PARTICULAR SPECIFICATION

APPENDIX F

CIVIL DESIGN SAFETY SUBMISSION - HAZARD REGISTER

Project Name	CR16	Stage	CCSS
Date Created			
Stage Contract		Site Contract	

* Mandatoy Fields

Summary of initial risk classes A 4 / B 37 / C 25 / D 0 — Total: 66

Summary of residual risk classes A 0 / B 0 / C 66 / D 0 — Total: 66

*Hazard No			Previous Hazard No	*Hazard Description (max. length is 2000 characters)	*Hazard Cause (max. length is 2000 characters)	*Incident/ Accident (max. length is 2000 characters)	Current Measure (max. length is 4000 characters)	*Initial Severity	*Initial Frequency	*Initial Risk	Proposed Control Measures (max. length is 4000 characters)	Actionee/ Haz Owner	*Residual Severity	*Residual Frequency	*Residual Risk	*Status	HA Form No.	Remarks
Hazard No	Haz Code	Run No																
Station																		
(100) EARTH RETAINING SUPPORT STRUCTURES (ERSS)																		
CR16/CCSS/100/001/-	100	001		Instability of ERSS: 1. Station (390m long) 2. Launching Shaft	**Inappropriate ERSS design system:** 1. Uncertainity in geotechnical design parameters 2. Poor soil-structure interaction modelling or lack of understanding of design software 3. Incorrect loading assumption 4. Incorrect work sequence 5. Incorrect information on adjacent structures 6. Not identifying the behaviour and response of the ground and adjacent structures 7. Misinterpretation / inappropriate use of design codes 8. Incompatible design with adjacent structures	1. Collapse of ERSS 2. Collapse of / damage to adjacent structures 3. Injury/fatality of public / construction personnel 4. Construction equipment topples into excavation site	1. Conduct adequate site investigation (reported in Factual geotechnical Reports provided in tender documents) 2. Interpret geological profile of excavation site and derive moderately conservative geotechnical design parameters (GIBR) 4. Robust ERSS Design with minimum design requirement in the working drawings provided 5. Detailed Instrumentation & Monitoring (IM) plan proposal	5	2	B	1. Contractor to produce robust design 2. Sensitivity analysis of design input parameters and cross checking of design 3. Independent checking by AC 4. Disaster planning including emergency services 5. Contingency planning, e.g. stop all excavation, ensure safe escape route for workers, additional temporary struts 6. Develop detailed IM monitoring with review levels 7. Stand-by recharge wells for settlement control 8. Perform trial trenching / probing	D&B Contractor	5	1	C	Open		
CR16/CCSS/100/002/-	100	002		Instability of ERSS: 1. Station (390m long) 2. Launching Shaft	**Strutting does not provide sufficient support:** 1. Poor workmanship 2. Accidental damage 3. Incorrect design implementation 4. Insufficient control of the works	1. Collapse of ERSS 2. Collapse of / damage to adjacent structures 3. Injury/fatality of public / construction personnel 4. Construction equipment topples into excavation site	1. Robust strutting design with minimum requirements to minimise movement 2. One strut failure analysis	5	2	B	1. Contractor to produce robust design with one strut failure analysis 2. High quality construction records 3. Sensitivity analysis of design input parameters and cross checking of design 4. Independent checking by AC 5. Disaster planning including emergency services 6. Contingency planning 7. Briefing of site staff by contractor's designer 8. Implement review levels for I&M monitoring of strut loads 9. Regular site visits and checking by contractor's design engineers	D&B Contractor	5	1	C	Open		
CR16/CCSS/100/003/-	100	003		Instability of ERSS: 1. Station (390m long) 2. Launching Shaft	**Unforeseen ground conditions:** 1. Sand layers 2. Loose and Highly permeable fills 3. Highly variable soil parameters 4. A buried valley is encountered 5. Unexpected high pore water pressure	1. Collapse of ERSS 2. Collapse of / damage to adjacent structures 3. Injury/fatality of public / construction personnel 4. Construction equipment topples into excavation site	1. Conduct adequate site investigation (reported in Factual geotechnical Reports provided in tender documents) 2. Interpret geological profile of excavation site and derive moderately conservative geotechnical design parameters (GIBR) 3. Adopt robust ERSS Design with minimum design requirement in the working drawings provided 4. Sensitivity study of design input parameters 5. Detailed I&M plan proposal	5	2	B	1. Contractor to produce robust design 2. Sensitivity analysis of design input parameters 3. Interview people with relevant knowledge 4. Probing (Minimum alternate panels / 12m) 5. Site investigation by Contractor 6. Proper record of penetration into hard stratum on installation site records 7. Review site records post-installtaion and pre-excavation 8. Pre-qualify contractors	D&B Contractor	5	1	C	Open		

