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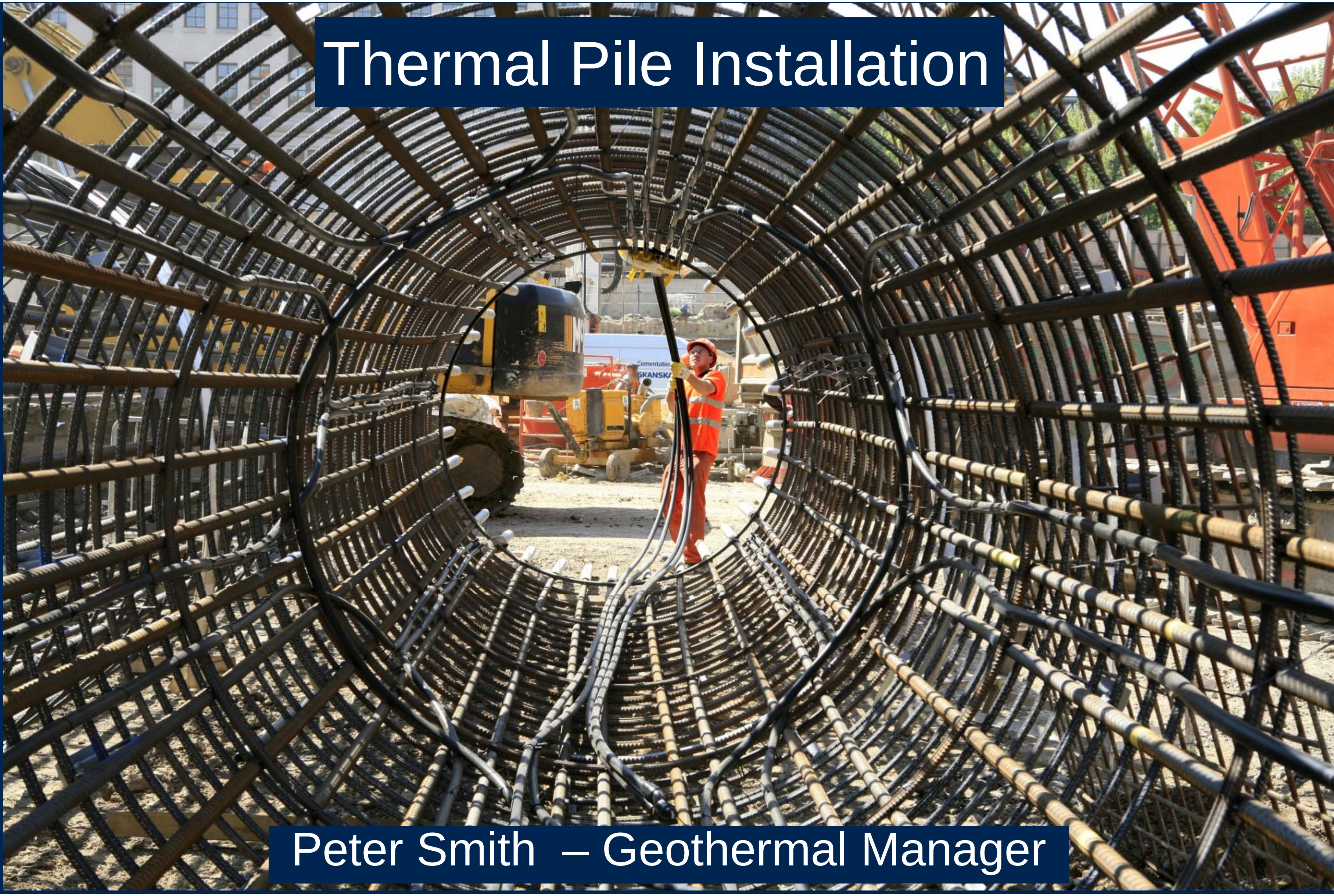
Thermal Pile Installation



Peter Smith – Geothermal Manager

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Thermal Pile Standard Overview

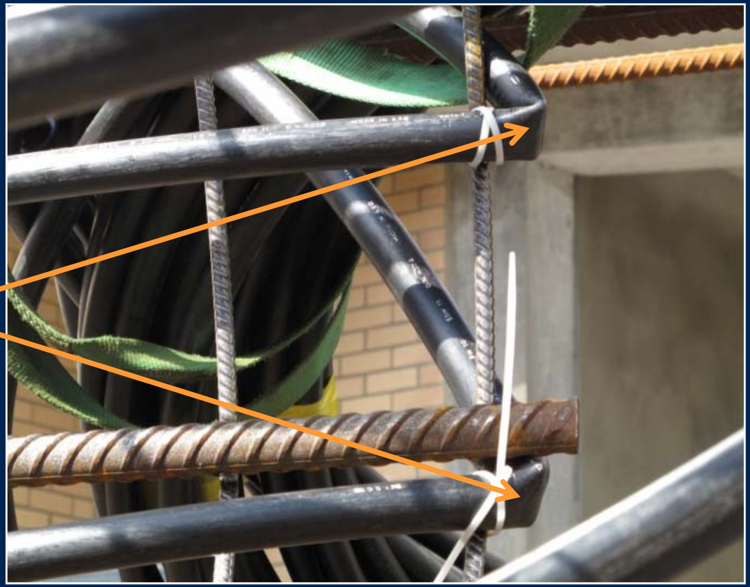
1 Preamble (as BHS)
2 Regulatory & Government Agency Requirements (as BHS)
3 Contractual Responsibilities
4 Training Requirements
5 Design
6 Thermal Response Testing
7 Pipe Materials and Jointing Methods
8 Thermal Pile Concrete
9 Loops Installation
10 Pressure Testing
11 Indoor Piping / Values (as BHS)
12 Thermal Transfer Fluids (as BHS)
13 Design Drawings
14 Monitoring and Checking
15 Alterations

Contents

1. The integration of the loops into various construction activities without loss of loop integrity
   - Loop installation good practice
   - Standard Rotary and CFA piles loop
   - Loop Protection
   - Testing during installation.
2. The integration of a thermal pile solution into the construction programme, with cause minimal delay and disruption
   - Design
   - Project performance
   - Coordination
3. Thermal piles on Crossrail Station Boxes (Bond St)

