
  - Gas lines
- Building expansion
  - Increased demand/volume
- Congestion
  - Highways
  - Cities/Towns

Sewer Lines

- Offset pipes
- Cracks and fractures
- Deterioration
- Root intrusion
- Hole in pope
- Leaking
- Under capacity
- Infiltration/exfiltration
- Many others identified as WRc or PACP defects

Water Mains

- Encrusted
- Corroded
- Leaking (loss up to 40%)
- Under capacity

Pipe Replacement

Trenchless Pipeline Replacement

PIPE BURSTING

pe Bursting - Introduction

PIPE BURSTING

Proven field of pipe replacement technique

"Replacement of the host pipe by fragmenting the existing conduit and installing a completely ***new pipe of equal diameter or larger in its place***."

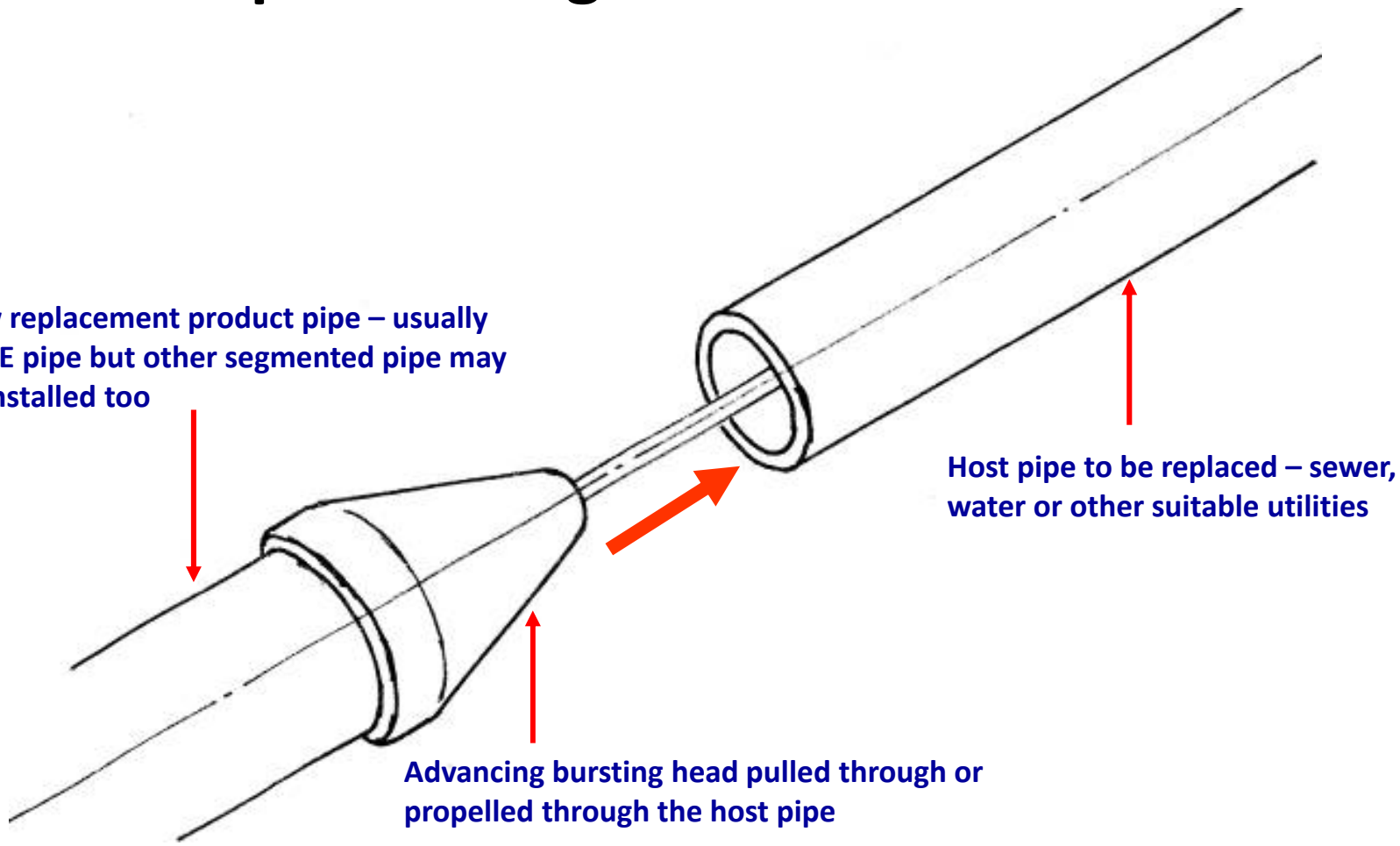
e Bursting

enchless replacement of host or original pipe by application of rce to burst pipe.

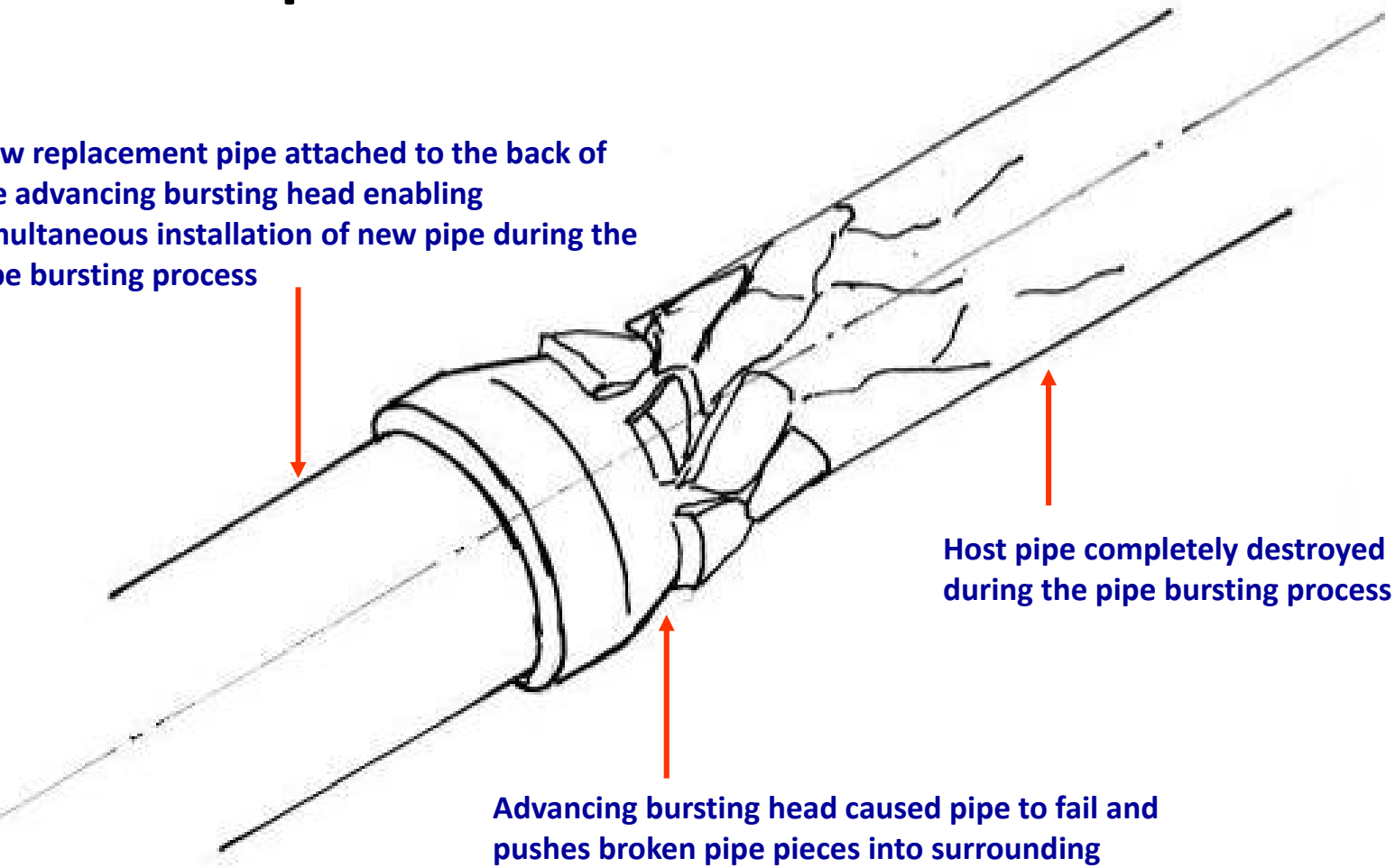
ocess involves initial cracking, followed by fragmenting the host pe, creation of new tunnel and installation of new replacement pe.

Only process other than conventional open cut method that replaces an existing pipe with a completely new structural pipe of equal or larger diameter, to maintain or allow an increase in flow capacity.

What is Pipe Bursting?



What is Pipe Process



w replacement pipe attached to the back of
e advancing bursting head enabling
nultaneous installation of new pipe during the
pe bursting process

Host pipe completely destroyed
during the pipe bursting process

Advancing bursting head caused pipe to fail and
pushes broken pipe pieces into surrounding
ground creating a tunnel

Where can I use pipe bursting?

- Sewer main replacement
- Sewer lateral replacement
- Water main replacement
- Gas pipeline replacement
- Other suitable utilities

KEY FEATURES – Important things at a glance

- Total pipe replacement
- Structural pipe – HDPE or engineer specified product including rigid sectional pipes
- Typical upsize – 20% to 30%
- Major upsize – 150% or larger possible
- Replacement length – 50 feet to 450 feet
- Diameters – 50mm to 1000mm

ADVANTAGES

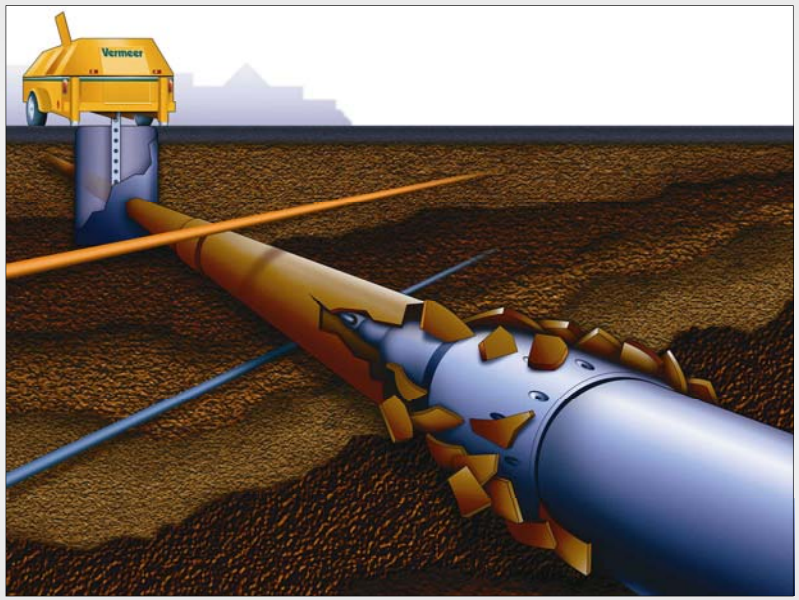
- Minimized excavation required
- Limit inconvenience to public and business
- Use in situations where open trench replacement is not suitable or appropriate
- Lower construction period
- Lower replacement cost

onventional Open Cut vs. Pipe Bursting

	Open Cut	Pipe Bursting
Pipe Type	New	New
Pipe Size	Same size or larger	Same size or larger
Pipe Life Cycle	100 years	100 years
Site Preparation	Severely Disruptive	Low To Moderately Disruptive
Replacement Cost	High	Medium
Social Impact	Maximum	Low to Moderate

ost Pipe Suitable For Pipe Bursting

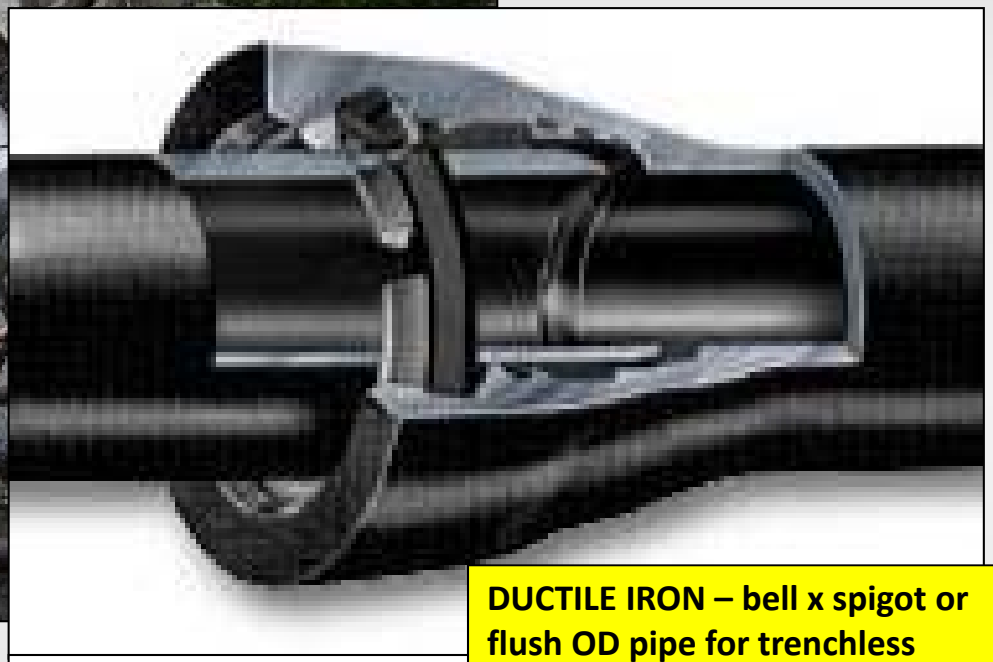
- Concrete & reinforced concrete
- Clay
- Asbestos cement
- Cast iron
- Ductile iron
- Steel
- PVC & HDPE



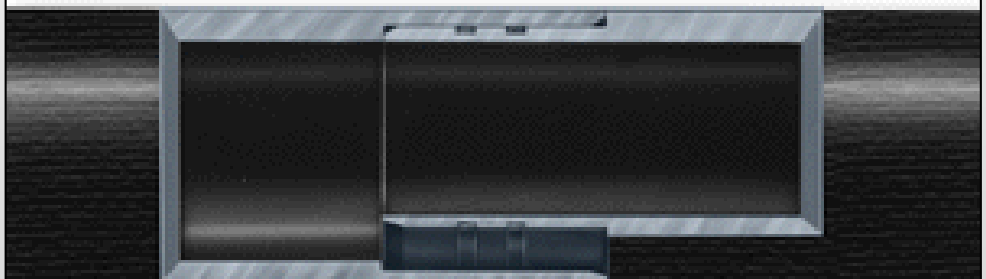
OST TYPES OF PIPES CAN BE INSTALLED

- HDPE – more than 90% of all new pipes
- Ductile iron (Flex-Lok)
- Vitrified Clay Pipe
- PVC (Terra Brute / Cobra Lok)
- Steel
- FRP, GRP, HOBAS or equal
- Other specified pipes

HDPE PIPE – fused into continuous pipe, NO JOINTS



DUCTILE IRON – bell x spigot or flush OD pipe for trenchless



PVC

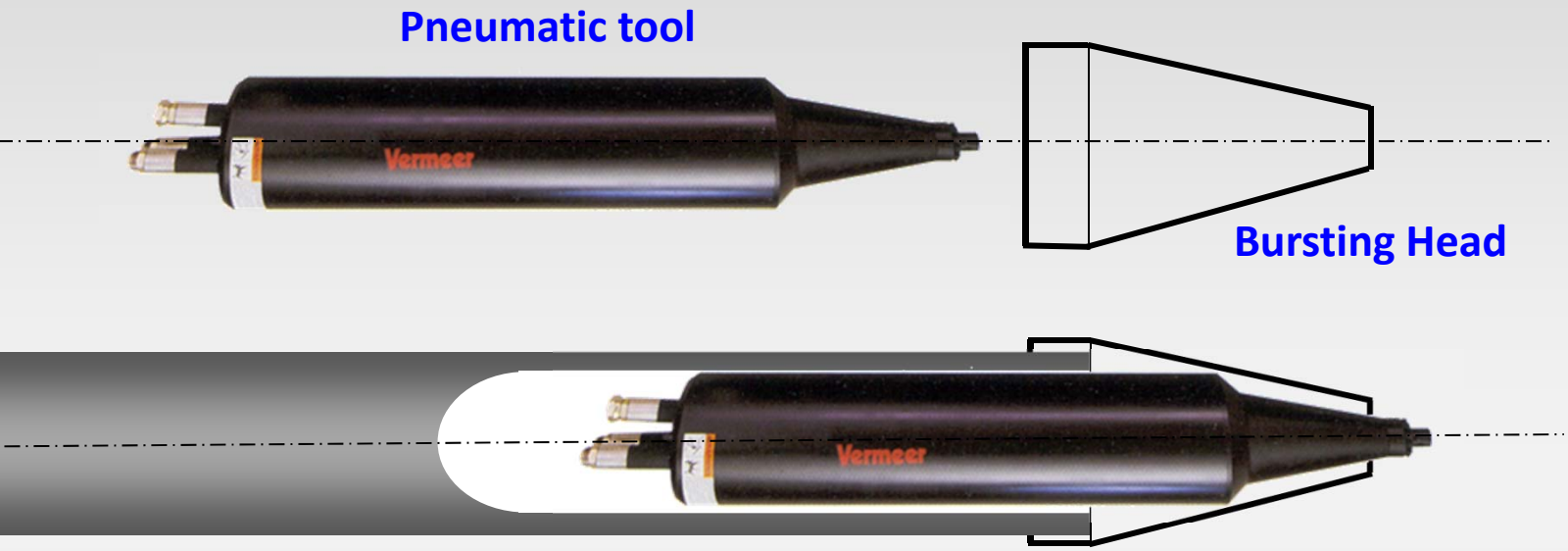
Specially d
bell and spi

SEGMENTED CLAY

PIPE BURSTING METHODS

- **Pneumatic Pipe Bursting**

EUMATIC PIPE BURSTING

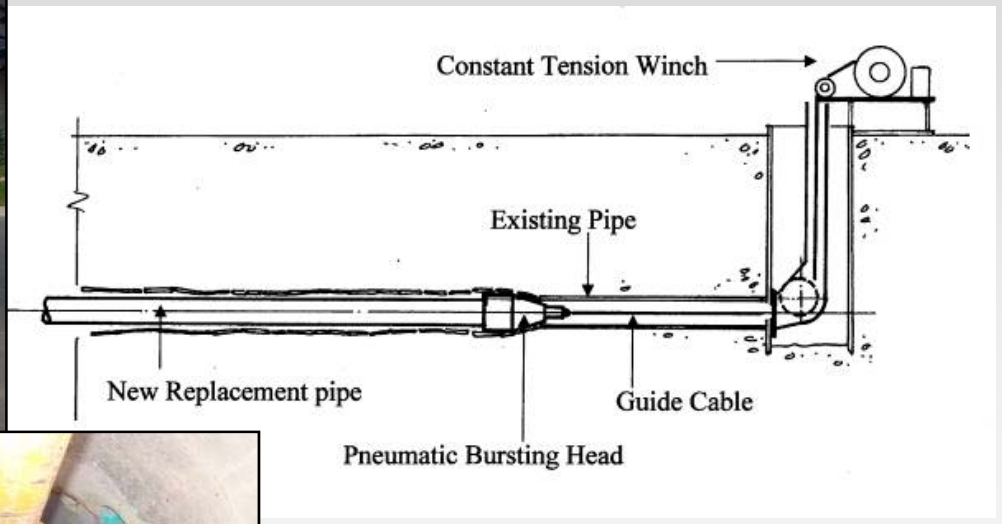


Assembled pneumatic tool with bursting head towing HDPE pipe

es pneumatic hammer to propel the bursting head through the host pipe.