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Summary of initial risk classes

A	4	
B	37	
C	25	Total:
D	0	66

Summary of residual risk classes

A	0	
B	0	
C	66	Total:
D	0	66

*Hazard No			Previous Hazard No	*Hazard Description (max. length is 2000 characters)	*Hazard Cause (max. length is 2000 characters)	*Incident/ Accident (max. length is 2000 characters)	Current Measure (max. length is 4000 characters)	*Initial Severity	*Initial Frequency	*Initial Risk	Proposed Control Measures (max. length is 4000 characters)	Actionee/ Haz Owner	*Residual Severity	*Residual Frequency	*Residual Risk	*Status	HA Form No.	Remarks
Hazard No	Haz Code	Run No																
CR16/CCSS/100/004/-	100	004		Instability of ERSS 1. Station (390m long) 2. Launching Shaft	**Instability of wall toe:** 1. Local valleys 2. Insufficient penetration into hard stratum	1. Collapse of ERSS 2. Collapse of / damage to adjacent structures 3. Injury/fatality of public / construction personnel 4. Construction equipment topples into excavation site	1. Conduct adequate site investigation (reported in Factual geotechnical Reports provided in tender documents) 2. Geotechnical Interpretative Baseline Report 3. Sensitivity analysis of design input parameters / robust design to minimise movement 4. Minimum design requirement in the working drawings for ERSS design 5. Minimum penetration of panels is specified	5	2	B	1. Contractor to produce robust design 2. Minimum probing requirements ahead of ERSS wall installation given in Particular Specification 3. Probing(minimum alternate panels / 12m) 4. Site investigation by contractor 5. Proper record of penetration into hard stratum on installation site records 6. Review site records post-installtaion and pre-excavation 7. Pre-qualify contractors	D&B Contractor	5	1	C	Open		
CR16/CCSS/100/005/-	100	005		Instability of ERSS 1. Station (390m long) 2. Launching Shaft	**Inadequate structural connection between strut, waler to ERSS walls / shafts / excavations:** 1. Workmanship 2. Incorrect ERSS design by Contractor 3. Error during erection	1. Collapse of ERSS 2. Collapse of / damage to adjacent structures 3. Injury/fatality of public / construction personnel 4. Construction equipment topples into excavation site	1. Correct stiffener plate/packers design approach adopted 2. Sensitivity analysis of design input parameters 3. Proposed real time monitoring of strut loads	5	2	B	1. Statutory requirement for QP(S) to be responsible for supervision of ERSS 2. Contractor to produce robust design of ERSS with appropriate sensitivity study, cross checking of design and to be checked by AC 3. Contractor's Method Statements 4. Implement real time monitoring of strut loads 5. Contractor's emergency management plan	D&B Contractor	5	1	C	Open		
CR16/CCSS/100/006/-	100	006	NA	Instability of ERSS 1. Station (390m long) 2. Launching Shaft	**Contractor does not follow the prescribed construction sequence:** 1. Substandard materials 2. Changes made on site do not comply with the design 3. Lack of understanding by the site staff	1. Collapse of ERSS 2. Collapse of / damage to adjacent structures 3. Injury/fatality of public / construction personnel 4. Construction equipment topples into excavation site	1. Conduct adequate site investigation (reported in Factual geotechnical Reports provided in tender documents) 2. Interpret geological profile of excavation site and derive moderately conservative geotechnical design parameters (GIBR) 3. Robust ERSS Design with minimum design requirement in the working drawings provided 4. Sensitivity study of design input parameters 5. Detailed Instrumentation & monitoring plan proposal	5	2	B	1. Contractor to produce robust design 2. Method statements 3. High quality construction records 4. Disaster planning including emergency services 5. Contingency planning 6. Briefing of site staff by contractor's designer 7. Proper site supervision 8. Regular site visits and checking by contractor's design engineers 9. Pre-qualify contractors	D&B Contractor	5	1	C	Open		
CR16/CCSS/100/007/-	100	007	NA	Instability of ERSS 1. Station (390m long) 2. Launching Shaft	**Insufficient monitoring during construction:** 1. Insufficient coverage of instruments 2. Wrong instruments specified 3. Instruments are faulty or not correctly calibrated 4. Frequency of readings is insufficient 5. Inadequate review of monitoring	1. Collapse of ERSS 2. Collapse of / damage to adjacent structures 3. Injury/fatality of public / construction personnel 4. Construction equipment topples into excavation site	1. Conduct adequate site investigation (reported in Factual geotechnical Reports provided in tender documents) 2. Interpret geological profile of excavation site and derive moderately conservative geotechnical design parameters (GIBR) 3. Robust ERSS Design with minimum design requirement in the working drawings provided 4. Sensitivity study of design input parameters 5. Detailed Instrumentation & monitoring plan proposal	5	2	B	1. Contractor to develop a system to ensure instruments are calibrated and checked within the allowable time frame 2. Clear responsibility / action chains 3. Regular monitoring review meetings 4. Disaster planning including emergency services 5. Contingency planning 6. D&B Contractor to witness installation of instruments by the Instrumentation Contractor 7. Instrumentation Contractor is responsible for the accuracy of the instrumentation readings 8. Pre-qualify contractors	D&B Contractor	5	1	C	Open		