Potential defects

- Scratch or abrasion
- Creasing
- Puncture

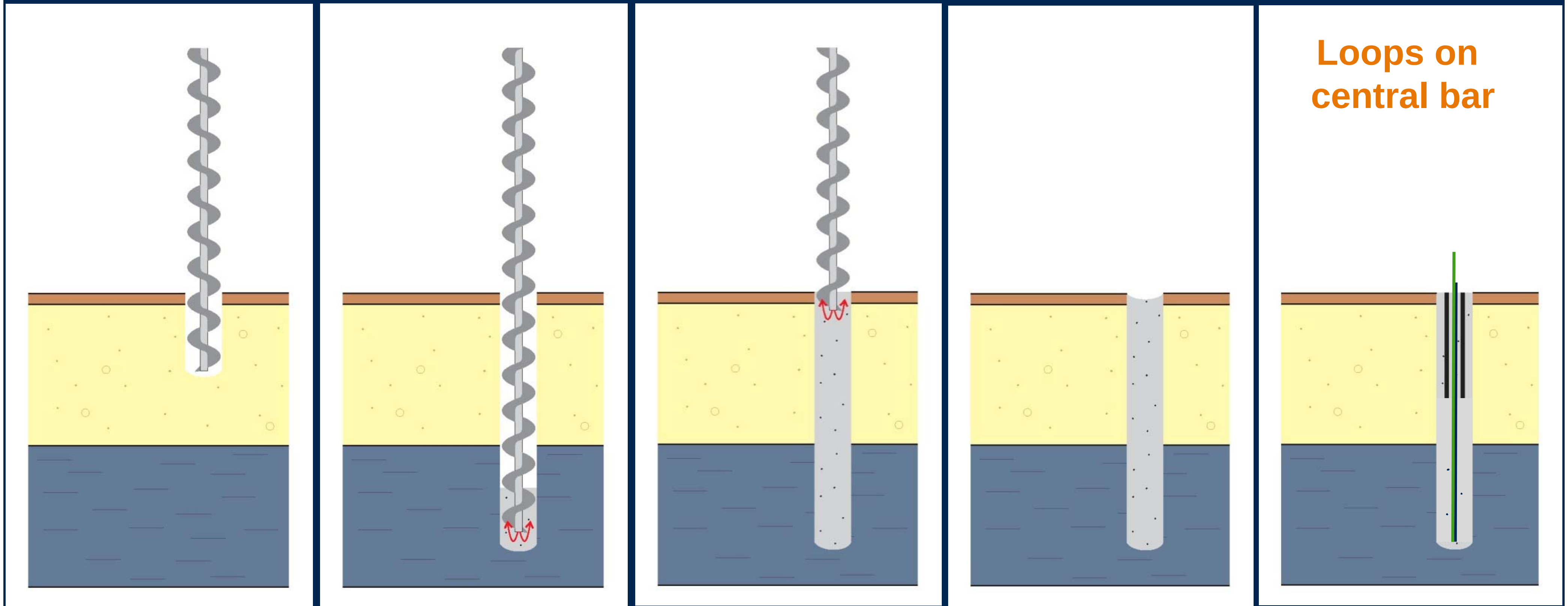


- Misuse
- Lack of understanding

Loop installation: Good practice

- Loops attached to reinforcement cage – depends on the pile technique and depth of installation
- Plastic ties are recommended
- Optimum loop fixing on cages is between bars
- Fishtails must be straightened
- Loops filled with water and capped off
- Fusion welds can be used in the factory manufacture of loops but best avoided during pile installation
- Consider any methods to reduce loop abrasion / scratching

Continuous Flight Auger (CFA) Sequence

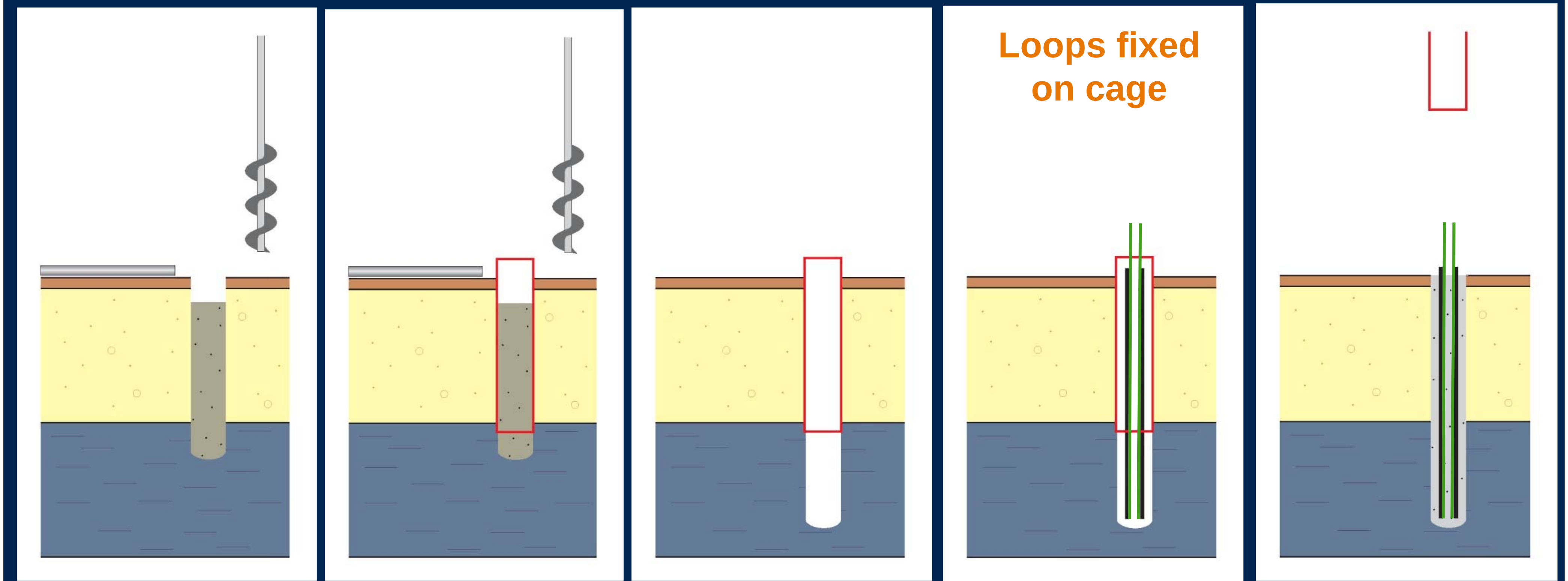


Bore | **Pump concrete** | **Withdraw auger** | **Finish concrete** | **Plunge loop then cage**

