

RACE BANK WIND FARM
EMBANKMENT MONITORING PLAN
POST-CONSTRUCTION
DONG ENERGY RB (UK) LIMITED
APRIL 2016

FINAL VERSION002

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Appendix 1: Monitoring Location and Detail Plan: MMD-357166-C-DR-00-XX-0105

1 Introduction

Background

- 1.1 This strategic frontline sea defence Monitoring Plan has been prepared in response to discussions with the Environment Agency in order to set out the post-construction monitoring programme for the reinstated sea defence, the reporting process for that monitoring, and the protocol for discussion and action as may be required based on that reporting.
- 1.2 It is expected that the monitoring plan will be secured through a condition attached to the Flood Defence Consent (FDC) and also within the legal agreement for the works.

Monitoring Locations

- 1.3 7 No. permanent survey stations will be installed on the sea defence post-construction (SS01, SS02, SS03, SS04, SS05, SS06 and SS07). SS01 and SS06 will be installed 50m westwards and eastwards of the breach location respectively in order to monitor seasonal vertical movement of the embankment due to swelling and shrinkage. The survey stations will be located as follows (figure 1.1 below refers):

ID	Location (relative to centre of cable install location/sea defence crest)
SS01	50m westwards along crest
SS02	17m westwards est along crest
SS03	3.5m westwards along crest
SS04	3.5m eastwards along crest
SS05	17m eastwards along crest
SS06	50m eastwards along crest
SS07	12m southwards on landward toe

- 1.4 The survey stations will comprise a 300mm long steel survey ground marker, installed flush to the surface. An indicative detail of the survey station is provided on the appended drawing
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MMD-357166-C-DR-00-XX-0105. To install the stations a borehole 0.5m deep will be drilled in each location.

- 1.5 An extensometer will also be installed between SS03 and SS04, between the centre point of the installed cables. This will monitor any vertical movement within the defence itself, post-construction. An indicative detail of the extensometer is provided on the appended drawing MMD-357166-C-DR-00-XX-0105.
- 1.6 The survey stations and extensometer would be installed following the reinstatement of the defence crest to turf level. The survey stations will be hand dug in/backfilled. The extensometer tubing and sensors (spider magnets) will be installed in a borehole, dug using a cable percussive drill rig which will be backfilled with a bentonite/cement mix. The survey stations and the extensometer will all be flush to the crest of the defence.
- 1.7 All long term ground movement monitoring points are installed flush with the ground and are to be concreted into position. Maintenance plant operators should be mindful of these locations and not disturb them, however, as these are to be concreted in place, machinery typically used for grass cutting by the Environment Agency (EA) will not affect the installations.

Off-site survey stations

- 1.8 A possible location for an off-site survey station is the ditch outfall structure on the river side embankment (shown below). Two points are available, the top manhole cover and the concrete capping beam on the seaward side. It is understood these locations were used as off-site survey points for the monitoring of the Lincs cables post-construction.

Maintenance and monitoring liability

- 1.9 DONG Energy will remain responsible for any settlement directly attributable to the cable installation works for a period of ten years from the complete reinstatement of the sea defence.
- 1.10 The process for agreeing and instructing any future remedial or unplanned maintenance works and potential future costs recovery will be set out in the separate legal agreement between the EA and DONG Energy.

2 Monitoring Requirements

Monitoring Schedule

- 2.1 The embankment monitoring activity schedule below endures for ten years. The frequency of monitoring is more intense in the first year post-construction and reduces on a staged basis in the following years. Subject to the outcome of the surveys it is expected that the monitoring schedule will be adjusted as may be necessary to increase or decrease the frequency by agreement.