pact forces causes the host pipe to fail in tension (inside out)

eumatic Pipe Bursting



constant tension cable winch will guide the pneumatic bursting tool through
e host pipe and allowing on line, on grade pipe replacement

e Burst – reversible tool (video)

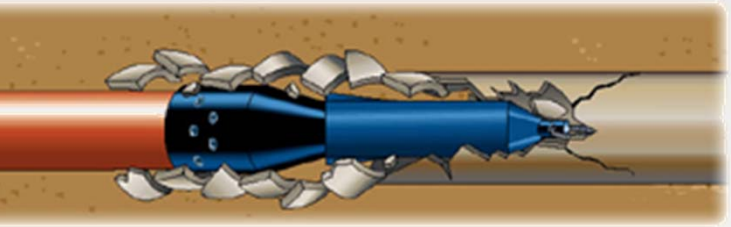
eumatic Pipe Bursting

Advantages

- Same size or upsize replacement pipe
- Cost effective manhole exits* reduce excavation
- Helps reduce destruction of buildings, landscaping and paved surfaces

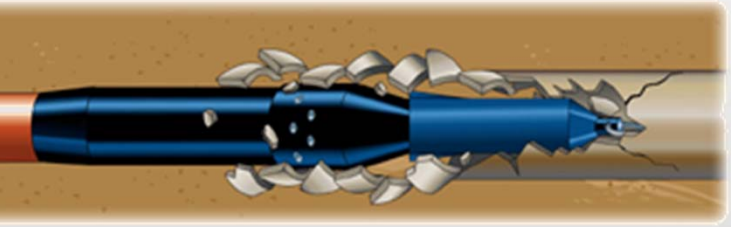
ursting Head Configurations

- Front mount



- Front mount with pilot

- Rear puller with pilot

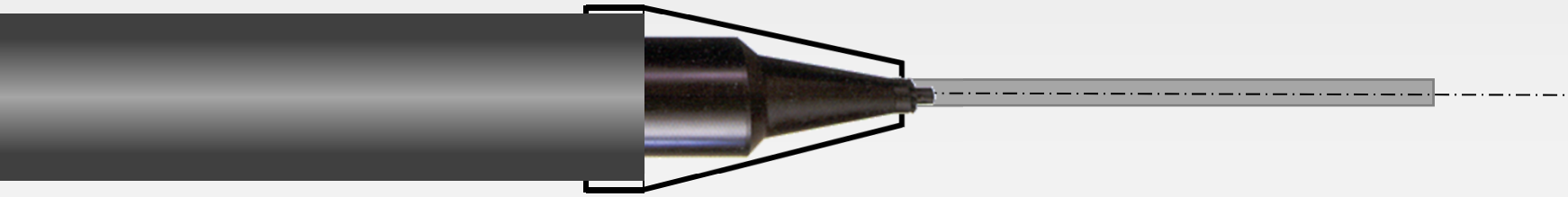


- “Tractor Effect” with pilot

PIPE BURSTING METHODS

- Pneumatic Pipe Bursting
- **Static Pull Pipe Bursting**

TIC PIPE BURSTING



Typical pneumatic pipe burst tool set-up

The static method replaces the host pipe with the burst head being pull through the host pipe using rigid rod, cable or chain

TIC PIPE BURSTING MACHINES – 50 TONS TO 300 TONS

Static pipe bursting – cracking process

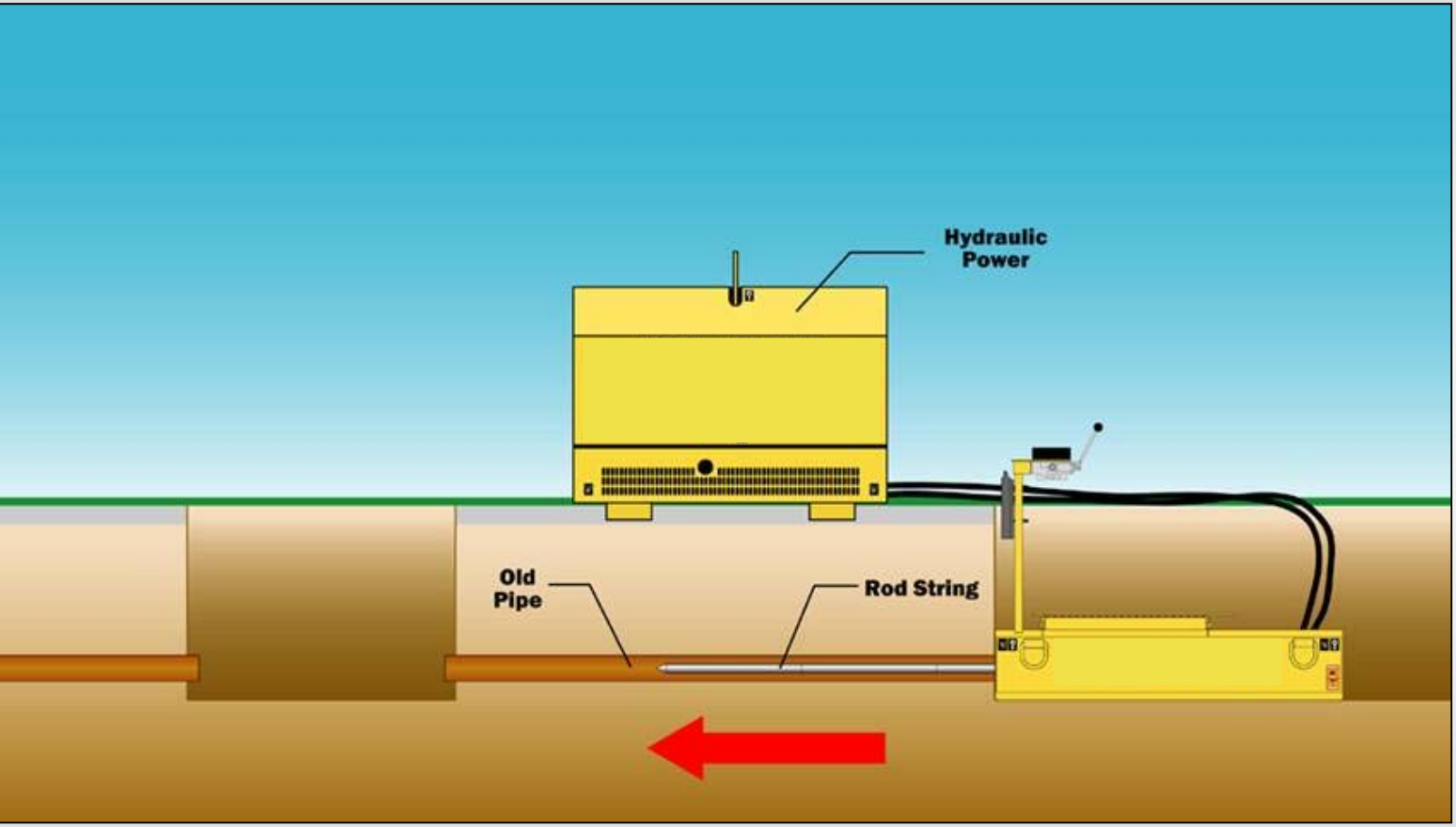
Static pipe bursting – cracking process

Static pipe bursting – cracking process

ep #1 -

sitioning static bursting machine in pull pit

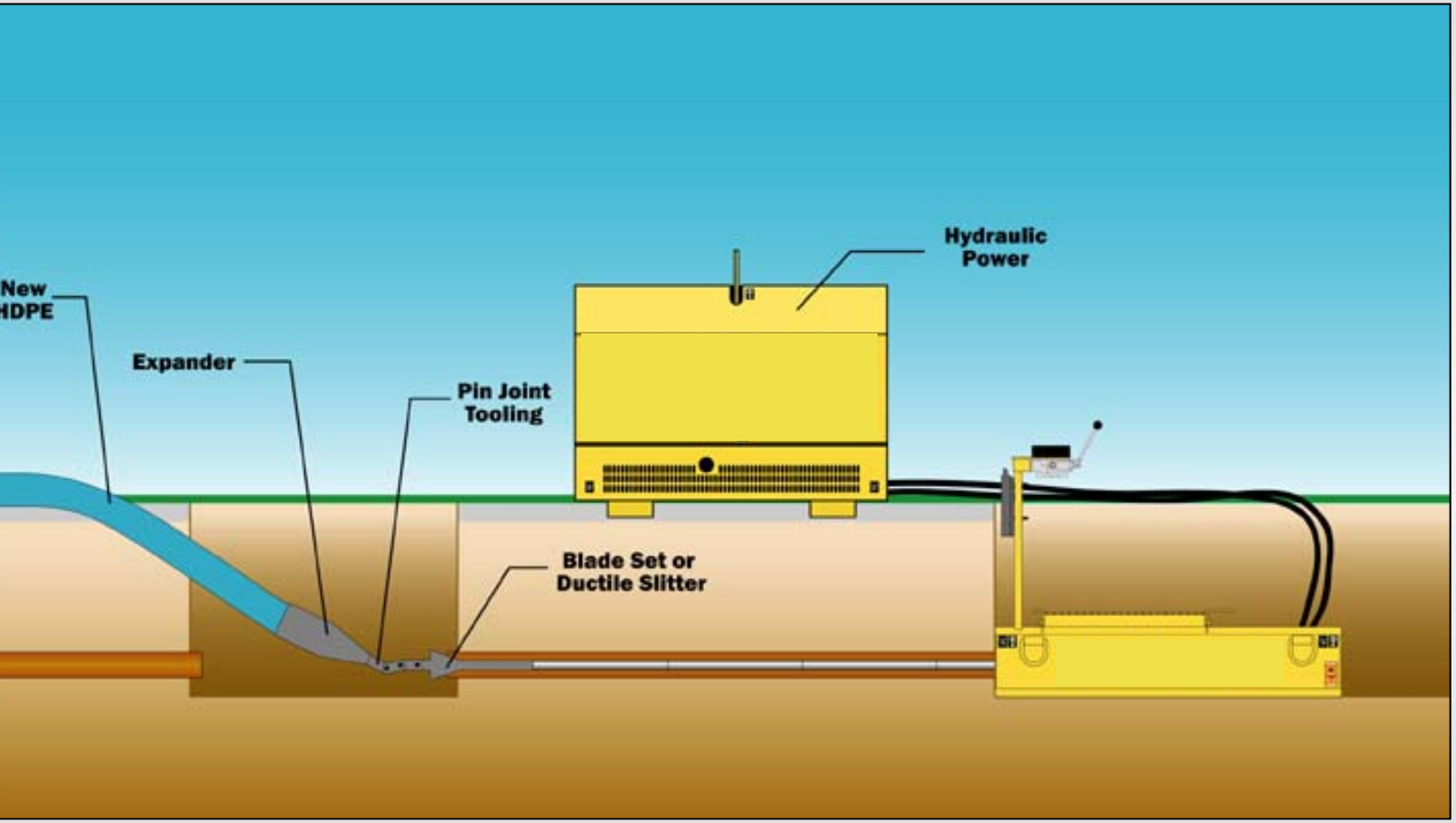
tic Burst – Step 1



ep #2 -

ding pull rods to new pipe insertion pit

atic Burst – Step 2



p #3 -

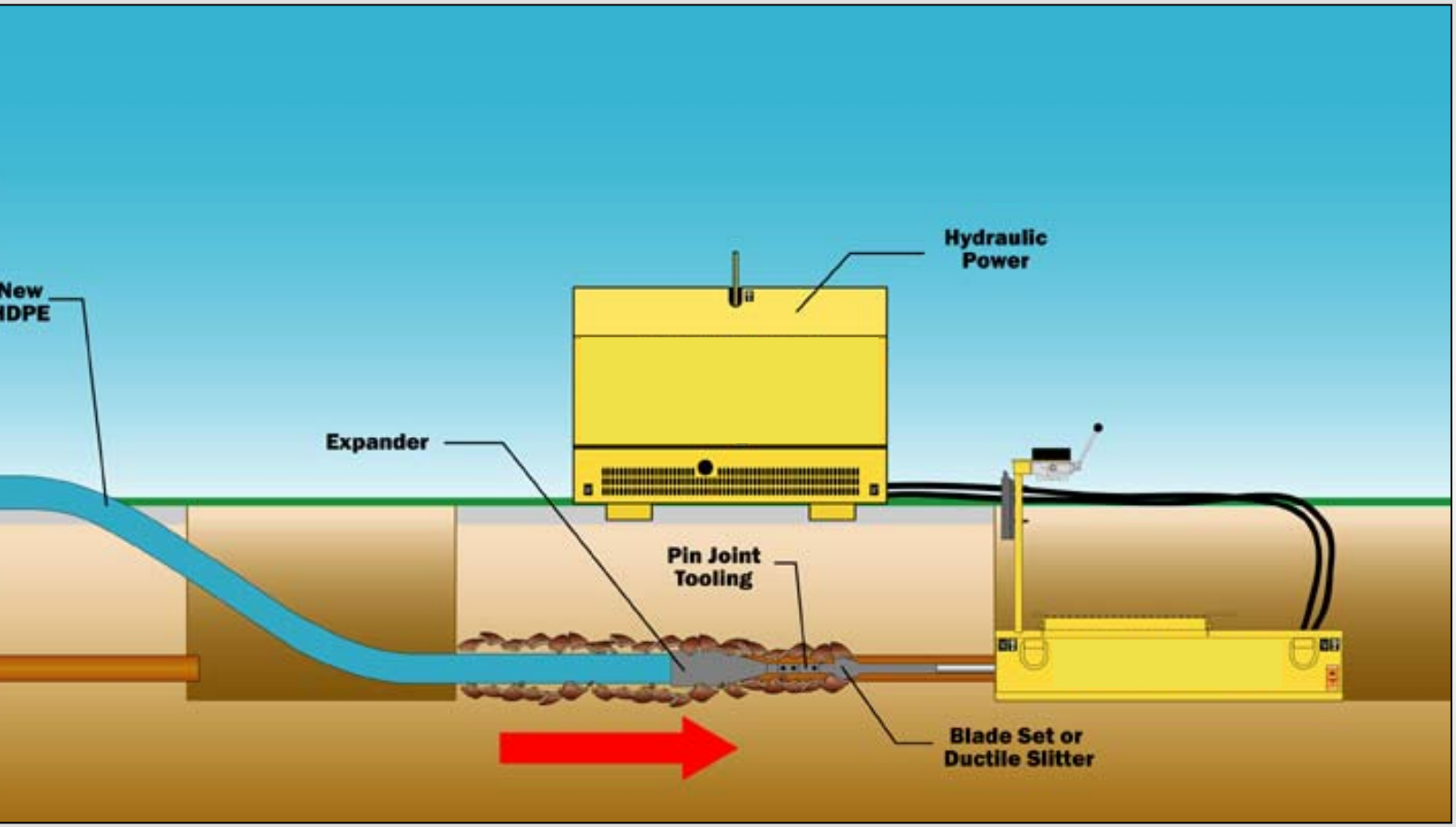
sting head with blade starter rod set-up & ready for back to start pipe bursting operation

nder
ng new
E pipe

Existing cast iron water main

Bladed starter rod

tatic Burst – Step 3



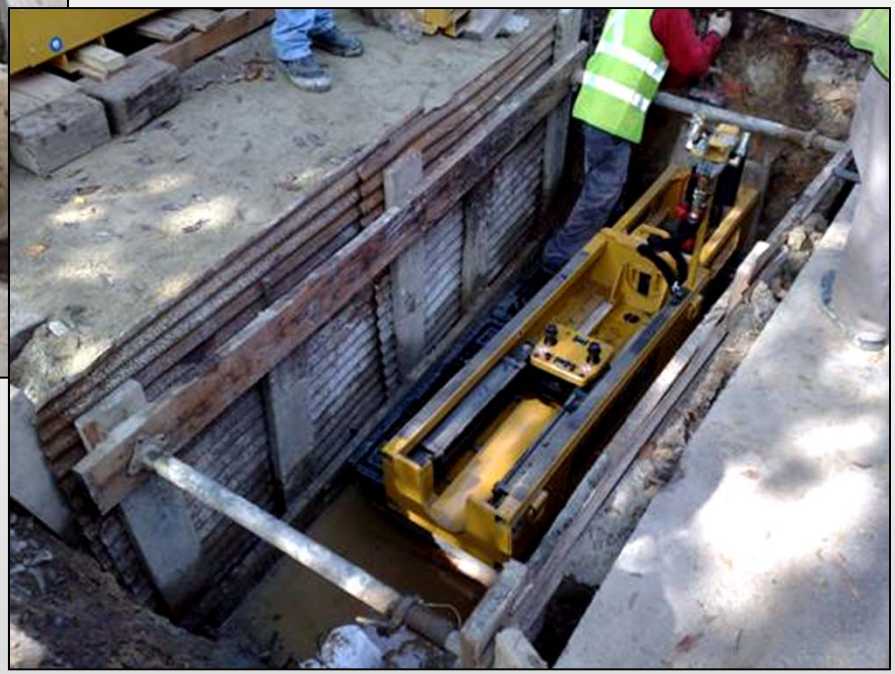
rsting cast iron pipe

SAME SIZE AND UPSIZING PIPELINE BY PIPE BURSTING METHOD

Example 1:

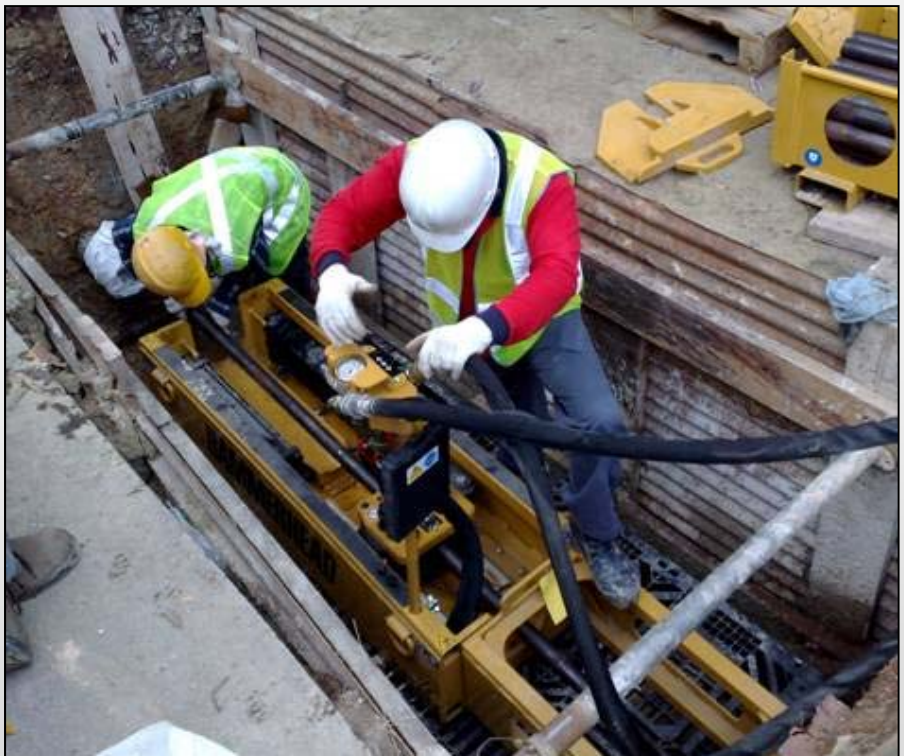
- 180mm Hydrant Main Replacement
- 100m Long
- 1.5m Deep
- Location - Singapore 

- Starting at 9:00AM
- 50 ton static pipe bursting
- Machine pit prepared the day before with concrete pit base



New pipe insertion pit

Replacement took 9 hours from morning start to hydrant fully re-commissioned for service



Example 2:

- 100% Upsizing Replacement (250mm cast iron to 500mm HDPE)
- 400m Long
- 3m Deep
- Location – White Rock, British Colombia, Canada  

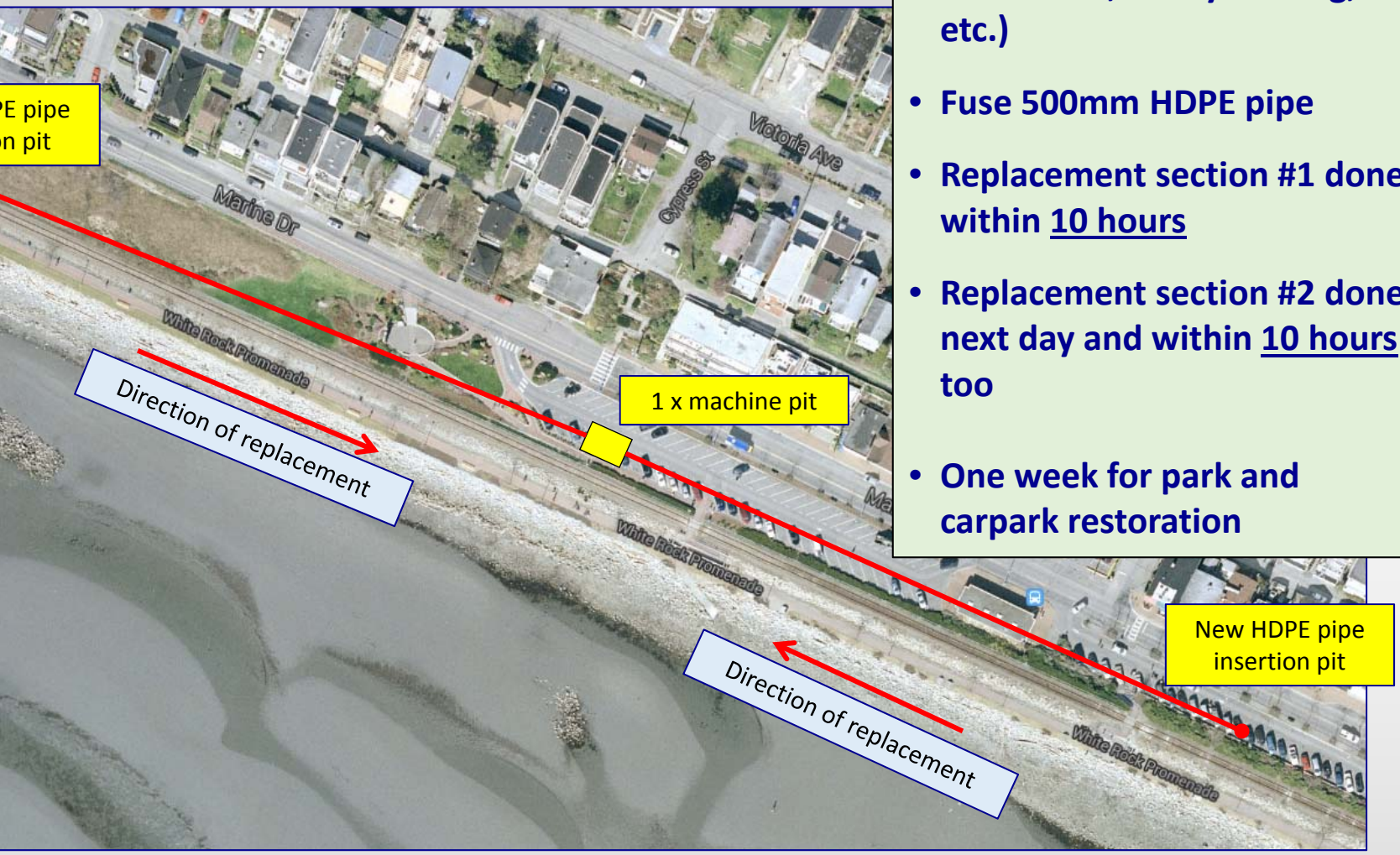
White Rock, British Columbia, Canada
upsize 10” cast iron water drain to 20” HDPE pipe

Static Bursting Machine

Bursting Head

Rigid Pull Rod

New 20” HDPE Replacement Pipe



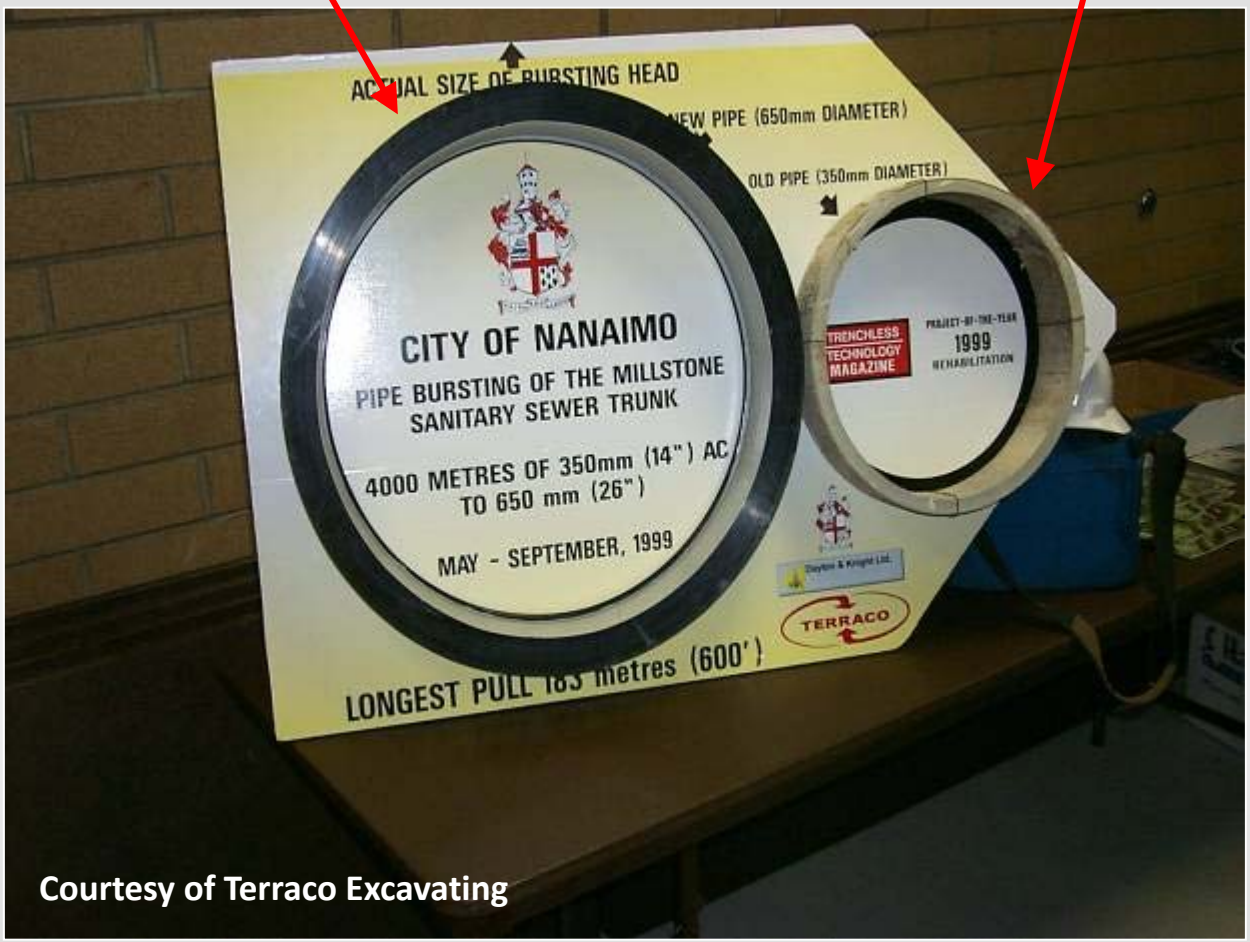
- **Site preparation – 1 week (pits excavation, safety shoring, etc.)**
- **Fuse 500mm HDPE pipe**
- **Replacement section #1 done within 10 hours**
- **Replacement section #2 done next day and within 10 hours too**
- **One week for park and carpark restoration**

Example 3:

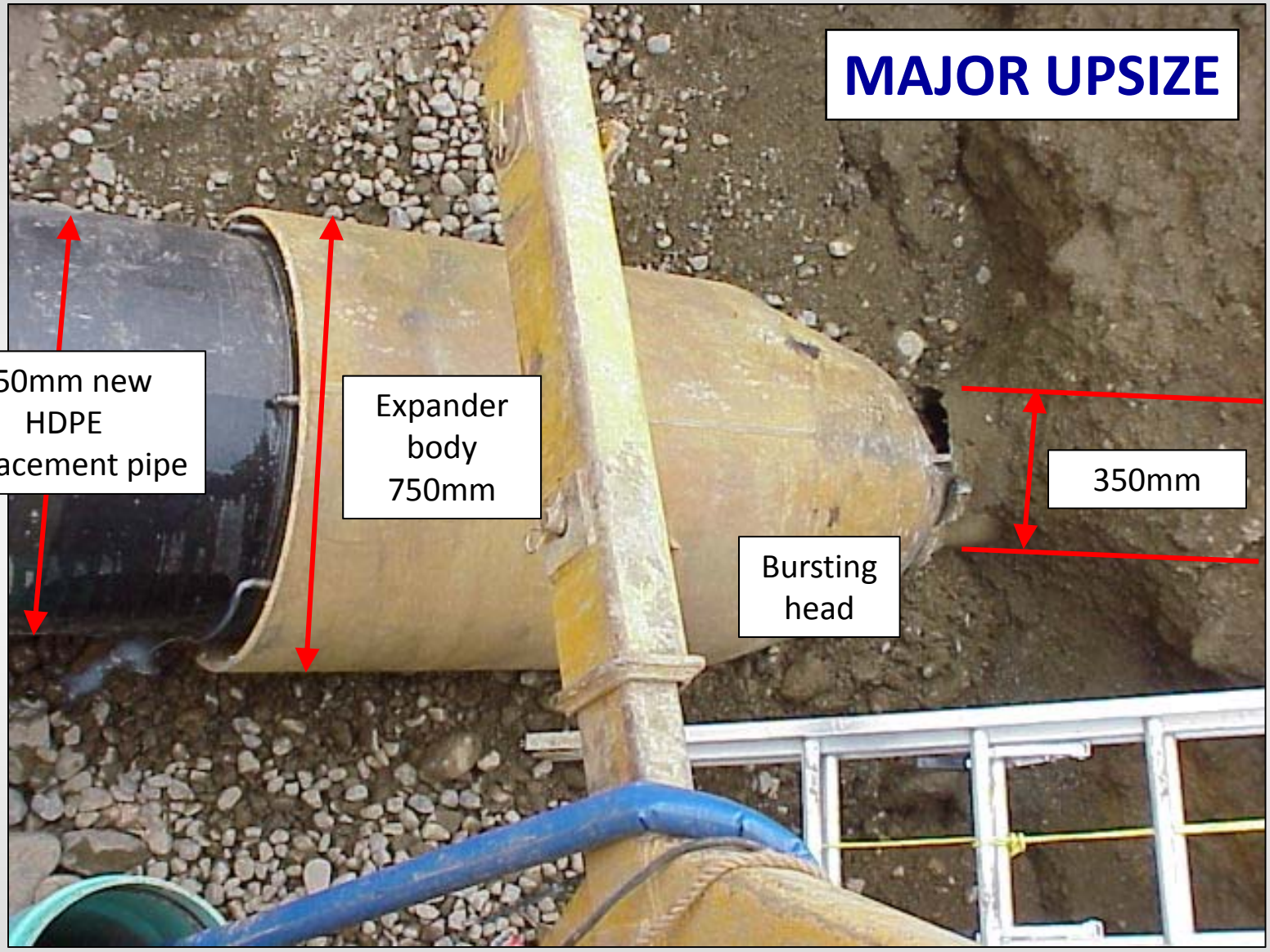
- >150% Upsizing Replacement (350mm Asbestos Cement to 630mm HDPE)
- 4,000m Long
- 2.5m to 4m Deep
- Location – Nanaimo, British Colombia, Canada  

To New 650mm HDPE Pipe

From 350mm AC Pipe



Courtesy of Terraco Excavating


MAJOR UPSIZE
50mm new
HDPE
acement pipe
Expander
body
750mm
350mm
Bursting
head

High capacity static pipe bursting machine required engineered shoring and maintained dry at all times

Pit face treatment required for critical projects

Sure this is going to work?????

Host pipe 350mm to 650mm new HDPE pipe replacement with 750mm diameter bursting head…..POSSIBLE????

Sure this is going to work?????

Nanaimo, British Colombia, Canada
350mm to 630mm Sewer Replacement Project

1999 NASTT Rehabilitation Project of the Year

2000 ISTT International Project of the Year

atic Pipe Bursting

pe Bursting Force Simulation
ogram.

