BARROW OFFSHORE WIND FARM
SUSPENDED SEDIMENT MONITORING

MONITORING RESULTS

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REPORT AUTHORISATION AND DISTRIBUTION

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SUSPENDED SEDIMENT MONITORING

REPORT

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For the attention of:-

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1. INTRODUCTION

On the instructions of RSK ENSR, Osiris Projects were commissioned to provide turbidity (suspended sediment) monitoring services during mono-pile installation at the Barrow Offshore Wind Farm site, specifically during drilling operations. The levels of sediment, agitated into suspension by the drilling process were monitored to provide DEFRA with information to assist in assessing the environmental impact of this aspect of the construction process.

Turbidity is a measure of the amount of suspended sediment within the water column. Water with high turbidity is cloudy, while water with low turbidity is clear. The cloudiness is produced by light reflecting from particles in the water; therefore, the more particles in the water, the higher the turbidity.

Turbidity is measured in *Nephelometric Turbidity Units,* NTU.

A series of transects were recorded, over a single tide, during the drilling operations. A recording water quality sensor was deployed from a small vessel, directly down tide of the works. The direct reading unit was equipped with an Optical Backscatter Sensor (OBS) in order to record the suspended sediment concentrations in addition to temperature, conductivity and depth values (CTD). The vessel moved across the area of anticipated sediment plume in a zig-zag pattern, moving very slowly and gradually getting further away from the mono pile location. A series of water samples were collected adjacent to the sensor and cross correlated to reference the sensor readings, in NTU, to actual sediment concentrations in milligrams per litre (mg/l). A series of 'background' observations were also taken up-tide of the operation in order to monitor the naturally occurring suspended sediment levels. The majority of the water samples and readings were taken at a point approximately 25% of the water depth above the seabed (4m-5m). The sensor was heavily weighted in order for it to maintain a constant depth whilst the vessel tracked across the sediment plume. Water depth was measured throughout the survey using a hydrographic echo sounder and positioning was provided by a sub-metre dGPS navigation system.

2. FIELD PROCEDURES AND METHODS

2.1 Equipment List

The following equipment was mobilised to site and utilised during the survey: -

- MV 'BARINTHUS' 13.0m Survey Vessel
- CSI 'Vector' sub-metre differential Global Positioning and heading System
- KNUDSEN 320M Dual Frequency Hydrographic Echo Sounder
- TRIMBLE ' Hydro*Pro* ' Navigation and Processing Software System
- HYDROLAB DATASONDE 4A Water Quality Monitor
- 4.5litre 'Niskin' water sampler.

Technical specifications for each of the major items of equipment can be found in Appendix 2 to this report.

2.2 Survey Vessel

Ocean Marine's dedicated survey vessel, MV *'Barinthus'* was utilised throughout the survey period. The vessel was based at Barrow for the duration of the survey works. This provided a safe port of operation with 24-hour access and transit time to the area of survey being approximately 30 minutes away.

MV *'Barinthus'* is a 13-metre fast workboat of glass fibre construction, which carries Category 2 certification (60 miles from a safe haven) under the current MCA Code of Practice for Small Workboats and Pilot Boats. A 12-hour operational day is normally adopted aboard the vessel in the interests of Health & Safety.

A vessel offset diagram, showing navigation antenna position relative to the various sensor towing points, is presented in Appendix 3 to this report. In addition, a detailed specification for the vessel can be found in Appendix 4 to this report.

2.3 Personnel

The following personnel were involved during the site and reporting stages of the contract: -

- P. Clark - Hydrographic Surveyor
- N. Longfield - Vessel Skipper

2.4 Survey Control

2.4.1 Horizontal Control

Primary positioning was provided by the use of a CSI Vector Sensor, sub-metre differential Global Positioning System (dGPS) and GPS gyro. The system utilised differential correction data from the General Lighthouse Authority's (GLA) permanent base station at Point Lynas on the North Wales coast. A positional check was carried out over a National GPS Network passive station located by the Ro-Ro berth in Fleetwood, as described in section 2.4.1.1 below.

In addition to providing accurate heading data (<0.5˚) from it's dual antenna moving baseline RTK configuration, the Vector Sensor system also delivers sub-metre positioning accuracy when using differential correction data. The Vector Sensor is able to receive broadcast correction data from the land-based General Lighthouse Authority (GLA) stations and from a Satellite Based Augmentation Systems (SBAS), such as the U.S. Wide Area Augmentation System (WAAS) or the European GPS Navigation Overlay System (EGNOS). Although the EGNOS system is currently functional, it is still in its test phase and is not officially available for commercial use until early 2006. In practice, the observed position differed by <0.3m when changing between the Beacon and L band EGNOS corrections, although the GLA beacon correction service was utilised throughout the survey period.

