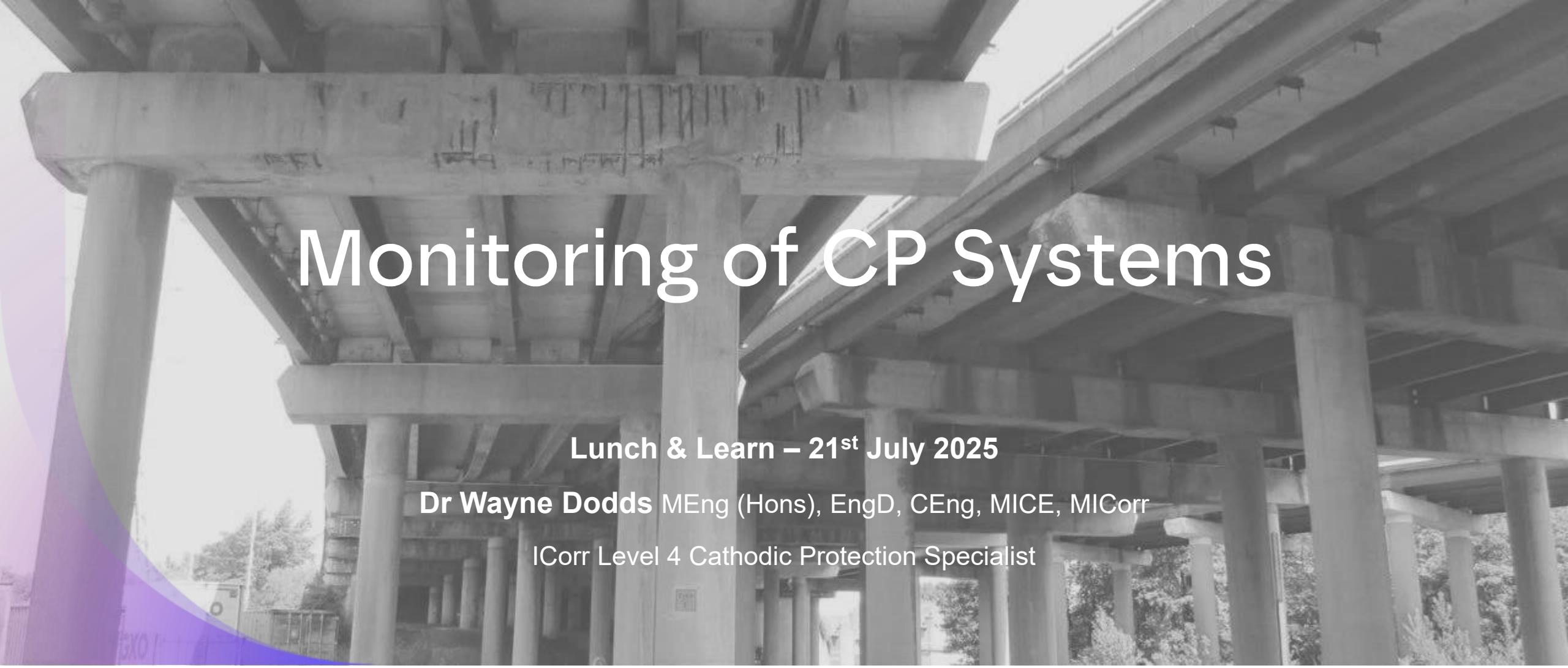


Monitoring of CP Systems

Lunch & Learn – 21st July 2025

Dr Wayne Dodds MEng (Hons), EngD, CEng, MICE, MICorr

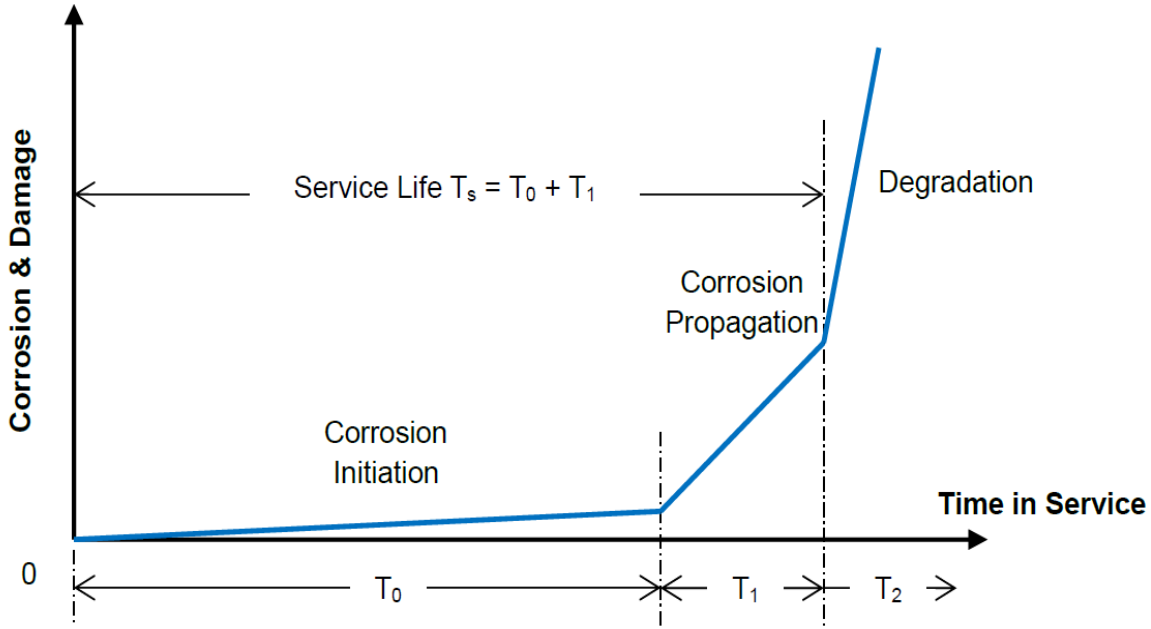
ICorr Level 4 Cathodic Protection Specialist