Dr. Samuel Ariaratnam

University of Alberta, Canada

Trenchless Replacement
Systems

Pipe Parameters

d_{oe} =	203.2	mm	8	in	outside diameter of existing pipe		
d_{ie} =	254	mm	10	in	inside diameter of existing pipe		
t_e =	-25.4	mm	thickness of existing pipe				
σ_1 =	20	MPa	material strength or existing pipe				
			(concrete - possible reinforced class 2)				
d_{on} =	381	mm	15.00	in	outside diameter of new pipe		
d_{in} =	304.8	mm	12.00	in	inside diameter of new pipe		
t_n =	38.1	mm	thickness of new pipe		Pipe Wt. lbs/ft =		10.00
γ_p =	14.33	kN/m³	unit weight of new pipe			SDR	17
Head Parameters							
θ_h =	25	°	bursting head angle				
d_{oh} =	457.2	mm	18	in	outside diamete of bursting head		
L_{os} =	38.1	mm	oversize of bursting head to new pipe diameter (one side)				
Soil Parameters							
γ_1 =	15.7	kN/m³	soil unit weight	1.6	g/cm³	(from Terzaghi)	
D_{ave} =	3.7	m	12	ft			
Universal Parameters							
π =	3.14						
μ_{sp} =	0.1		polymer lubricant				
Empirical Factors							
f_{bl} =	0.3		breaking length factor				
f_{nb} =	24	breaks	number of breaking pieces factor				
			15	° angle pieces			
			24	number of pieces			
f_{scl} =	1		soil compression limit factor				
Correction Factors							
C_f =	1.0						
C_b =	1.0						
C_{sc} =	1.0						

Data	Length	Pulling Force	Friction Force				
			C_f	$F_f = \mu_{sp} F_n$			
					μ_{sp}	$F_n = P_s S_{pn} + W_{pn}$	
	L_p						$P_s = \Sigma \gamma_i h_i$
Feet	(m)	(kN)		(kN)		(kN)	(kN/m²)
300	91.5	997.2	1.0	633.9	0.1	6338.8	57.4

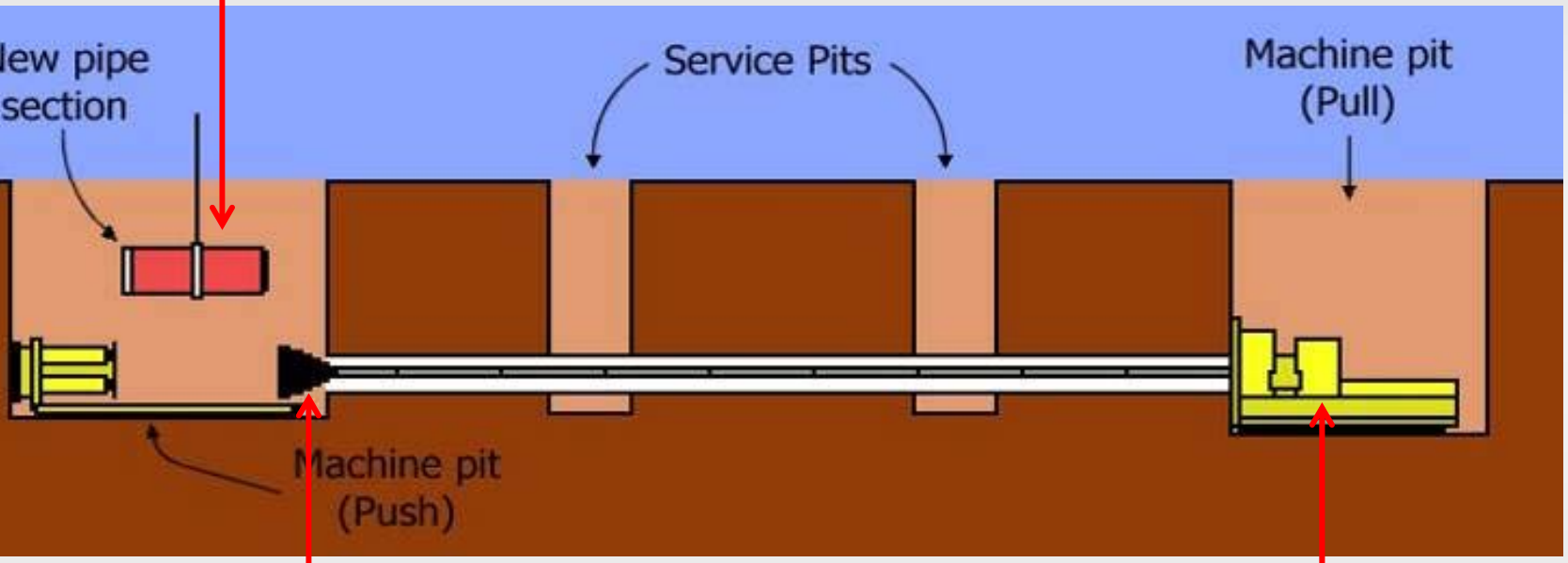
Pulling Force =	997.22	224,185	**Pound Force**
		102	**Tons**

PIPE BURSTING METHODS

- Pneumatic Pipe Bursting
- Static Pull Pipe Bursting
- **Static Pull Pipe Bursting – Segmented Pipe Installation**

egmented Pipe Installation

egment pipe – concrete,
lay, GRP, etc. used



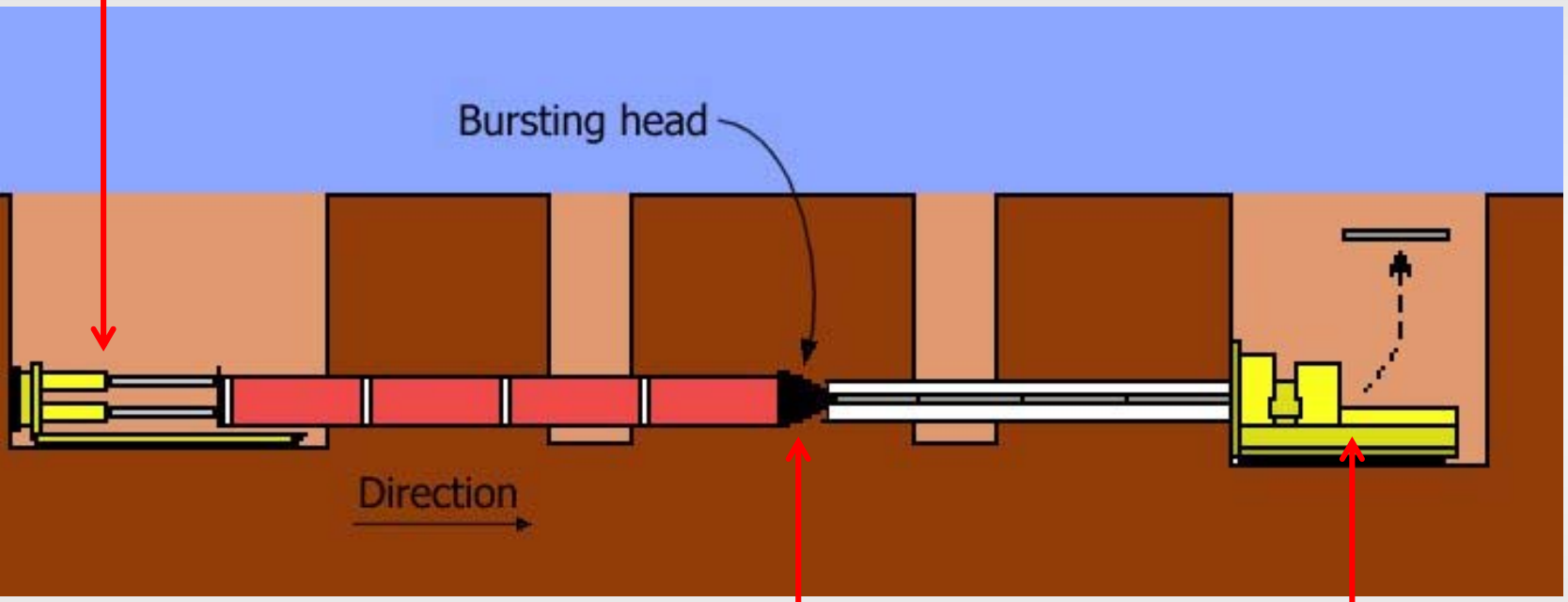
Bursting head not attaching new HDPE replacement pipe

Static pipe bursting machine

Bursting for fracturing host pipe and opening new tunnel for incoming replacement pipe

egmented Pipe Installation

cking frame insert segmented
pe behind bursting head



Burst head fractures host pipe, push broken pieces into surrounding ground and creating new tunnel

Static machine pulls bursting head towards machine pit

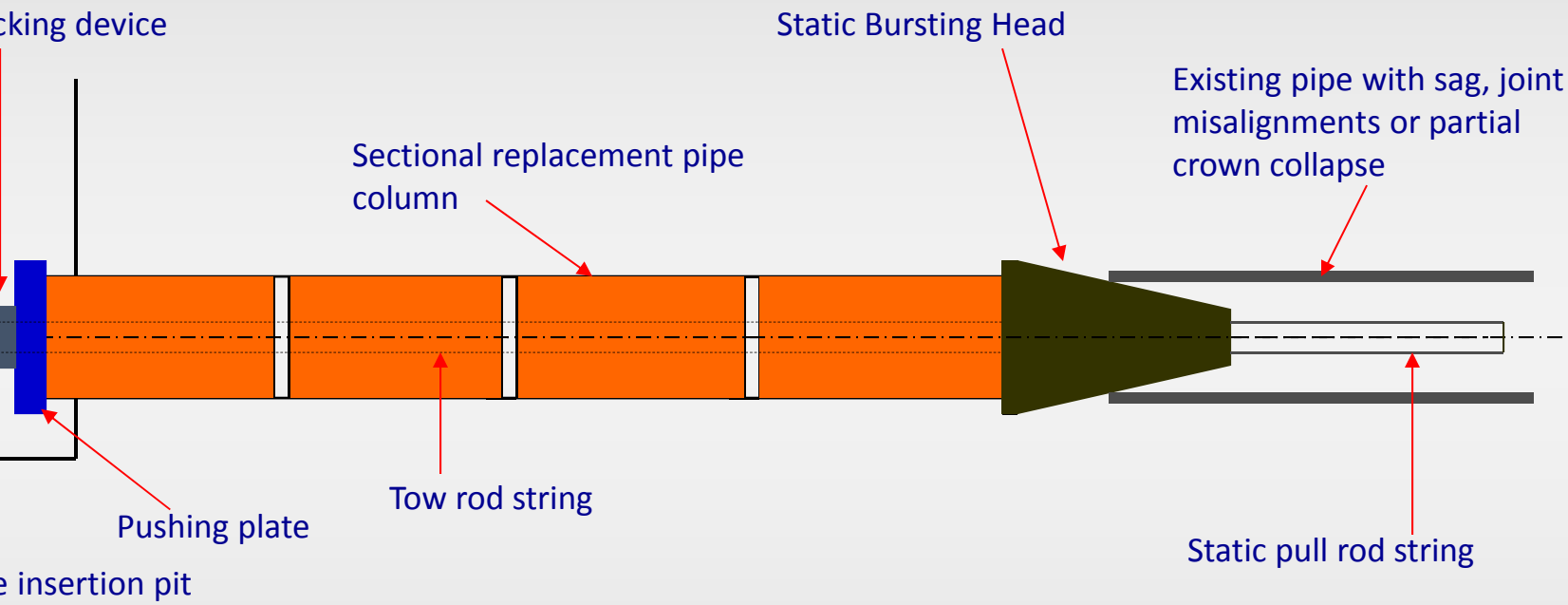
eonix, Arizona 26” clay pipe replacement project

Pushing Head

New Segmented
Vitrified Clay Pipe

Pushing or
Jacking Frame

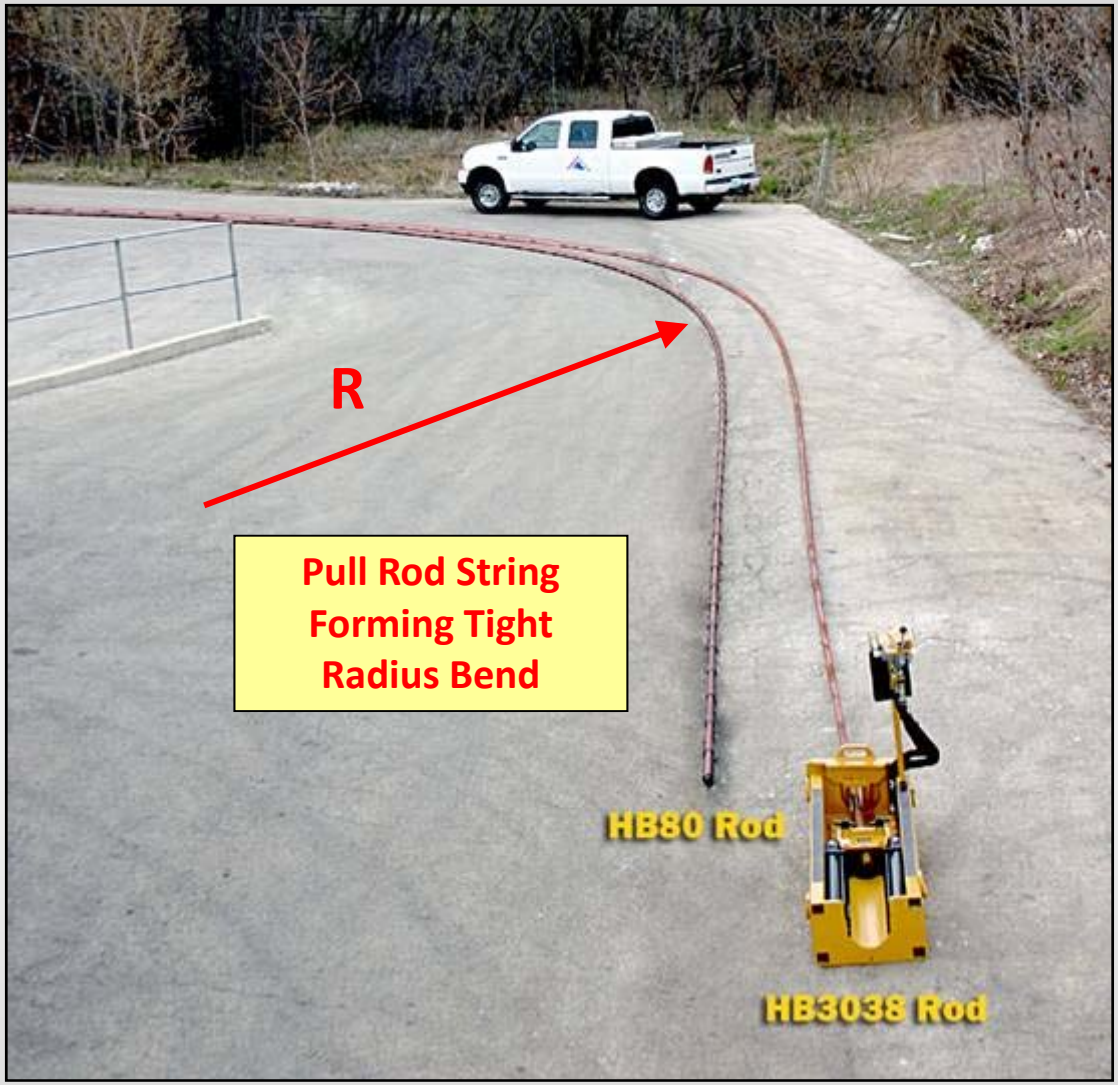
G CORRECTIONS



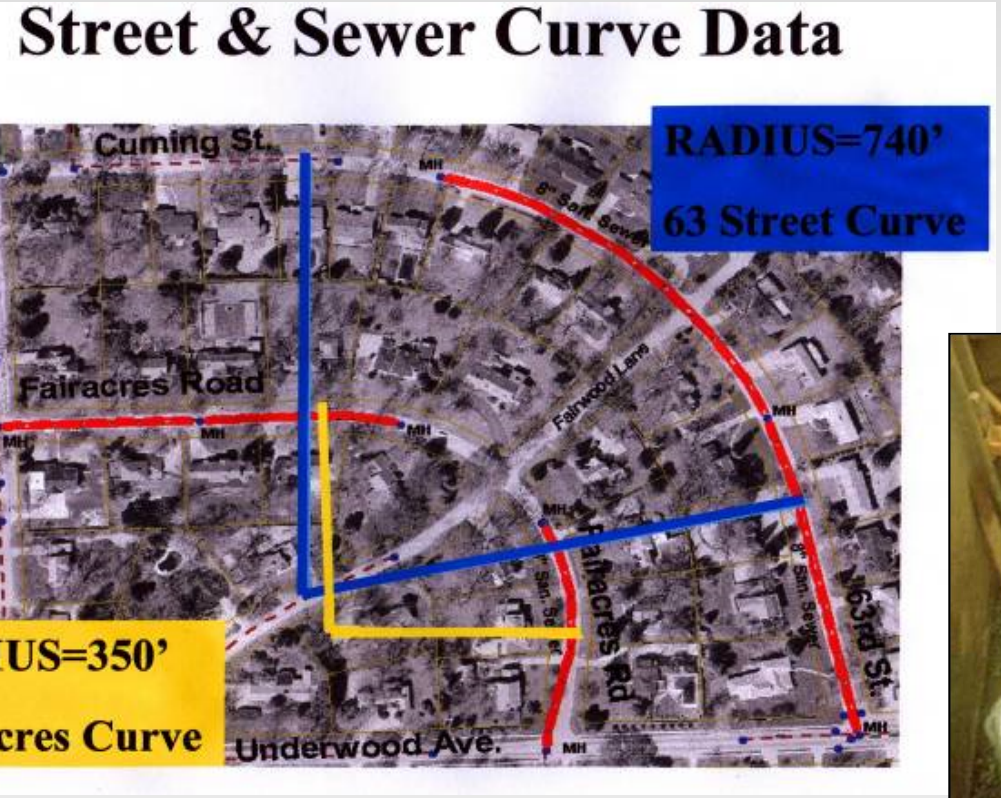
New sectional pipes pushing face to face creates new pipe column maintaining on-axis replacement and correcting sags and joint misalignment(s) in existing pipeline

PIPE BURSTING METHODS

- Pneumatic Pipe Bursting
- Static Pull Pipe Bursting
- Static Pull Pipe Bursting – Segmented Pipe Installation
- **Static Pipe Bursting – Curved Sewer**


R
Pull Rod String
Forming Tight
Radius Bend
HB80 Rod
HB3038 Rod

tic Pipe Bursting – Curved Sewer



8" Concrete Pipe Replaced with New 8" VCP Pipe

, Nebraska sewer replacement

PIPE BURSTING METHODS

- Pneumatic Pipe Bursting
- Static Pull Pipe Bursting
- Static Pull Pipe Bursting – Segmented Pipe Installation
- Static Pipe Bursting – Curved Sewer
- **Pneumatic Air Impactors**

