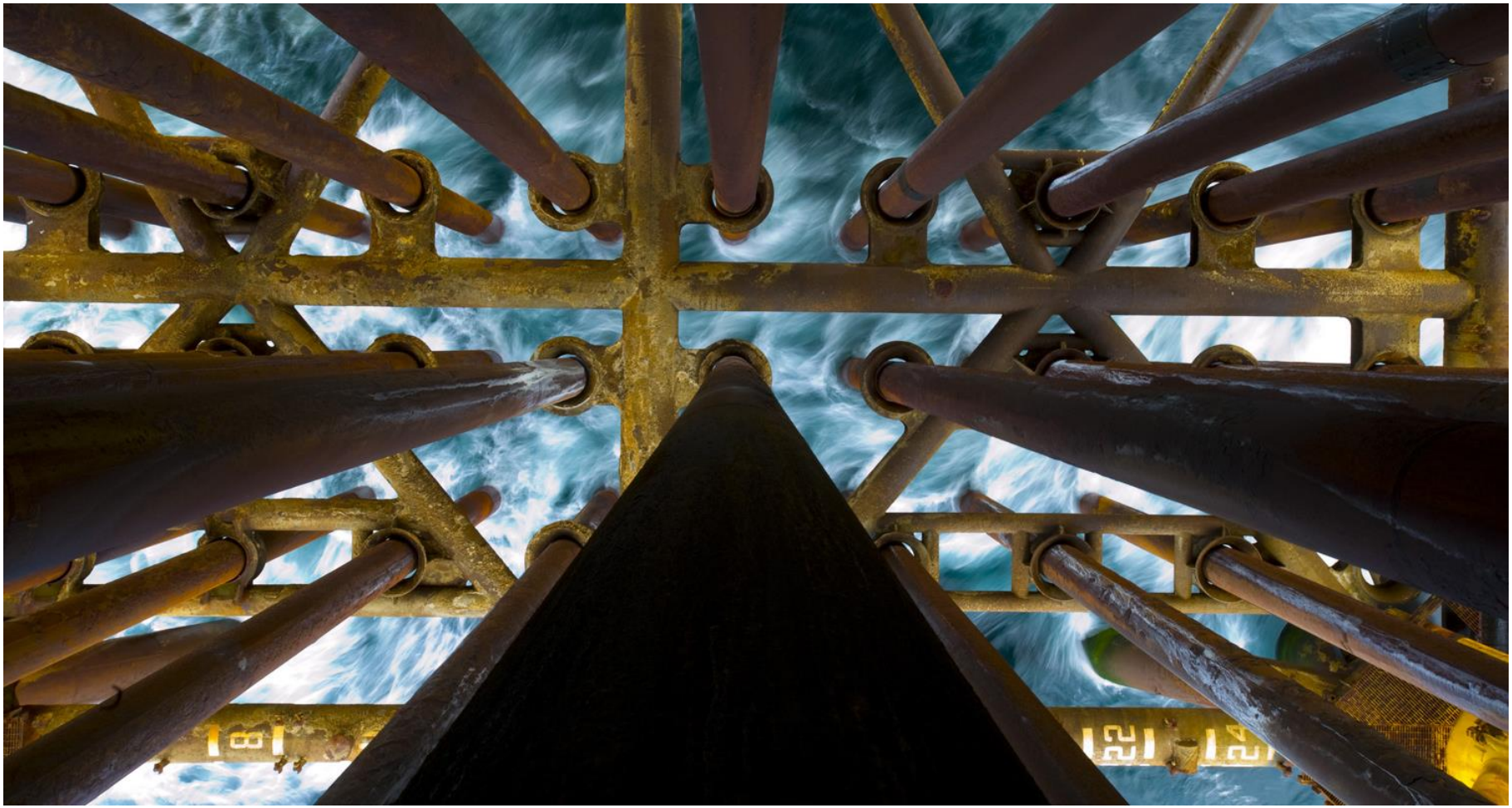
Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

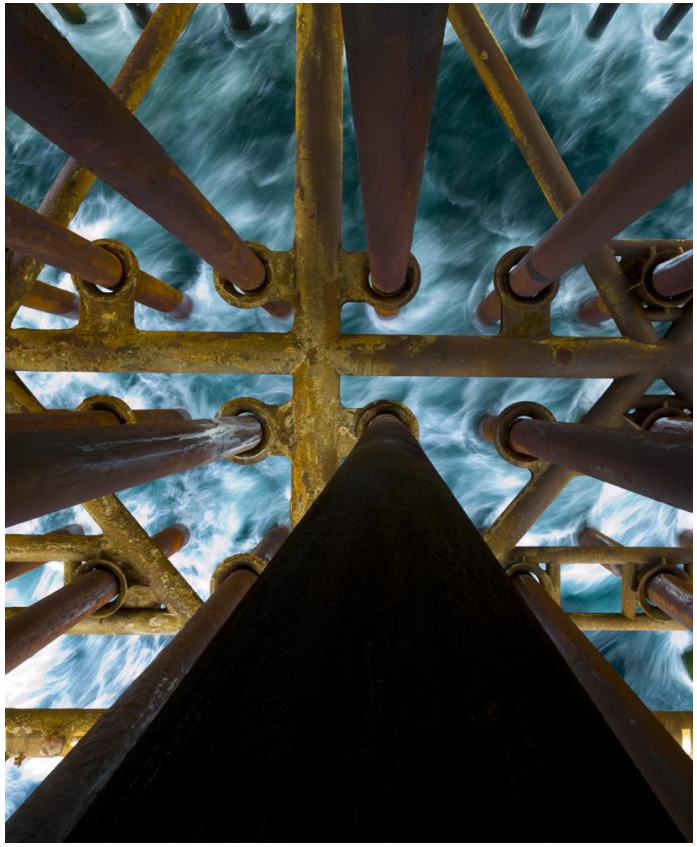
Edgar Rodrigues
Corrosion and Materials Technical Authority



Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

Agenda

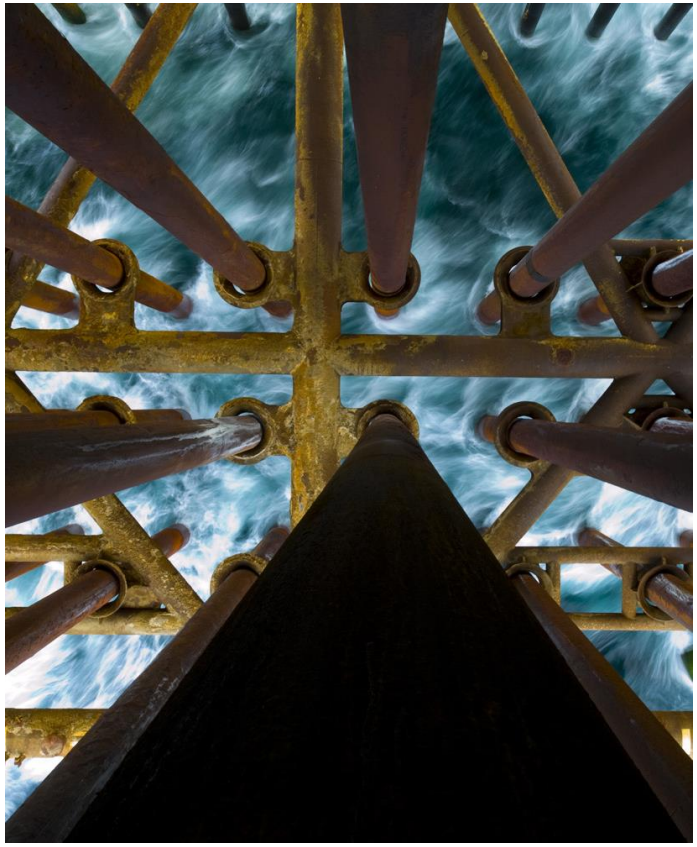
1. TAQA
2. Sacrificial Anodes Vs Impressed Current
3. History – North Cormorant
4. CP Inspection History – North Cormorant
5. Facts – North Cormorant
6. CP Assessments
7. ICCP Project Scope and Requirements
8. Commissioning
9. Results
10. Conclusions



Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

Agenda

1. TAQA
2. Sacrificial Anodes Vs Impressed Current
3. History – North Cormorant
4. CP Inspection History – North Cormorant
5. Facts – North Cormorant
6. CP Assessments
7. ICCP Project Scope and Requirements
8. Commissioning
9. Results
10. Conclusions



Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

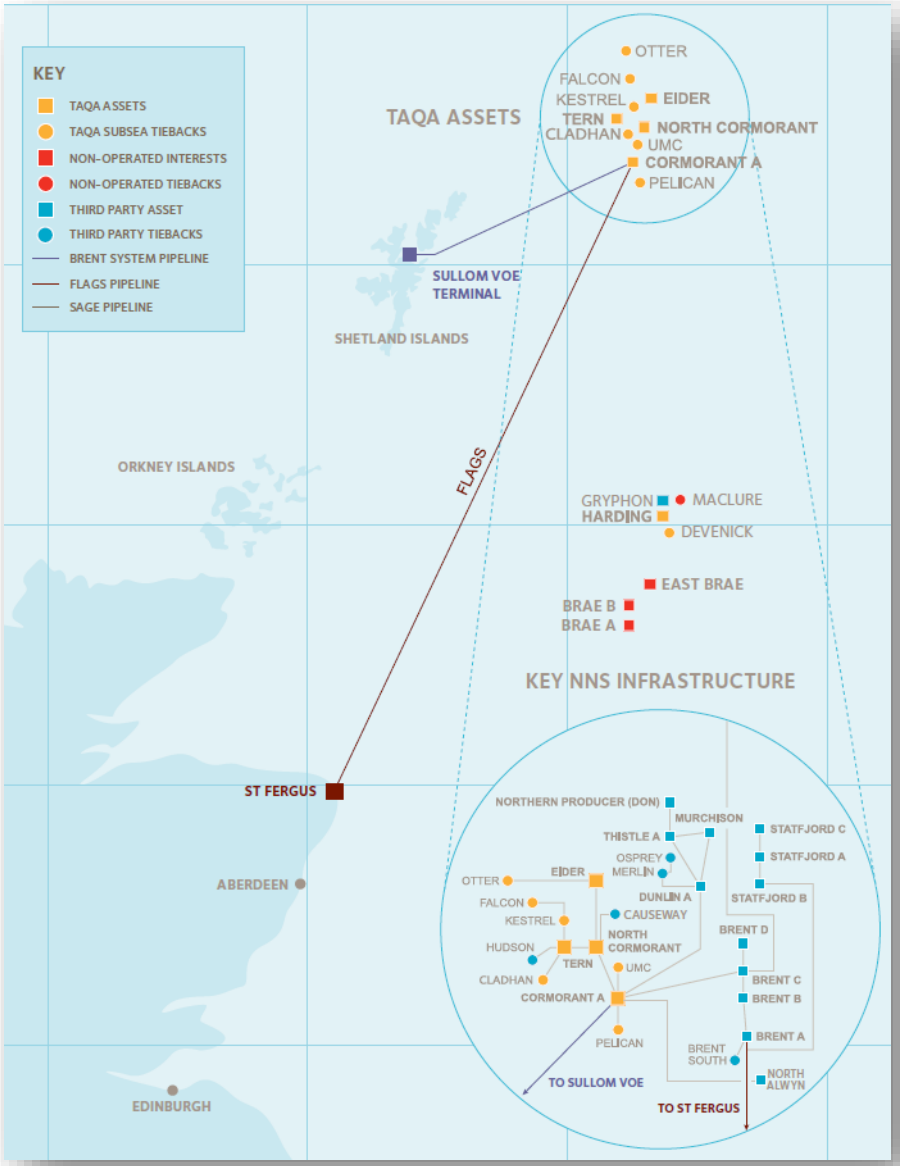
1. TAQA

Northern North Sea (2008)