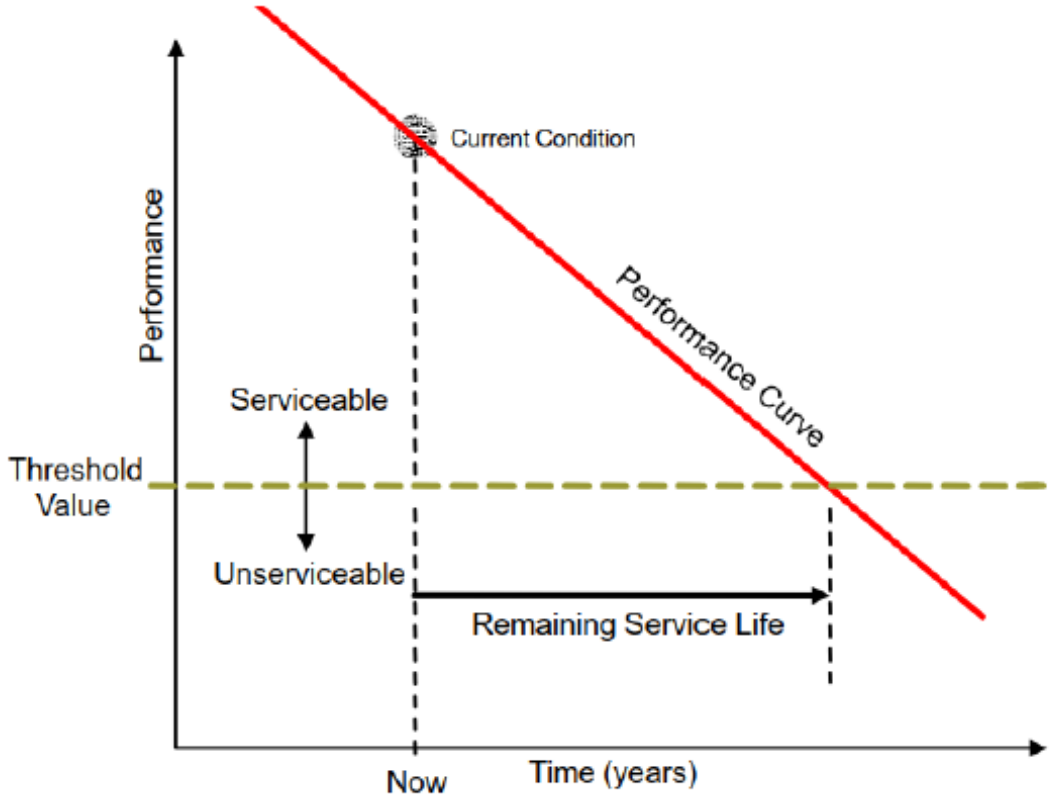
Amey

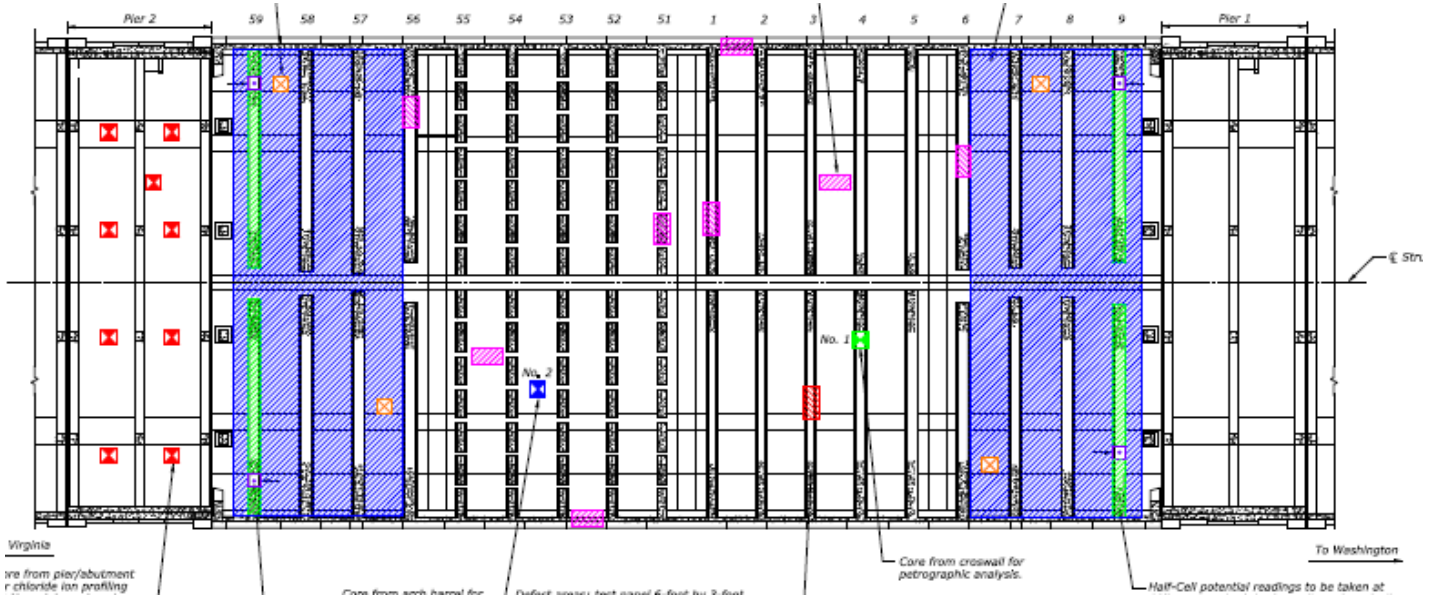
Life's better connected

- DMRB CS 462 ‘Management of a concrete highway structure shall commence as soon as a structure is commissioned to ensure it **remains safe for the public to use** without significant impact on **long term performance or durability**’

- External – transport of aggressive components/chemicals
  - Chloride ions
  - Carbon dioxide
  - Acids
  - Sulphates
- Internal – breakdown of cement matrix
  - Alkali-silica reaction
  - Delayed ettringite formation

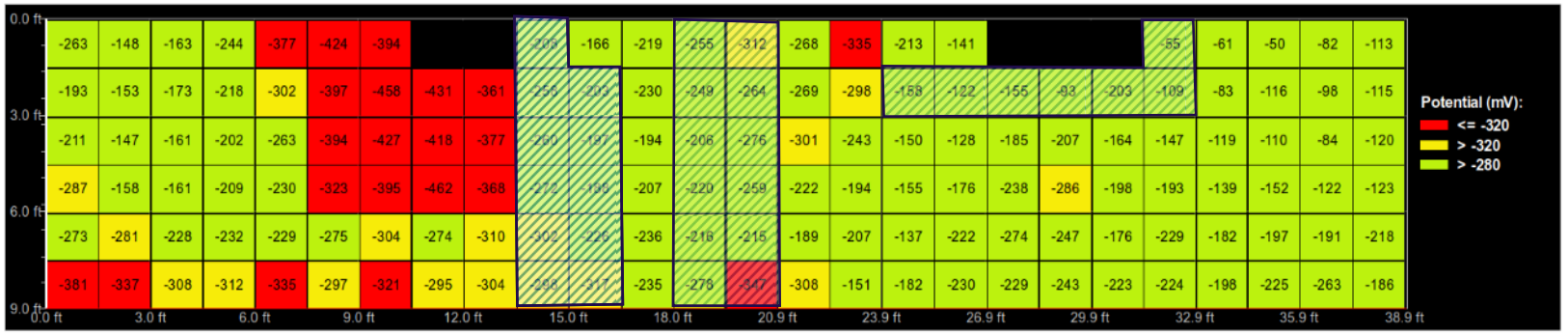

Corrosion & Damage
Service Life $T_s = T_0 + T_1$
Degradation
Corrosion Propagation
Corrosion Initiation
Time in Service
0
T_0
T_1
T_2


Performance
Current Condition
Performance Curve
Serviceable
Threshold Value
Unserviceable
Remaining Service Life
Now
Time (years)



Name	Date & Time	Mode	Rebars	Lines	Distance	Snapshots	Unit
Arch 9 CW 59 NE (E Face)	07/11/2018 3:09 PM	Corrosion-Scan	--	6	226.375 '	--	Imperial