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Summary of initial risk classes A 4 B 37 C 25 D 0 Total: 66

Summary of residual risk classes A 0 B 0 C 66 D 0 Total: 66

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Hazard No	Haz Code	Run No																
CR16/CCSS/100/008/-	100	008	NA	Excessive ground movement due to ERSS excavation 1. Station (390m long) 2. Launching Shaft	**Higher than expected lateral deflection of ERSS wall during excavations:** 1. Unforeseen ground conditions 2. Inappropriate removal of struts 3. Over-excavation 4. Excavation of cut and cover tunnel 5. Unforeseen higher than designed surcharge	1. Structural damage/deflection of existing structures 2. Injury to public / construction personnel 3. Wall toe movementERSS 4. Construction equipment topples into excavation site	1. Conduct adequate site investigation (reported in Factual geotechnical Reports provided in tender documents) 2. Sensitivity analysis of design input parameters / robust design to minimise movement 3. Over-excavation allowance in design 4. Recharge wells, toe grouting and shear pins 5. AE Consultant will provide minimum design requirement in the working drawings for ERSS design.	4	3	B	1. Contractor to produce robust design 2. Method Statements to ensure safe working methods 3. Closely monitoring on site and surronding areas to identify impact of excessive ground movement 4. Interview people with relevant knowledge 5. Visual inspection 4. Disaster planning including emergency services 5. Contingency planning	D&B Contractor	4	2	C	Open		
(101) TEMPORARY STRUCTURES																		
CR16/CCSS/101/001/-	101	001	NA	Instability of temporary slopes adjacent to the proposed station (390m long)	**Excessive loading or stockpiling close to excavation:** 1. Loading due to TSA 2. Loading due to TBM logistics including segment storage 3. Loading due to precasting activities	1. Slope failure 2. Injury 3. Excessive settlement and damage to adjacent structures 4. Collapse of adjacent structures	1. Review site conditions to assess an appropriate location for the stockpiling 2. Assess loading impact of stockpile on slopes	4	2	C	1. Contingency planning e.g. immediate shotcreting or ground improvement 2. Instrumentation / Monitoring with LBs and LGs on adjacent structures and ground 3. Review levels to be developed	D&B Contractor	4	1	C	Open		
CR16/CCSS/101/002/-	101	002	NA	Instability of temporary slopes adjacent to the proposed station (390m long)	**Flawed design of slopes:** 1. Inappropriate use / misinterpretation of design codes 2. Lack of understanding of design software and output 3. Incorrect information on adjacent structures 4. Design is incompatible or inadequate design with adjacent structures 5. Not identifying the behaviour and response of the ground and adjacent structures	1. Slope failure 2. Injury 3. Excessive settlement and damage to adjacent structures 4. Collapse of adjacent structures	1. Review site conditions to assess an appropriate location for the stockpiling 2. Assess loading impact of stockpile on slopes	4	2	C	1. Contingency planning e.g. immediate shotcreting or ground improvement 2. Instrumentation / Monitoring with LBs and LGs on adjacent structures and ground 3. Review levels to be developed 4. Perform further structural or geotechnical investigations e.g. coring, trial trenching 5. Sensitivity analysis of design input parameters	D&B Contractor	4	1	C	Open		