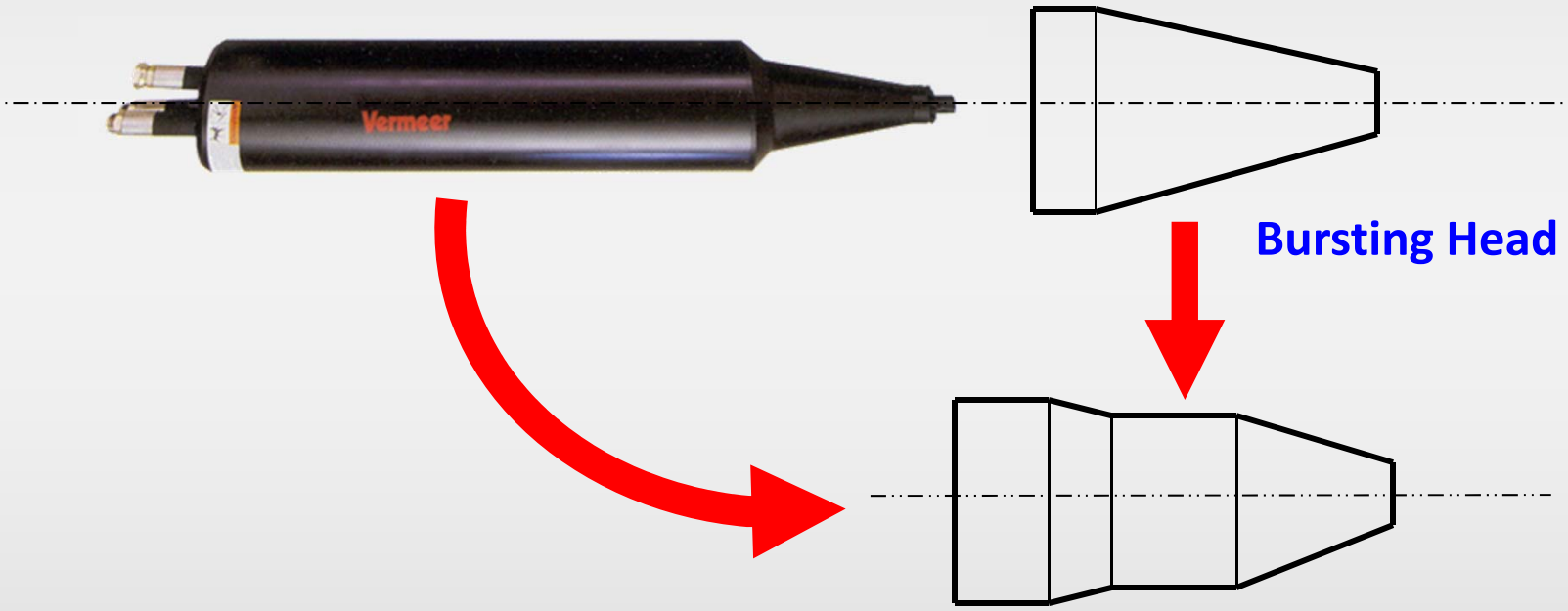
Impactor Pipe Bursting System

erging Horizontal Directional Drilling and Pipe Bursting

- **Simplify the pipe bursting process**
- **Reduce excavation**

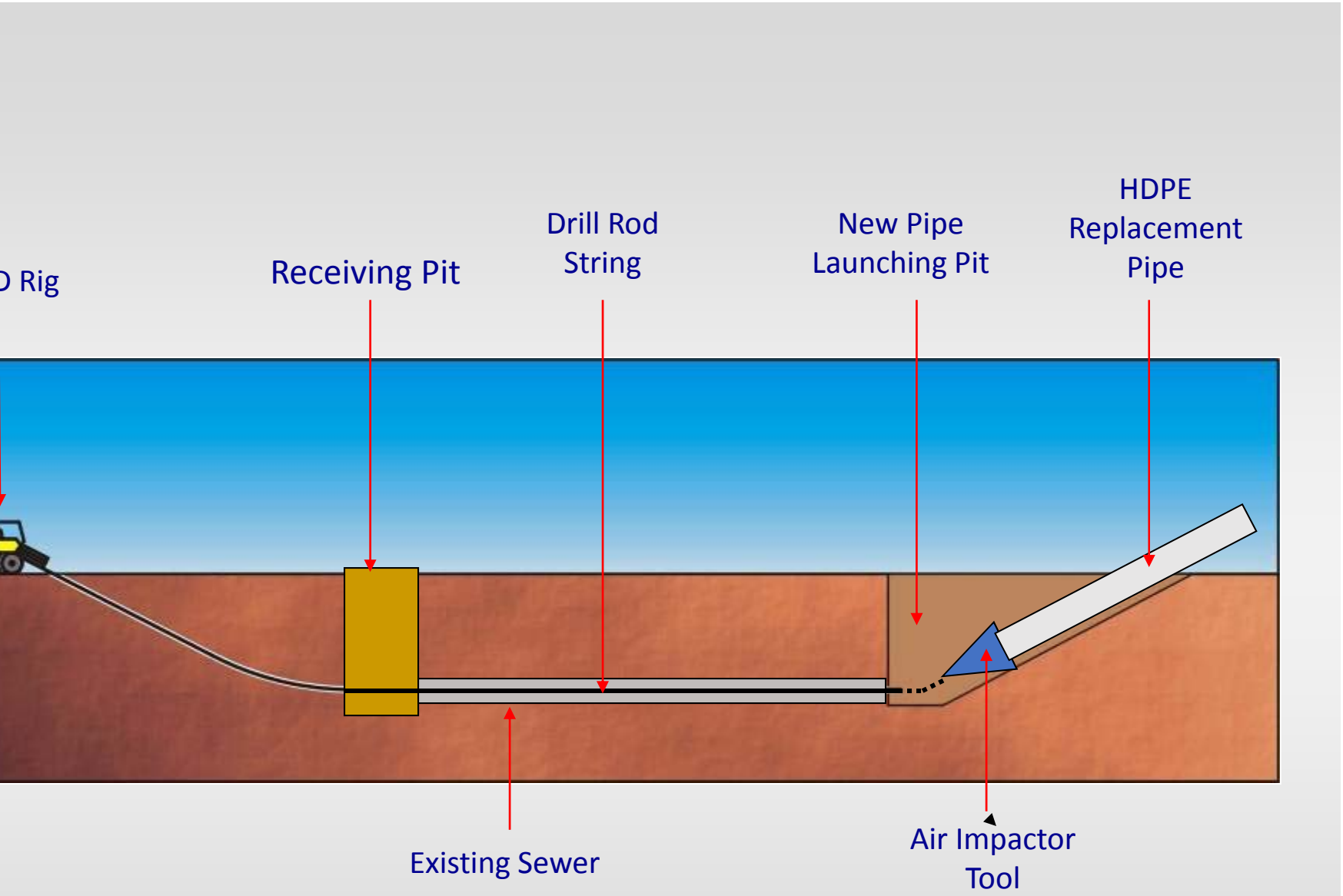
PICAL PNEUMATIC BURSTING TOOL vs. AIR IMPACTOR

Pneumatic Pipe Bursting –
pneumatic tool and bursting head



Air Impactor –
Pneumatic tool incorporated inside bursting head

Impactor (video)



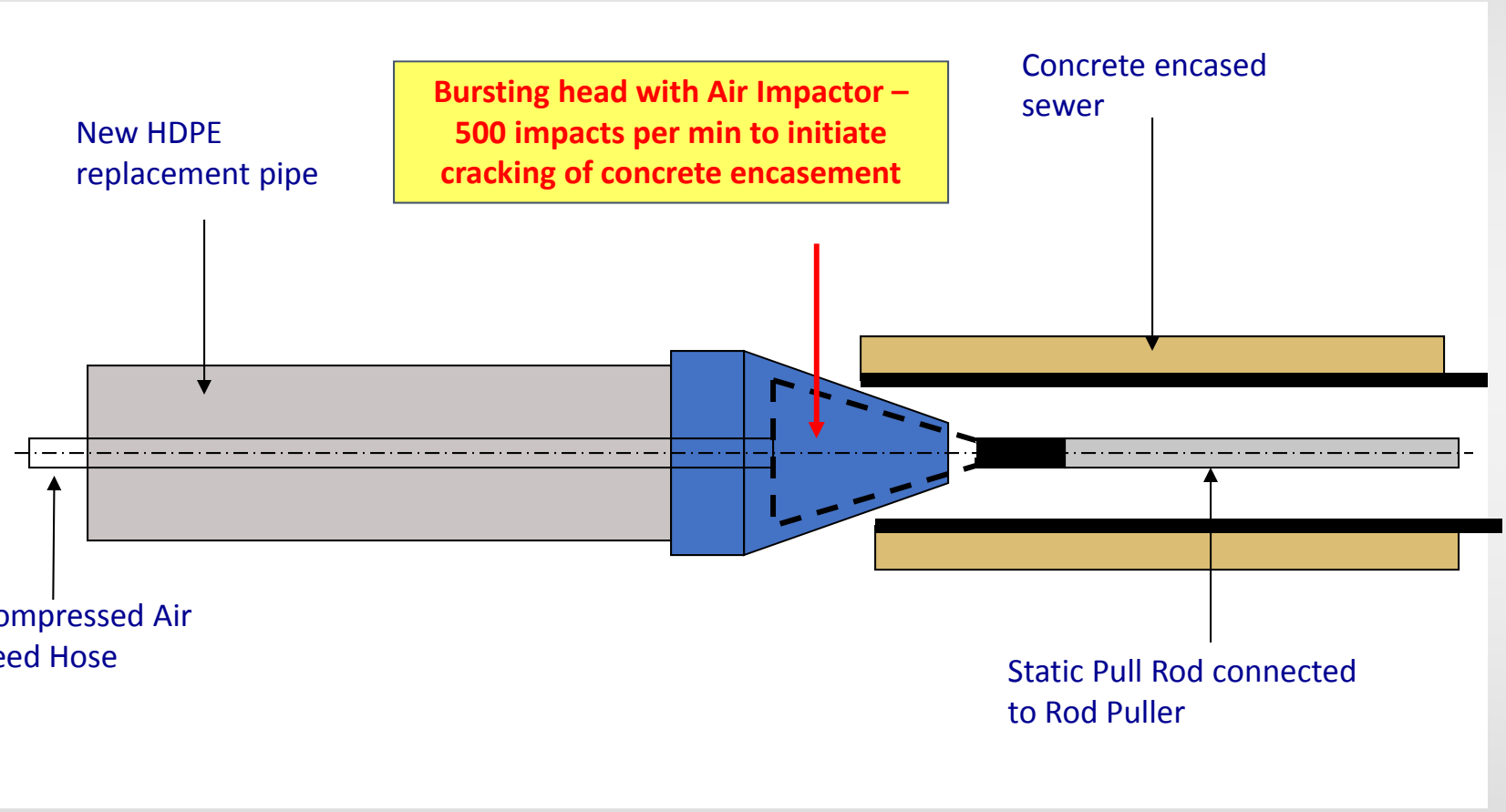
SEGMENTED CLAY

300mm Air Impactor Burst, replacement exiting 300mm sewer between to houses just 2.4m apart.

PIPE BURSTING METHODS

- Pneumatic Pipe Bursting
- Static Pull Pipe Bursting
- Static Pull Pipe Bursting – Segmented Pipe Installation
- Static Pipe Bursting – Curved Sewer
- Pneumatic Air Impactors
- **Air Impactor Static Pipe Bursting**

e Bursting Concrete Encased Sewer using Rear d Air Impactor



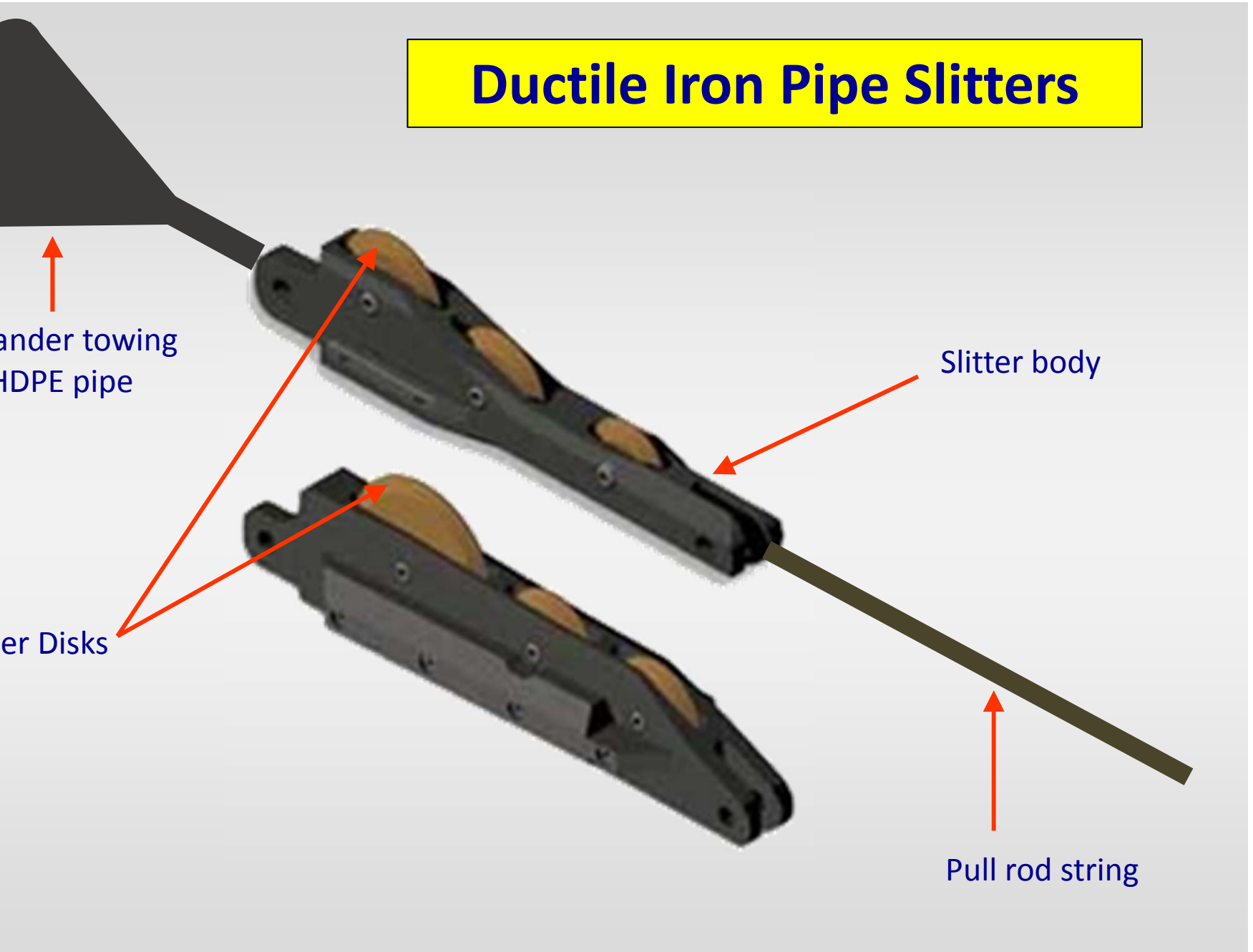
Bursting head driven by Air Impactor and guided by static pull machine


Impactor
Smart Hammer Technology

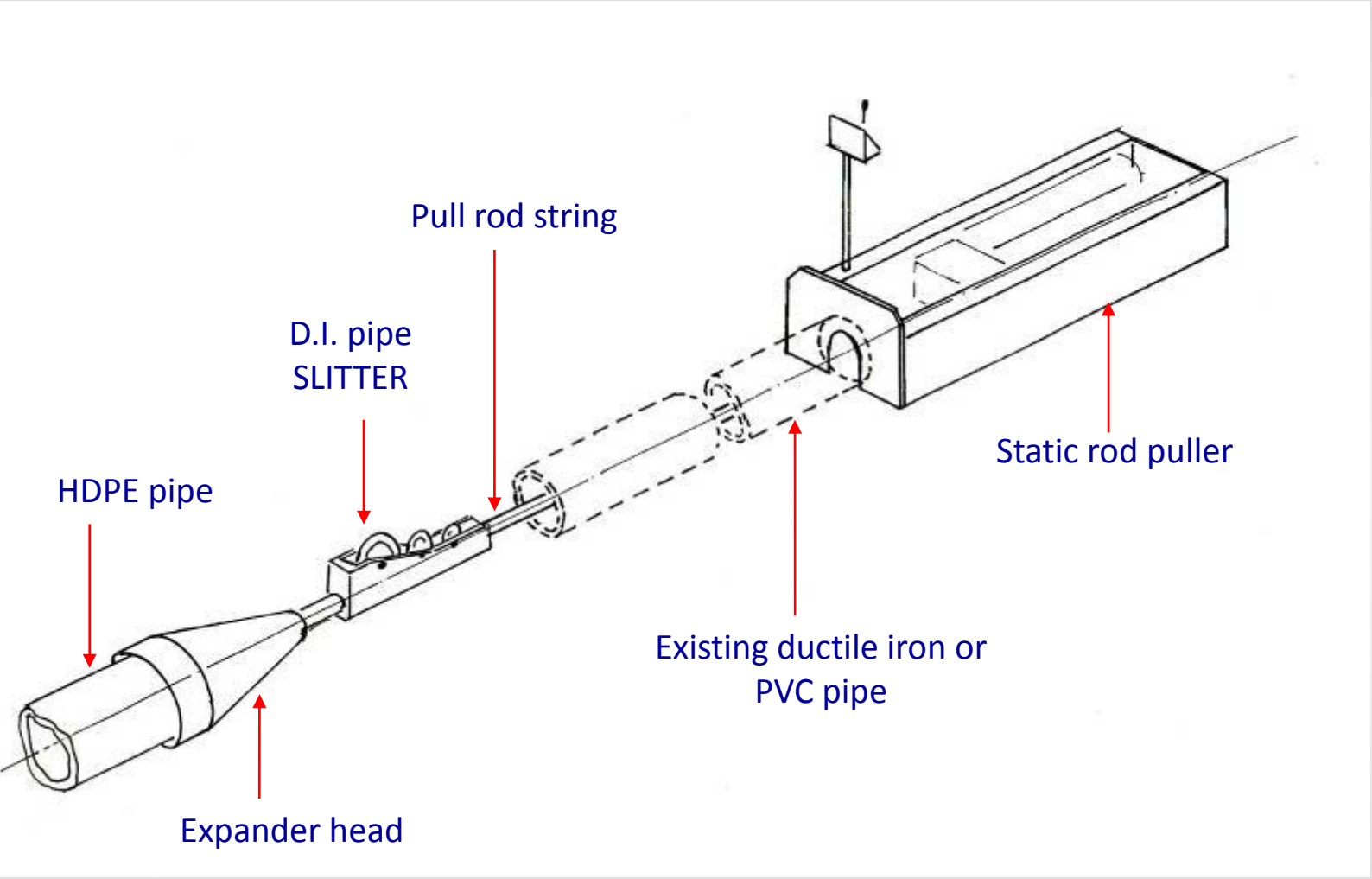
REPLACING STEEL PIPELINES

- **Ductile Iron Pipe Splitting**

Ductile Iron Pipe Slitters



ctile Iron Pipe Slitters



e Slitting Ductile Iron Water Main & Clamp (video)