View: Chipping Graph



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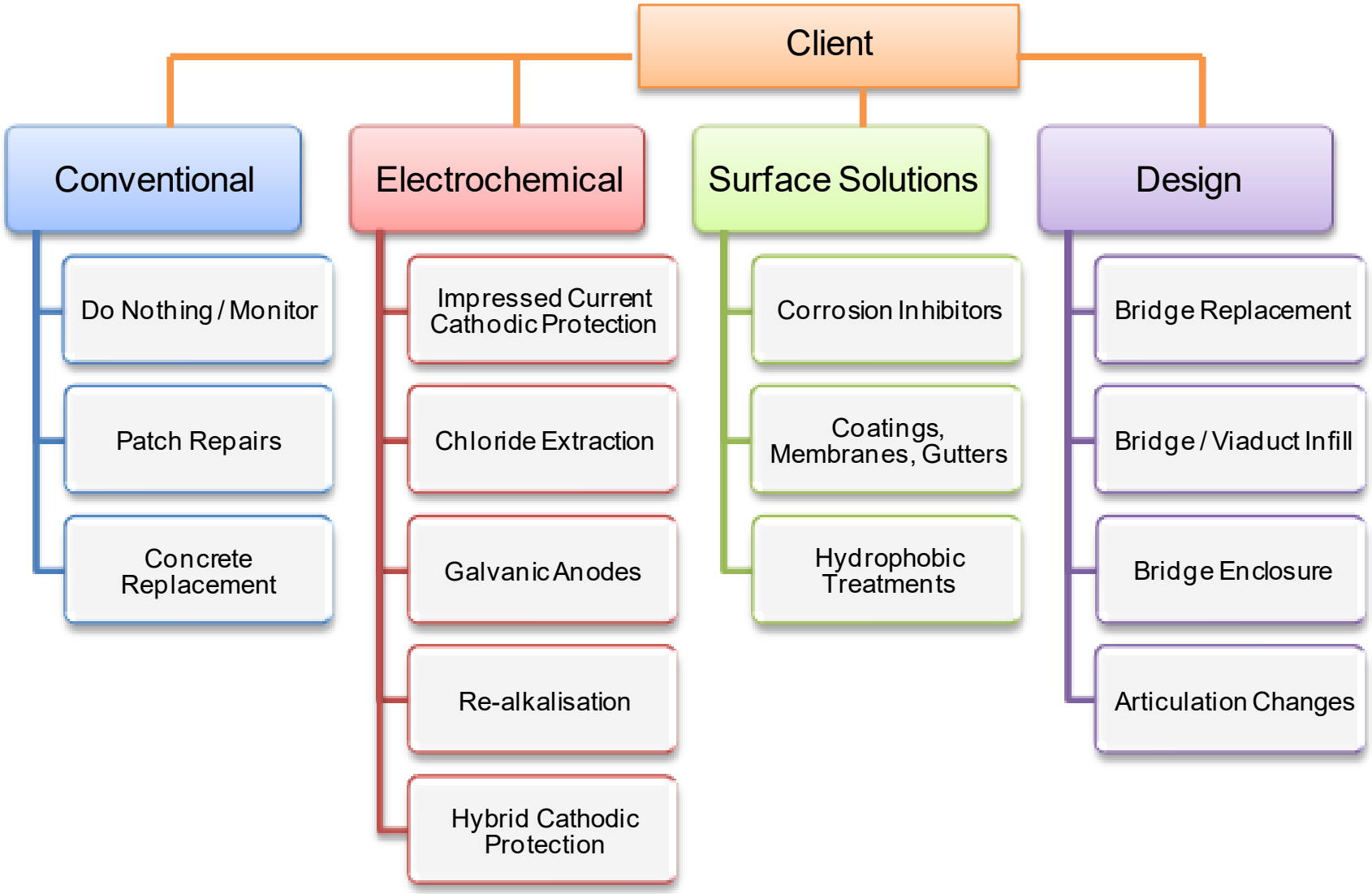
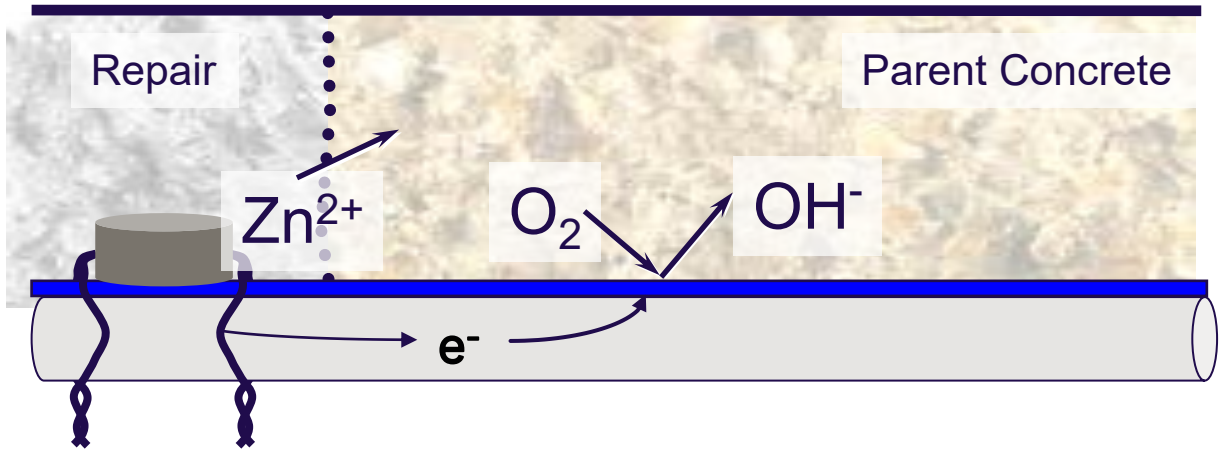