- Cormorant Alpha
- North Cormorant
- Tern
- Eider

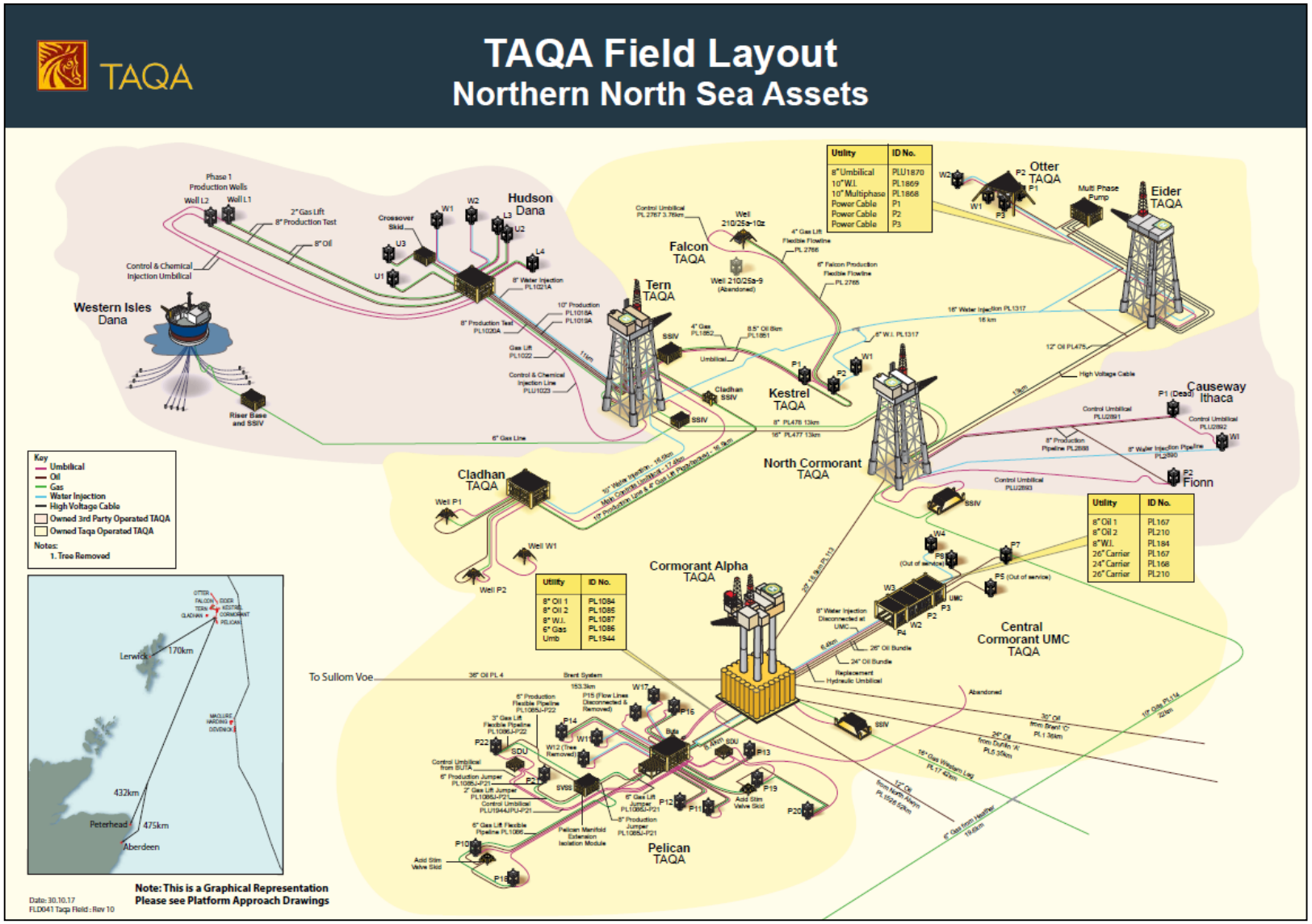
Central North Sea (2013)

- Harding



Impressed Current Cathodic Protection Retrofit System

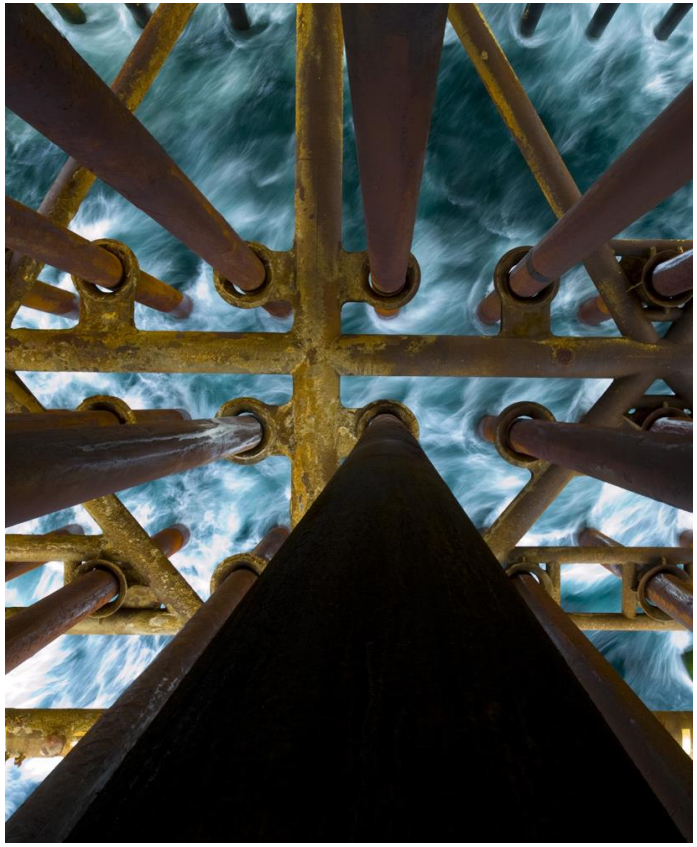
Icorr Aberdeen



Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

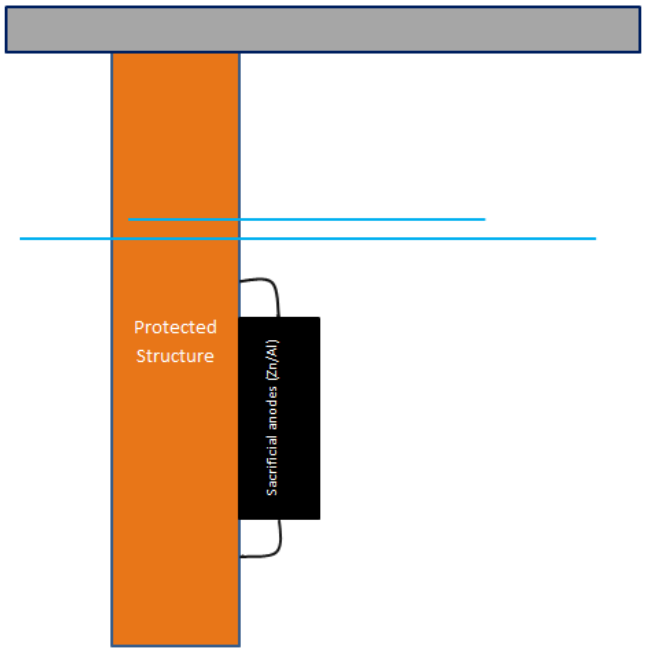
Agenda

1. TAQA
2. Sacrificial Anodes Vs Impressed Current
3. History – North Cormorant
4. CP Inspection History – North Cormorant
5. Facts – North Cormorant
6. CP Assessments
7. ICCP Project Scope and Requirements
8. Commissioning
9. Results
10. Conclusions

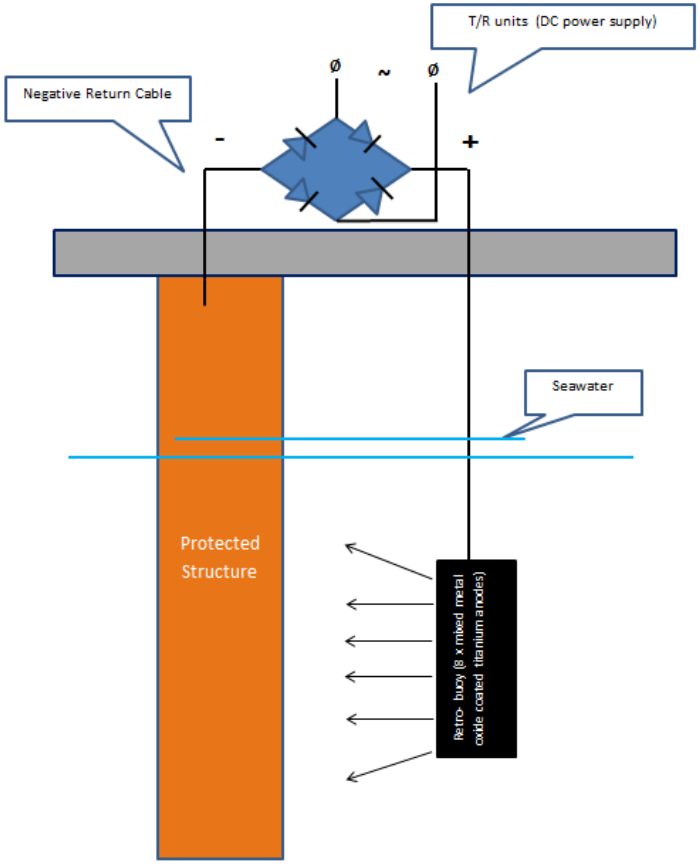


Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

2. Sacrificial Anodes Vs Impressed Current



Sacrificial Anode System



Impressed Current Cathodic Protection (ICCP)

From BS CP1021:1973

Impressed Current Cathodic Protection Retrofit System

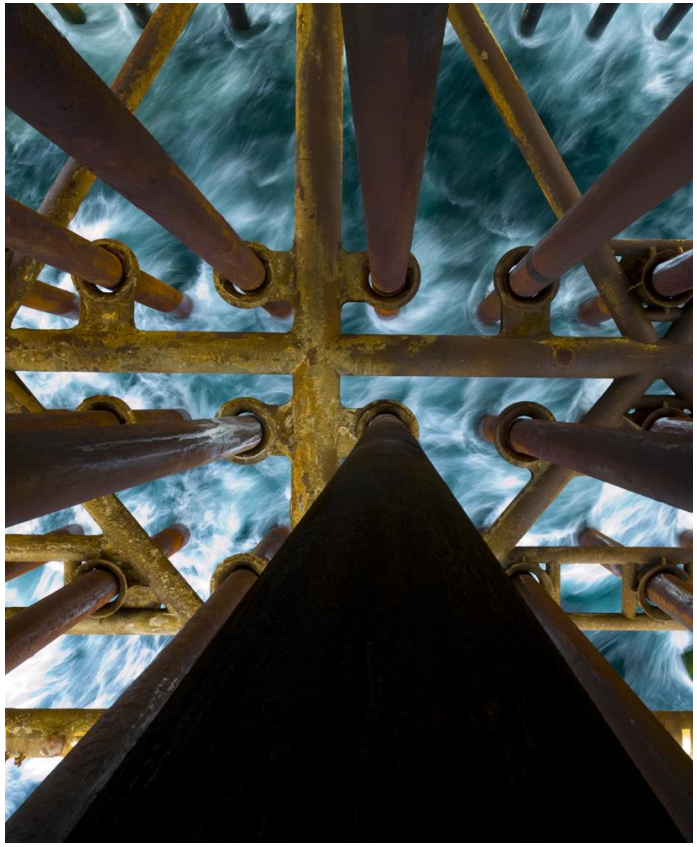
Icorr Aberdeen

Sacrificial anodes versus Impressed current	
Sacrificial Anodes	**Impressed Current**
1) Independent of any source of electrical power	**1)Requires a mains supply or other source of electric power**
2)They may be required at large number of positions. Their life varies with conditions so that replacements may be required at different intervals of time at different parts of the system	**2)Requires generally a small total number of anodes**
3) Their output cannot be controlled but there is a tendency for their current to be self-adjusting	**3) Requires relatively simple controls and can be made automatic to maintain potentials within close limits despite wide variations of conditions**
4) They cannot be misconnected so that polarity is reversed	**4) Requires the polarity to be checked during commissioning because misconnection, so that polarity is reversed, can accelerate corrosion**

Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

Agenda

1. TAQA
2. Sacrificial Anodes Vs Impressed Current
3. History – North Cormorant
4. CP Inspection History – North Cormorant
5. Facts – North Cormorant
6. CP Assessments
7. ICCP Project Scope and Requirements
8. Commissioning
9. Results
10. Conclusions



Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

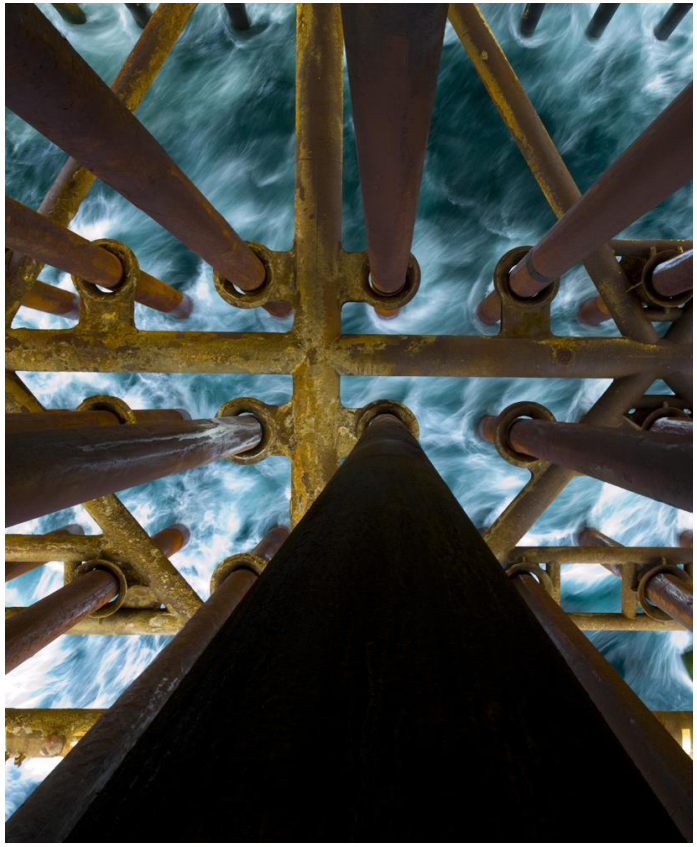
3. History – North Cormorant

- North Cormorant was constructed in the late 1970s
- Installed in 1980/81
- Eight-legged steel piled jacked
- No coatings applied other than the risers
- No corrosion allowance was considered for structural steels
- Original designed by using sacrificial aluminium alloy galvanic anodes
- The asset remains viable and serves as a critical hub for major fields in the area

Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

Agenda

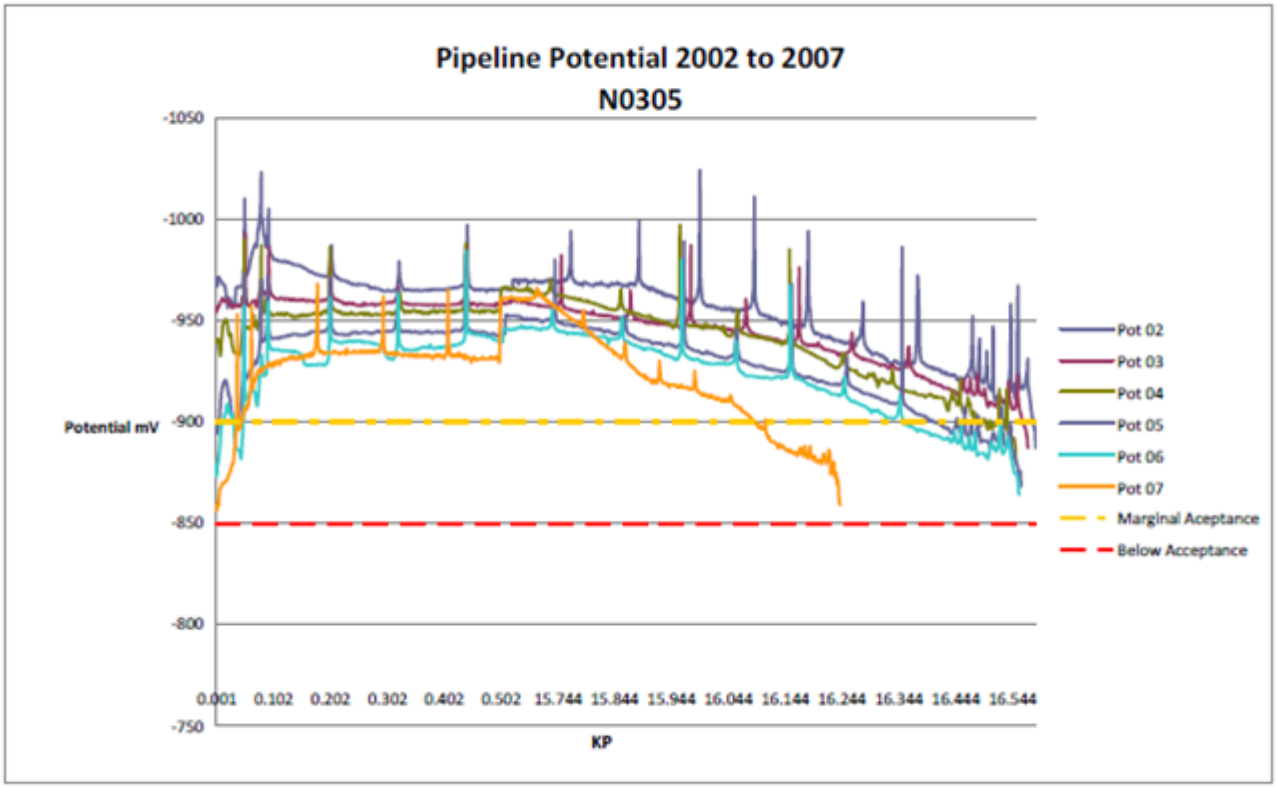
1. TAQA
2. Sacrificial Anodes Vs Impressed Current
3. History – North Cormorant
4. CP Inspection History – North Cormorant
5. Facts – North Cormorant
6. CP Assessments
7. ICCP Project Scope and Requirements
8. Commissioning
9. Results
10. Conclusions



Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

5. CP Inspection History – North Cormorant

Graph 1 indicates pipeline potentials from 2002 to 2007. The potentials show a gradual decline during this period at the North Cormorant end – KP 16.54.



Grapgh 1: Pipeline Potemtials from 2002 to 2007.

Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

5. CP Inspecti

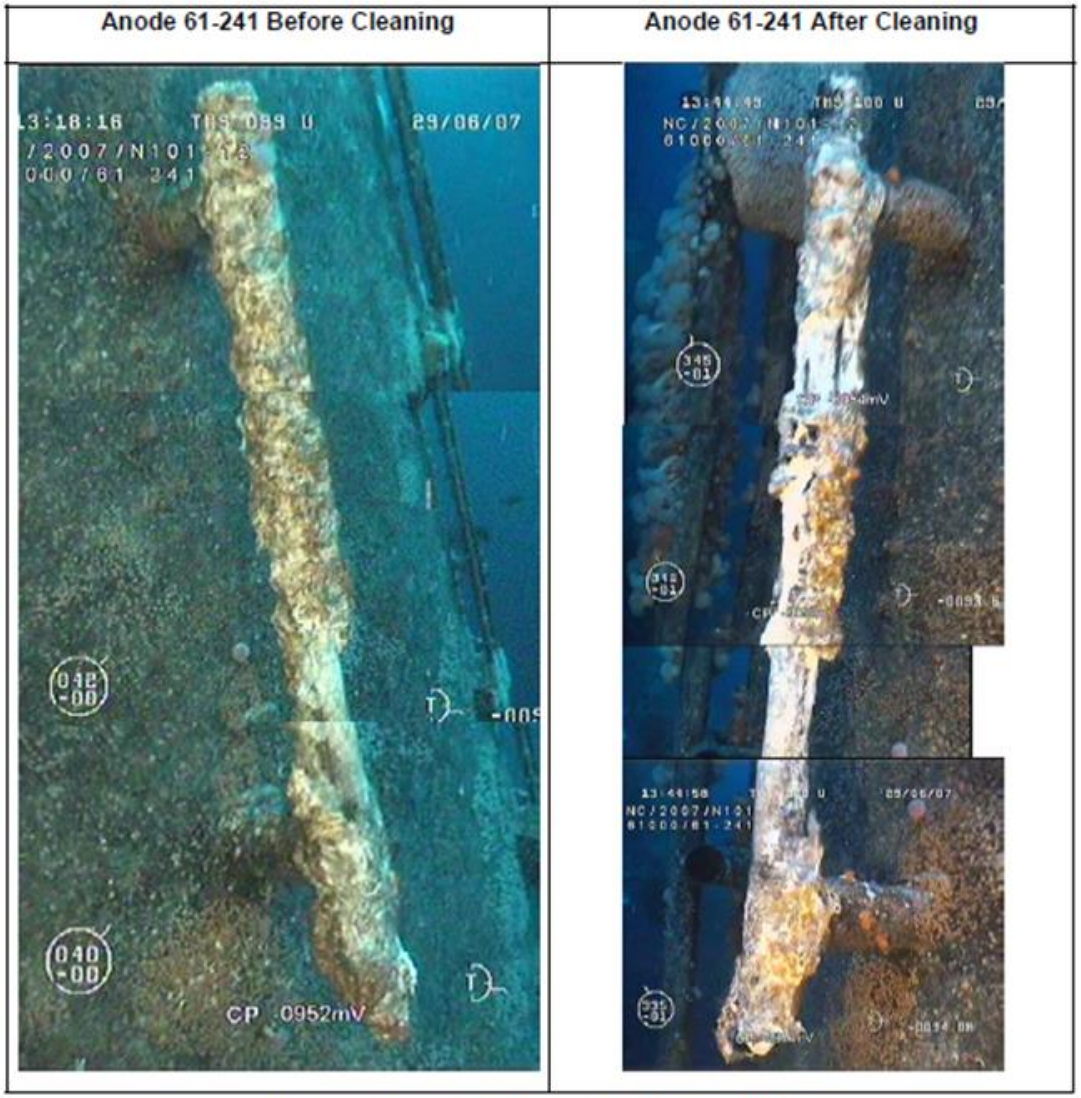
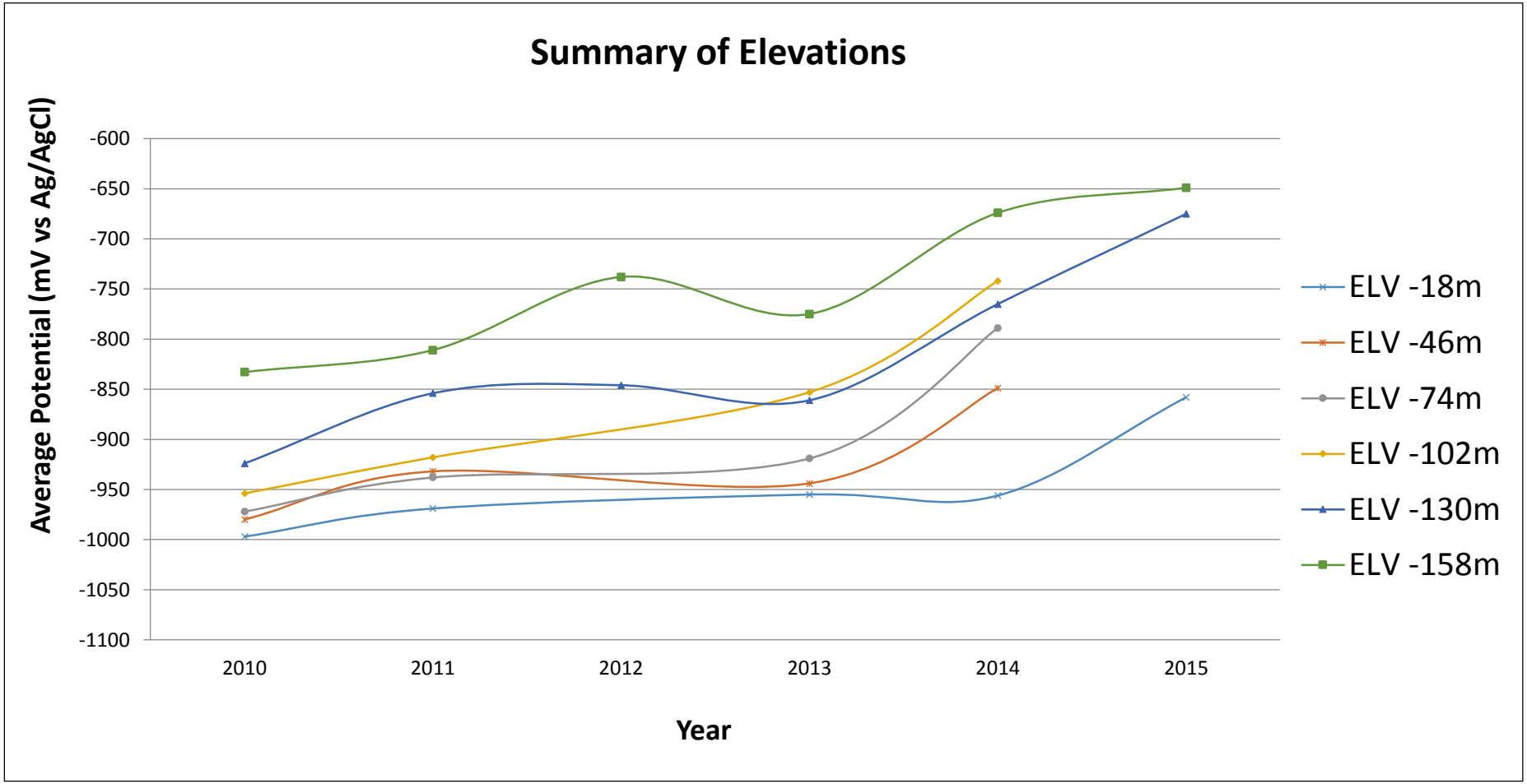