Monitoring activity	Time Post Construction
Baseline Topographic survey & Inspection	Pre-Construction
Topographic survey, extensometer reading & visual inspection	Construction completion
Topographic survey, extensometer reading & visual inspection	Weekly for 1 month post completion
Topographic survey, extensometer reading & visual inspection	2 months post completion
Topographic survey, extensometer reading & visual inspection	3 months post completion
Topographic survey, extensometer reading & visual inspection	4 months post completion
Topographic survey, extensometer reading & visual inspection	5 months post completion
Topographic survey, extensometer reading & visual inspection	6 months post completion
Topographic survey, extensometer reading & visual inspection	7 months post completion
Topographic survey, extensometer reading & visual inspection	8 months post completion
Topographic survey, extensometer reading & visual inspection	9 months post completion
Topographic survey, extensometer reading & visual inspection	10 months post completion
Topographic survey, extensometer reading & visual inspection	11 months post completion
Topographic survey, extensometer reading & visual inspection	12 months post completion
Topographic survey, extensometer reading & visual inspection	1.5 years post completion
Topographic survey, extensometer reading & visual inspection	2 years post completion
Topographic survey, extensometer reading & visual inspection	2.5 years post completion
Topographic survey, extensometer reading & visual inspection	3 years post completion
Topographic survey, extensometer reading & visual inspection	3.5 years post completion
Topographic survey, extensometer reading & visual inspection	4 years post completion
Topographic survey, extensometer reading & visual inspection	4.5 years post completion
Topographic survey, extensometer reading & visual inspection	5 years post completion
Topographic survey, extensometer reading & visual inspection	6 years post completion
Topographic survey, extensometer reading & visual inspection	7 years post completion
Topographic survey, extensometer reading & visual inspection	8 years post completion
Topographic survey, extensometer reading & visual inspection	9 years post completion
Topographic survey, extensometer reading & visual inspection	10 years post completion

Table (above) notes:

- Should the topographic or level surveys or previous inspections indicate any unexpected change in the embankment, the frequency of topographic surveys or inspections may be increased.
- A topographic survey may be required should the inspection indicate any cause for concern which requires further investigation.

2.2 In addition to the above monitoring schedule a topographic survey, set of extensometer reading and an inspection takes place following the occurrence of an extreme tidal and/or storm event during the first 5 years post reconstruction. This can be defined as an event that results in the embankment retaining water above a level of 5.15mAOD (the working platform level) and/or being exposed to significant wave action until the vegetation is fully established.

2.3 Interim surveys can be requested by either the Environment Agency or DONG Energy/the relevant OFTO if, following receipt of a monitoring report, that is considered to be necessary.

Baseline survey

2.4 A baseline topographic survey of the sea defence will be undertaken prior to construction starting, covering the breach location and an area 50m either side (i.e. inclusive of all post monitoring survey stations). That same survey scope will be repeated within 1 week of the sea defence being fully reinstated (to turf level). The baseline survey will be undertaken with a representative of the EA present. The results of the baseline survey will be provided to the Environment Agency.

Visual inspection requirements

2.5 Visual inspections will; be carried out at each survey interval. Those inspections will be carried out by a suitably qualified person with relevant geotechnical experience and will consider the following matters (indicative):

- Differential settlement of the embankment.
- Signs of seepage on the landward side of the embankment, specifically above the line of the cable trench.
- Scour to the seaward toe of the embankment above the line of the cable trench.
- Damage to the embankment that can be attributed to the works undertaken in connection with the cable installation works.
- Quality/condition and coverage of vegetation/topsoil covering the breach location.
- Damage to survey stations (stations replaced if noticed to be damaged).

Monitoring Report

- 2.6 A separate monitoring report will be prepared each time a topographic survey, extensometer reading or a visual inspection is undertaken. As a guide the monitoring report should include the following sections:
1. Introduction
 2. Topographic survey results
 3. Extensometer Readings
 4. Visual inspection record
 5. Comparison with previous monitoring
 6. Recommendations
- Appendix 1 – Photographic record
- Appendix 2 – Survey drawings
- Appendix 3 – Extensometer records
- 2.7 Each monitoring report will set out a comparison with the findings of the baseline survey and the previous report. A trend analysis should be undertaken on the topographic survey and extensometer data to determine settlement rates and identify any unexpected issues.
- 2.8 To ensure consistency between monitoring reports it is recommended that a template is developed based on the section headings above. This will serve as the basis for all monitoring reports. The monitoring reports will be produced as both a hard and digital copy with all survey data supplied on a CD accompanying the hard copy of each report.

