GEOTECHNICAL RISK REGISTER

Front Sheet

CA Client : NorthConnect KS
Project : NorthConnect
Project No : C831

Revision History

Revision	Purpose	Author(s)	Reviewed:	Approved:	Date
1	DRAFT for HAZID	EJO	EJO	JIR	06/11/2017
2	Interim DRAFT	PTH	EJO	EJO	01/12/2017
3	Issued	PTH	EJO	EJO	08/03/2018
4	Re-Issued	PTH	EJO	EJO	11/05/2018

Risk Rating

Probability	Definition
1	Never heard of in Industry
2	Heard of in Industry
3	Incident has occurred near the project area
4	Happens several times a year in Industry
5	Happens several times a year at project location

Consequence	Definition
1	Negligible Damage
2	Minor Damage / Exposure to other hazards
3	Localised Damage / No unplanned loss of capacity
4	Major Damage - replacement of small section / Unplanned loss of capacity
5	Extensive Damage - replacement of significant section of cable/ Unplanned loss of capacity

Geotechnical Risk Matrix		Consequence				
		1	2	3	4	5
Probability	1	1	2	3	4	5
	2	2	4	6	8	10
	3	3	6	9	12	15
	4	4	8	12	16	20
	5	5	10	15	20	25

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CATHIE ASSOCIATES — NORTHCONNECT CONNECTING RENEWABLES

GEOTECHNICAL RISK	Data Sources / Data Adequacy	Risks to Cable: Hazard Details	Initial Risk: Freq	Initial Risk: Cons	Initial Risk: Rank	Quantification / Mitigation	Residual Risk: Freq	Residual Risk: Cons	Residual Risk: Rank
Cable Installation / Protection Risks									
Metocean Conditions	Metocean Report	Noted dangerous waves and confused seas near the Norwegian coast pose a risk to installation vessels and the launch and recovery of equipment. Offshore installation operations are similarly vulnerable to storm events. High seabed currents noted near the UK end of the cable pose a risk to the stability of ROV equipment. This risk is particularly elevated during the landing/removal of tools onto a cable product, which may be damaged. High current in Blocks 9, 10 and 11 Possible unexpected and uncharted currents in fjords	5	2	10	Planning and execution of the project should give consideration to a dedicated weather analysis / operability study carried out by the chosen contractor. Exceedance probabilities arising from an analysis should be used by the contractor to estimate the anticipated duration of weather-related stoppage time.	2	2	4
Seabed Topography	WebGIS, Survey Report, DTS	Presence of localised slopes can impact on burial performance / achievable burial depths and slack requirements, particularly where associated with ridges or outcrops of material of increased strength or competence and areas of mobile bedforms. Reduced burial can lead to increased cable risk from external threats e.g. anchor strike, fishing gear etc. Steep gradients observed on the flanks of iceberg scars, pock marks, rock outcrops and slip-scarps.	5	2	10	Route engineering should be sympathetic to seabed features to be avoided where possible and mitigated through other means (e.g. pre-lay and post-lay rock where not feasible, in order to maximise cable protection. A more in depth analysis of slopes can be undertaken at installation stage. Theoretical slack requirements can be calculated at installation stage	2	2	4
Fjord Topography	WebGIS, Survey Report	High cliffs impact on vessel dynamic positioning placing operations at risk of DP run off.	5	1	5	Mobile base station for installation	5	1	5
Unstable sediments (Avalanches)	WebGIS, Survey Report, Academic Papers	Snow/ice avalanches could impact the cable. Fjord depth means any impact (if depth is reached) is likely to be gentle and not pose a risk of damage.	3	1	3	Routeing cable centrally in the Fjord will maximise distance from hazard.	2	1	2