Figure 1: Anode depletion in 2007

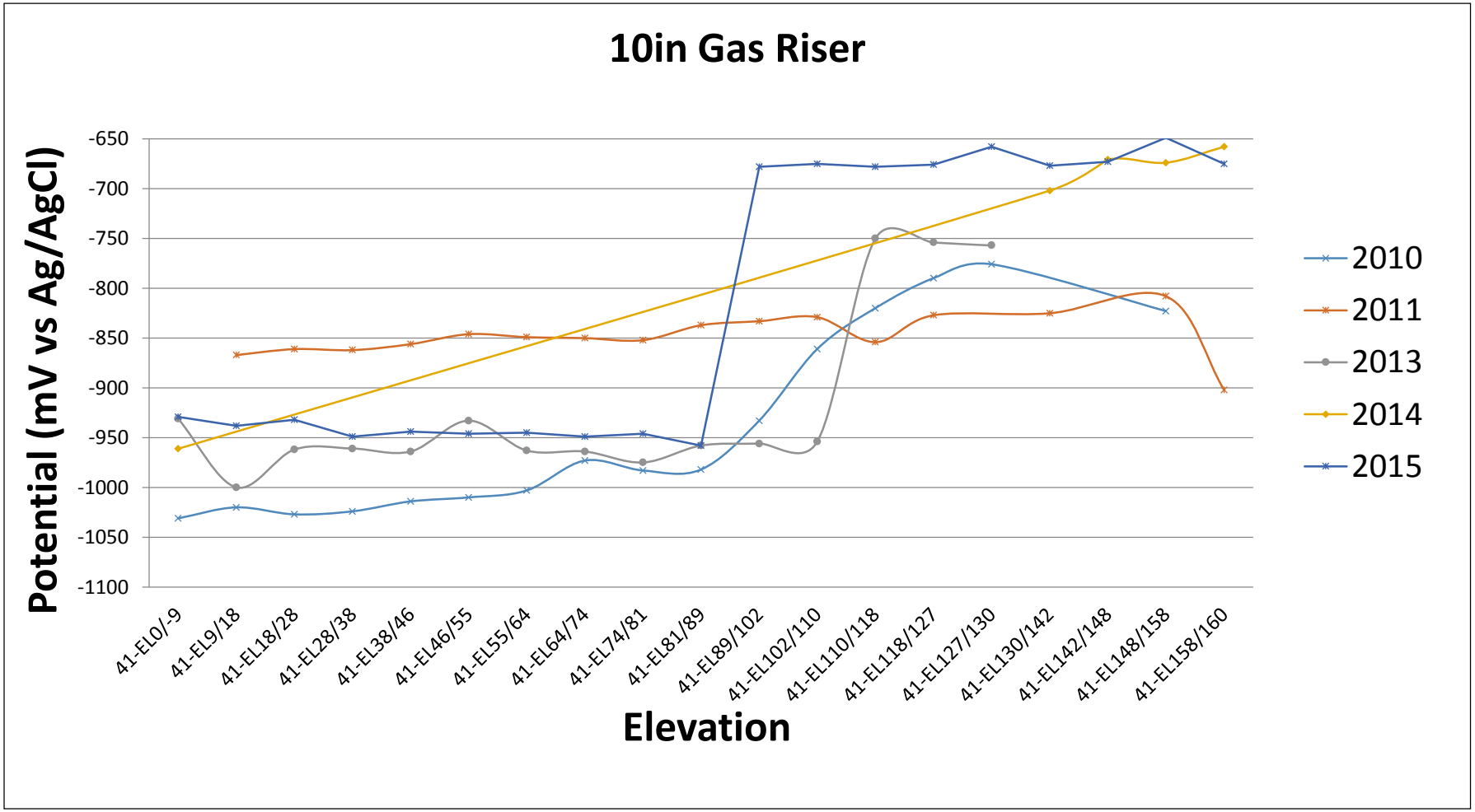
Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

5. CP Inspection History – North Cormorant



Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

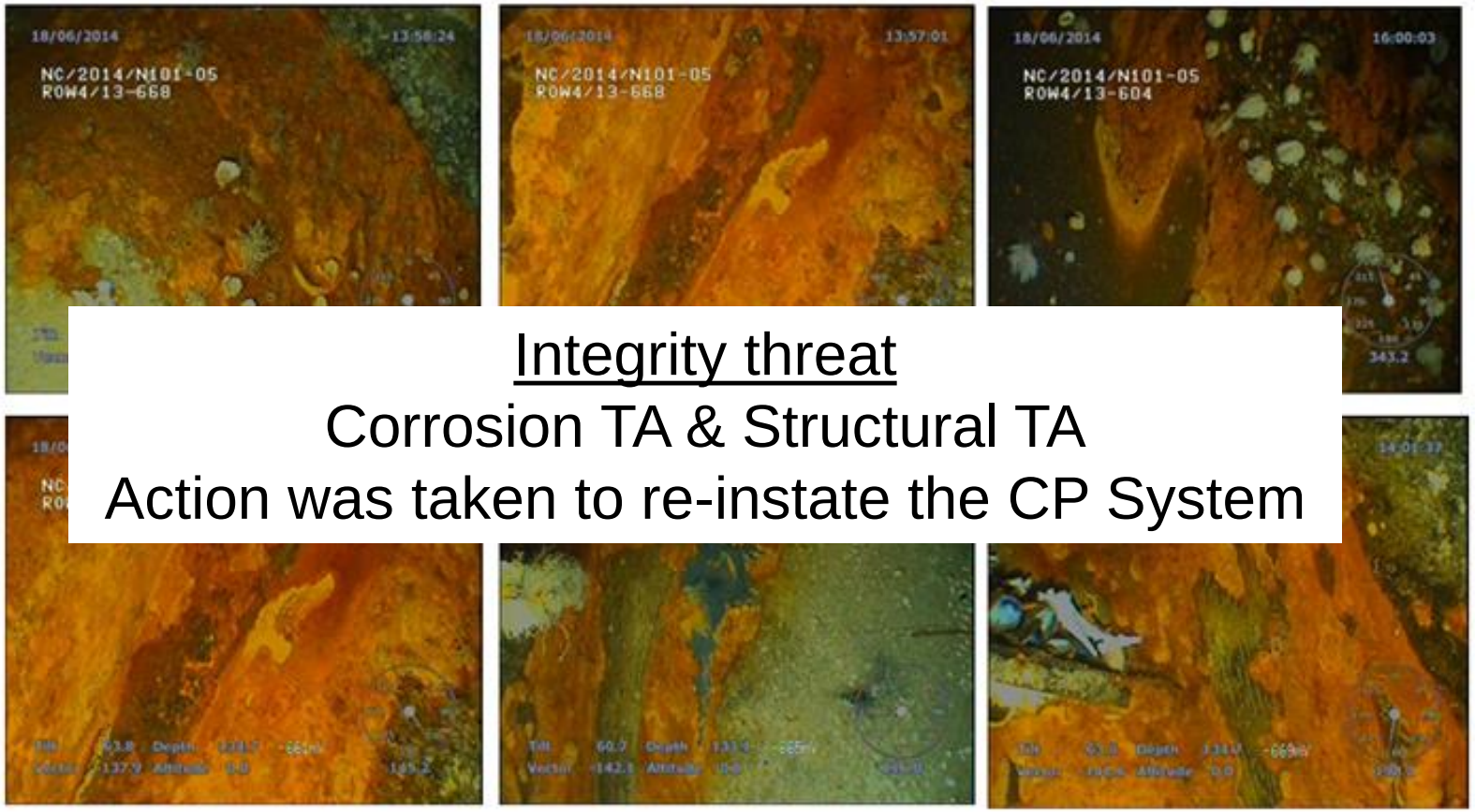
5. CP Inspection History – North Cormorant



Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

5. CP Inspection History – North Cormorant

ROV SURVEY RESULTS – 18/06/2014



<u>Integrity threat</u>

Corrosion TA & Structural TA

Action was taken to re-instate the CP System

Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

5. CP Inspection History – North Cormorant

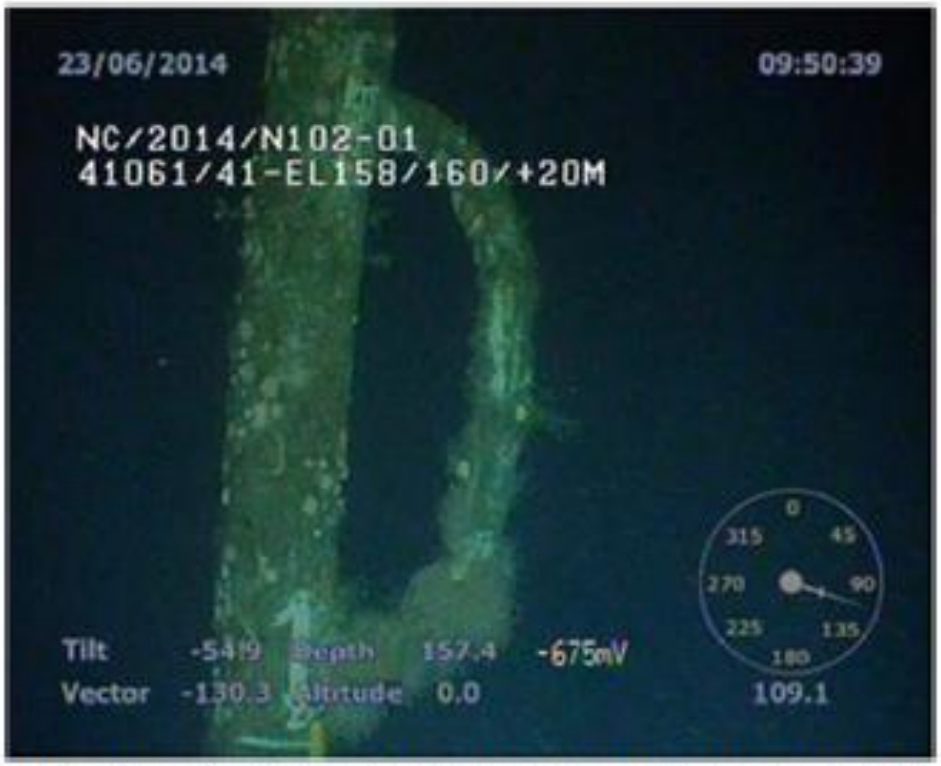
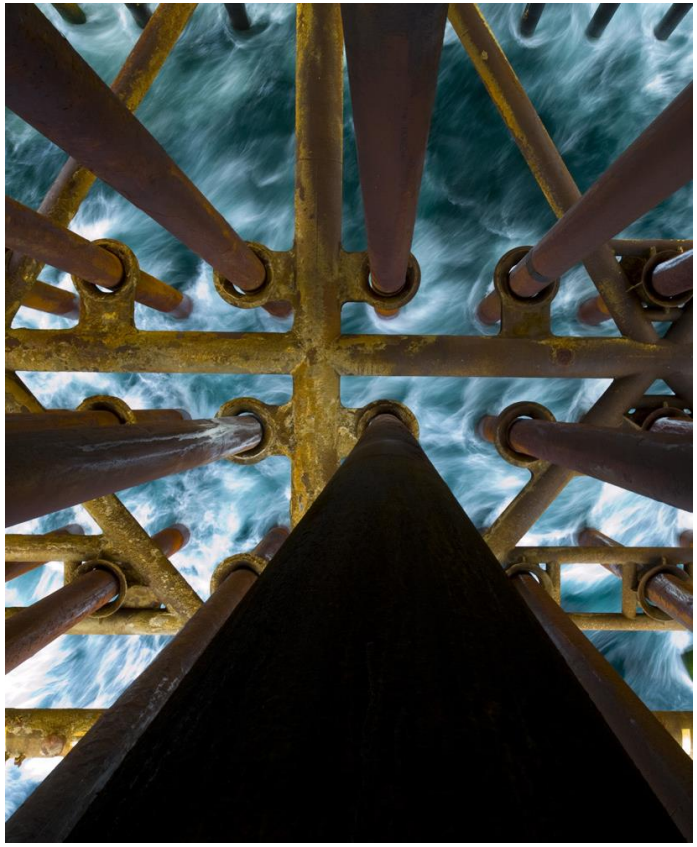


Figure 4: Example of Depleted Anode at EL158

Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

Agenda

1. TAQA
2. Sacrificial Anodes Vs Impressed Current
3. History – North Cormorant
4. CP Inspection History – North Cormorant
5. Facts – North Cormorant
6. CP Assessments
7. ICCP Project Scope and Requirements
8. Commissioning
9. Results
10. Conclusions



Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

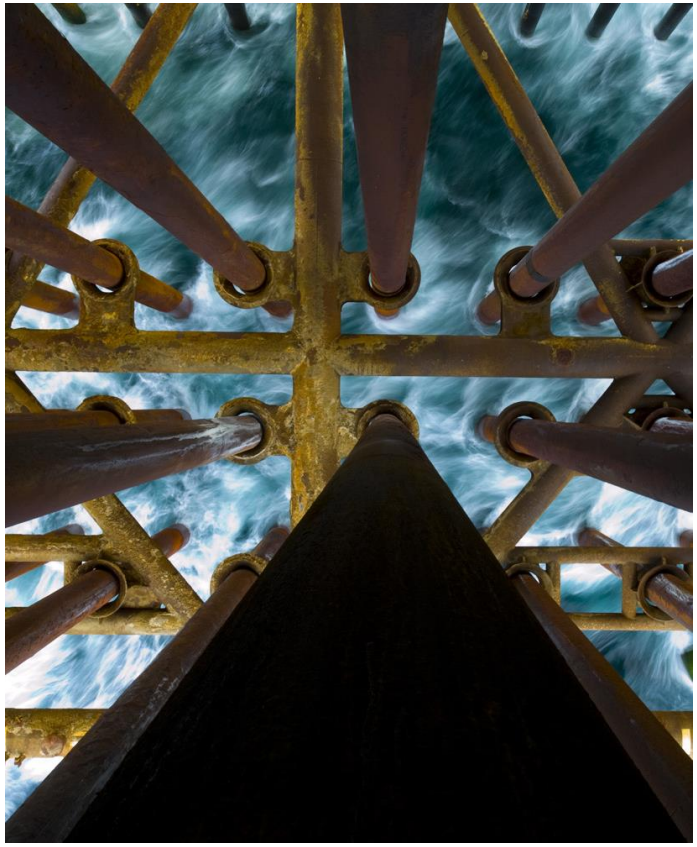
4. Facts – North Cormorant

- Submerged jacket structure is 3x height of St Nicholas House,
- Structural members made of offshore submerged arc welded structural steel grade – BS7191
- Fabricated from 5 km of tube diameter 0.7m to 6m and wall thickness between 20mm to 65 mm,
- Any attempt to justify a corroding jacket would require extensive subsea inspection,
  - Widespread removal of marine growth before CVI and NDT inspection,
  - Annual cost for inspecting 1% of the welds (30welds) £3.75m; 10% of welds (300 welds) £37.5m,
- Corrosion was extremely difficult to predict and could be influenced by galvanic corrosion, MIC, pitting and PWC

Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

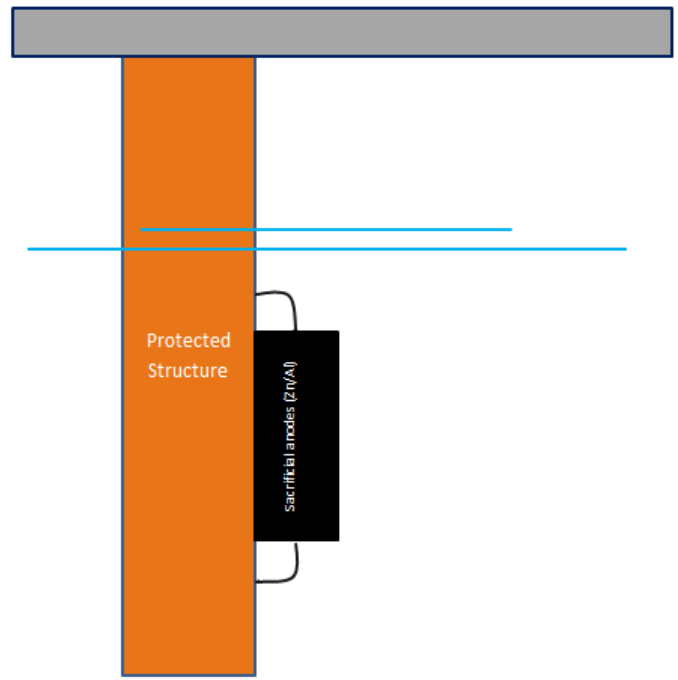
Agenda

1. TAQA
2. Sacrificial Anodes Vs Impressed Current
3. History – North Cormorant
4. CP Inspection History – North Cormorant
5. Facts – North Cormorant
6. CP Assessments
7. ICCP Project Scope and Requirements
8. Commissioning
9. Results
10. Conclusions



Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

6. CP Assessments



Sacrificial Anode System

Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

6. CP Assessments

- Assessment,

✓ Massive daunting task to calculate the surface area from pre-electronic drawing era and old scanned documents; it was calculated to be in the region of between 75,000 and 85,000 m^2,

✓ There is currently no guide or standard for offshore retrofit CP designs,

✓ Previous studies and structure current average were used to calculate current requirements,

✓ **A galvanic anode system would have required over 600 gross tonnes of anodes to the structure**,

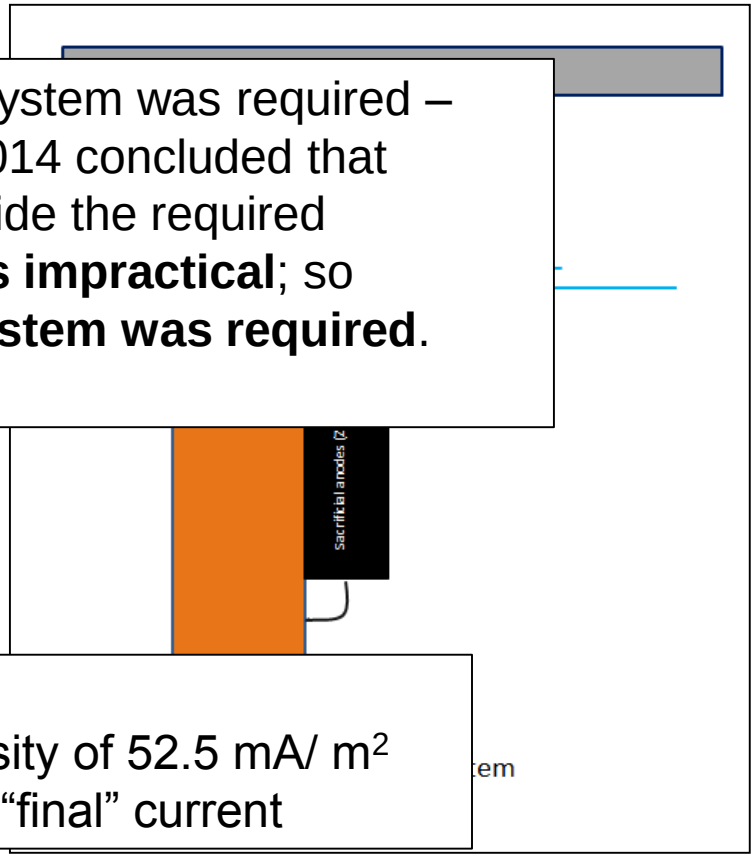
Challenges being:

- How much contingency does one add in to account for re-polarization of the existing system?
- How long will take the system to re-polarised?
- When will retro-fit system get installed and commissioned?
- Financial constraints
- Safety

Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

6. CP Assessments

- After 33 years length a new protection system was required – studies conducted between 2011 and 2014 concluded that retrofit sacrificial anodes would not provide the required repolarization current and their **size was impractical**; so installation of an **impressed current system was required**.

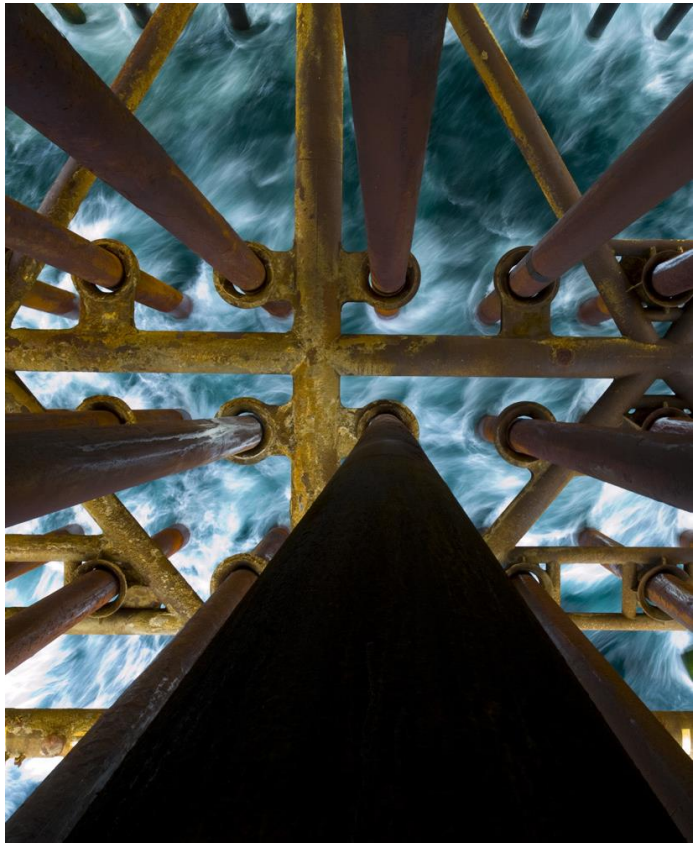


- Assuming 80,000 m^2 surface area,
- @ 4200 A equated “mean” current density of 52.5 mA/ m^2
- Capacity available for redundancy and “final” current

Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

Agenda

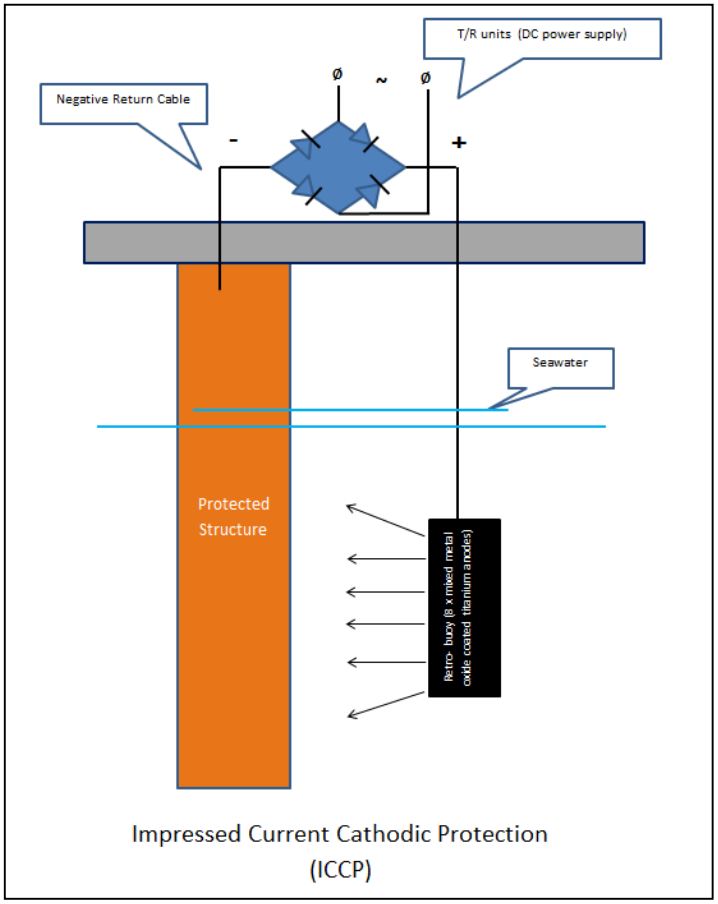
1. TAQA
2. Sacrificial Anodes Vs Impressed Current
3. History – North Cormorant
4. CP Inspection History – North Cormorant
5. Facts – North Cormorant
6. CP Assessments
7. ICCP Project Scope and Requirements
8. Commissioning
9. Results
10. Conclusions



Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

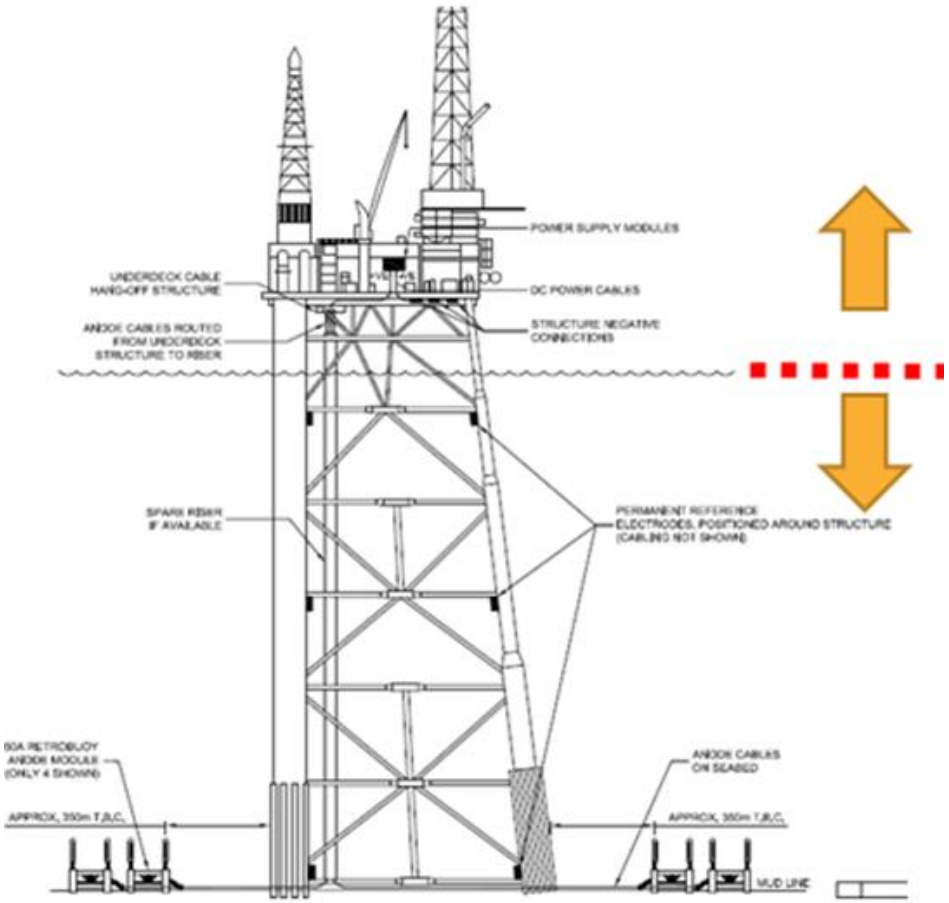
7. ICCP Project Scope and Requirements

- Purchase eight transformer rectifier units (TRU) and subsea anode retro-buoys
- Purchase new subsea cables; one for each retro-buoy
- Attach the subsea cable to the ICCP retro-buoys, install on seabed, including stabilisation and protection as may be required,
- Hook-up subsea cables to the TRU and TRU to North Cormorant power supply
- Commission system