Management of the Monitoring Programme

- 2.9 A third party will be appointed to carry out the monitoring and provide the reporting to the EA and DONG Energy/the relevant OFTO. The third party will be appointed by joint agreement between the EA and DONG Energy/the relevant OFTO. The costs incurred from that appointment will be met by DONG Energy/the relevant OFTO, subject to agreement of commercial terms.
- 2.10 Each monitoring report will be issued at the same time to both parties within seven days of the survey taking place. Each report will follow the format set out in section 2.6 of this EMP, unless that format is varied by mutual agreement of the EA and DONG Energy/the relevant OFTO.
- 2.11 Any variations to the monitoring scope will be by mutual agreement however DONG Energy/the relevant OFTO will be responsible for instructing the appointed third party.
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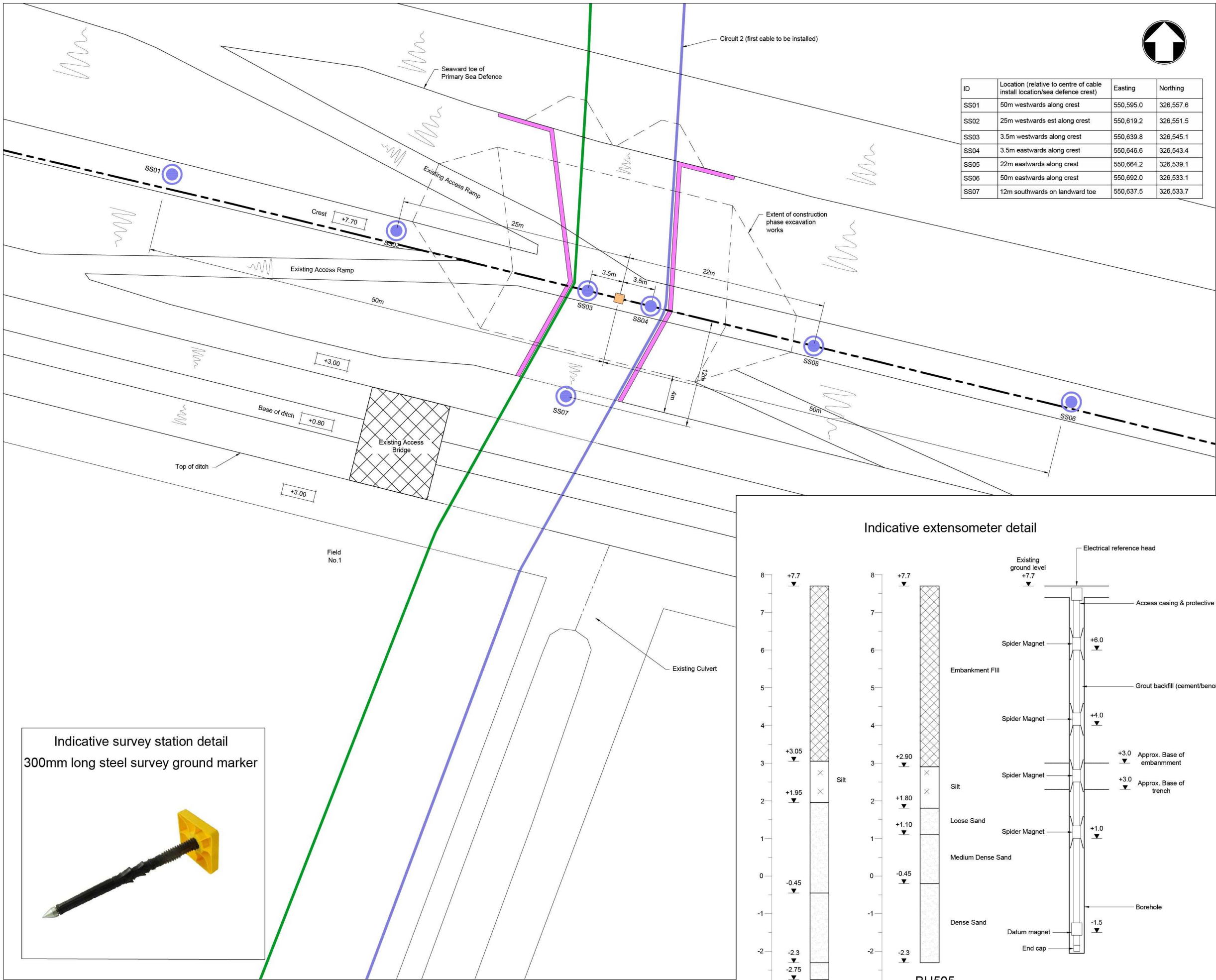
Magnetic Extensometer