Unstable sediments (Rockfall)	WebGIS, Survey Report, Academic Papers	Rockfall or other mass movement from the Fjord sides may cause impact damage to the cable, or lateral displacement inducing tensions or kinks. Rockfall is recorded all the way along the Fjord, and the survey provides evidence of these deposits on the Fjord bottom.	3 (survey data suggests historic falls, return period unknown)	3	9	Softness of sediment in the majority of the Fjord area means that protection from rockfall is unlikely to be gained by burial. The simplest way to reduce the risk will be to use routeing to avoid areas of historic mass transport/rockfall deposition originating from the side of the Fjord, as recorded by the survey. Keeping the cable route central to the Fjord where possible should reduce the likelihood that material will strike the cable from either side.	1	3	3
Unstable sediments (Fjord slide scarps)	WebGIS, Survey Report, Academic Papers	Numerous slip-scarp features cross the width of the Fjord, generally perpendicular to the survey centre line. The installed cable will have to traverse these features. Failure of the ground underneath the cable at the scarp-slope crest or impact by mass-movement material originating upslope could cause cable damage by inducing cable tension, creating freespans or causing slack areas of cable to become kinked.	3 (survey data shows historic slips, return period unknown)	4	12	Avoid slopes where possible. Transition of cable across existing slip-scarps or potential future scarps is in many cases unavoidable. Triggering of failure may be seismic, with a suggested return period of 1000 years (based upon dating mass-flow deposit sequences), however use of heavy tools across slip-scarps should be avoided to reduce the risk of artificially causing a failure. NGI have indicated that most critical slopes are stable, except that at c. KP 661.5. Slopes have not been asessed for additional loading of external material.	2	4	8
Pock Marks	WebGIS, Survey Report, DTS	Pock marks are usually associated with ancient or ongoing gas seepage/shallow gas, which can pose a risk to the cable integrity and potentially impact burial tool performance. Numerous pock marks identified along the survey corridor.	5	2	10	Route engineering should be sympathetic to seabed features such as pock marks and avoided where possible, especially where ongoing gas seepage is noted, and mitigated through other means (e.g. pre-lay and post-lay rock placement) where not feasible, in order to maximise cable protection. Cable armouring to account for risk of shallow gas.	2	2	4
Cemented hard ground (Pock marks)	WebGIS, Survey Report, DTS	Cemented hard ground can prove problematic for cable burial, exhibiting far higher strength than uncemented sands or lower strength clays, which may not be accounted for in the choice of installation tool. Preliminary information from the 2017 site investigation suggests the route corridor has generally avoided large areas of cemented sediments, however cemented hard ground is anticipated where pockmarks are present.	5	1	5	Route engineering should be sympathetic to seabed features such as pock marks and avoided where possible. Residual risk of encountering cemented hard ground should be further assessed by installation contractor and suitable contingency/redundancy built into design solution.	2	1	2
Seabed Obstructions / Boulders	WebGIS, Survey Report, DTS	Obstructions along routes can inhibit lay / burial increasing risk of cable damage from external threats. Numerous sidescan, sub bottom and magnetometer contacts have been identified along the cable route.	4	2	8	Adequate survey to identify obstructions e.g. cobbles and boulders accurately. Micro routing utilising appropriate buffer zones placed around targets. Clearance of obstructions e.g. boulders where necessary. Magnetometer contacts to be investigated to mitigate UXO risk to ALARP. UXO strategy is for avoidance through routing rather than removal. Additional survey prior to cable lay along the proposed cable route to confirm risks are suitably mitigated.	3	2	6
Archaeological Exclusion Zones	WebGIS, Survey Report, Wessex Report, DTS	Protected sites which require avoidance. Can impact on cable routing. Wrecks / protected archaeological areas identified in vicinity of the cable route within the offshore section and the Norwegian fjords.	3	2	6	Cable routing to avoid wrecks / archaeological exclusion zones.	2	2	4