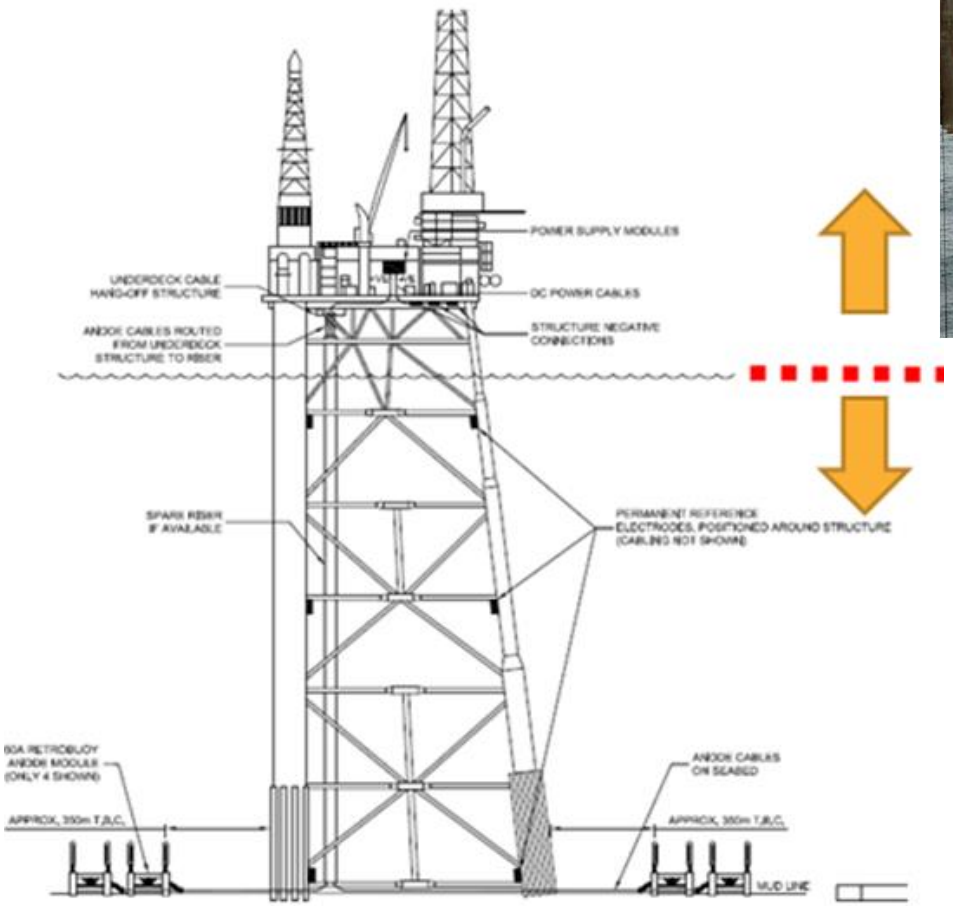
Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