- 2.12 The topographic survey will quantify any surface settlements on the embankment in the vicinity of the cable installation location. However, in order to monitor the settlement of the reconstructed embankment directly above the cable trench at depth a magnetic extensometer will be installed.
- 2.13 The extensometer will be installed between the location of the two cables, to a depth approximately –1.5m AOD. The extensometer will be installed from the crest of the embankment using a cable percussive boring rig. The machinery used for installing the extensometers will be a Terrier rig or similar to this: <http://www.dando.co.uk/geotechnical/terrier-site-investigator>. The plan location of the cable trench centre line will be marked out on the embankment crest. The cable percussive rig will be able to set up within 75mm of the target location and the borehole will be vertical provided no obstructions are encountered during boring. The borehole will be formed using ‘open hole’ drilling techniques (no samples will be required) and the rate of boring will be compatible with the need to establish the precise depth at which changes in the soil type occur.
- 2.14 The base of the extensometer will terminate in dense sand. As the extensometer relies on a series of magnets to determine precise levels, a datum magnet is installed at the base of the hole on the outside of an access casing. Spider magnets are to be installed at key elevations within the ground profile. The locations of the spider magnets will be revised or confirmed following a review of the ground profile encountered in the borehole, however it is anticipated that there will be:
- A datum magnet at approximately -1.5m AOD
 - A spider magnet at
 - +1.0m AOD
 - +2.5m AOD (cable level)
 - +4.0m AOD (base of embankment toe level)
 - +6.0m AOD
- 2.15 . It is not determined yet whether readings will be taken manually using a probe and reel unit, or if a remote monitoring solution can be used. This will be determined prior to the installation of the extensometer, and is dependent on consistency of mobile signal strength in this location (it is understood to be variable).
- 2.16 The borehole will be backfilled with a 1 to 4 (cement/bentonite) grout, mixed to a creamy pumpable consistency, and the installation will be robustly capped with concrete and a lockable cast iron stopcock cover, suitable for a minimum service life of 10 years.
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- 2.17 On completion of the installation, three consecutive sets of base readings will be taken (from the bottom up) which record the depth of the target magnets relative to the top of the extensometer tube. The top of the extensometer tube will be surveyed into Ordinance Datum, and relative to a local stable datum.



Appendix 1: Monitoring Location and Detail Plan: MMD-357166-C-DR-00-XX-0105



ID	Location (relative to centre of cable install location/sea defence crest)	Easting	Northing
SS01	50m westwards along crest	550,595.0	326,557.6
SS02	25m westwards est along crest	550,619.2	326,551.5
SS03	3.5m westwards along crest	550,639.8	326,545.1
SS04	3.5m eastwards along crest	550,646.6	326,543.4
SS05	22m eastwards along crest	550,664.2	326,539.1
SS06	50m eastwards along crest	550,692.0	326,533.1
SS07	12m southwards on landward toe	550,637.5	326,533.7

- Notes
- All dimensions are in metres unless noted otherwise.
 - All levels are in metres relative to Ordnance Datum Newlyn (ODN) unless noted otherwise.
 - All positions are in metres relative to OSGB36.
 - Indicative drawings only. Not to be used for construction.
 - Topographic data reproduced from LSTC Onshore Topographic Survey (2014) & Fugro Geophysical Investigation (2014).
 - See MMD-357166-C-DR-00-XX-0001 and MMD-357166-C-DR-00-XX-0002 for the Site Plan and Topographic Plan respectively.
 - Datum magnet in medium dense / dense sand does not move and thus provides reference for other magnet movements.
 - Borehole and extensometer installed after reinstatement of sea defence embankment.
 - See Race Bank Export Cable Installation 2016 Sea Defence Breach and Reinstatement Consents Application Study Report (Document No.: 357166_011) and associated Consents documentation ("Post-Construction Monitoring Plan") for further details on the proposed monitoring plan.
 - See Fugro Engineering Seacore Limited (FESCL) October 2012 and August 2014 reports for available Ground Investigation information.