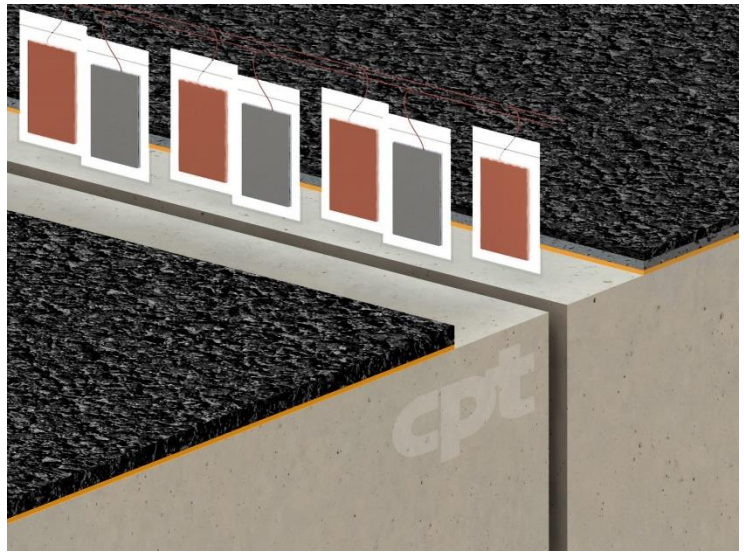
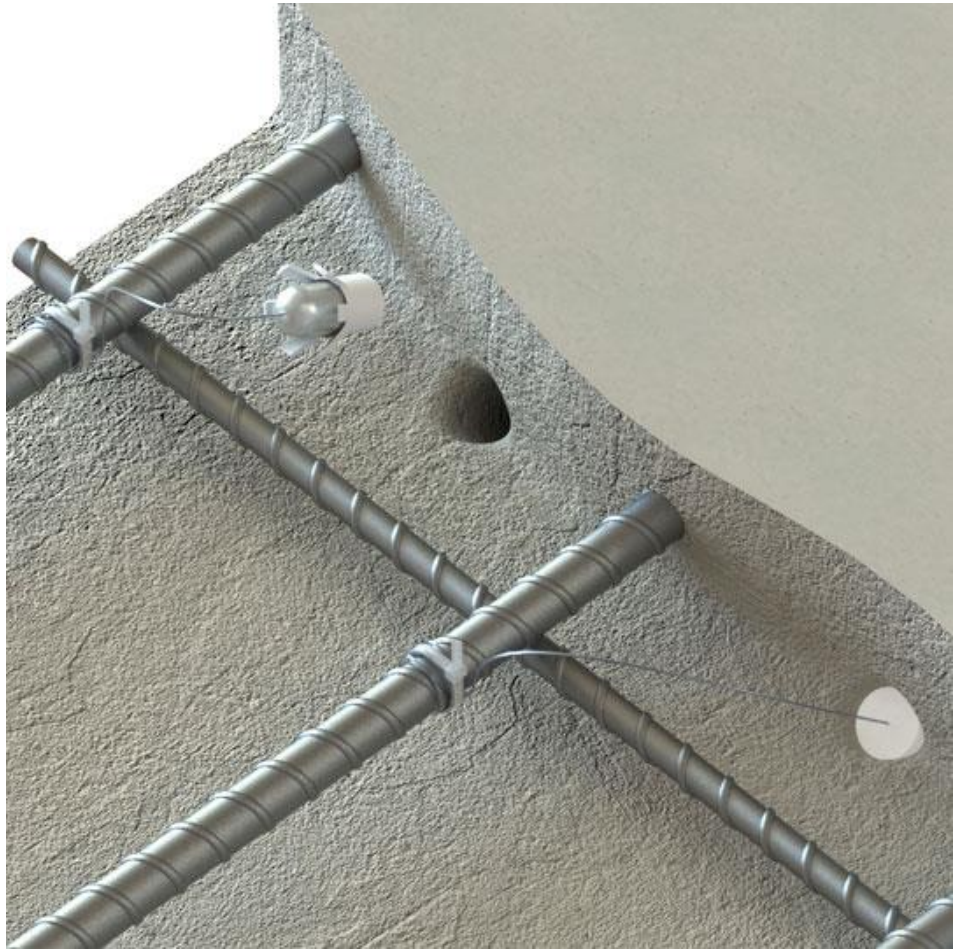
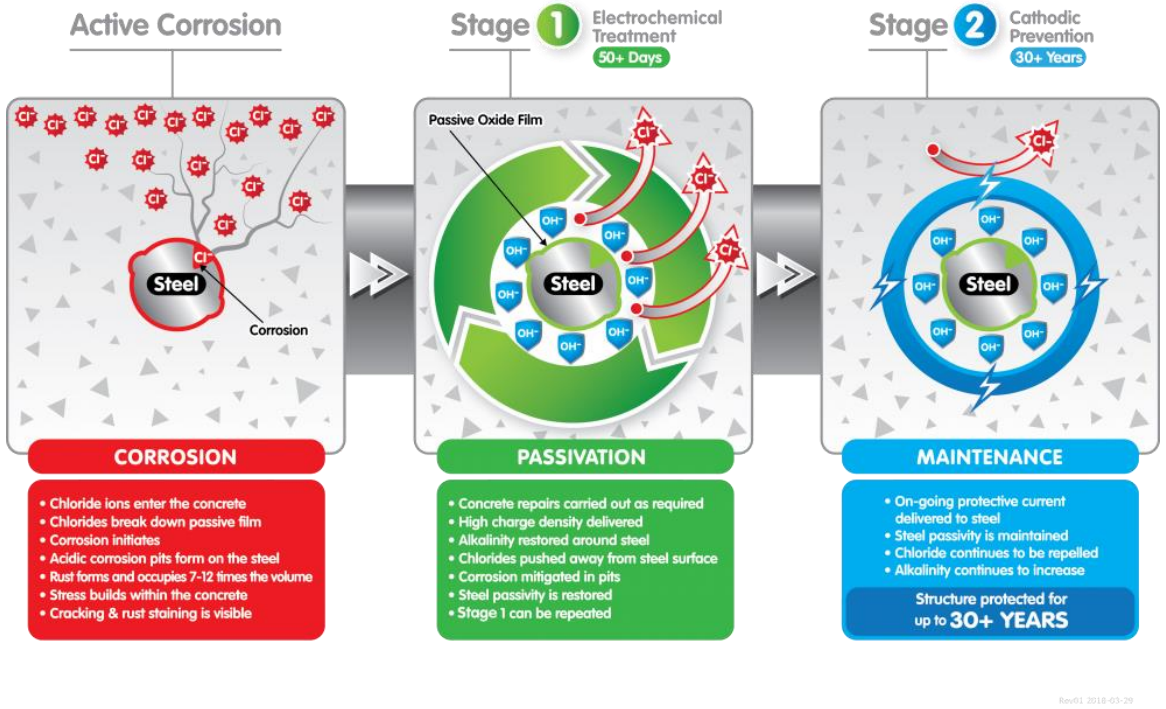