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Summary of initial risk classes A 4 / B 37 / C 25 / D 0 — Total: 66

Summary of residual risk classes A 0 / B 0 / C 66 / D 0 — Total: 66

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Hazard No	Haz Code	Run No																
CR16/CCSS/101/003/-	101	003	NA	Slope failure due to erosion	**Slope erosion**	1. Slope failure 2. Injury 3. Excessive settlement and damage to adjacent structures	1. Specify slope protection measures 2. Conduct visual inspection to watch out sign of potential erosion.	4	2	C	1. Method Statements to ensure safe working methods 2. Closely monitoring of the slope and surronding areas 3. Instrumentation and monitoring with LBs on adjacent structures	D&B Contractor	4	1	C	Open		
(102) DIAPHRAGM WALLING / PILLING																		
CR16/CCSS/102/001/-	102	001		Inadequate water tightness due to gaps between Diaphram walls joints	Gaps between Diaphram Wall Joints	1. Cracking / leakage 2. Strcutural damage 3. Waterproofing problems and associated repair	1. Robust ERSS design 2. Specify performance ceriteria for ERSS 3. Utility study shows no provision is required for services to pass through retaining systems	4	2	C	1. Contractor to produce robust design to mitigate possibility of leakage 2. Contingency planning, e.g. grouting of gaps 3. Method statements to ensure safe working methods	D&B Contractor	4	1	C	Open		
CR16/CCSS/102/002/-	102	002	NA	Inadequate water tightness due to gaps in Diaphram walls concretes	1. Poor concrete compaction 2. Inadequate concrete cover and reduced durability due to honeycomb 3. Poor workmanship	1. Water ingress 2. Loss of toe stability 3. Loss of fines 4. Settlement of structures	1. Robust ERSS design 2. Specify minimum required depths for ERSS walls for water tightness 3. Minimum rebar spacing to comply with code and staggered laps to reduce honey comb	4	2	C	1. Contractor to use adequate plant / equipment for ERSS wall construction	D&B Contractor	4	1	C	Open		
CR16/CCSS/102/003/-	102	003	NA	D-Wall cage too heavy to be lifted	Unsuitable D-Wall design 1. Inappropriate use / misinterpretation of design codes. 2. Lack of understanding of design software and output. 3. Not identifying the behaviour and response of the ground and adjacent structures.	1. Delay of works.	Carry out the following: 1. Practical D-Wall design. 2. Independent check and review of designs within the team.	3	2	C	Contractor to carry out the following: 1. Use adequate plant / equipment for DWall construction.	D&B Contractor	3	1	C	Open		
CR16/CCSS/102/004/-	102	004	NA	Poor durability of D-Walls	1. Inadequate cover. 2. Poor workmanship. 3. Mix design.	Unable to meet the design life requirements	Carry out the following: 1. Specify suitable concrete cover and provide details to ensure that this can be maintained with good workmanship. 2. Issue Durability Report.	3	2	C	Contractor to carry out the following: 1. Review quality assurance systems and workmanship.	D&B Contractor	3	1	C	Open		
CR16/CCSS/102/005/-	102	005	NA	Larger deflection than envisaged of D-Wall	1. Ground conditions and ground water table misunderstood or not properly addressed in the design. 2. Lack of understanding of codes. 3. Lack of understanding of software and its limitations. 4. Over-excavation.	1. Excessive ground movement and building settlement. 2. Breach of spatial requirements.	Carry out the following: 1. Allow for all deflection and setting out tolerances in design. 2. Additional soil investigations (SI). 3. Optimise footprint by combining elements of structure to reduce impact.	3	3	B	Contractor to carry out the following: 1. Instrumentation and monitoring program. 2. Staged review levels.	D&B Contractor	3	1	C	Open		
(103) PERMANENT STRUCTURES																		
CR16/CCSS/103/001/-	103	001	NA	Instability of permanent slopes 1. Near station entrance	**Flawed design of slopes:** 1. Inappropriate use / misinterpretation of design codes 2. Lack of understanding of design software and output 3. Incorrect information on adjacent structures 4. Design is incompatible or inadequate design with adjacent structures 5. Not identifying the behaviour and response of the ground and adjacent structures	1. Slope failure 2. Injury 3. Excessive settlement and damage to adjacent structures 4. Collapse of adjacent structures	1. Review site conditions to assess an appropriate location for the stockpiling 2. Assess loading impact of stockpile on slopes	4	2	C	1. Disaster planning including emergency services 2. Contingency planning e.g. immediate shotcreting or ground improvement 3. Instrumentation / Monitoring with LBs and LGs on adjacent structures and ground 4. Review levels to be developed 5. Perform further structural or geotechnical investigations e.g. coring, trial trenching 6. Sensitivity analysis of design input parameters	D&B Contractor	4	1	C	Open		