CFA

- Reinforced shoe
- No surging
- Loop length restriction (circa 20m)
- Additional craneage and central steel bar
- Approx 30% cost uplift over normal piling rate (small dia)

Rotary Sequence



Bore | Place Casing | Bore to depth | Place steel and loops | Pour concrete, extract casing

Rotary

- Loops positioned inside (preferable) or outside cage - depends on depth of pile
- Loops can extend beyond the cage base
- No depth limit
- 10 / 15% cost uplift over normal piling rate
- Protect loops from vertical impact of concrete using appropriate length of tremmie tube

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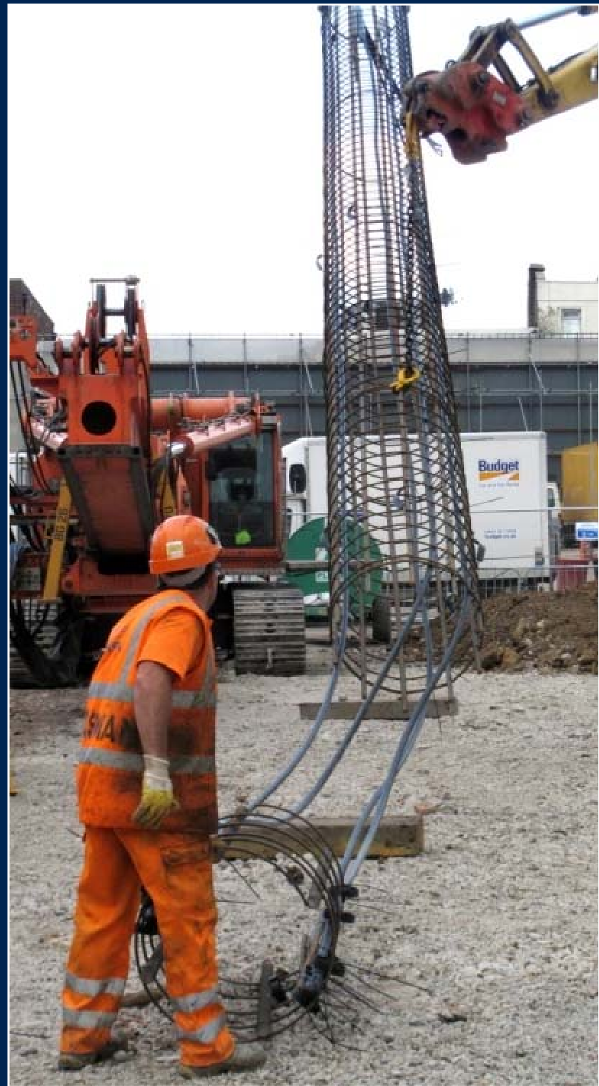
Loops fixed on outside
52m deep on full depth cage
Placed under bentonite



Loops fixed on inside and extend below the cage using a cage former

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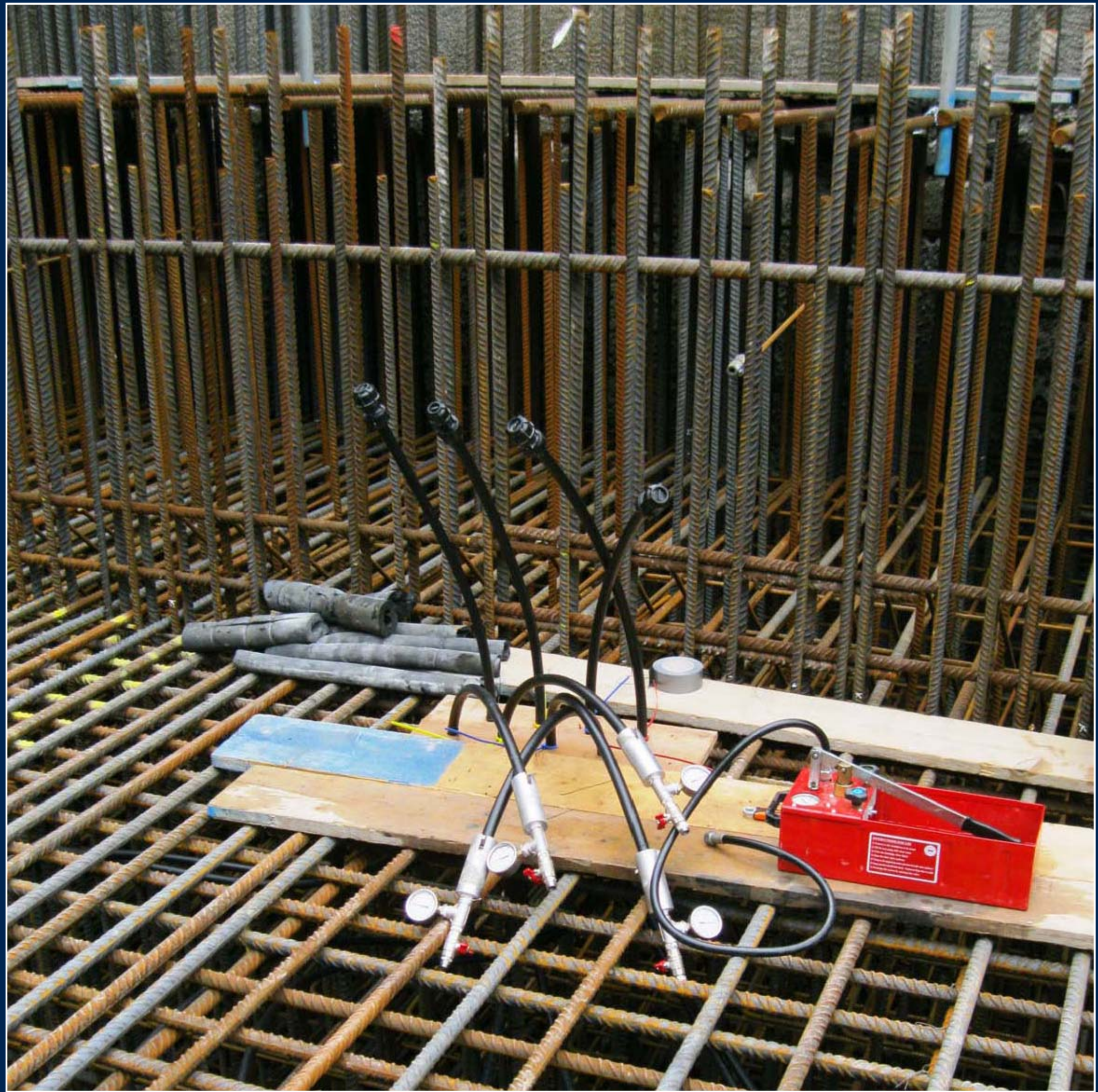
Protection