Client
Conventional
Do Nothing / Monitor
Patch Repairs
Concrete Replacement
Electrochemical
Impressed Current Cathodic Protection
Chloride Extraction
Galvanic Anodes
Re-alkalisation
Hybrid Cathodic Protection
Surface Solutions
Corrosion Inhibitors
Coatings, Membranes, Gutters
Hydrophobic Treatments
Design
Bridge Replacement
Bridge / Viaduct Infill
Bridge Enclosure
Articulation Changes

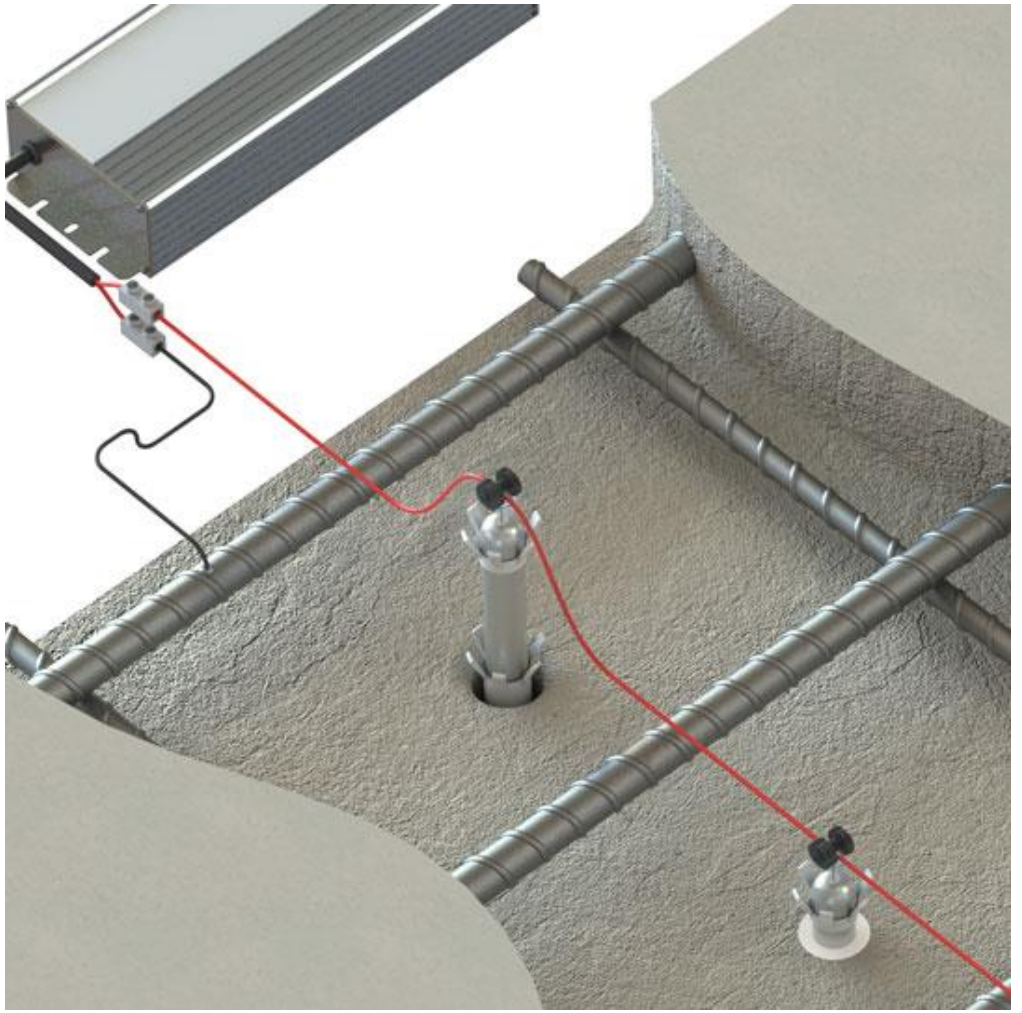

Repair
Parent Concrete
Zn^{2+}
O_2
OH^-
e^-



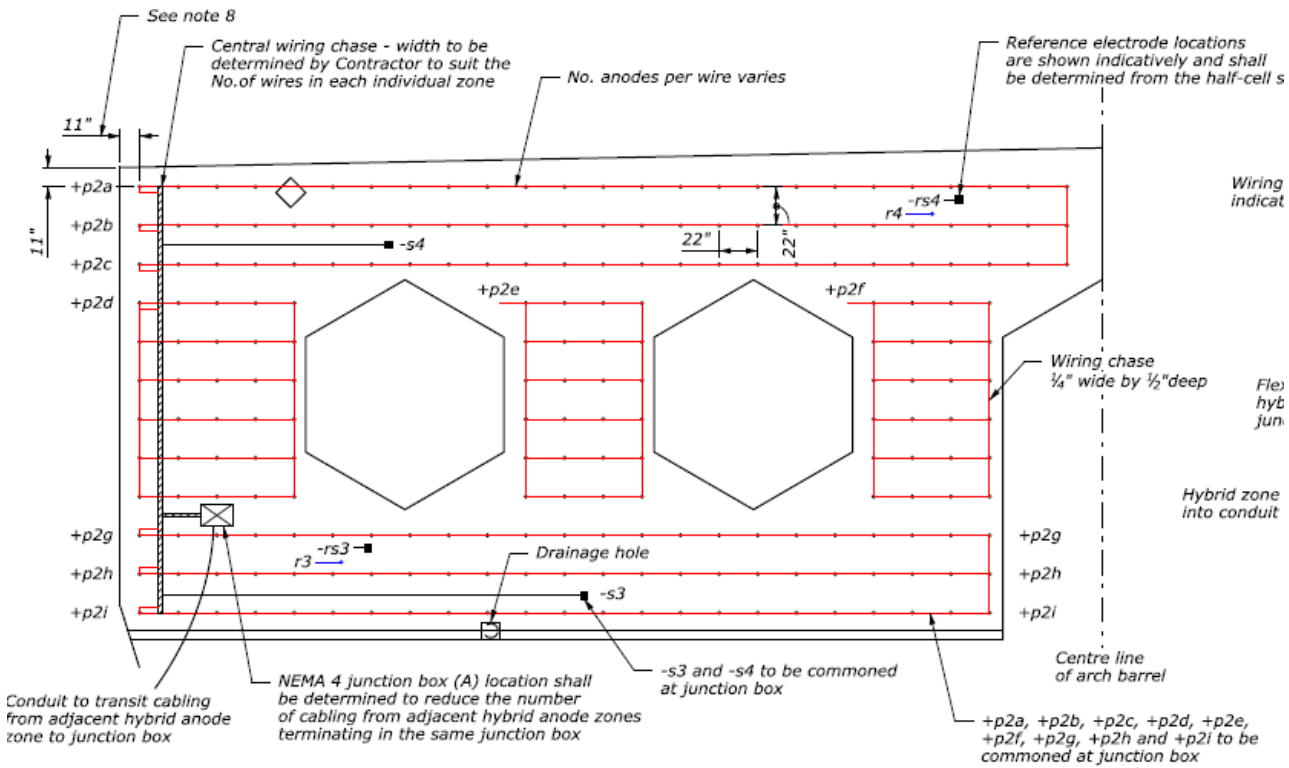


Hybrid Anodes



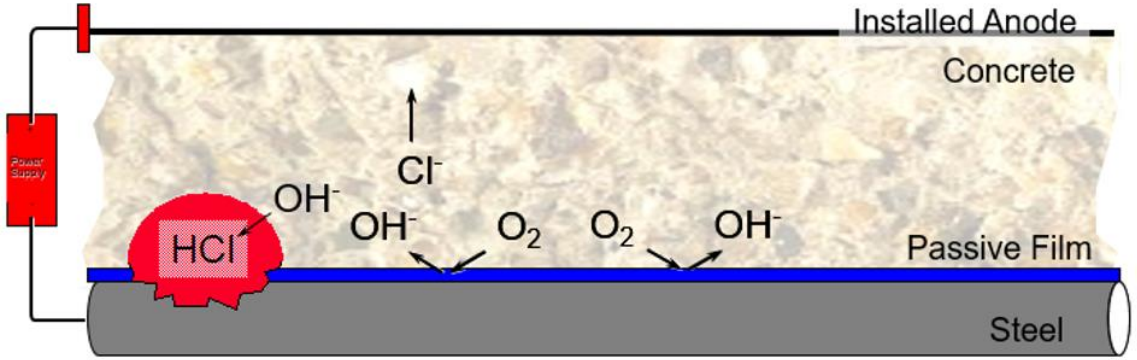


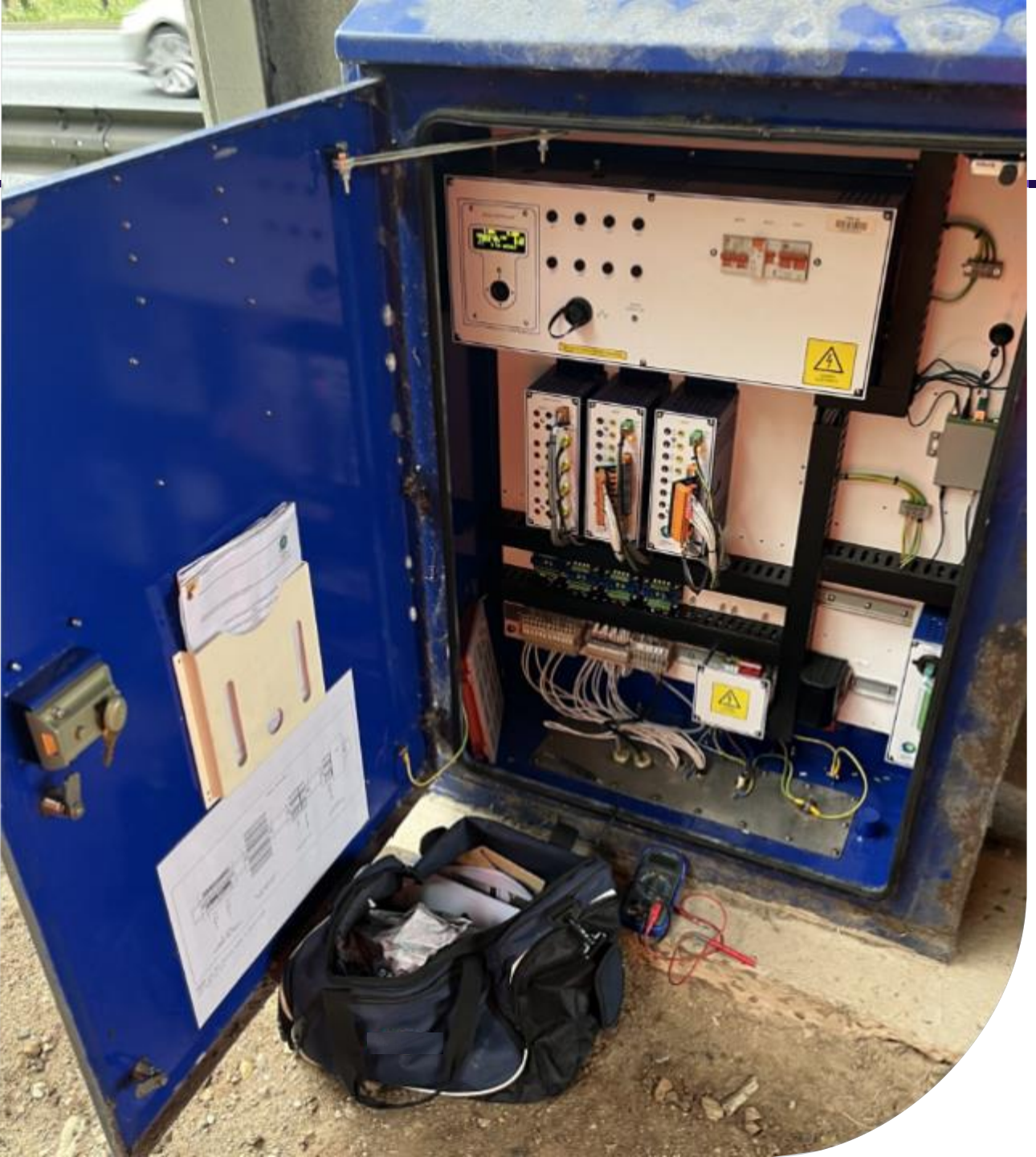
Hybrid Anodes



Amey

- Anode types:
  - MMO/Ti expanded mesh
  - MMO/TI ribbon
  - Discrete
  - Conductive mortar
  - Conductive organic paint coating
  - Thermal sprayed metal