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Summary of initial risk classes
A 4
B 37
C 25
D 0
Total: 66

Summary of residual risk classes
A 0
B 0
C 66
D 0
Total: 66

*Hazard No			Previous Hazard No	*Hazard Description (max. length is 2000 characters)	*Hazard Cause (max. length is 2000 characters)	*Incident/ Accident (max. length is 2000 characters)	Current Measure (max. length is 4000 characters)	*Initial Severity	*Initial Frequency	*Initial Risk	Proposed Control Measures (max. length is 4000 characters)	Actionee/ Haz Owner	*Residual Severity	*Residual Frequency	*Residual Risk	*Status	HA Form No.	Remarks
Hazard No	Haz Code	Run No																
CR16/CCSS/103/002/-	103	002	NA	Slope failure due to erosion	Slope erosion	1. Slope failure 2. Injury 3. Excessive settlement and damage to adjacent structures	1. Specify slope protection measures	4	2	C	1. Method Statements to ensure safe working methods 2. Closely monitoring on site and surronding areas 3. Instrumentation and monitoring with LBs on adjacent structures	D&B Contractor	4	1	C	Open		
CR16/CCSS/103/003/-	103	003	NA	Differential settlement between tunnels and station box	1. Different foundations/support systems between tunnel and station box. 2. Additional surcharge from road top up	Damage to structures.	1. Produce and issue Development Interface Report (DIR) 2. Produce details for grout block to improve local ground conditions. 3. Outline for instrumentation and monitoring during construction.	4	2	C	Contractor to carry out the following: - Instrumentation and monitoring programme.	D&B Contractor	4	1	C	Open		
CR16/CCSS/103/004/-	103	004	NA	Partial failure of structures	1. Misinterpretation of codes. Lack of understanding of design software and output. 2. Inadequate design capacities.	1. Damage to adjacent structures. 2. Fatalities/ injuries to construction workers and/or public.	1. Independent checks within team. 2. Conduct peer reviews.	3	2	C	Contractor to carry out the following: - Liaise with the AC/QP.	D&B Contractor	3	1	C	Open		
CR16/CCSS/103/005/-	103	005	NA	Seepage of water	Poor implementation of the details on site	1. Ingress of excessive water leading to maintenance problems	1. Provide moment connection designs for the outer hull of the structures. 2. Robust design and detailing of waterproofing and water stop.	4	4	A	Contractor to carry out the following: - Ensure that the waterproofing implementation is in compliance with the design details.	D&B Contractor	4	2	C	Open		
CR16/CCSS/103/006/-	103	006	NA	Poor durability of permanent structures	Inadequate cover, poor workmanship, mix design	Unable to meet the design life requirements	1. Issue Durability Report 2. Confirm the exposure conditions and specify cover in accordance with the codes. 3. Chemical contamination investigation.	4	2	C	Contractor to carry out the following: - Review quality assurance systems and workmanship. - Check for compliance with durability.	D&B Contractor	4	1	C	Open		
(104) GROUND CONDITIONS																		
CR16/CCSS/104/001/-	104	001	NA	Base heave exceeds acceptable torerances	**Bearing capacity failure:** 1. Soils strength less than assumed in design 2. Weak wall with insufficient moment capacity 3. Excessive pore pressures in granular soils below formation	1. Collapse of temporary works 2. Damage of adjacent structures 3. Injury to construction workers and public	1. Extensive site Investigation 2. Previous experience and review of published literature contributes to design methodology 3. Sensitivity analysis of design input parameters / robust design to minimise movement 4. Shear pins specified where toe depth is small	5	2	B	1. Interpret geological profile of excavation site 2. Derive moderately conservative geotechnical design parameters 3. Sensitivity analysis of design input parameters 4. Instrumentation and monitoring	D&B Contractor	5	1	C	Open		