- Key to symbols
- Cable Alignment No. 1 (Circuit 1, second cable installation)
 - Cable Alignment No. 2 (Circuit 2, first cable installation)
 - Landward Boundary of designated sites
 - Extent of construction phase excavation works
 - Extent of sheet piles
- Post Construction Monitoring Points
- Survey Stations - 300 mm long steel survey ground marker
 - Extensometer, including level survey monitoring point

Reference drawings

1:200 0 10m 20m

P1	08.03.16	IAS	Flood Defence Consent Issue	MW	RT
Rev	Date	Drawn	Description	Ch'k'd	App'd

Mott MacDonald

Mott MacDonald House
8-10 Sydenham Road
Croydon
CR0 2EE
United Kingdom
T +44 (0)20 8774 2000
F +44 (0)20 8681 5706
W www.mottmac.com

DONG energy

DONG Energy RB (UK) Limited
5 Howick Place SW1P 1WG
London, United Kingdom

Title
**Race Bank Export Cable Installation
Sea Defence Breach
Reference Drawings
Indicative Post Construction Monitoring
Location Plan**

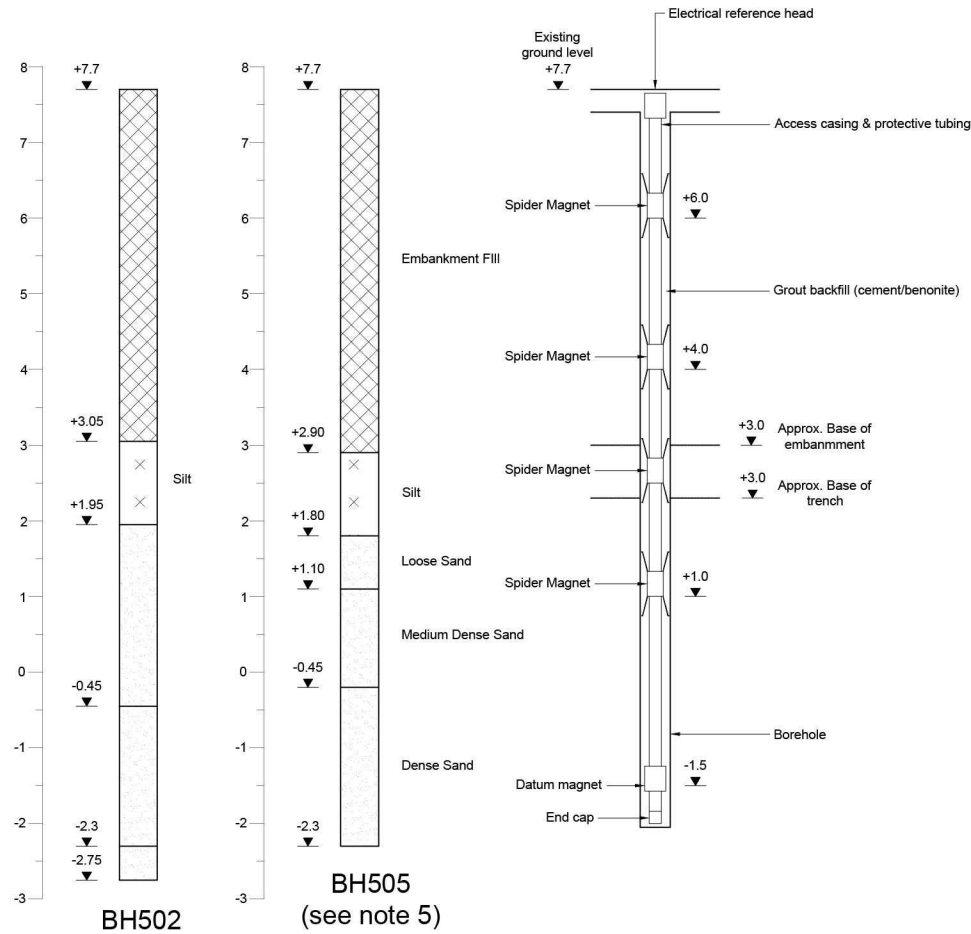
Designed	E Shaw-Smith	ESS	Eng check	E Shaw-Smith	ESS
Drawn	P Starnes	PS	Coordination	M Wearmouth	MW
Dwg check	M Wearmouth	MW	Approved	P Phipps	PJP
Scale at A1	1:200	Status	APR	Rev	P1
				Security	STD

Drawing Number
MMD-357166-C-DR-00-XX-0105

Indicative survey station detail
300mm long steel survey ground marker



Indicative extensometer detail



Plan
1:200