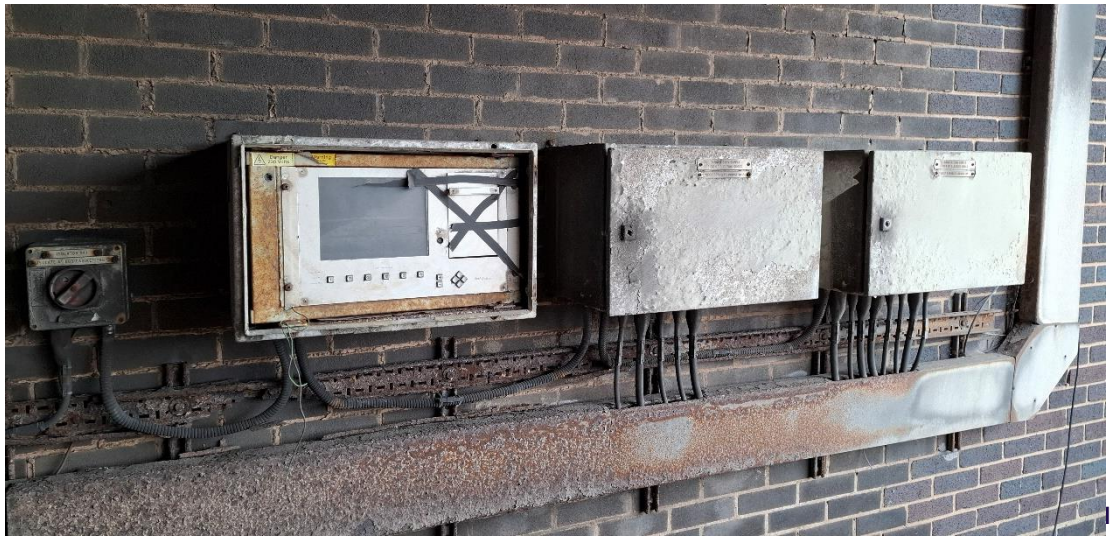


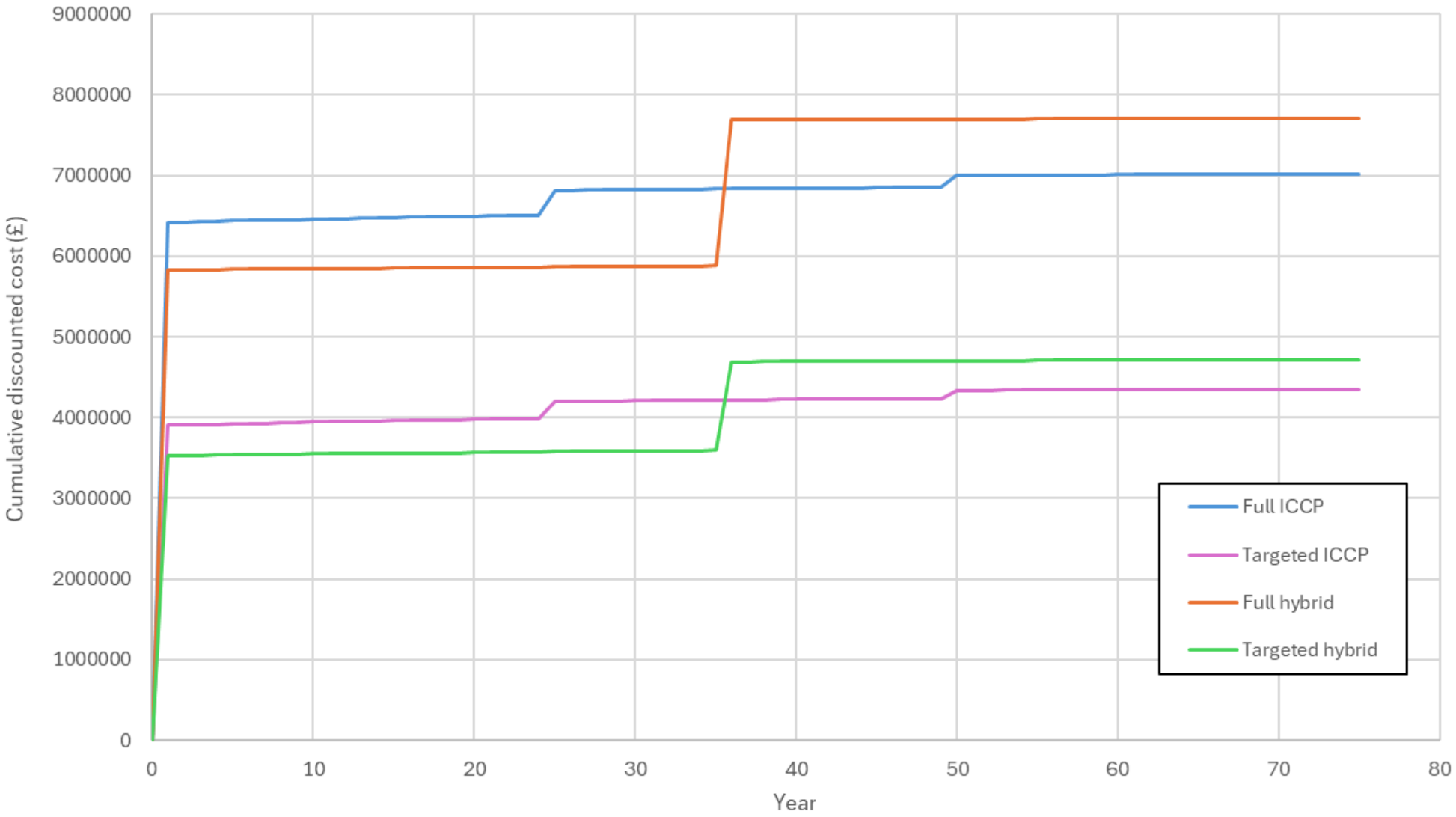


Limitations of Impressed Current Cathodic Protection

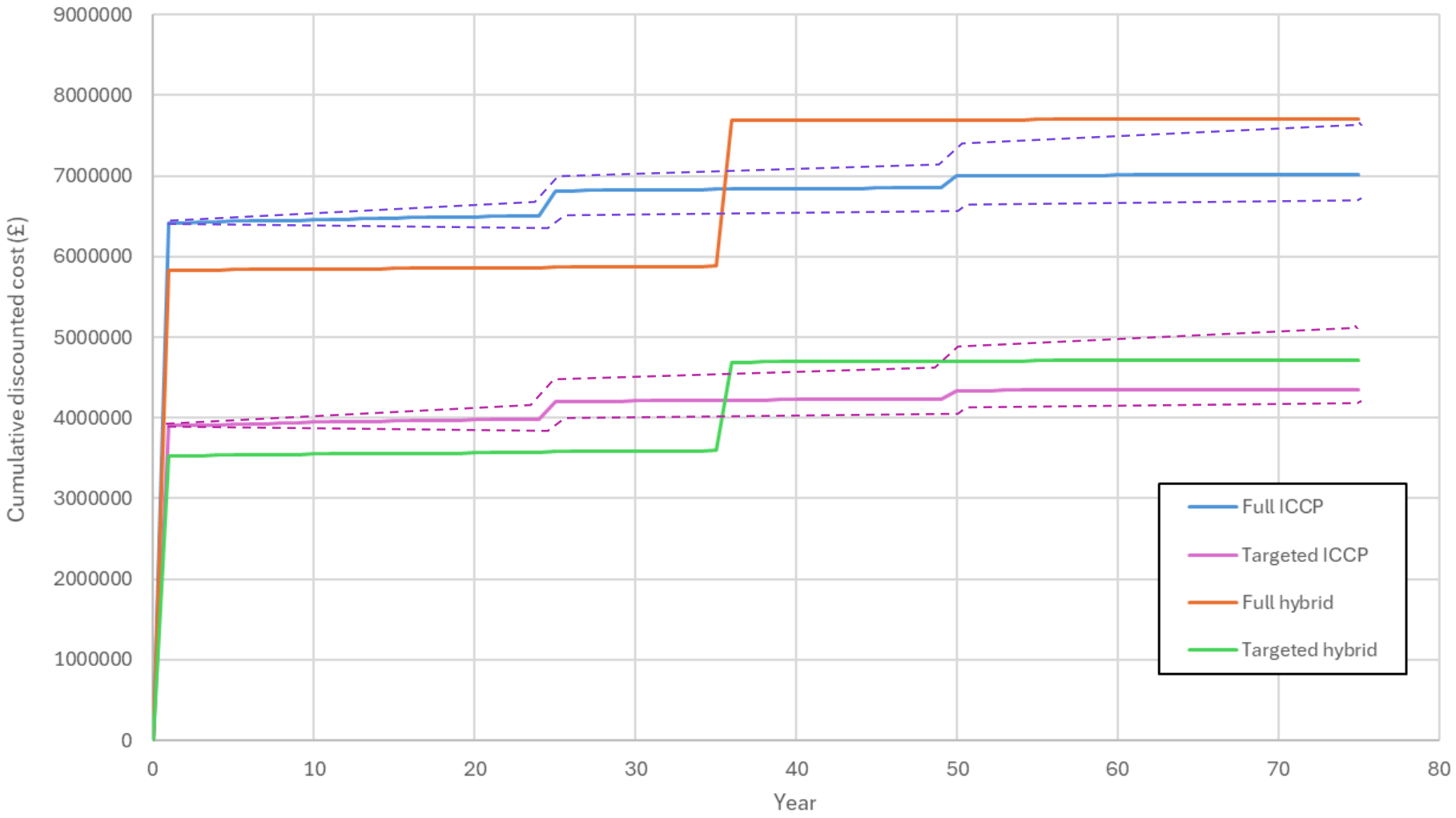
Amey

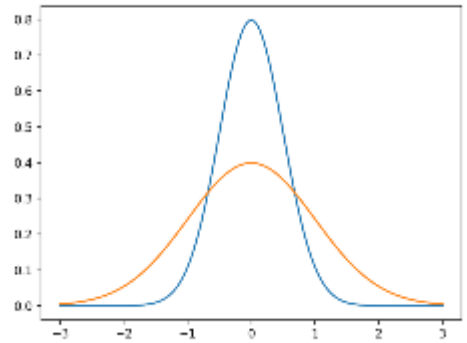
- AC supply
- Regular maintenance to maintain functionality
- Monitoring in accordance with BS EN ISO 12696:2022
- Adjustment to output voltage and current
- Electrical certification
- Damage to equipment
- Vandalism & theft




9000000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
Cumulative discounted cost (£)
0
10
20
30
40
50
60
70
80
Year
Full ICCP
Targeted ICCP
Full hybrid
Targeted hybrid