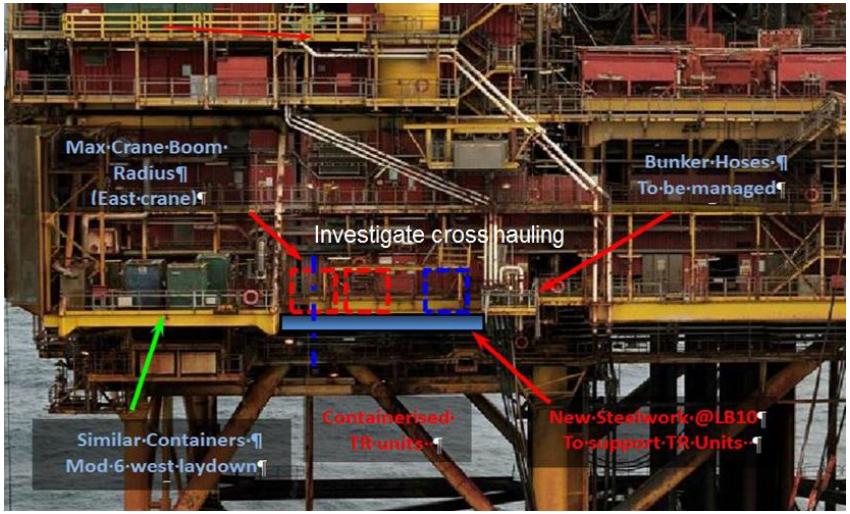
7. ICCP Project scope and Requirements



Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

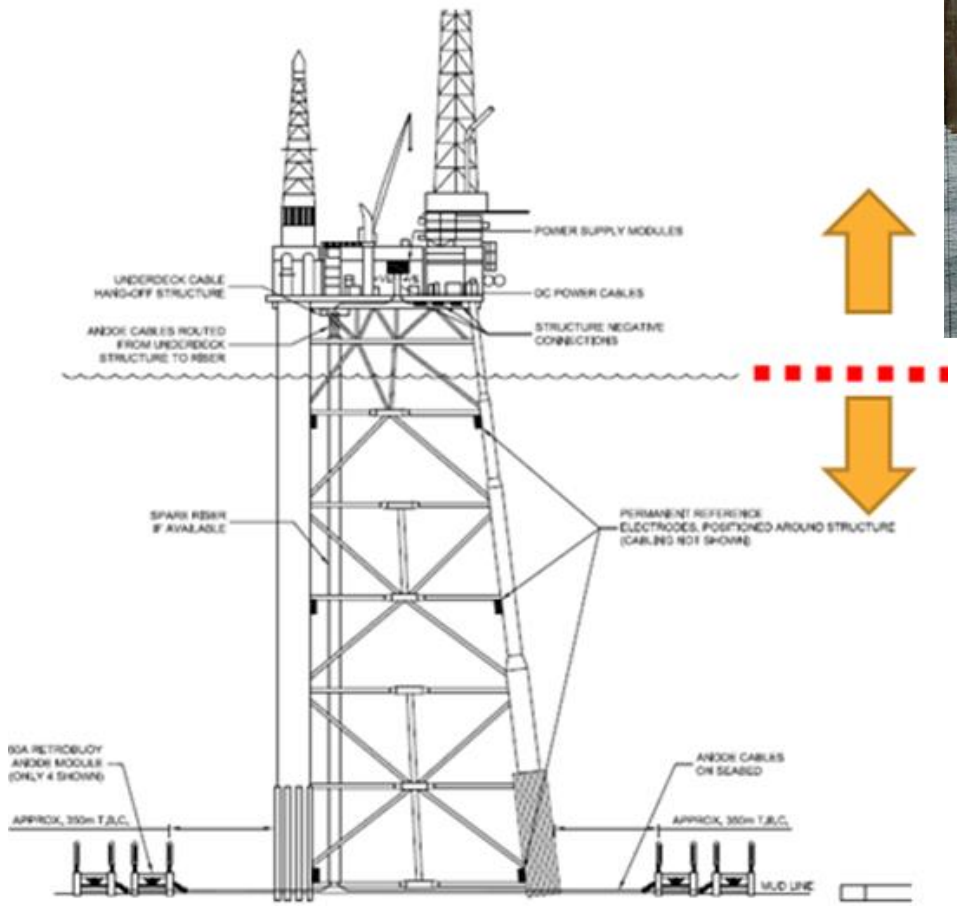
7. ICCP Project scope and Requirements

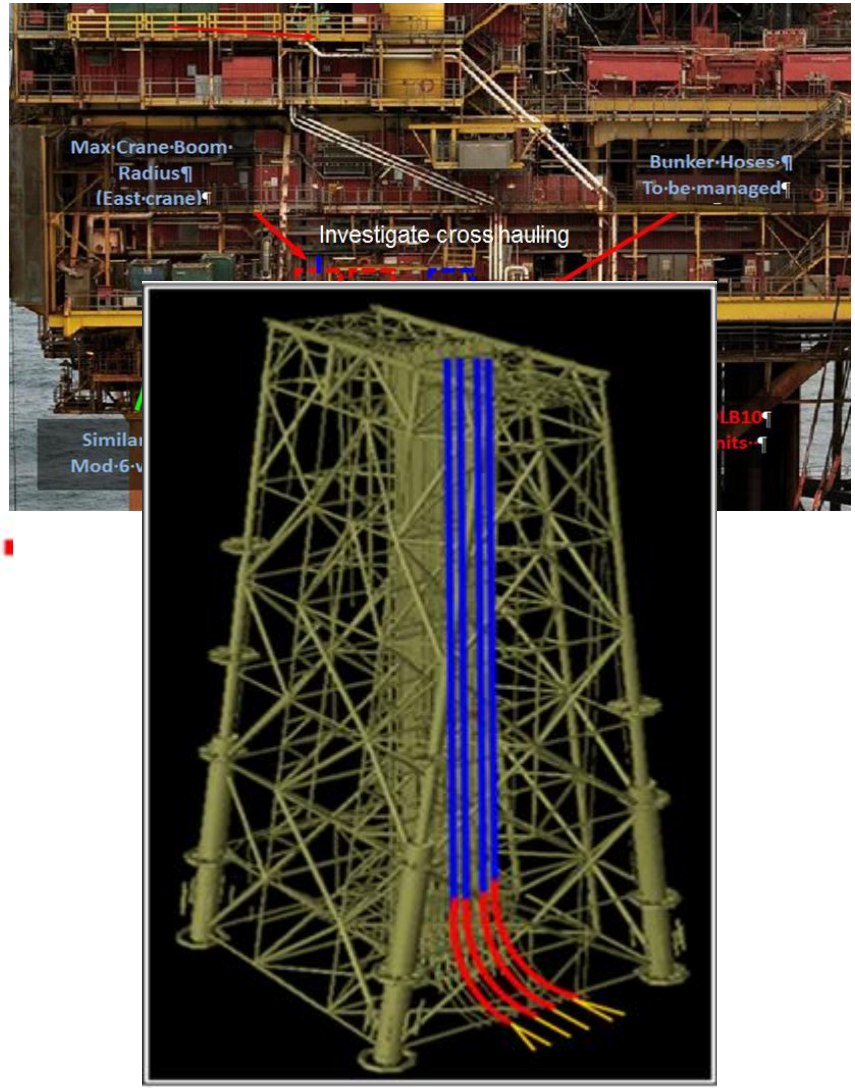




Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

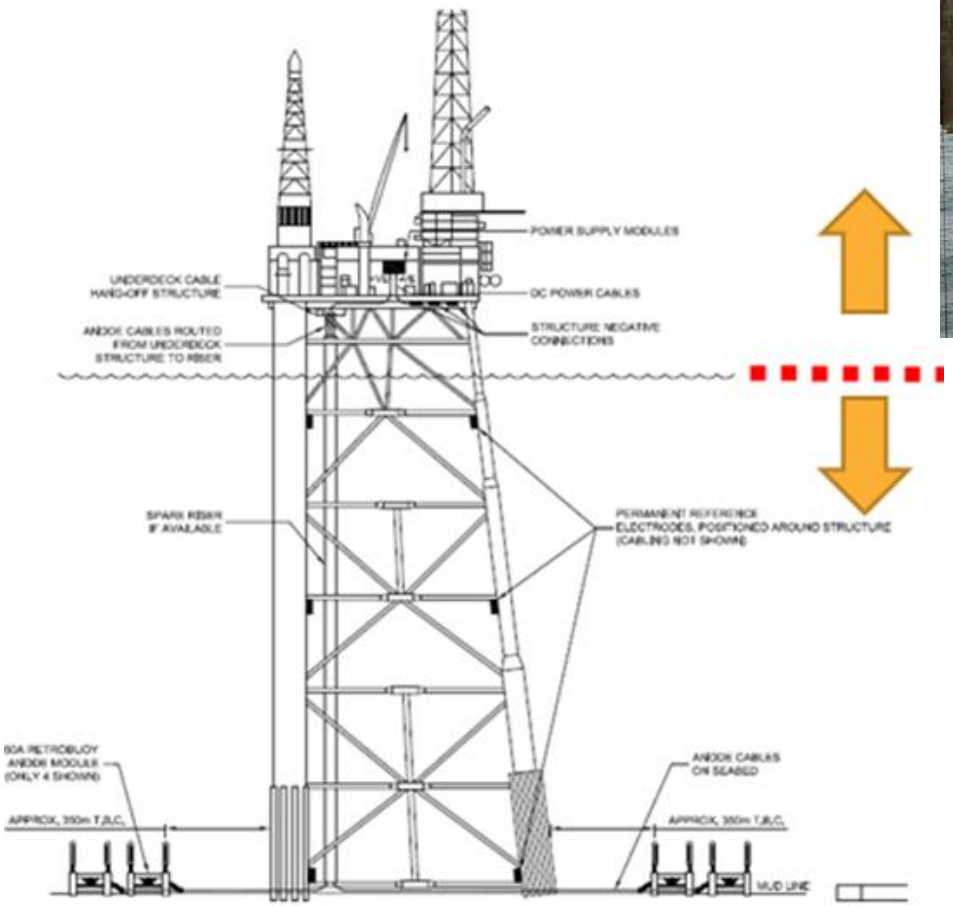
7. ICCP Project scope and Requirements

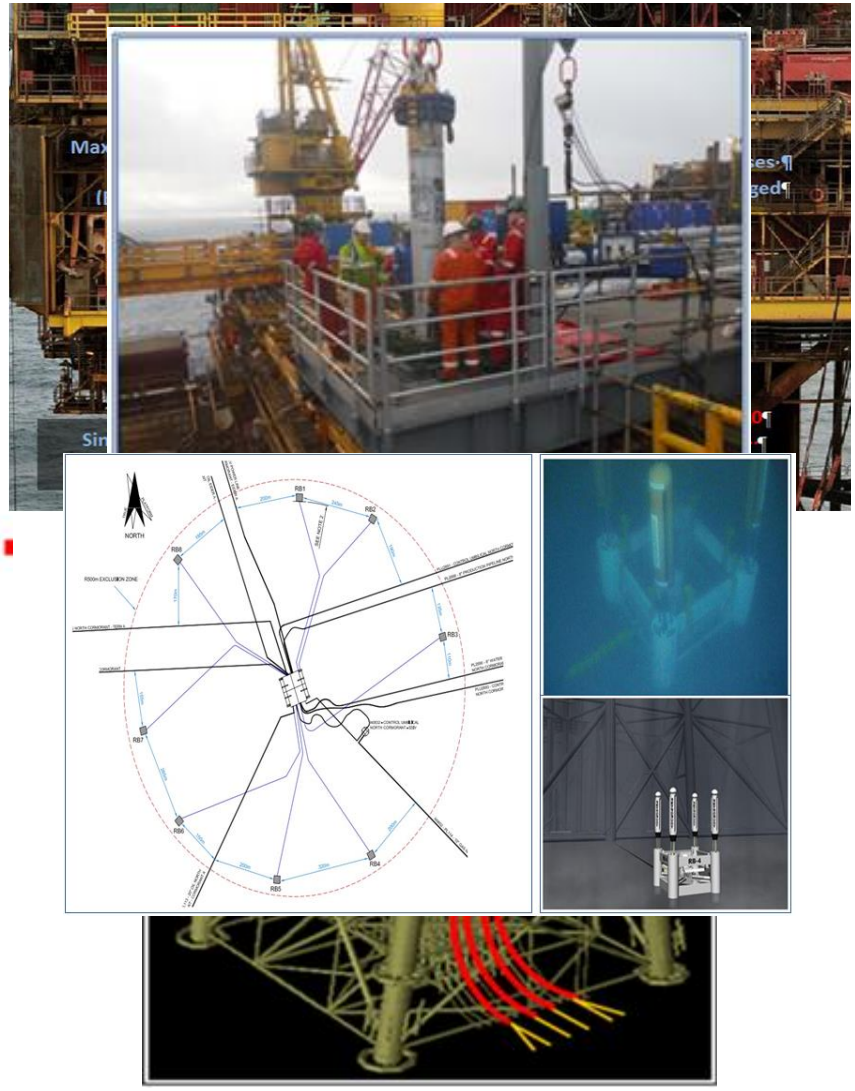




Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

7. ICCP Project scope and Requirements

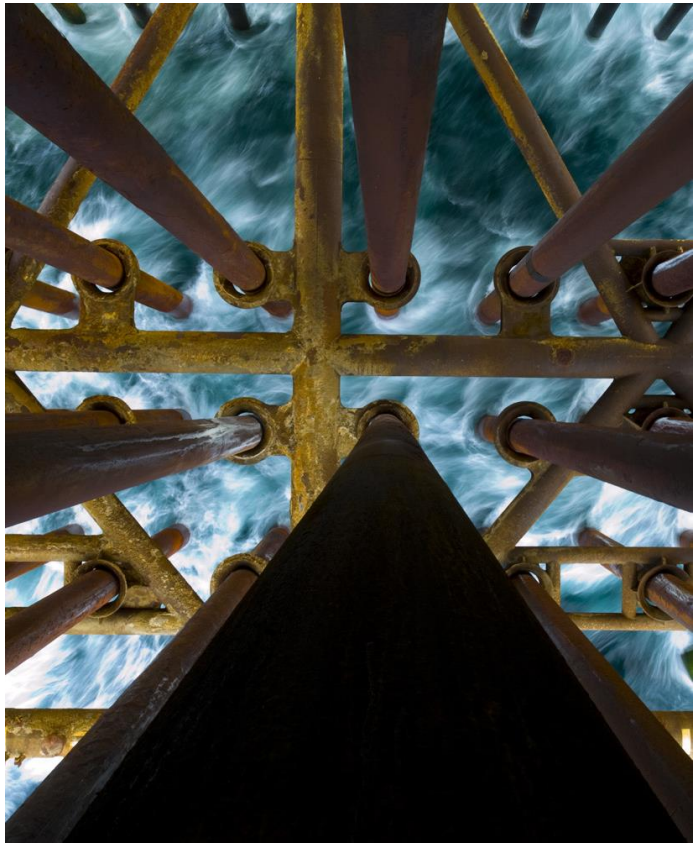




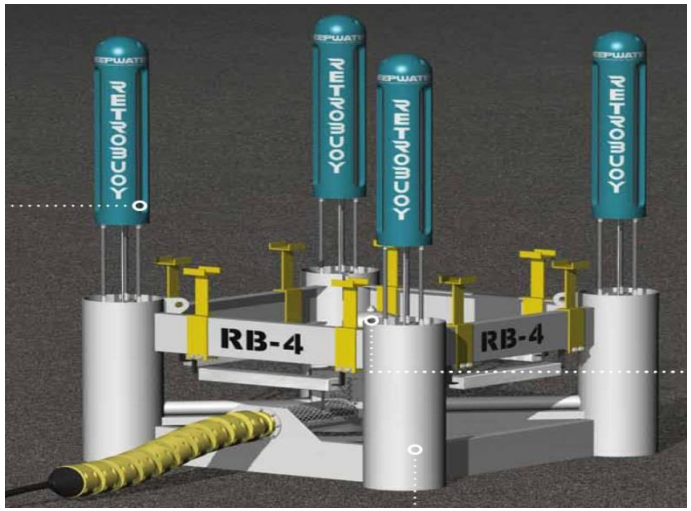
Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

Agenda

1. TAQA
2. Sacrificial Anodes Vs Impressed Current
3. History – North Cormorant
4. CP Inspection History – North Cormorant
5. Facts – North Cormorant
6. CP Assessments
7. ICCP Project Scope and Requirements
8. Commissioning
9. Results
10. Conclusions



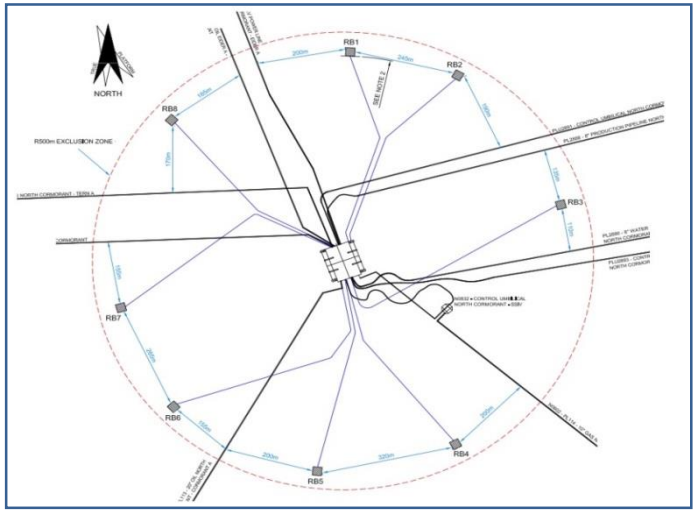
Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen



8. Commissioning

The retrofit Impressed Current CP (ICCP) solution for TAQA's North Cormorant Platform was commissioned in January 2016 and consists of 8 complete systems each with the following components:

- 8-off seabed mounted impressed current Retrobuoy anode skids
- 8-off subsea anode power cables
- 8-off transformer rectifier (DC power supply)
- CP monitoring systems.

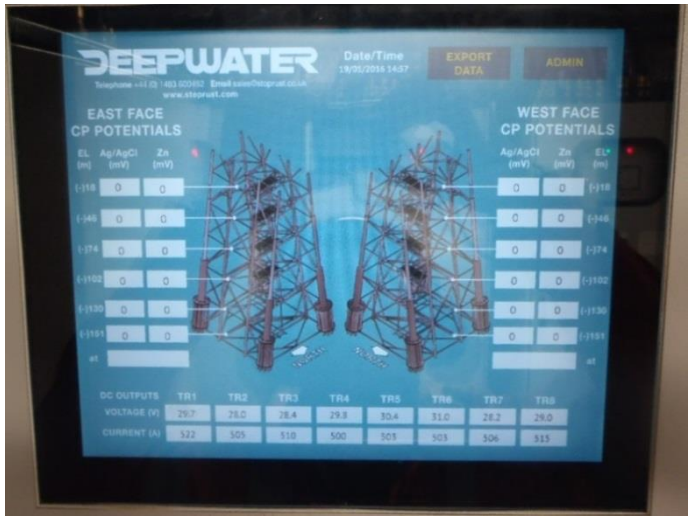


Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

8. Commissioning

The retrofit Impressed Current CP (ICCP) solution for TAQA's North Cormorant Platform was commissioned in January 2016 and consists of 8 complete systems each with the following components:

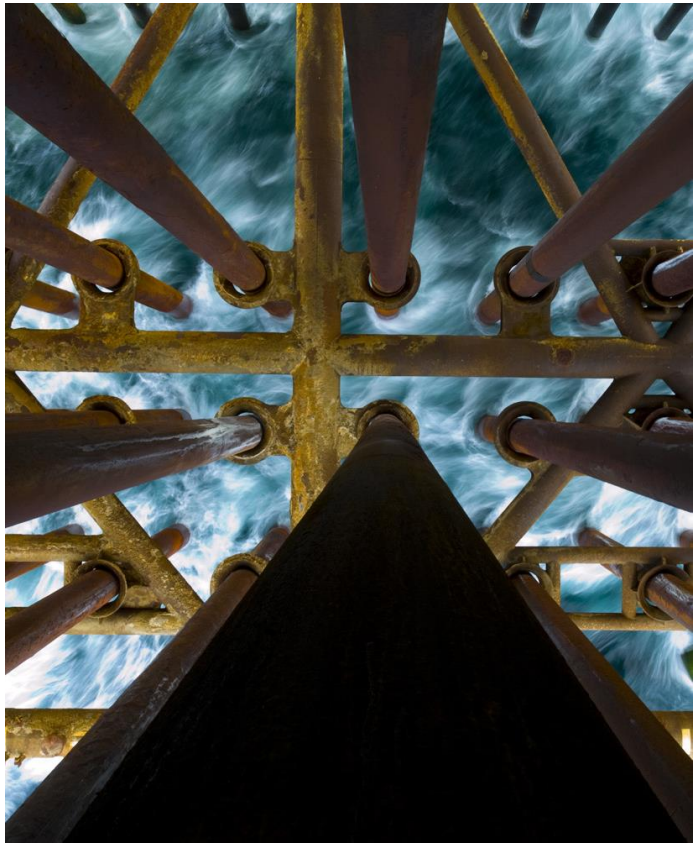
- 8-off seabed mounted impressed current Retrobuoy anode skids
- 8-off subsea anode power cables
- 8-off transformer rectifier (DC power supply)
- CP monitoring systems.



Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

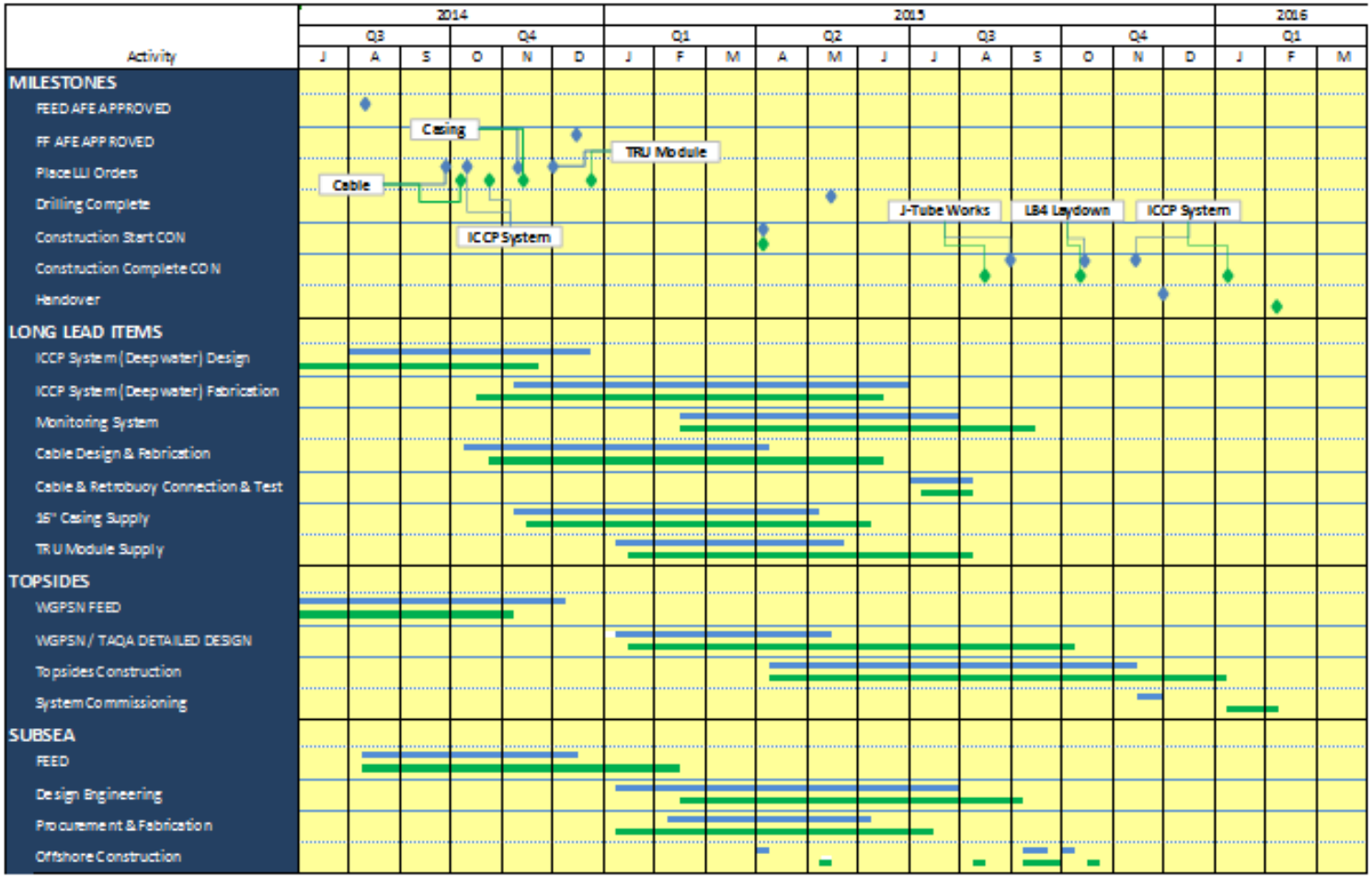
Agenda

1. TAQA
2. Sacrificial Anodes Vs Impressed Current
3. History – North Cormorant
4. CP Inspection History – North Cormorant
5. Facts – North Cormorant
6. CP Assessments
7. ICCP Project Scope and Requirements
8. Commissioning
9. Results
10. Conclusions



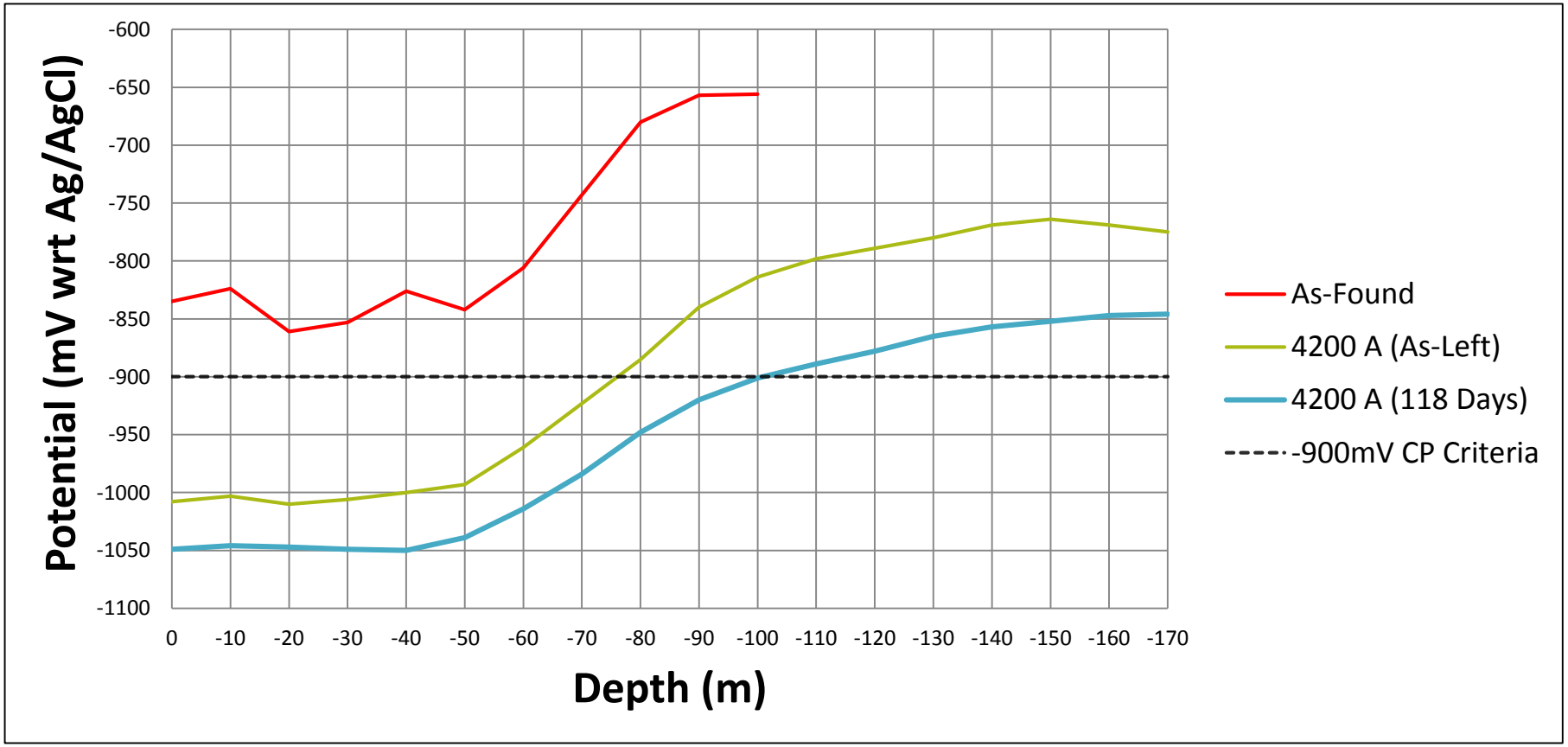
Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

9. Re



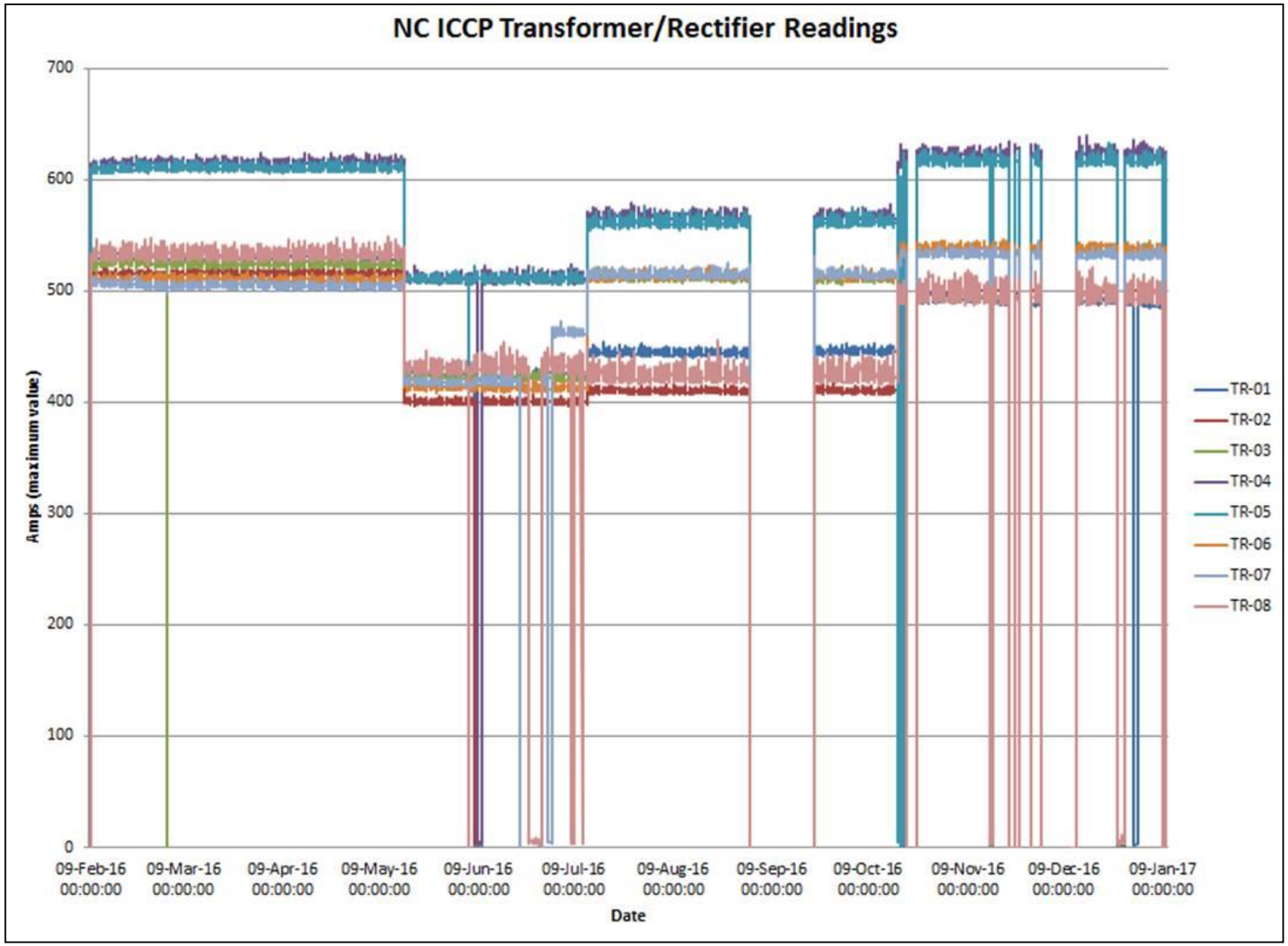
Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

9. Results



Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

9. Results



Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

9. Results

Paper No.
8957

NACE INTERNATIONAL CORROSION 2017 Conference & Expo

Strategy and Results of an Impressed Current Cathodic Protection Retrofit in the North Sea

Edgar Rodrigues
TAQA Bratani Limited
Prospect Road, Westhill,
Aberdeenshire
AB32 6FE United Kingdom

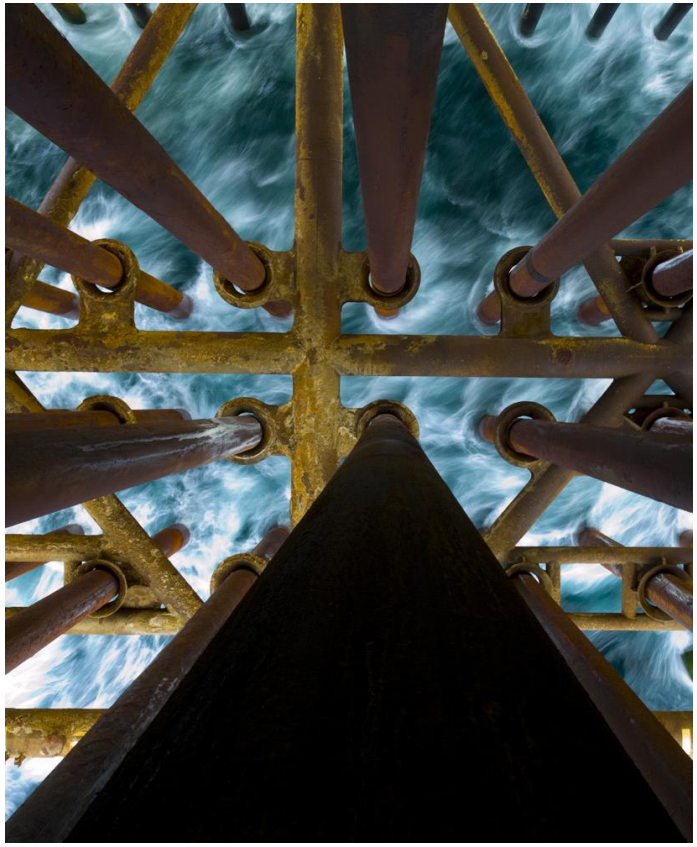
Alex Delwiche
Deepwater EU Ltd
Unit 4.8 Frimley Business Park
Camberley, Surrey
GU16 7SG United Kingdom

Tim Queen
Deepwater EU Ltd
Unit 4.8 Frimley Business Park
Camberley, Surrey
GU16 7SG United Kingdom

Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

Agenda

1. TAQA
2. Sacrificial Anodes Vs Impressed Current
3. History – North Cormorant
4. CP Inspection History – North Cormorant
5. Facts – North Cormorant
6. CP Assessments
7. ICCP Project Scope and Requirements
8. Commissioning
9. Results
10. Conclusions



Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

10. Conclusions

- ✓ Project was successfully completed on time and under budget
- ✓The galvanic CP system on a large offshore fixed structure in the North Sea lasted 30 years
- ✓The most cost effective method of extending the CP life of a structure of this magnitude is with a remote ICCP system
- ✓Polarisation is ongoing and could take another year

Impressed Current Cathodic Protection Retrofit System
Icorr Aberdeen

- Many thanks to TAQA whom allowed me to publish and present this data
- Big thanks to the Project Team – Project Manager Ronnie Toal and Lead Project Engineer Graham Woodland
- Big thanks to Deepwater
- Thanks to Icorr Aberdeen for this opportunity

TAQA