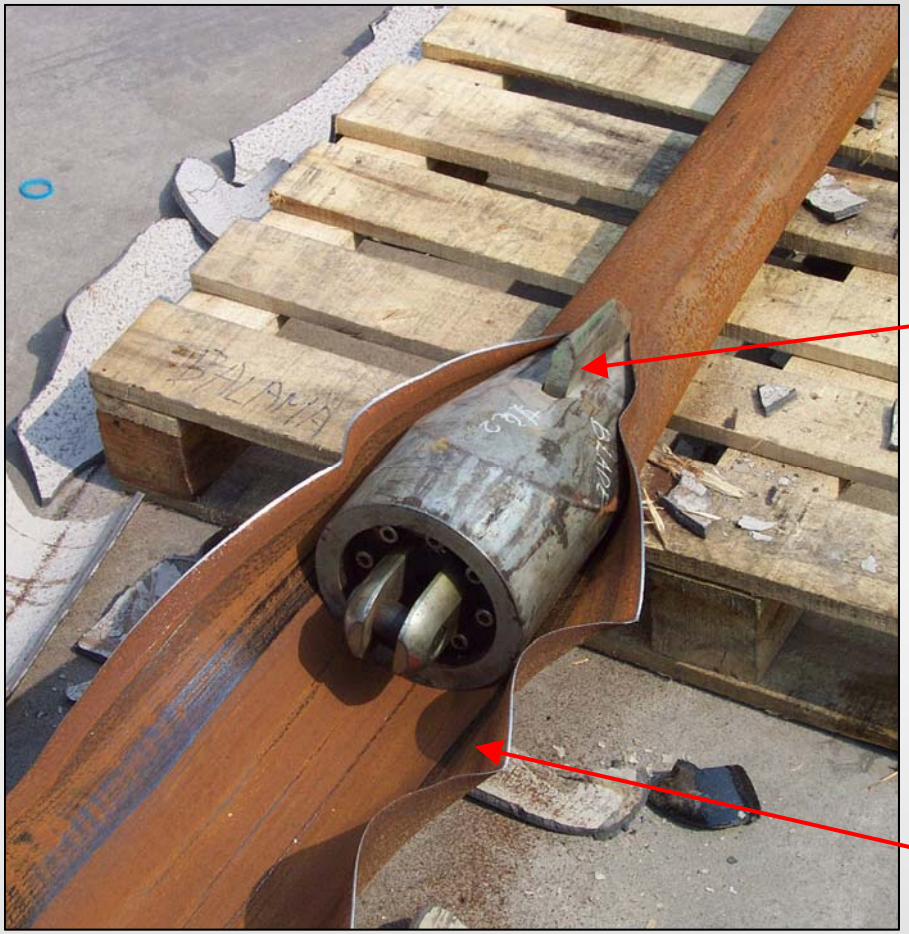
REPLACING STEEL PIPELINES

- Ductile Iron Pipe Splitting
- **Steel Pipe Slitting**

PE SLITTING REPLACEMENT METHODS

- Ductile Iron Pipe Splitting
- **Steel Pipe Slitting**

eel Pipe Slitting



Fixed Blade Slitting Tool

Replacement Pipe Attached To Back Of Slitting Tool

Slitting 6”(150mm) Steel Pipe with Expander (video)

WATER MAIN REPLACEMENT BY STATIC PIPE BURSTING

Pre-Chlorinated Coiled HDPE pipe

HDPE pipe delivered to secured yard

HDPE pipe connected to common manifold

Chemical dosage station

Chemical stay in pipe for 12 hours follow by de-chlorination process

Deliver treated HDPE pipe to site

Replace existing pipe with pre-chlorinated HDPE pipe by static pipe bursting method


Daniel

xample:

Large diameter sewer replacement

Pneumatic Burst

600mm concrete replace with 600mm HDPE

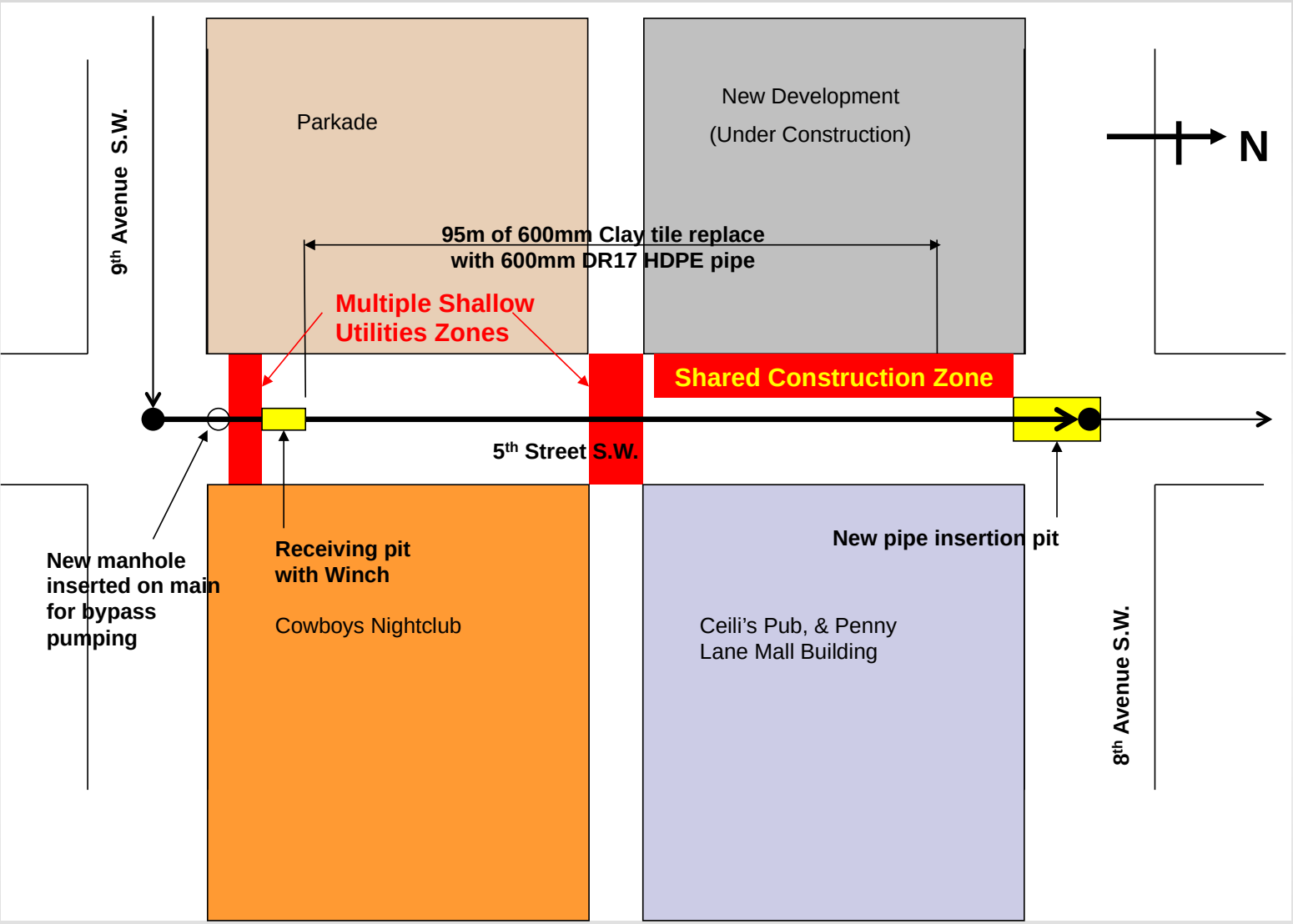
6m deep, 95m long

Location: Calgary, Alberta, Canada

Design Considerations

lgary Downtown - 5 Street SW

- Downtown Calgary
- Very deep, requires wide trench (if open cut)
- Very poor soil conditions (running pit run)
- Cracked and partial collapsed host pipe
- Utility congestion in middle of replacement
- Major traffic concerns
- Business congestion, pedestrian congestion
- Identified as a potential soil contaminated location


9th Avenue S.W.
Parkade
New Development
(Under Construction)
N
95m of 600mm Clay tile replace
with 600mm DR17 HDPE pipe
Multiple Shallow
Utilities Zones
Shared Construction Zone
5th Street S.W.
New manhole
inserted on main
for bypass
pumping
Receiving pit
with Winch
Cowboys Nightclub
New pipe insertion pit
Ceili's Pub, & Penny
Lane Mall Building
8th Avenue S.W.

Poor soil conditions

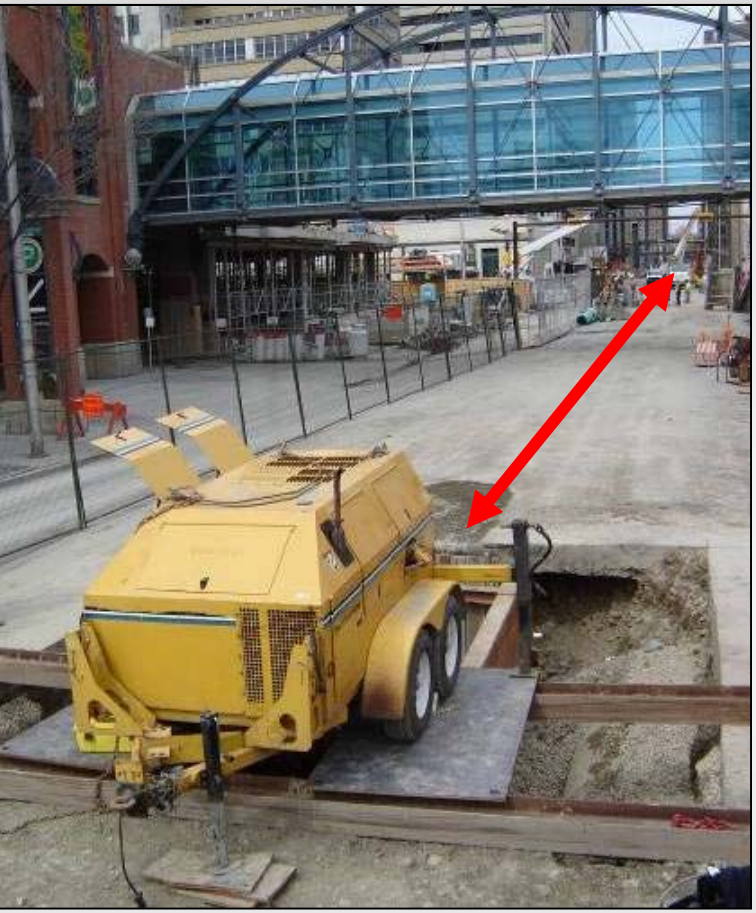
C-Train
Power Line

Assembling 500mm diameter pneumatic tool and bursting head

Look at the size of that burst head….

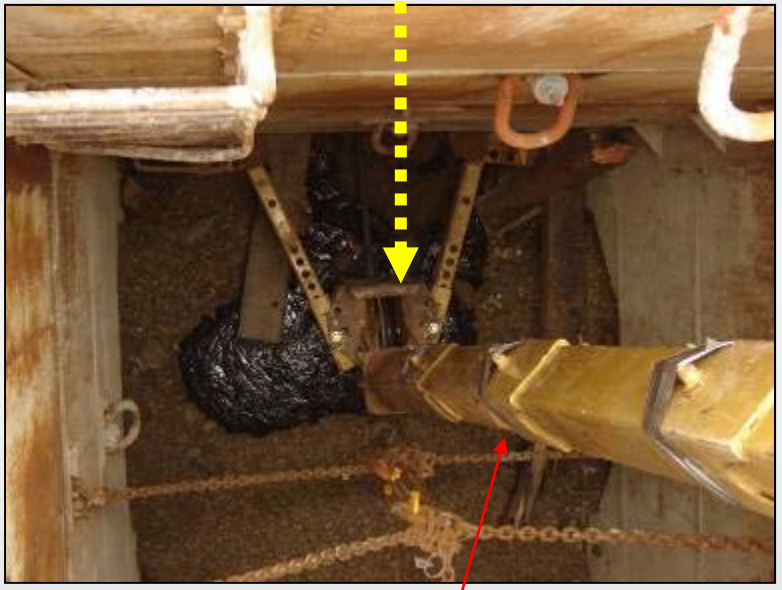
Bolting down burst head onto new HDPE replacement pipe

Supply air hoses and lubricating hoses installed inside replacement



nstant tension cable guide winch over pulling pit. Red line indicates pipe bursting path

Yellow line indicates cable path from insertion pit to winch pit



Down leg braced against shoring box

oving new replacement pipe to insertion pit location

Challenging site condition…

Oiler control station – supplies lubricated compressed air to activate pneumatic hammer

Crew assembling supply air hoses to oiler control station

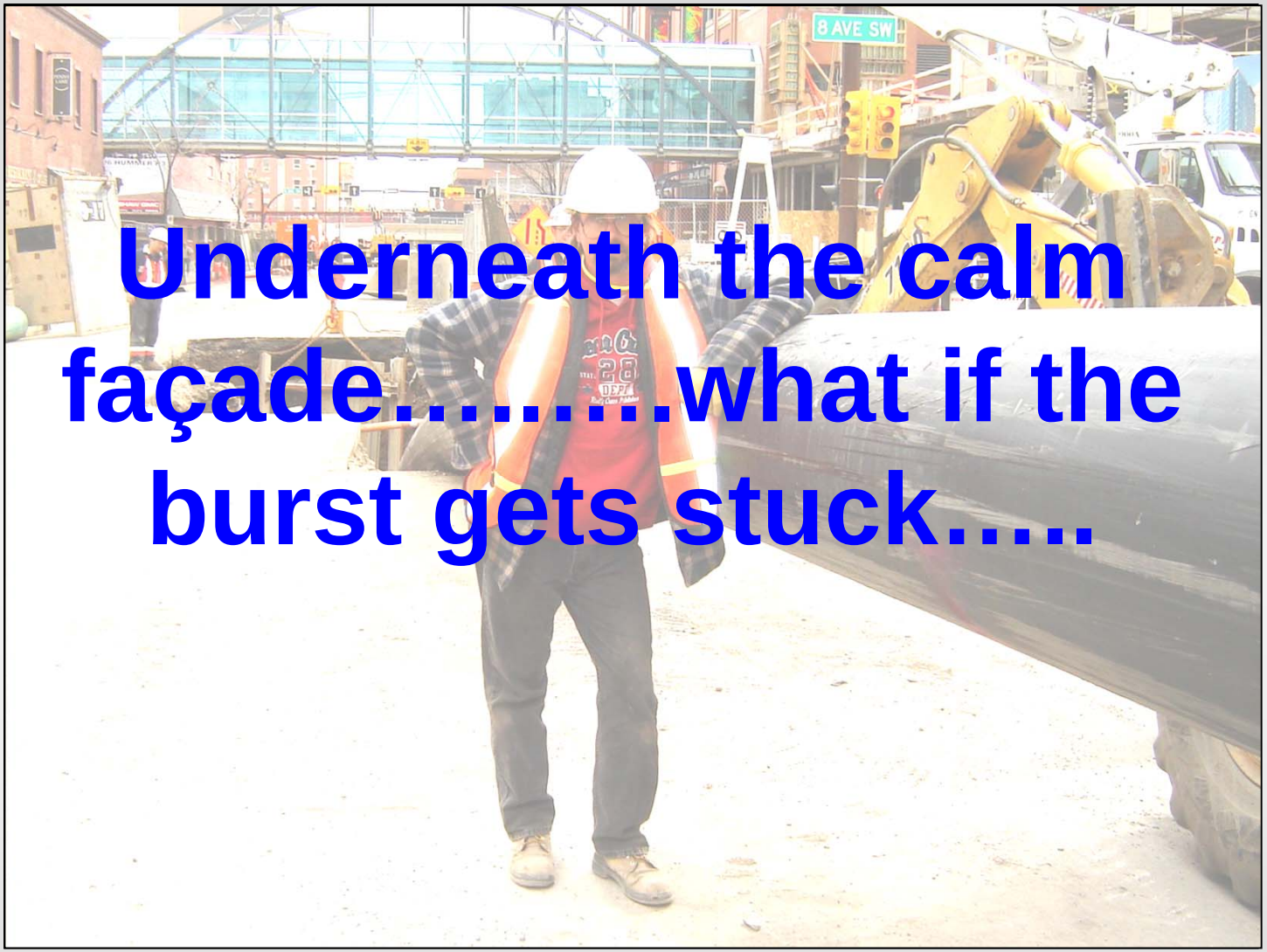
Lubricant mixing tank and delivery pump

Checking lubricant quality and flow before pipe bursting

Lubrication feed line inside replacement pipe

ated supply air hoses delivers compressed air
ctivate tool to propel bursting head through
t pipe

During bursting operation, constant tension maintains directional stability to advancing burst head



Underneath the calm façade……..what if the burst gets stuck…..

re-Design

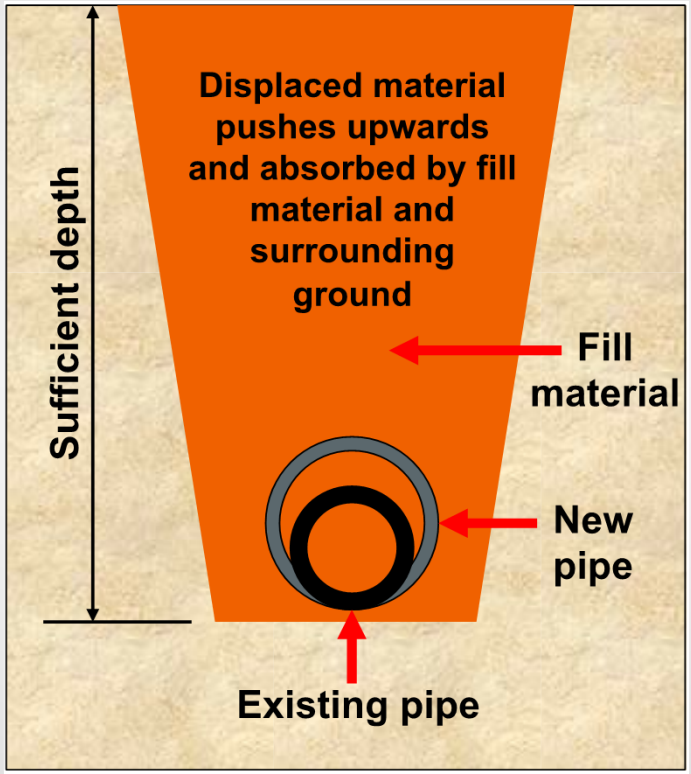
- Soil Displacement
- Upsizing Considerations
- Type of Existing Pipe
- Existing Ground Conditions
- Product Pipe
- Utility Locates

oil Displacement During Pipe Bursting

- Volumetric displacement of fragmented pipe and ground material will occur during pipe bursting process
- Good to know how much material being displaced
- WHERE DID THEY ALL GO?