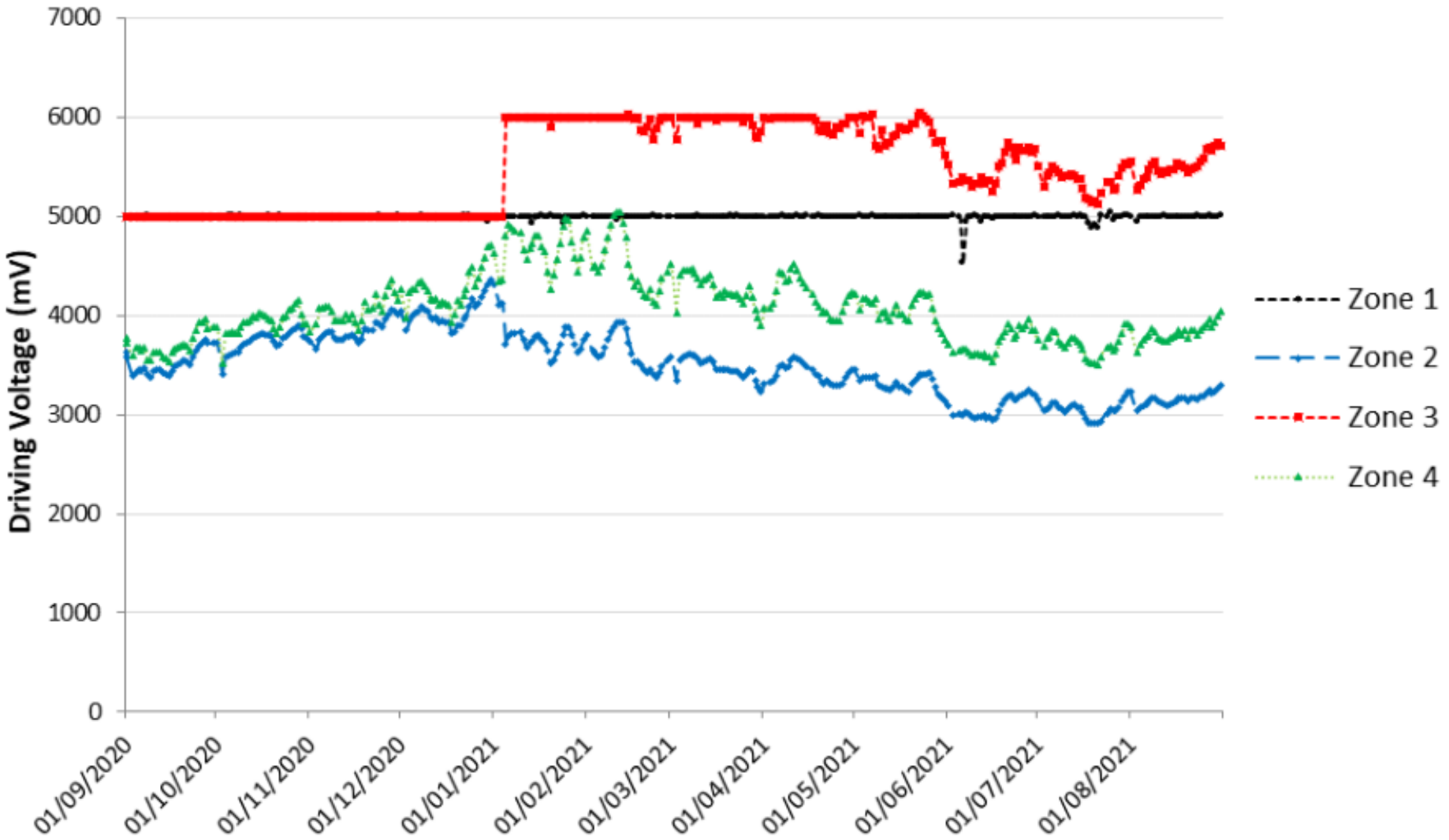
Amey

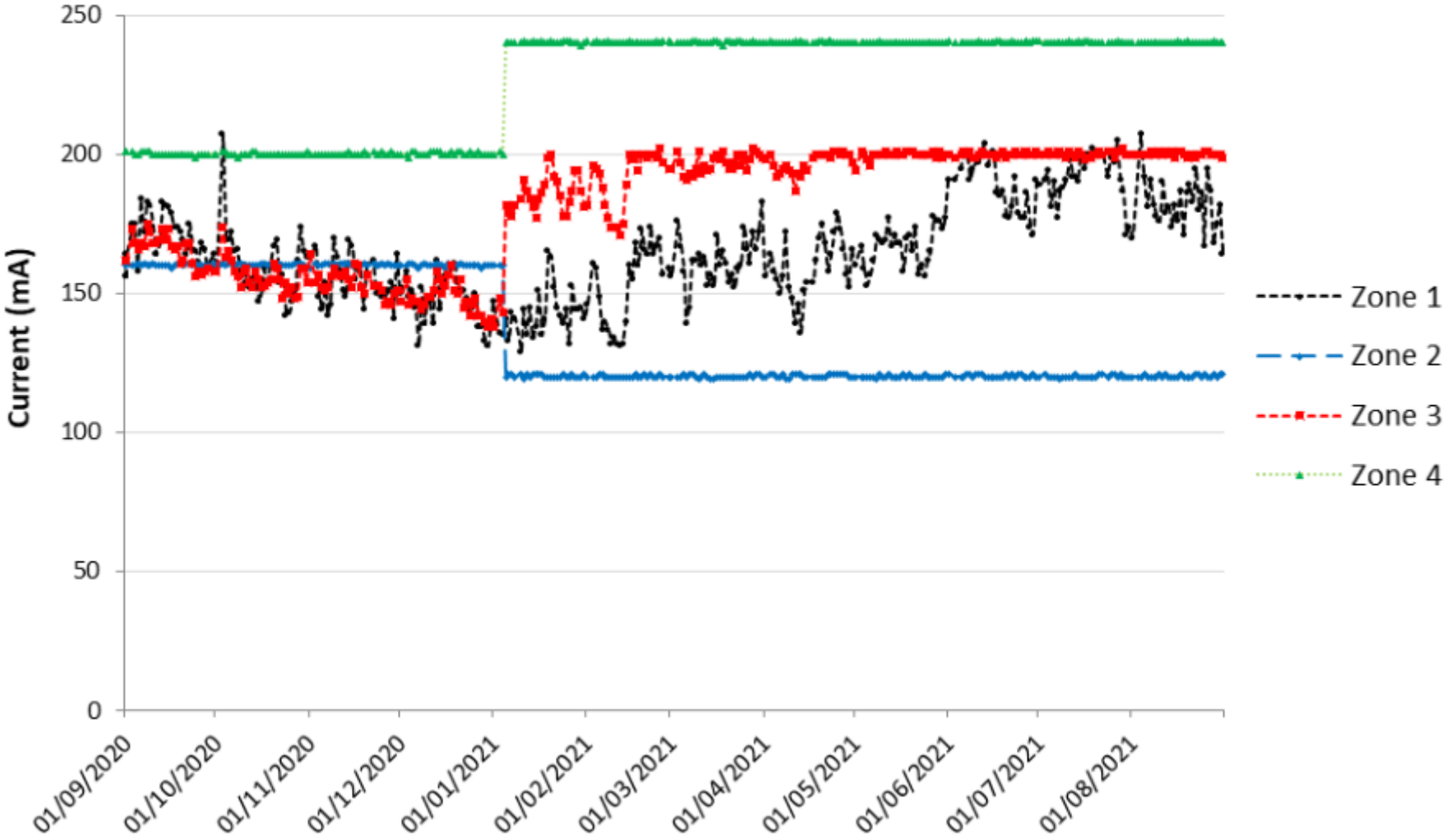

9000000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
Cumulative discounted cost (£)
0
10
20
30
40
50
60
70
80
Year
Full ICCP
Targeted ICCP
Full hybrid
Targeted hybrid