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Summary of initial risk classes A 4 / B 37 / C 25 / D 0 — Total: 66

Summary of residual risk classes A 0 / B 0 / C 66 / D 0 — Total: 66

*Hazard No			Previous Hazard No	*Hazard Description (max. length is 2000 characters)	*Hazard Cause (max. length is 2000 characters)	*Incident/ Accident (max. length is 2000 characters)	Current Measure (max. length is 4000 characters)	*Initial Severity	*Initial Frequency	*Initial Risk	Proposed Control Measures (max. length is 4000 characters)	Actionee/ Haz Owner	*Residual Severity	*Residual Frequency	*Residual Risk	*Status	HA Form No.	Remarks
Hazard No	Haz Code	Run No																
CR16/CCSS/104/002/-	104	002	NA	Base heave exceeds acceptable torerances	**Hydraulic uplift / excess pore pressure:** 1. Weight of soil above < uplift water pressure 2. Insufficient tie-down 3. Excessive pore water pressure in isolated soils beneath formation	1. Collapse of temporary works 2. Damage of adjacent structures 3. Injury to construction workers and public	1. Extensive site Investigation 2. Sensitivity analysis of design input parameters / robust design to minimise movement	5	2	B	1. Conduct adequate site investigation to record permeable bands 2. Sufficient toe-in length 3. Monitoring of pore water pressures 4. Design for sufficient cut-off	D&B Contractor	5	1	C	Open		
CR16/CCSS/104/003/-	104	003	NA	Instability of temporary slopes adjacent to the proposed station (390m long)	**Insufficient soil investigation:** Unforseen ground conditions	1. Slope failure 2. Injury 3. Excessive settlement and damage to adjacent structures	1. Extensive site Investigation 2. Robust instrumentation and monitoring	4	2	C	1. Conduct adequate site investigation by contractor 2. Sensitivity analysis of design input parameters 3. Instrumentation and monitoring with LBs & LGs on adjacent structures & ground	D&B Contractor	4	1	C	Open		
CR16/CCSS/104/004/-	104	004	NA	Excessive ground movements	**Excessive water draw down due to unknown ground conditions:** Undetected kallang formation	1. Excessive movement of temporary works 2. Damage of adjacent structures 3. Injury to construction workers and public	1. Extensive site Investigation 2. Robust instrumentation and and recharge regime proposed 3. Detailed Impact Assessment 4. Detailed settlement contours developed	4	2	C	1. Method Statements to ensure safe working methods 2. Install Recharge wells 3. Closely monitoring on site and surronding areas 4. Interview people with relevant knowledge	D&B Contractor	4	1	C	Open		
CR16/CCSS/104/005/-	104	005	NA	Excessive ground settlement	**Permeability of the ground:** Undetected F1 layers with high permeability	1. Excessive settlement 2. Damage of adjacent structures	1. Extensive site Investigation 2. Robust instrumentation and and recharge regime proposed 3. Detailed Impact Assessment 4. Detailed settlement contours developed	4	2	C	1. Sensitivity study 2. Install Recharge wells 3. Monitoring with LBs and LGs on adjacent structures and ground 4. SI by contractor	D&B Contractor	4	1	C	Open		
CR16/CCSS/104/006/-	104	006	NA	Insufficient structural and geotechnical design for bored tunnels and TBM	**Insufficient soil investigation due to bored tunnel realignment**	1. Excessive settlement 2. Damage of adjacent structures 3. Instability of the permenant tunnel linings	1. Extensive phase 3 site Investigation in the new alignment 2. Robust instrumentation and and recharge regime proposed 3. Detailed Impact Assessment 4. Detailed settlement contours developed	4	2	C	1. Sensitivity study 2. Install Recharge wells 3. Monitoring with LBs and LGs on adjacent structures and ground 4. SI by contractor	D&B Contractor	4	1	C	Open		
(106) EXISTING UTILITIES																		
CR16/CCSS/106/001/-	106	001	NA	Damage / Movement to existing DTSS 2.1m Internal Diameter Link Sewer, 5.5m-23m away from deep excavation.	**Deep excavation near existing utility**	1. Damage to utility 2. Disruption of essential service 3. Injuries of construction workers	1. Study available utilities as-built drawings 2. Robust ERSS design to minimise movement 3. Detailed utility subsidence report	4	3	B	Contractor to: 1. Carry out additional SI 2. Interview people with relevant knowledge 3. High quality site records taken and checked on site 4. Review site records post-installtaion and pre-excavation	D&B Contractor	4	2	C	Open		