heaval ? – Example 1, 25% upsizing

No Surface Heave

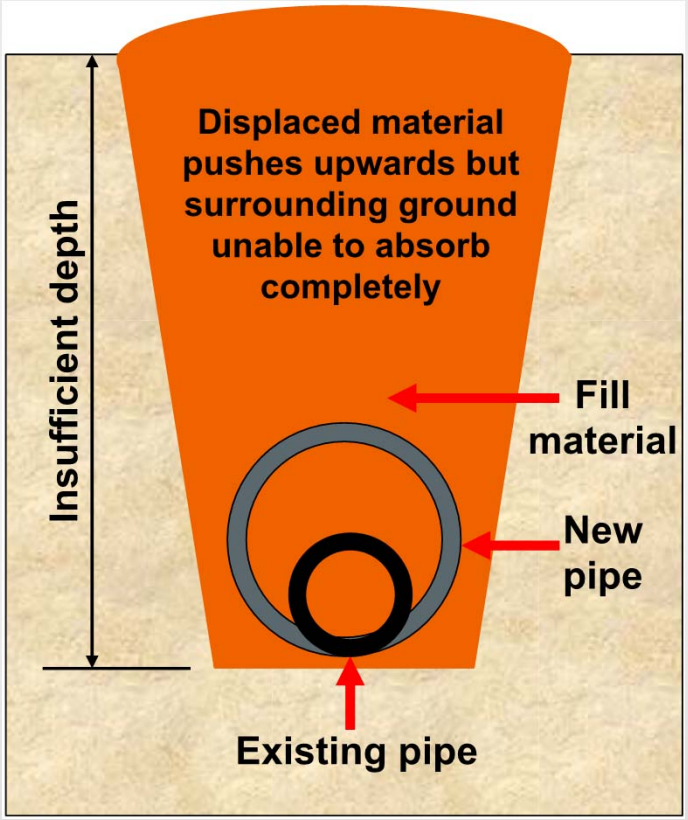


- Sufficient Cover
- Small volumetric soil displacement
- Minimum or no upheaval

Existing pie

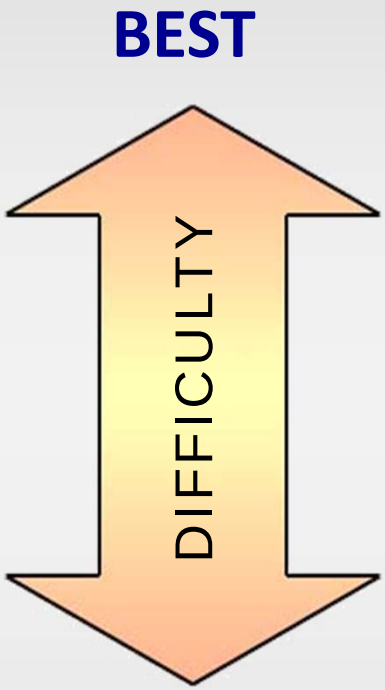
PHEAVAL ? – Example 2, 150% upsizing

Surface Heaved



- Insufficient Cover
- Large volumetric soil displacement
- Tendency for surface heave

xisting Ground Conditions



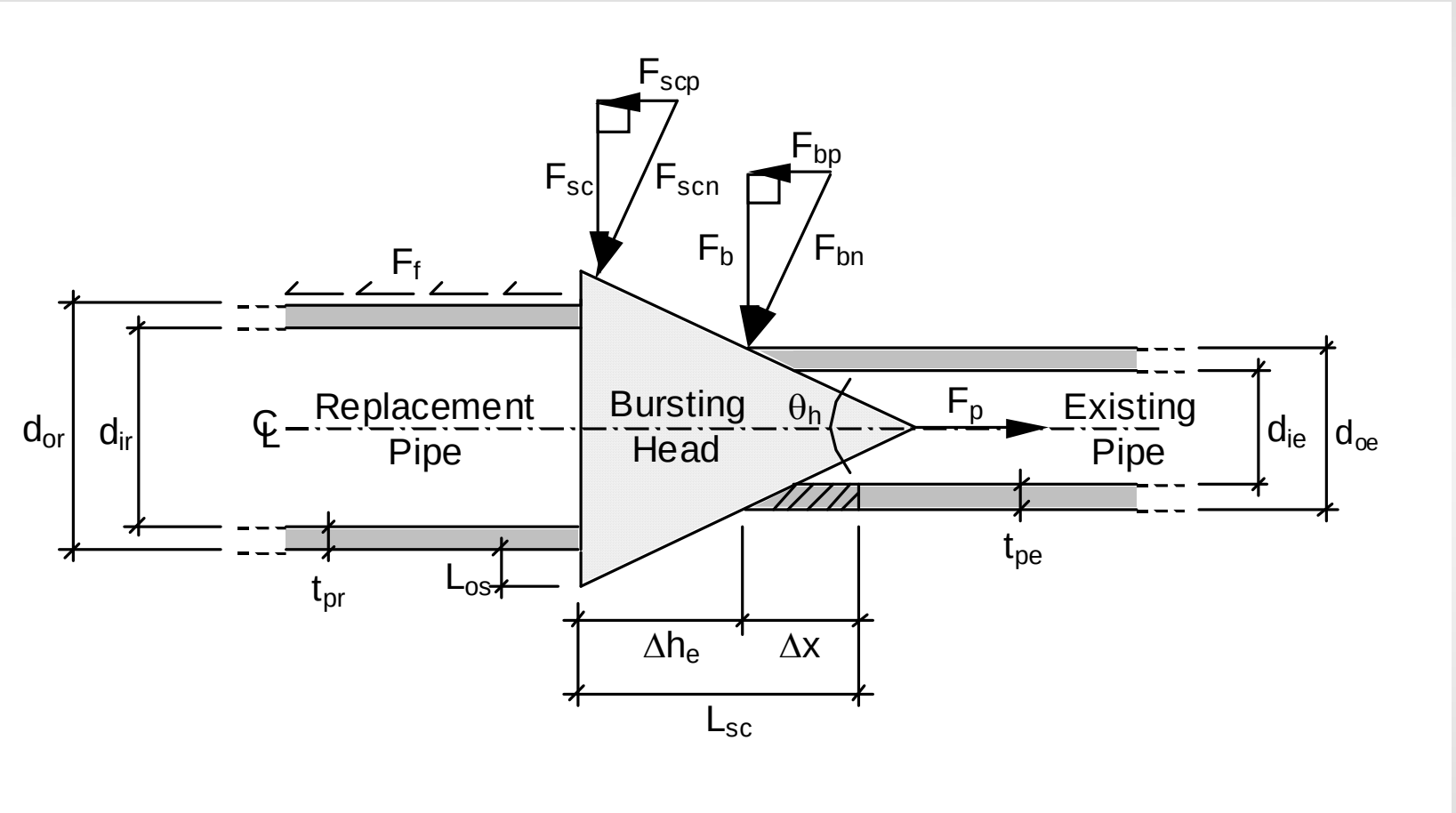
- Original backfill
- Expandable clay
- Loose cobble
- Beach & running sand
- Densely compacted clay
- Sandstone

ipe Bursting Force

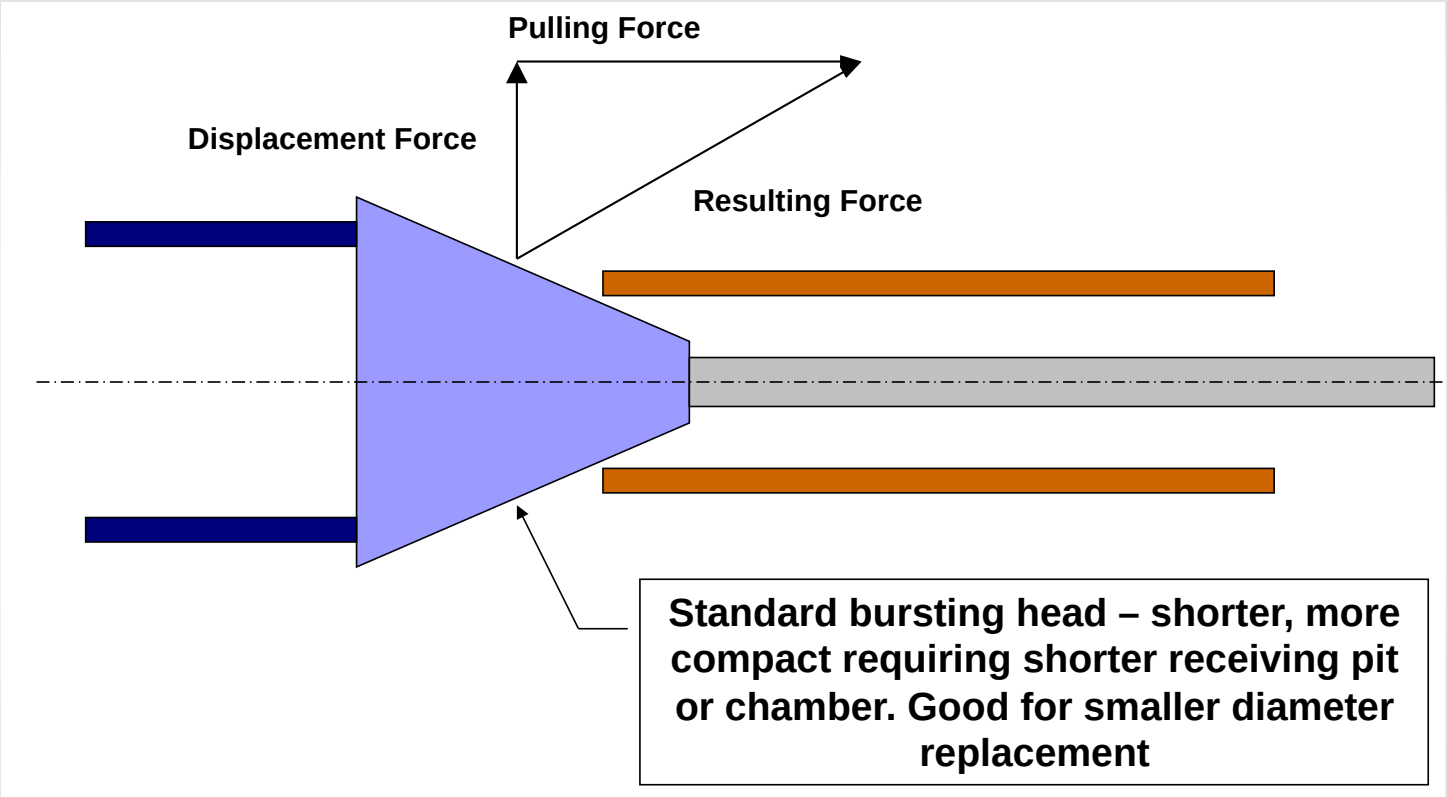
Pipe Bursting Equipment Selection)

- Four individual force components
  - Bursting Force
  - Friction Force
  - Soil Compression Force
  - Pipe Weight
  - Others