In order to allow the navigation computer to display grid co-ordinates in real time, a transformation is applied to the incoming satellite positional data, which is received as a WGS84 (GPS datum) Lat./Long co-ordinate. This transformation is applied by the navigation software (Hydro*Pro*). Ordnance Survey National Grid positions were used throughout the survey

The parameters used to convert ***from*** WGS84 are as follows: -

Spheroid	Airy
Datum	OS National Grid (OSTN 97)
Semi Maj. axis	6377563.4m
Semi Min. axis	6356256.91m
Inverse Flattening (I/F)	299.324975315
Δx	-375
Δy	111

Δz	-431
Projection	Transverse Mercator
Latitude of Origin	49˚00'00" N
Central Meridian	2˚00'00" W
Scale Factor on CM	0.999601272
False Northing	-100000m
False Easting	400,000m

In conjunction with the navigation computer, 'Hydro*Pro*' provides the facility for guiding the survey vessel along pre-determined run lines via a head-up display, whilst logging antenna position, echo sounder depths, compass heading and offset positions for the various sensors at a user defined interval.

2.4.1.1 Calibration Check

In order to calibrate the vessel's navigation system, the mobile dGPS receiver was removed from the vessel and placed over a point of known co-ordinate (Ordnance Survey GPS passive station in Fleetwood). This was carried out prior to commencing survey operations on the 5th October 2005. Details of this point were supplied by the Ordnance Survey and are presented in Appendix 3 to this report.

For the calibration, the receiver unit was left in place for a noted period, with readings taken at regular intervals.

2.5 Bathymetry

A Knudsen 320M single beam, dual frequency hydrographic echo sounder was utilised throughout the survey. The Knudsen 320M provides analogue and digital outputs; with the general measurement precision of the instrument given as +/- 0.12% full scale.

The unit was calibrated by the standard 'bar-check' method to ensure that the transducer draft and acoustic velocity were correctly applied to the data. The 'bar-check' calibration involves the use of a rigid steel plate, which is lowered to set depths on a graduated chain beneath the echo sounder transducer. The echo sounder is adjusted to display the real depth of the bar below the water surface, to the maximum working depth or the maximum practical depth achievable.

2.6 Water Quality Measurements

A Hydrolab Datasonde 4A water quality monitor was deployed at a point approximately 25% of the water depth above the seabed during the operations (4m to 5m above bed).

The sensor itself was heavily weighted in order to maintain a constant depth. The unit was set to sample and record at its shortest interval of 30 seconds.

In practice the survey boat traversed very slowly across the anticipated sediment plume, gradually moving further down-tide from the drilling operation. A series of water samples were collected using a 'Niskin' bottle water sampler. A direct correlation between the sensor, logging in NTU, and actual sediment loadings in mg/l was inconclusive. The results from this monitoring exercise, and another similar exercise in the area, have highlighted that the range of results was not broad enough to generate an accurate conversion factor from NTU to mg/l. As a result, the data has been reported in NTU values and all conclusions have been drawn from this data.

Positioning and water depth data was logged continuously throughout the sampling operation.

3.0 RESULTS AND CONCLUSION

The results are presented as data listings in spreadsheet form and are appended to this report.

The results show that the increase in sediment loading is relatively localised and that any detectable levels remain within 1 to 2 metres of the seabed. Background Turbidity levels are seen to be between 5 and 10 NTU during the survey and this is thought to be typical of the water column in this area under normal tidal conditions. It is also likely that natural sediment concentration is higher just above the seabed as some sediment transport will occur during the tidal flow. Tides of up to 1 knot were observed on the site.

Seabed composition at the site is known to be mainly medium grained sand and shells with some gravel and this would support the observations that much of the agitated sediment drops out of the water column relatively quickly and very little increase is seen much above 2.0 m above bed level.

Observations were made from within 100m of the pile location to approximately 700m down tide.

APPENDICES

APPENDIX 1

TABULATED RESULTS

APPENDIX 2

VESSEL TRACK CHART

APPENDIX 3

SURVEY CONTROL DATA

VESSEL OFFSET DIAGRAM

APPENDIX 4

TECHNICAL SPECIFICATIONS