- Foam around loop, encased in plastic as a standard
- Prevent ingress of materials likely to block fluid flow
- Protect from damage of follow on trades.

Testing

- Test at every stage to confirm ongoing system integrity
- Use the test as a handover of responsibility between contractors
- Variety of tests depending on the construction stage
- Tests to be independently witnessed



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Recommended Testing and hold points

GSHP Contractor (1)

⇩

Piling contractor (2-5)

⇩

Groundwork contractor (6)

⇩

GSHP contractor(7-9)

Hold point	Responsible Party	Recommended Test
1. Assembly of loops (potentially with connections/u-bends)	Loop manufacturer / GSHP Contractor	Type A - pressure test with documentation
2. Arrival of loops on site	GSHP Contractor / Piling contractor	Observation - no kinking or damage to pipe
3. During installation within cage	Piling Contractor	Observation - no kinking or damage to pipe
4. Preconcreting of pile	Piling contractor	Bi-directional flow test and Type B - pressure test
5. Immediately post concreting of pile	Piling contractor	Type C - pressure test
6. Pre-trimming of pile heads	Piling contractor / Groundworks Contractor	Bi-directional flow test and Type B pressure test
7. After trimming of pile heads pre connection into header arrangement	Groundworks Contractor / GSHP Contractor	Dip test/Bi-directional flow test and Type C pressure test /
8. Connection of thermal pile loops into zones	GSHP Contractor	Modified test / Type 2 test ref. WRc.
9. Connection of zones to plant room manifold	GSHP Contractor	Final handover test

Table 10.1: Recommended testing hold points

Types of Test

- Observation
- Bi directional Flush test
- Type A pressure test – Pressure test on manufacture + docs
- Type B pressure test - 8 bar 10 mins, reduce to 4 bar 30 mins
- Type C pressure test – same as type B but then held for 24 hrs

Acceptance is no loss of pressure

Integration of thermal pile projects

- Thermal piles are an integral part of the building structure
- A scheme implementation will impact on programme and several other trades
- This impact on programme and trades needs to be understood and managed
- Early engagement from the cross discipline project team

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Multi discipline Integration - Design

- Geotechnical, Structural and M&E designs must be integrated and compatible.
- Redundancy levels within each element should be mutually agreed between all parties. Redundancy arises from risk in:
    - Pile installation
    - Operational damage (ie trimming)
    - Geothermal design – (thermal conductivity)

Clash with headering and drainage

Integration – Project Performance

- The scope and responsibility of each package needs to be clearly and fully defined
- Procurement route needs careful consideration – several different options are available
- Co-operation and Interface management is essential during construction for a smooth programme
- BIM techniques are useful

Co-ordination

- Recommended as official role
- Most important during construction phase
- Ideally from the Main Contractor
    - Project management experience
    - Building development & HVAC experience

Typical Concurrent activities:

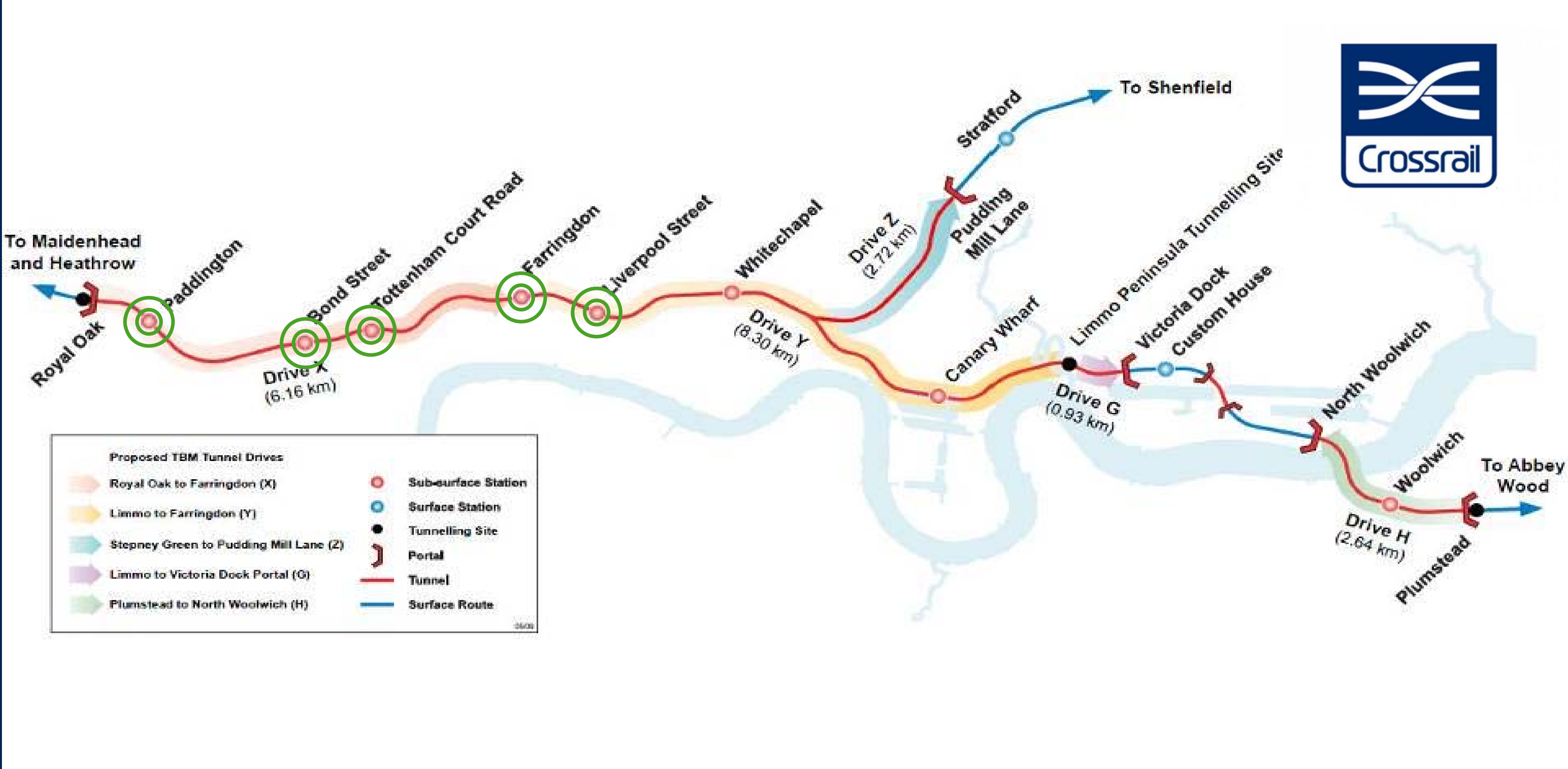
Excavation, Spoil removal, concreting, breaking down piles, geothermal headering