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Summary of residual risk classes A 0 / B 0 / C 66 / D 0 — Total: 66

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Hazard No	Haz Code	Run No																
CR16/CCSS/106/002/-	106	002	NA	Damage / Movement to Existing utilities (Gas, sewer, water ,telecom, electrical installations) and disruption to services	**Incomplete as-built information leading to inappropriate assumptions about utility locations**	1. Damage to utility 2. Disruption of essential service 3. Injuries of construction workers 4. Enviromental damage 5. Delay of project	1. Desk study to locate the utilities (as-built drawings) 2. Propose trial pit and review trial pit result (including the conditions of the utilities)	4	3	B	Contractor to: 1. Carry out his utility assessment 2. Propose trial pit and review trial pit result (including the conditions of the utilities) 3. Further investigation if required 4. Probing ahead of construction 5. High quality site records taken and checked on site 6. Review site records post-installtaion and pre-excavation	D&B Contractor	4	2	C	Open		
CR16/CCSS/106/003/-	106	003	NA	Damage / Movement to Existing utilities (Gas, sewer, water ,telecom, electrical installations) and disruption to services	**Failure to give due consideration to known existing utilities**	1. Damage to utility 2. Disruption of essential service 3. Injuries of construction workers 4. Enviromental damage 5. Delay of project	1. Study available utilities as-built drawings 2. Robust ERSS design to minimise movement 3. Detailed utility subsidence report	4	3	B	Contractor to: 1. Carry out his utility assessment 2. Liaison with utility owner 3. Disaster planning includeing emergency services	D&B Contractor	4	2	C	Open		
CR16/CCSS/106/004/-	106	004	NA	Damage / Movement to Existing utilities (Gas, sewer, water ,telecom, electrical installations) and disruption to services	**Impact to unknown utilities**	1. Damage to utility 2. Disruption of essential service 3. Injuries of construction workers 4. Enviromental damage 5. Delay of project	1. Study available utilities as-built drawings 2. Robust ERSS design to minimise movement 3. Detailed utility subsidence report	4	2	C	Contractor to: 1. Carry out his utility assessment 2. Propose trial pit and review trial pit result (including the conditions of the utilities) 3. Use Permit to Dig system 4. Probing ahead of construction 5. Locally divert, relocate or support utilities if encountered	D&B Contractor	4	1	C	Open		
(109) OBSTRUCTIONS																		
CR16/CCSS/109/001/-	109	001	NA	Dwall construction Encountering unforeseen buried stuctures	**Failure to locate buried structures, steel casings or bacfilled ground invesitgation holes**	1. Stoppage to works, delay of project 2. Possible injury to construction workers	1. Historical Land Use Survey 2. Site investigation (reported in Factual geotechnical Reports provided in tender documents) 3. Geotechnical Interpretative Baseline Report 4. Contingency recharge wells in sensitive areas	4	2	C	1. Interview people with relevant knowledge 2. Site investigation 3. Use of adequate plant / equipment for ERSS wall construction 4. Contingency plans e.g. grout gaps 5. Probing ahead of wall 6. High quality site records taken and checked on site 7. Review site records post-installtaion and pre-excavation	D&B Contractor	4	1	C	Open		

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Stage Contract		Site Contract	

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Summary of initial risk classes A 4 / B 37 / C 25 / D 0 — Total: 66