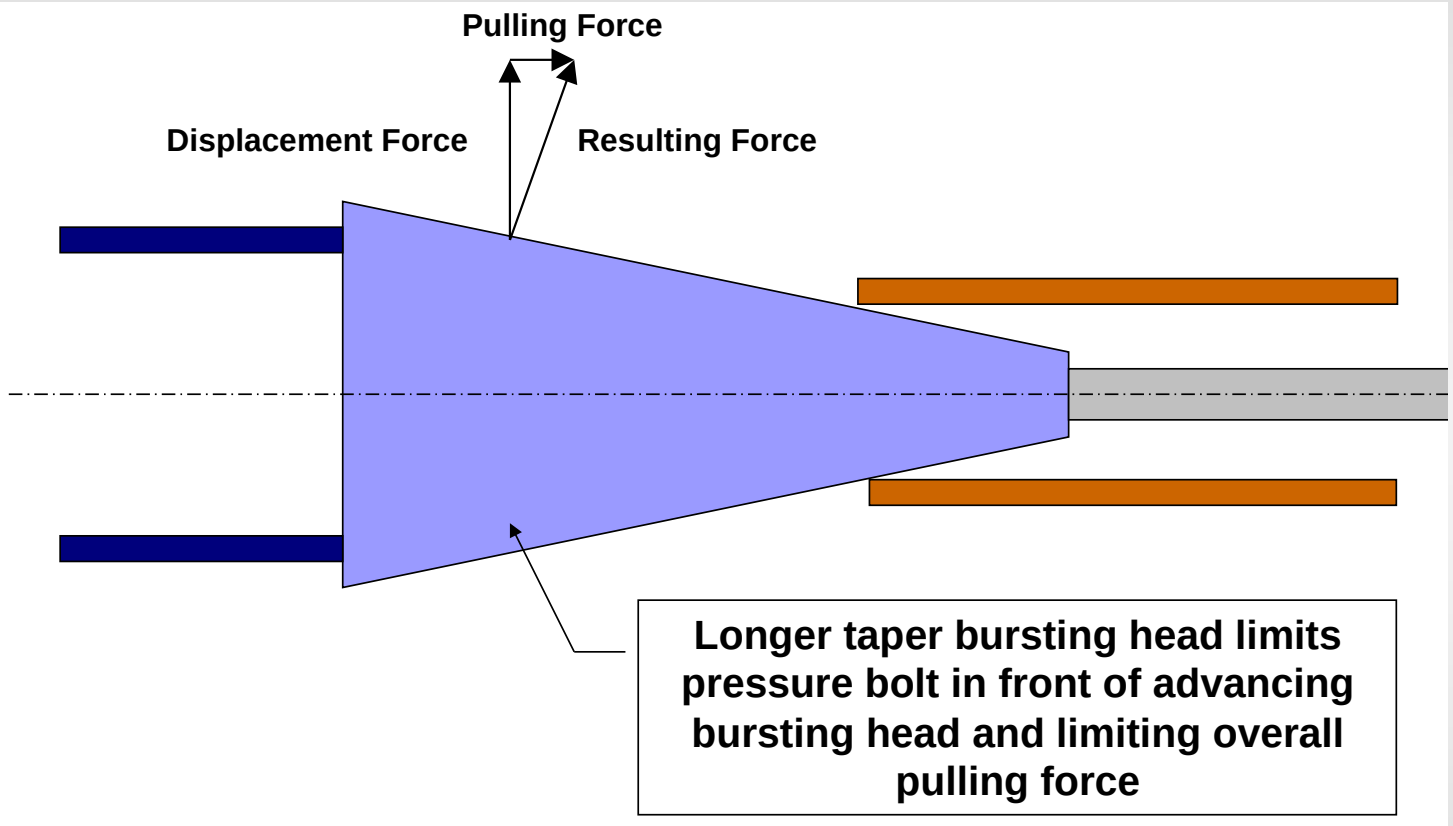
Force Diagram



rsting Head - General

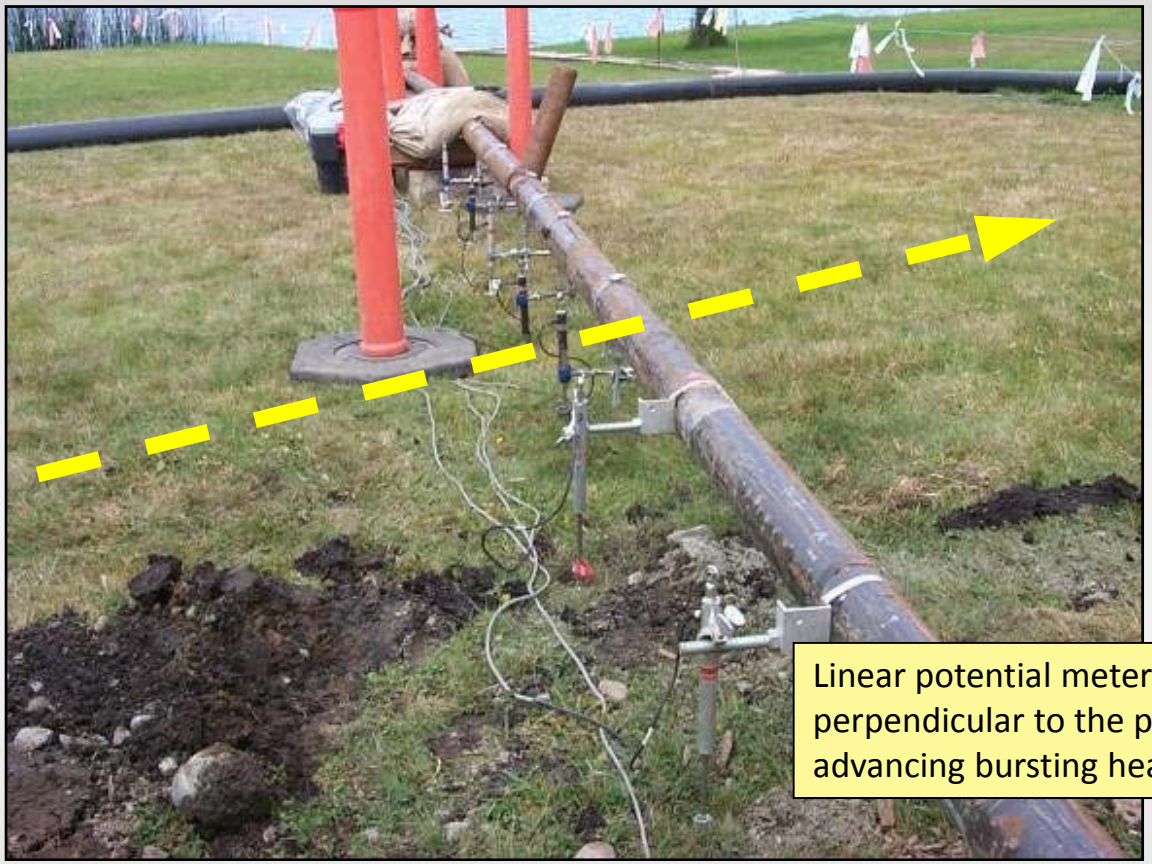


ursting Head – Critical Condition



SURFACE HEAVE

asuring Ground Upheaval

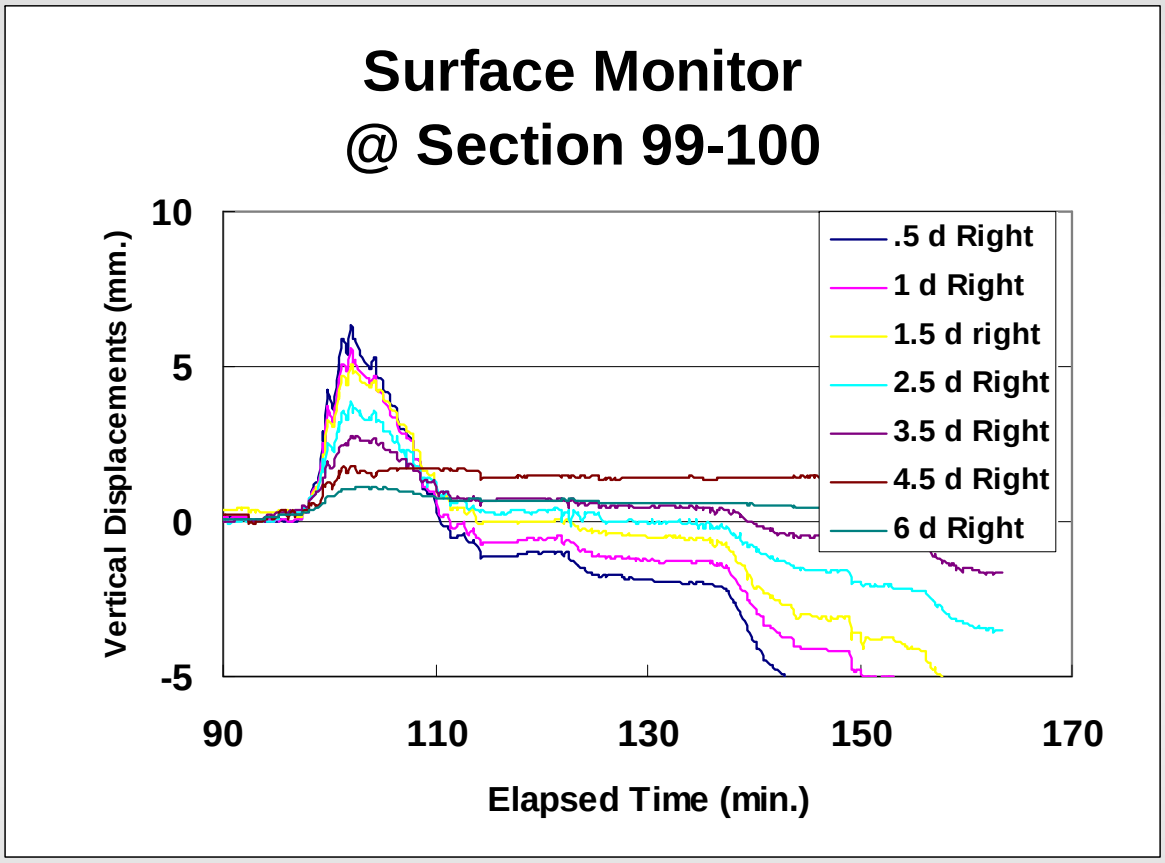


Linear Potential Meters used to measure ground surface up-heave effect during a major up-sizing replacement project

easuring Ground Upheaval

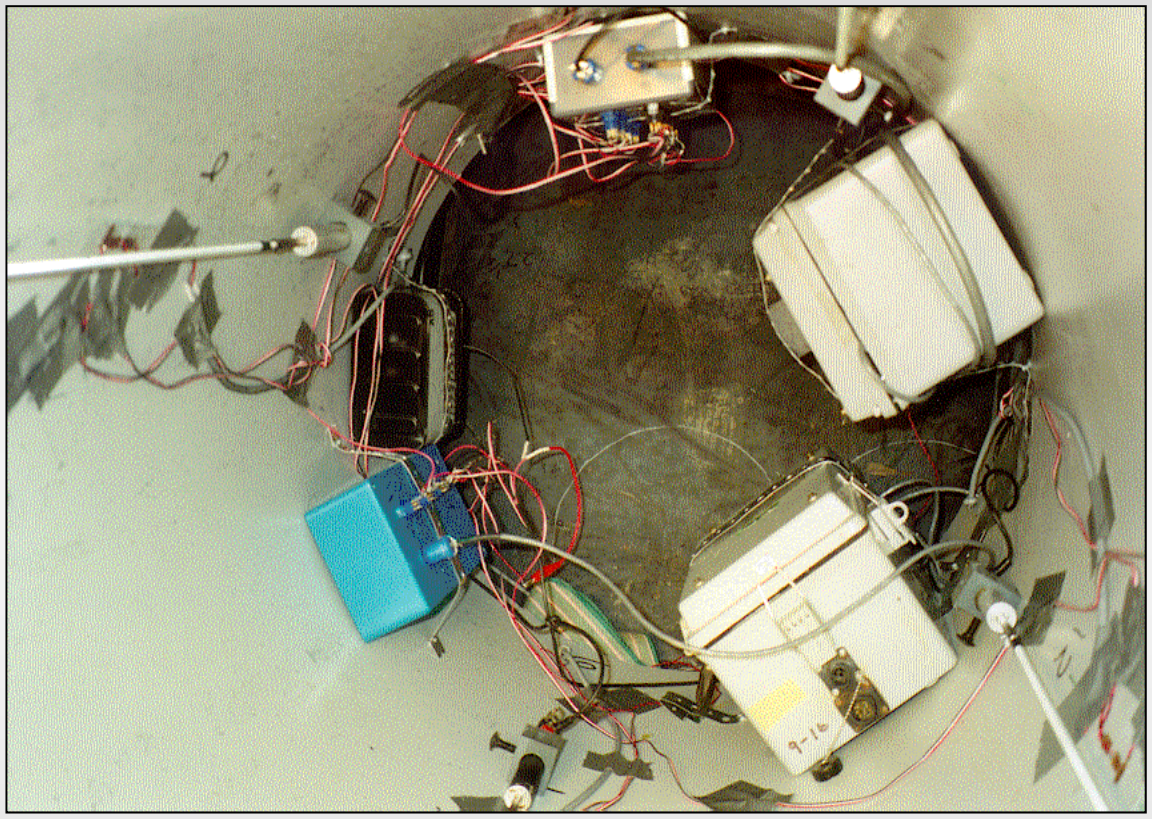
Linear Potentiometer

rface Up-heave Measurement –
0mm to 630mm upsizing



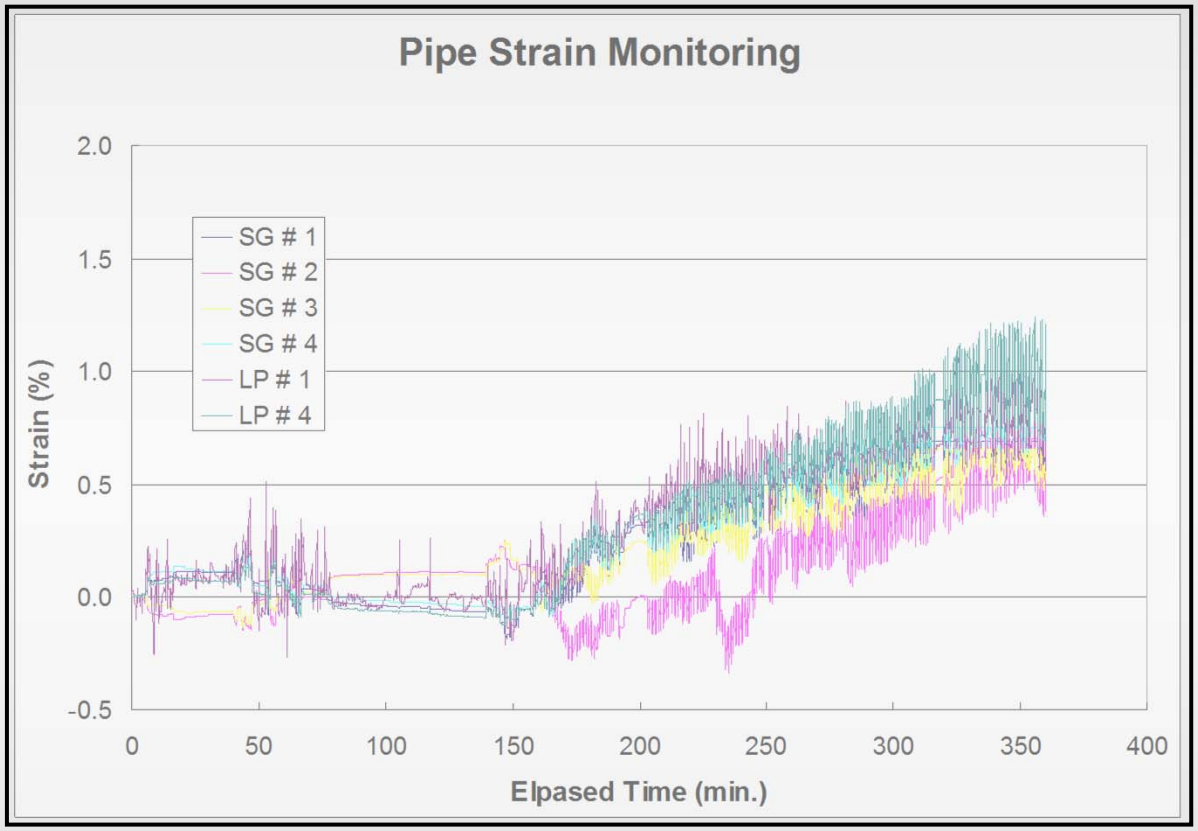
Measurement logged during an actual 14' to 28" major up-sizing replacement project, the depth-of-cover is approx. 10 feet and initial up-heave recorded = 7mm (0.276") and settled at neg. 5mm (neg. 0.25") after 2 ½ hours.

easuring HDPE Pipe Strain



Strain Gauges positioned inside HDPE pipe just behind the bursting head to measure pipe strain caused by possible elongation due to the static pulling action and pipe surface frictional drag forces

pe Strain Data – 350mm to 630mm
sizing, 2m deep



ata taken during an actual 14" to 28" up sizing replacement project, measured strain = 1.25% ccurring towards the end of replacement pull where maximum frictional drag forces are pected. Measured figures were later verified/confirmed in laboratory simulated test and is ell within manufacturer's specifications.

Project Planning

- Geometry of original pipe determines arrangement of pits and replacement sequence
- Most project planning occurs prior to bursting
- Replacement runs from manhole to manhole

Assign each man or team to specific task(s) and ensure they know exactly what their job descriptions are

AND

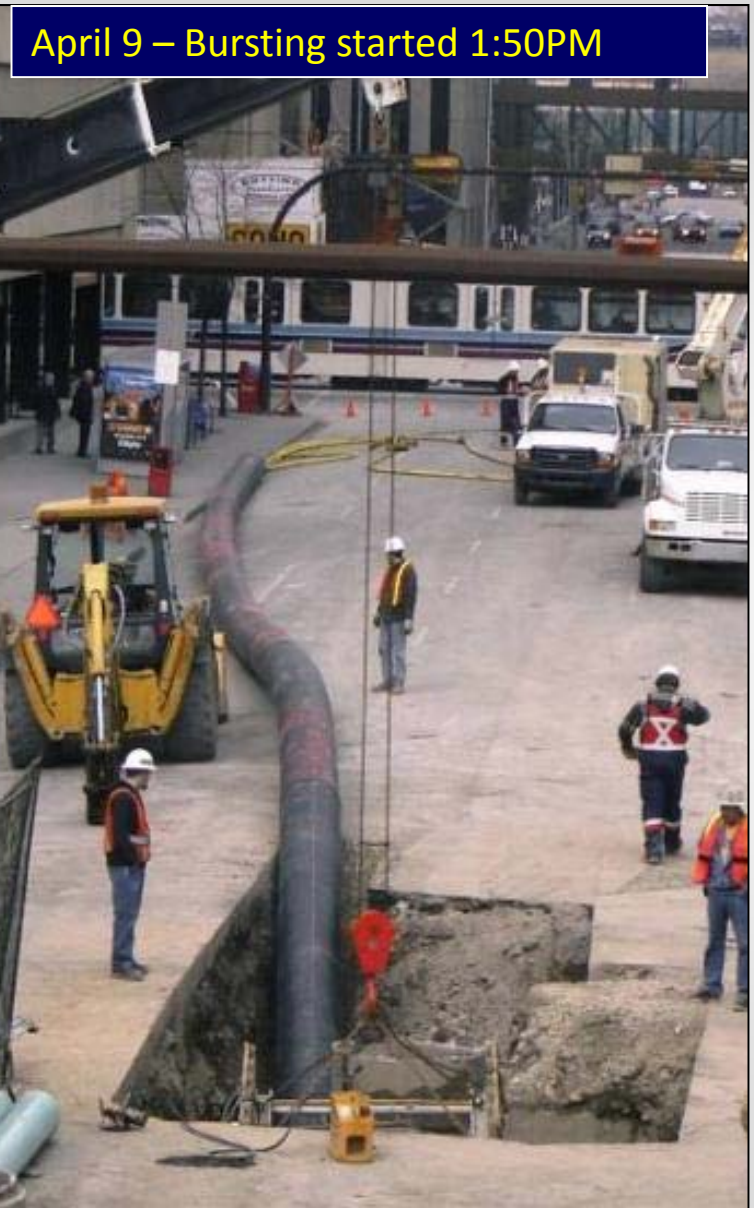
ESTABLISH EMERGENCY COMMUNICATIONS CHANNEL!

Theory and Method Explained & Crew Trained

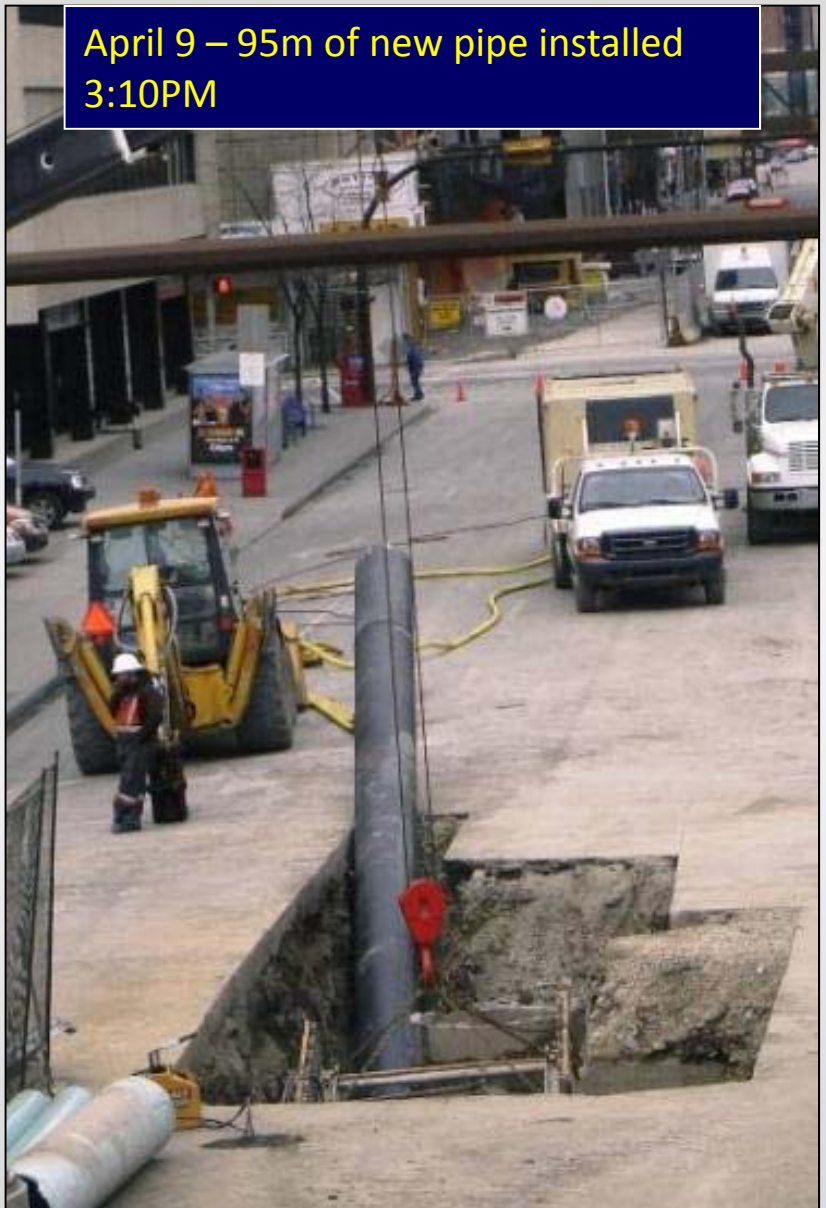
ALWAYS REMEMBER

Failure to Plan
Is
Planning to Fail

April 9 – Bursting started 1:50PM



April 9 – 95m of new pipe installed 3:10PM



April 6 – Winch pit and new pipe insertion pit excavations

Few days after the pipe bursting project……..

Successful?

3,000 Km – World Wide in 35 years….still going

* Market estimation..

THANK YOU

PASCO

Pipeline Assessment Services Company

China Hong Kong Society for Trenchless Technology