Crossrail Philosophy

Crossrail

- Committed to the environment
- Required to have 10% renewable energy
- Decided to use the deep station boxes and foundations for thermal collectors (ie diaphragm wall and bearing piles)
- Cost of the collectors borne by Crossrail
- Benefit available for future over site developments

Crossrail and Geothermal



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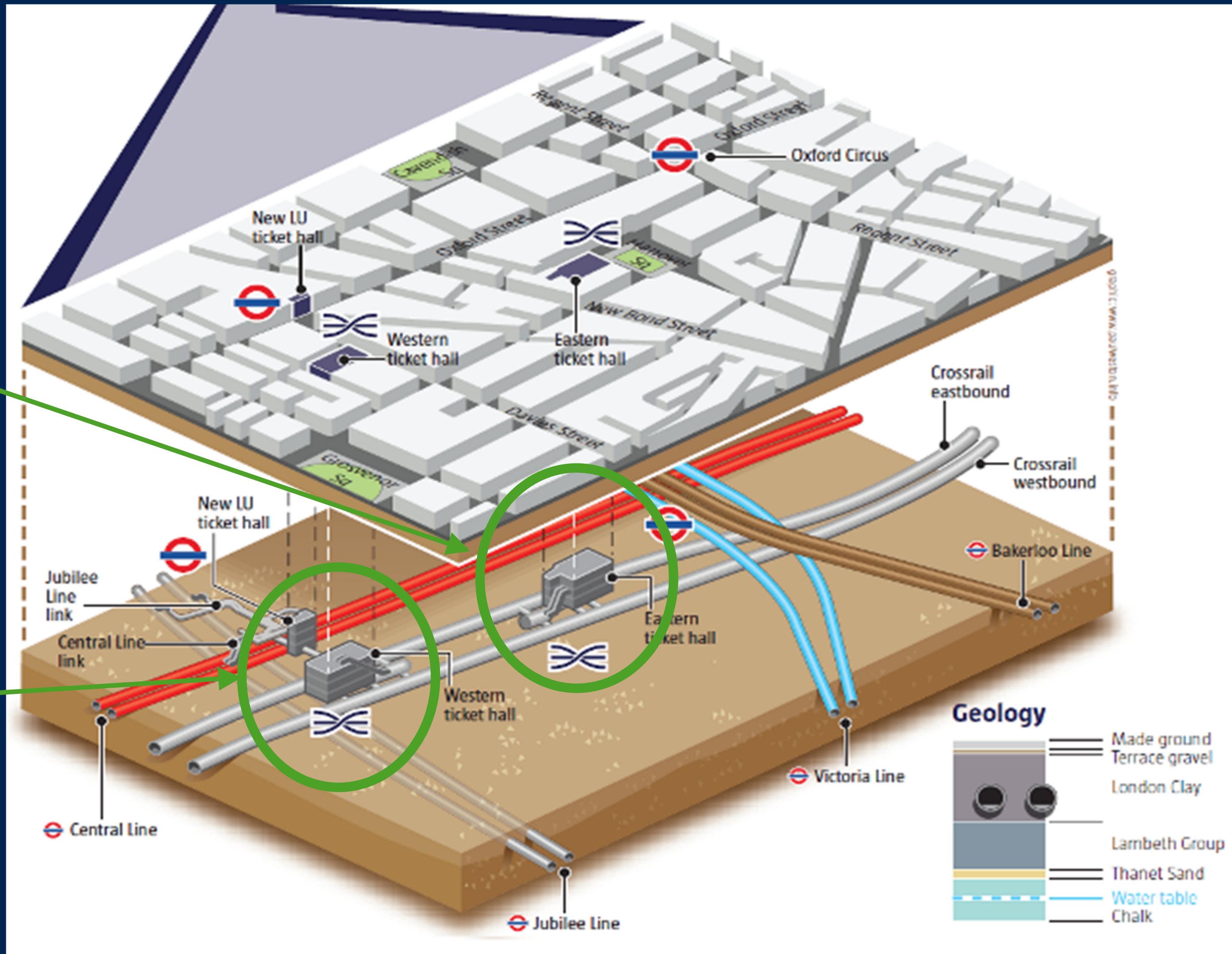
Crossrail Geothermal Capacity

Contract	No of Piles / Panels	Total linear m of pipe (m) (m)	CO2 potential saving (T /annum)	Heating peak power (kW)	Cooling peak power (kW)
Paddington Integrated	41	25,000	200	420	240
Bond St WTH	43	2,449	28	186	186
Bond St ETH	57	8,559	49	340	340
TCR West	65	4,729	21	160	160
TCR East	34	1,710	9	75	75
Fisher St	18	2,900	10	60	60
Liverpool St – Blomfield	62	15,000	11	150	80
Liverpool St – Moorgate	18	7,200	14	70	25
Farringdon West	26	3,432	16	120	120
Farringdon East	21	3,182	12	90	90
Totals	**385**	**74,161**	**370**	**1,671**	**1,376**