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Annex 1 Habitats / Protected areas	WebGIS, Survey Report, UK HVDC Scoping Report, DTS	Protected habitats where present require avoidance / mitigation. Can impact on cable routing and or protection requirements. Suspended sediments also to be considered. SPA at UK landfall (breeding seasons). Potential Annex 1 Habitats (cobble reefs / Sabellaria Spinulosa) identified in proximity to cable corridor. Corals at Norwegian end of route. Cable route also crosses the Southern Trench pMPA.	3	2	6	If protected habitats are confirmed to be present within corridor, ensure avoidance where practical through route engineering and seek further specialist support and consultation where unavoidable. Installation methods to comply with consents licenses e.g. suspended sediments.	2	2	4
Existing Seabed Infrastructure (oil and gas)	WebGIS, Survey Report, Crossings list, DTS	Existing infrastructure can impact on cable routing and cable protection methods. Several Fields and associated infrastructure present in the vicinity of/within the cable corridor.	2	5	10	Routing of cables should take into account existing infrastructure to avoid where possible. Where unavoidable, ensure that appropriate (crossing) protection measures are put in place. Use of crossing agreements / consultation with license holders and suitable guidelines, such as those provided by ICPC and Carbon Trust, to mitigate risk.	2	2	4
Existing Seabed Infrastructure (cables)	WebGIS, Survey Report, Crossings list, DTS	Existing infrastructure can impact on cable routing and cable protection methods. Several dis-used cables and live cables have been identified within the cable corridor. Unknown cables also identified during the 2017 survey	3	3	9	Routing of cables should take into account existing infrastructure to avoid where possible. Where unavoidable, ensure that appropriate (crossing) protection measures are put in place. Out-of-service cables to be removed prior to installation. Use of crossing agreements / consultation with license holders and suitable guidelines, such as those provided by ICPC and Carbon Trust, to mitigate risk.	3	2	6
Shallow Geology Spatial Variability: Channel Features, Subsurface Boulders etc.	WebGIS, Survey Report, DTS	Variable seabed conditions / shallow geology (incl. subsurface boulders) can hinder cable burial operations, leading to reduced burial depth and increased risk from external threats. Surveys indicate spatial variability in seabed strength and composition - especially in the glacial deposits which vary in shear strength considerably over short distances. (Iceberg ploughed area) Coarse surfical sediments within UK 12NM are expected to pose a significant impediment to jetting tools (based upon observed evidence of Hywind export cable burial difficulties. Features such as channels may present unexpected conditions.	5	2	10	Adequate survey and route engineering / sympathetic routing of cables where possible. Adequate burial assessment and selection of appropriate cable protection method(s) for the expected variations in ground conditions, in order to achieve target burial depths. Potential benefit in undertaking pre-trenching trial to gain knowledge of expected performance prior to cable installation operation.	4	2	8
Rock outcrops	WebGIS, Survey Report, DTS	Presence of hard sediments / strata at surface can lead to reduced burial, increasing risk to cables from external threats. Exposed bedrock identified at UK/Norwegian ends of cable.	4	2	8	Adequate mapping of hard sediments/rock outcrops, sympathetic routing of cables where possible. Adequate burial assessment and selection of appropriate protection method(s) for the expected variations in ground conditions, in order to mitigate identified risks (taking account of environmental considerations).	3	2	6
Peat	WebGIS, Survey Report	Presence of peat can result in geophysical survey blanking (increasing geological uncertainty). Peat can also contain biogenic gas which must be accounted for in cable design. Fibrous material can be difficult to trench through resulting in reduced burial / increased risk to cables from external threats. Can also pose risk of liquefaction. Preliminary information from the 2017 site investigation suggests the route corridor has largely avoided areas of peat.	2	2	4	Ensure adequate survey and integration of geotechnics with geophysics. Appropriate route engineering e.g. route around areas of peat if extents are well constrained, and where practical. Adequate burial assessment and selection of appropriate burial method(s) for the expected variations in ground conditions, in order to achieve target burial depths.	2	2	4
Unexploded Ordnance (UXO)	WebGIS, Survey Report, UXO reports, DTS	UXO can pose a risk to cables associated with the installation e.g. detonation by trenching equipment strike. Desk study indicates multiple sources of UXO threats in the area from both allied and axis WWII operations. Due to the presence of sand and migratory features such as sand waves on the site, it is possible that any UXO located on the seabed has subsequently become partially, or completely buried.	3	4	12	Consultation with UXO specialist has been undertaken. A UXO geophysical survey is to be undertaken to investigate any potential UXOs on site and depending on the results of this survey, further investigation and/or clearance campaign may be required. UXO clearance certificates should be obtained before any operations that interfere with the seabed commence. Additional micro-routing to be undertaken as necessary in preference to removal.	1	4	4
Fish Farms (moorings)	WebGIS	Anchor wires pose an obstruction to installation operations and are to be removed before, and replaced after the installation operation. A risk exists that in rough conditions or in the event of a third party vessel striking the fish farm, anchors may be dragged across the cable causing damage.	2	4	8	Anchors to be removed and replaced prior to and post completion of installation operations. Extra burial (Protection level D, NC FEED document) is planned to mitigate the risk of damage arising from Fish-Farm anchors.	1	4	4