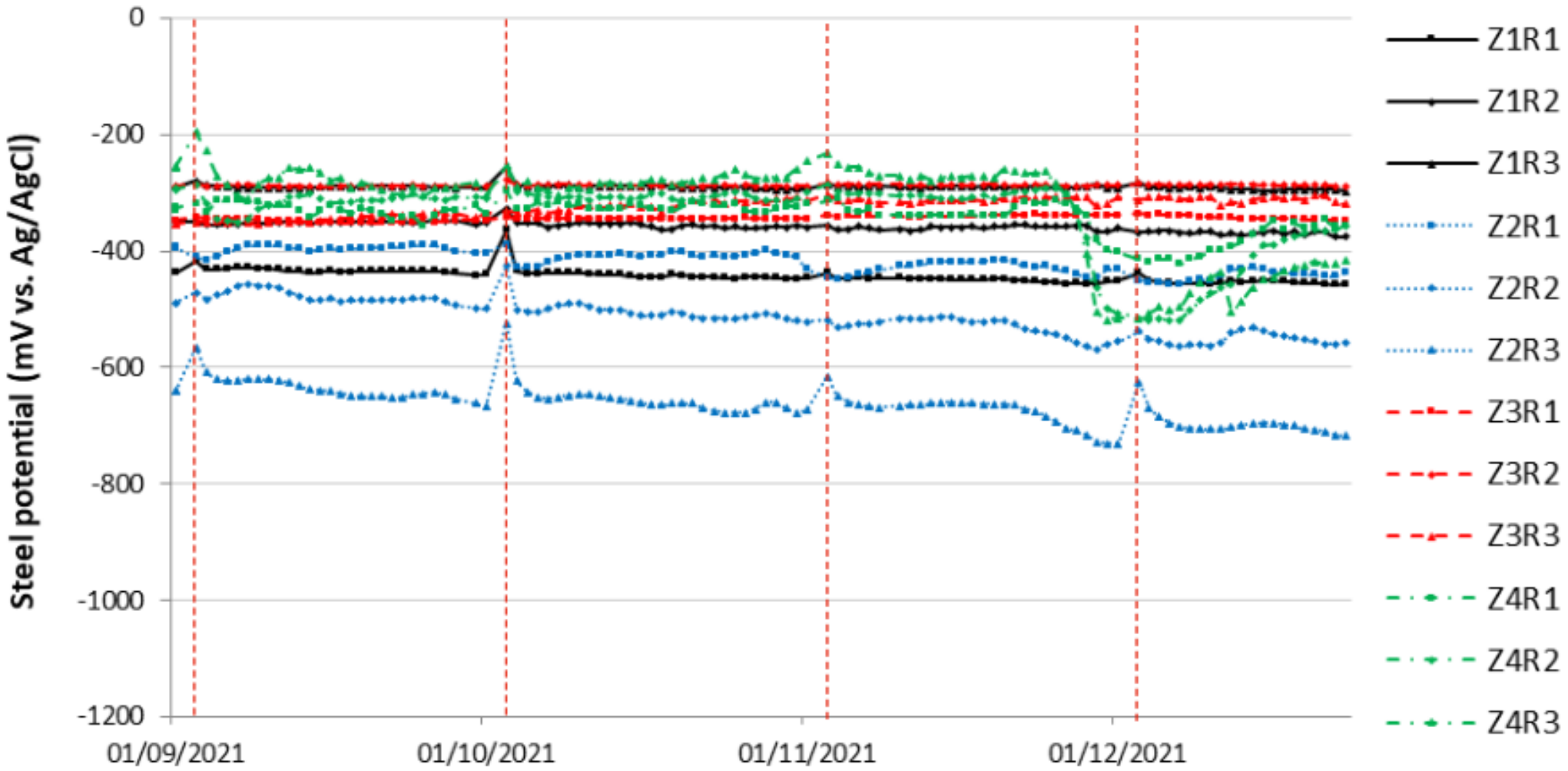


Amey

- Requirements in accordance with BS EN ISO 12696:2022.
  - ✓ Function checks
  - ✓ Performance assessments
  - ✓ System reviews
  - ✓ System review reports
- Intervals can be extended if no errors, damage or significant variation in system performance are indicated by successive inspections and tests.
- Data collected shall be reviewed and interpreted by persons competent in cathodic protection in accordance with BS EN ISO 15257:2017 (ICorr Level 3 or above)


Driving Voltage (mV)
7000
6000
5000
4000
3000
2000
1000
0
01/09/2020
01/10/2020
01/11/2020
01/12/2020
01/01/2021
01/02/2021
01/03/2021
01/04/2021
01/05/2021
01/06/2021
01/07/2021
01/08/2021
Zone 1
Zone 2
Zone 3
Zone 4


250
200
150
100
50
0
Current (mA)
01/09/2020
01/10/2020
01/11/2020
01/12/2020
01/01/2021
01/02/2021
01/03/2021
01/04/2021
01/05/2021
01/06/2021
01/07/2021
01/08/2021
Zone 1
Zone 2
Zone 3
Zone 4

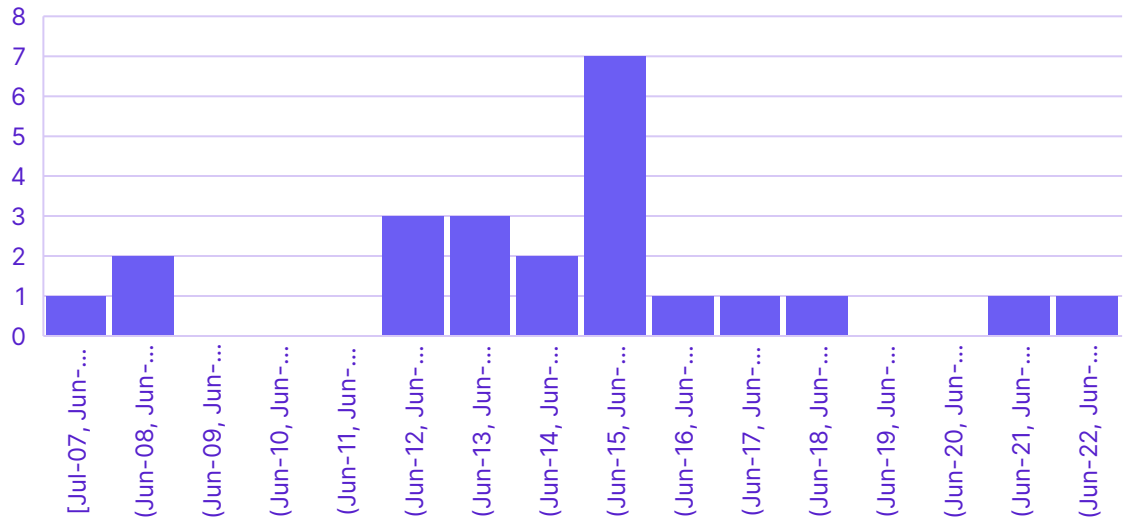

Steel potential (mV vs. Ag/AgCl)
0
-200
-400
-600
-800
-1000
-1200
01/09/2021
01/10/2021
01/11/2021
01/12/2021
Z1R1
Z1R2
Z1R3
Z2R1
Z2R2
Z2R3
Z3R1
Z3R2
Z3R3
Z4R1
Z4R2
Z4R3

Reference electrode locations – Depolarisation values (mV)

Month	Z1R1	Z1R2	Z1R3	Z2R1	Z2R2	Z2R3	Z3R1	Z3R2	Z3R3	Z4R1	Z4R2	Z4R3
Sept 21	214	128	55	202	249	163	10	38	6	124	73	110
Oct 21	215	132	53	210	256	179	11	42	10	106	76	39
Nov 21	214	127	49	233	269	178	9	41	8	90	62	44
Dec 21	206	113	46	229	293	182	8	38	-2	73	32	22

Types of ICCP systems:

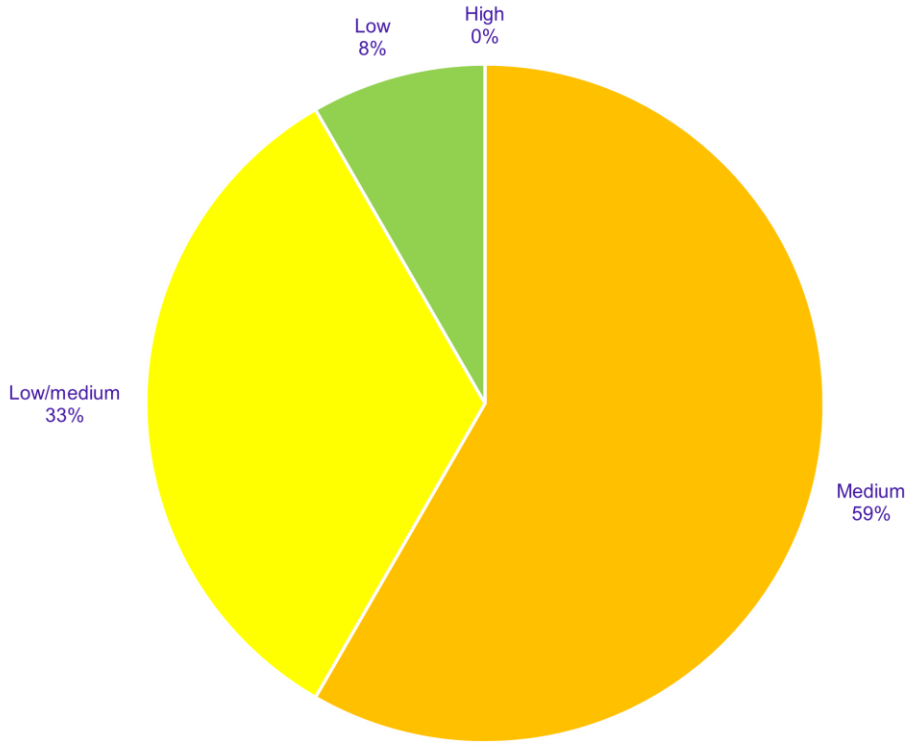
- 15No. MMO/Ti Mesh & Overlay (11No. of which also have discrete anodes installed)
- 3No. Discretes anodes
- 1No. Conductive mortar



Priority Rating & Monitoring Proposals

Amey

System Status	Priority Rating	Monitoring Proposal
Not operational	High	Site visit within 6 months Attempt to re-establish AC power or determine issue Connect temporary power supply and check if anode system is still operational
Operational & no monitoring check since last adjustment	Medium	Complete remote monitoring check (if possible), or Site visit within 12 months to perform manual depolarisation
Operational & annual system review check overdue (>2 years)	Low to Medium	Complete system review within 12 months
Operational & annual system review check within <2 years	Low	Complete system review within 24 months



Amey

- Cathodic protection can be an effective method of preventing the initiation of, and arresting ongoing, corrosion.
  - ✓ Risks and cost implications of maintenance and equipment failure should be considered when determining the appropriate corrosion management strategy.
  - ✓ A targeted approach results in lower costs, reduced programme and the optimisation of electrical equipment.
- Regular monitoring in accordance with BS EN ISO 12696:2022 is essential to ensure the longevity of the asset and achieve best value from the installed system.
- Sufficient funding should be allocated to the monitoring of CP systems to ensure longevity of the asset and to achieve best value from the installed system.
- Prioritisation of risk can assist in allocating available budgets for monitoring.