Crossrail - Bond Street Station

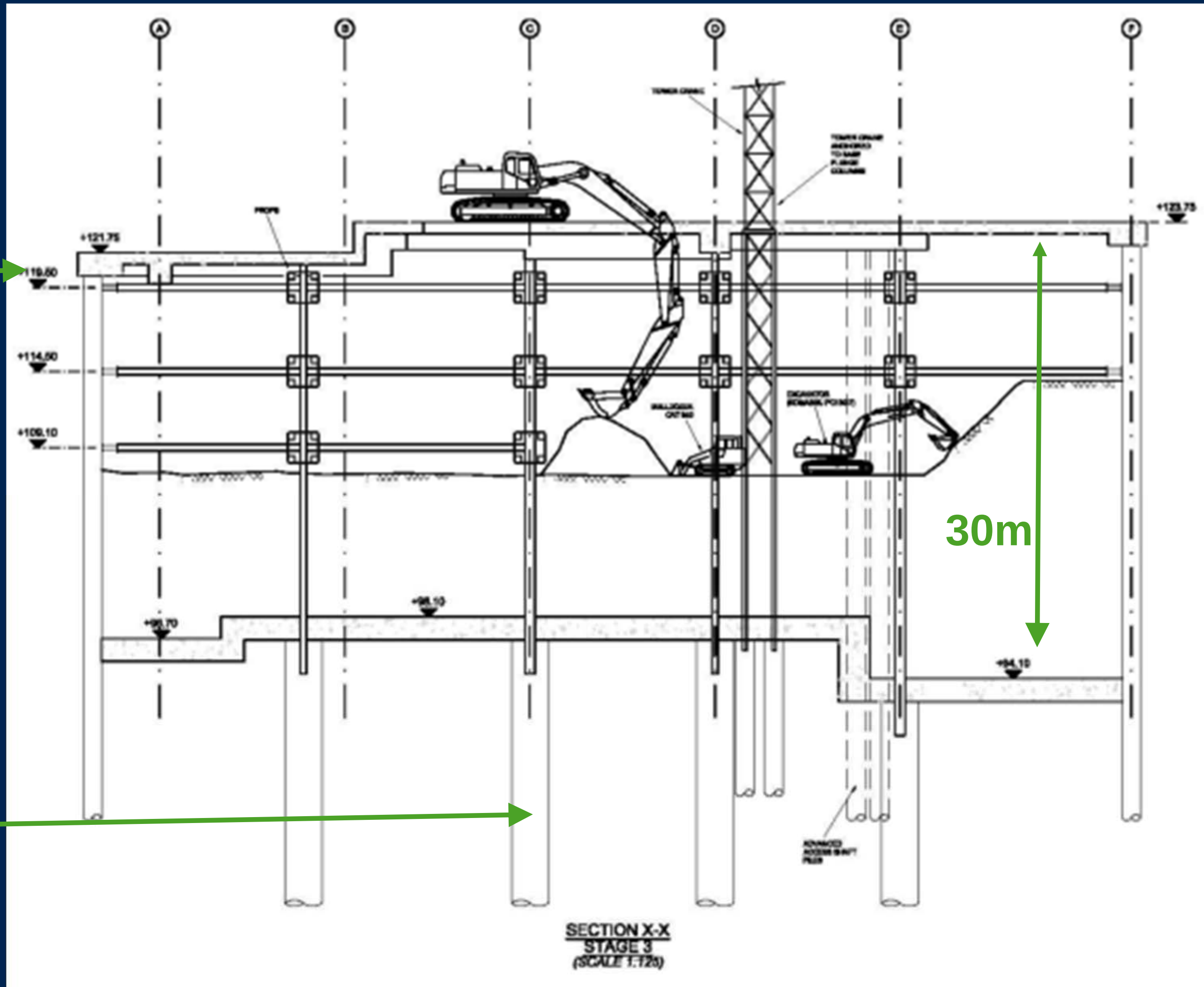
Eastern Ticket Hall

Western Ticket Hall



Bond St ETH Elevation

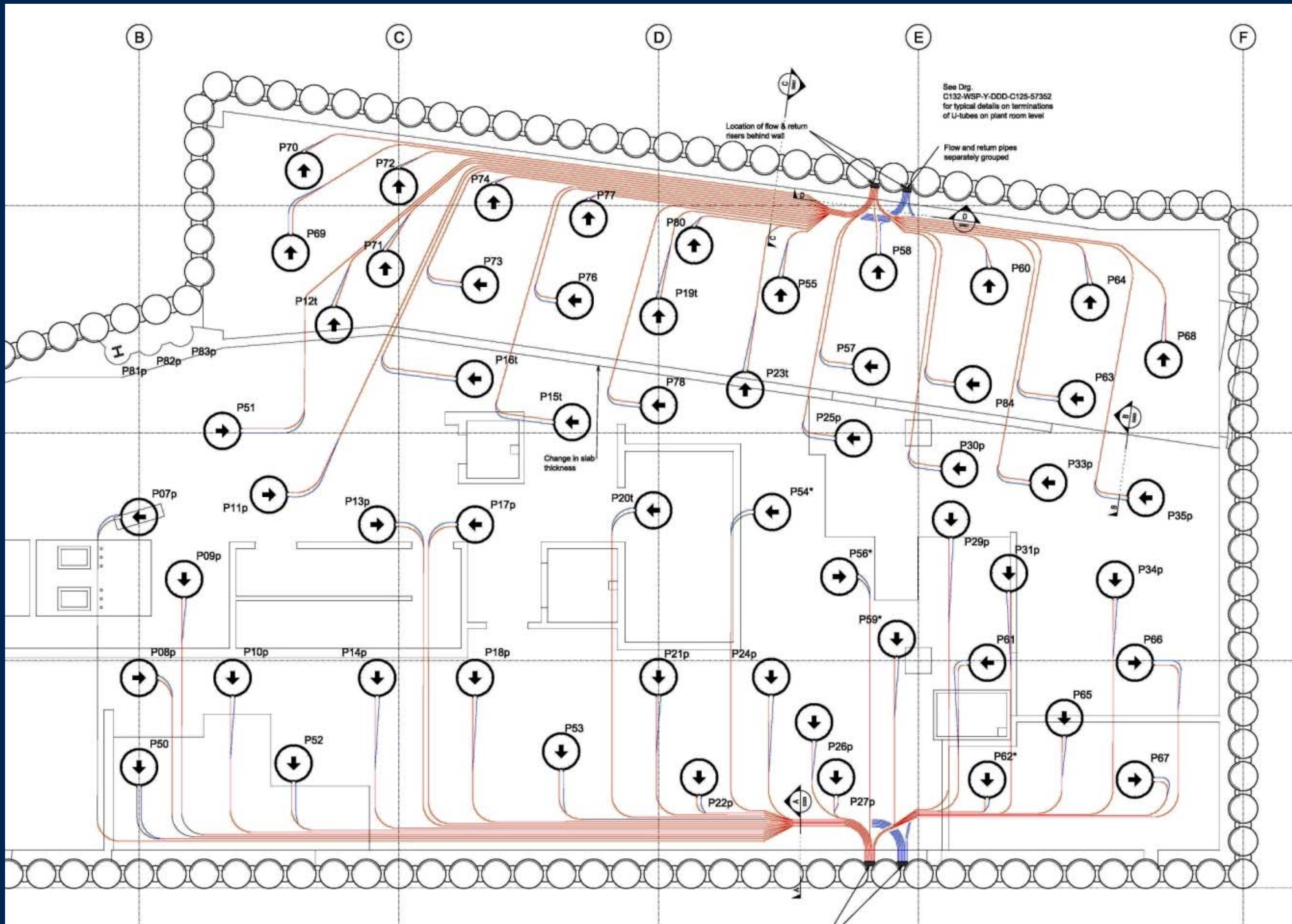
Ground Level



Thermal piles

Bond St ETH

- 57 Thermal pile
- 1.8m diameter
- 67m deep
- 6 loops per pile
- 30m Effective length due to deep cut off



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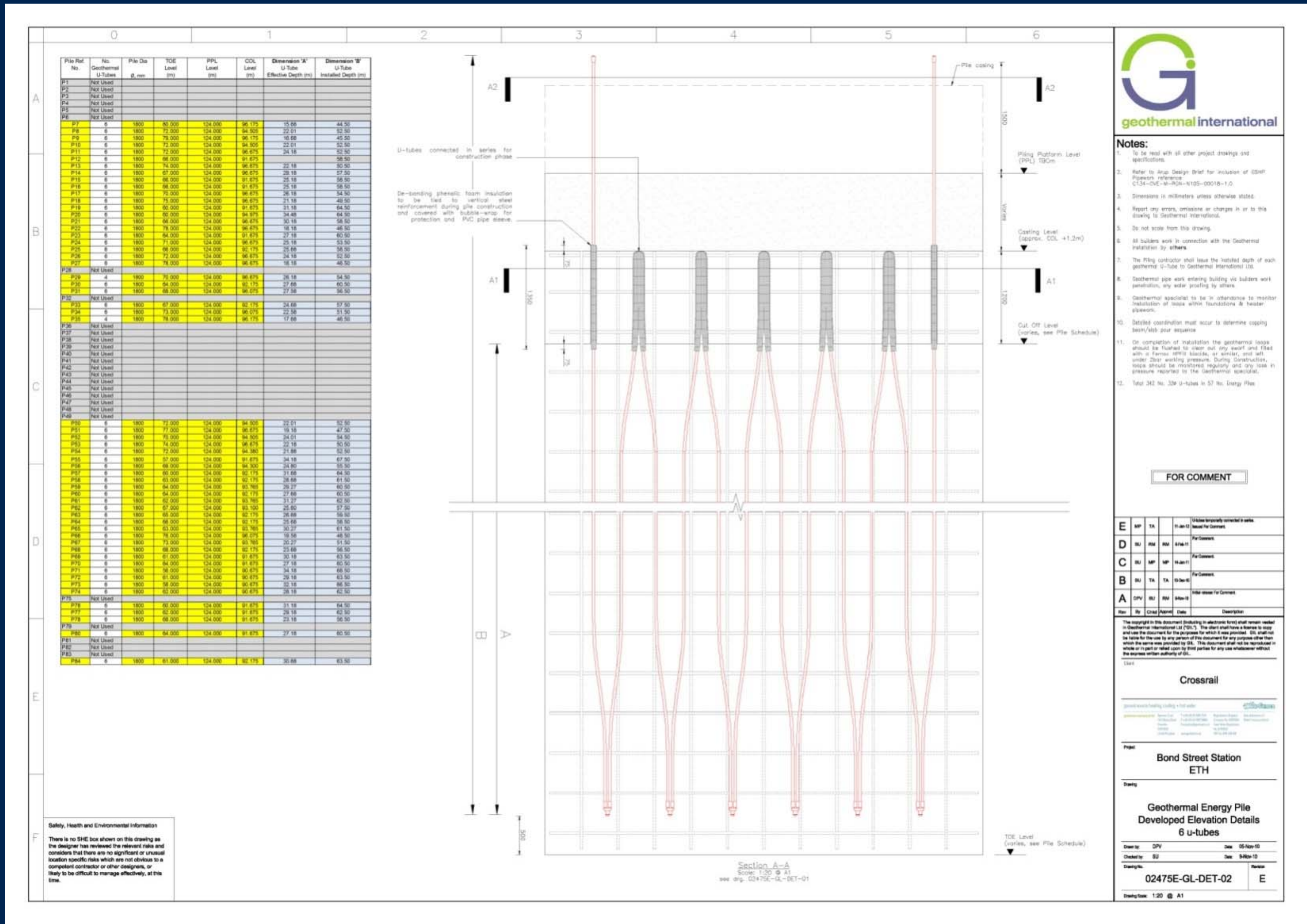
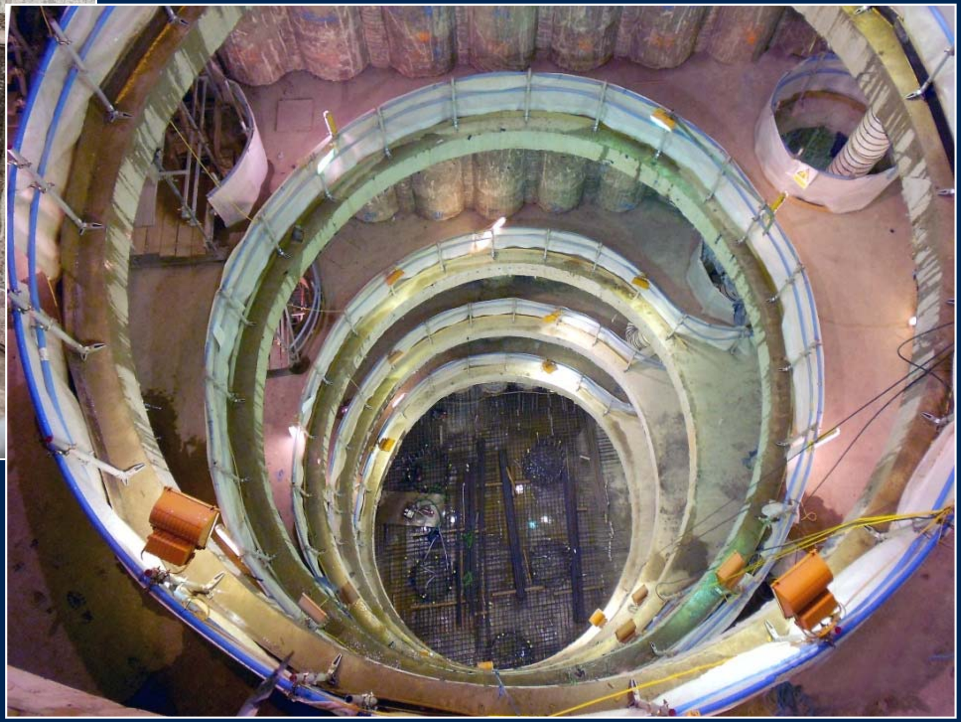
Bond St ETH – Loop design



Bond St ETH

Access tunnels



Thermal piles at base of shaft

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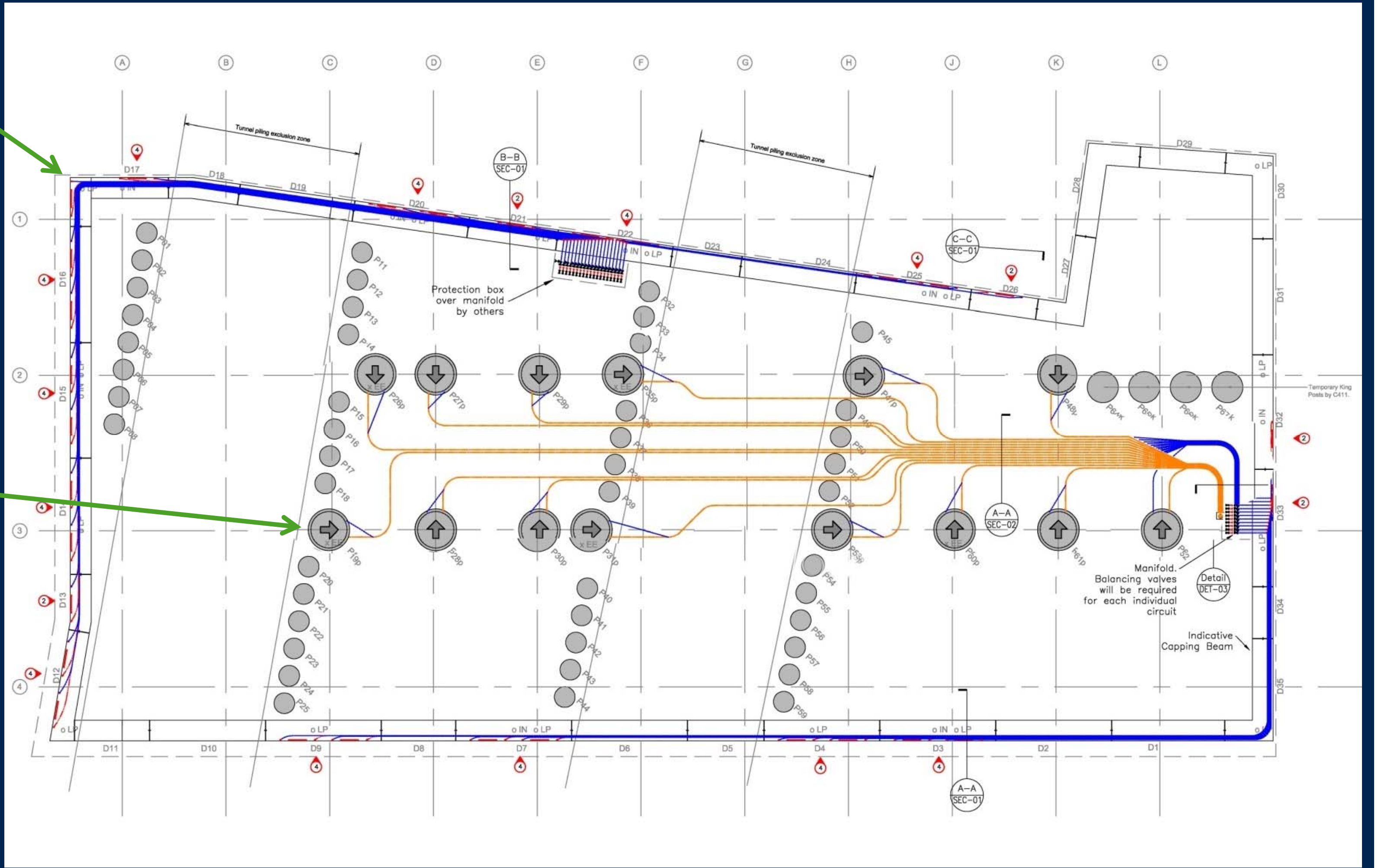
Bond St WTH

- 1.2m D-Wall
- 44m deep
- 29 panels
- 2 loops /panel

- 14 Thermal piles
- 2.5m diameter
- 20m deep
- 6 loops per pile



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Crossrail – WTH – Loop fixing

Diaphragm wall loops on outside of panel

Thermal loops prefixed on inside of reinforcement

WTH - Capping beams with loops

Loops collecting up inside the capping beam

Loops at central collection point

The good practices outlined and illustrated in this presentation, are all included in the Thermal Pile Standard.

So have a successful installation

and Happy Reading!

Thank You