Summary of residual risk classes A 0 / B 0 / C 66 / D 0 — Total: 66

*Hazard No			Previous Hazard No	*Hazard Description (max. length is 2000 characters)	*Hazard Cause (max. length is 2000 characters)	*Incident/ Accident (max. length is 2000 characters)	Current Measure (max. length is 4000 characters)	*Initial Severity	*Initial Frequency	*Initial Risk	Proposed Control Measures (max. length is 4000 characters)	Actionee/ Haz Owner	*Residual Severity	*Residual Frequency	*Residual Risk	*Status	HA Form No.	Remarks
Hazard No	Haz Code	Run No																
CR16/CCSS/109/002/-	109	002	NA	Dwall construction Encountering unknown buried stuctures	**Uncharted obstructions:** 1. Uncharted existing or abandoned culverts 2. Uncharted existing or abandoned utilities 3. Abandoned piles, outfalls, storm drains, sewers, sea-walls or other remnant structures	1. Stoppage to works, delay of project 2. Possible injury to construction workers	1. Historical Land Use Survey 2. Site investigation (reported in Factual geotechnical Reports provided in tender documents) 3. geotechnical Interpretative Baseline Report 4. Contingency recharge wells in sensitive areas	4	2	C	1. Interview people with relevant knowledge 2. Site investigation 3. Use of adequate plant / equipment for ERSS wall construction 4. Contingency plans e.g. grout gaps 5. Probing ahead of wall 6. High quality site records taken and checked on site 7. Review site records post-installtaion and pre-excavation	D&B Contractor	4	1	C	Open		
(110) INTERFACE WITH ADJACENT CONTRACTS																		
CR16/CCSS/110/001/-	110	001		Leakage / Differential settlement at the interface between launching shaft and bored tunnelling works	**Improper connection at interface or flawed waterproofing at interface:** 1. Poor workmanship 2. Bad detailing 3. Poor design coordination 4. Inappropriate structural detailing at interface 5. Lack of coordination of neighbouring (sub) contractors	1. Water ingress 2. Localised ground settlements 3. Excessive ground settlements 4. Potential hazards with level change 5.Remedial works would cause delay to construction	1. Ground treatment at interfaces 2. Specify waterproofing requirements 3. Extensive GI during detailed design 4. Robust interface detailing 5. Detailed interfacing clauses in Particular Specification	4	2	C	1. Contractor's Method Statement to ensure safe working methods 2. Regular inspection and maintenance 3. Specified TBM with grouting facility 4. Contingency planning 5. Instrumentation / Monitoring 6. Review levels to be developed 7. Sensitivity analysis of design input parameters	D&B Contractor	4	1	C	Open		
CR16/CCSS/110/002/-	110	002		Ground cave in / sinkhole formation at the interface between launching shaft and bored tunnelling works	**Soft-eyes opening during tunnels connection:** 1. Bad detailing 2. Inadequate grouting measures 3. Poor workmanshipundation systesms of adjacent structures	1. Water ingress 2. Localised ground settlements 3. Injury to construction workers	1.Proper interface detailing and specifications indicated 2. Ground improvement works at interface	4	3	B	1. Contractor's Method Statement to ensure safe working methods 2. Instrumentation / Monitoring 3. Review levels to be developed 4. Pre-qualify contractor	D&B Contractor	4	2	C	Open		
CR16/CCSS/110/003/-	110	003		Differential settlement at the interface between launching shaft and bored tunnelling works	**Use of different Foundation type DFE vs bored tunnels (no foundations):** 1. Poor detailing 2. Poor workmanship 3. Poor design coordination	1. Cracking / leakage 2. Misalginment of tracks in running tunnels 3. Operational issues / negative PR	1. Proper interface detailing and specifications indicated 2. Ground improvement works at interface 3. Tunnel settlement analysis 4. Sensitivity analysis of design input parameters	4	2	C	1. Contractor's Method Statement to ensure safe working methods 2. Instrumentation / Monitoring 3. Review levels to be developed 4. Pre-qualify contractor	D&B Contractor	4	1	C	Open		
CR16/CCSS/110/004/-	110	004		Differential settlement at the interface between launching shaft and bored tunnelling works	**Inappropriate structural detailing at interface**	1. Cracking / leakage 2. Misalginment of tracks in running tunnels 3. Operational issues / negative PR	1. Proper interface detailing and specifications indicated 2. Detailed interface clause in PS	4	2	C	1. Contingency planning 2. Instrumentation / Monitoring 3. Review levels to be developed 4. Pre-qualify contractor	D&B Contractor	4	1	C	Open		

Project Name	CR16	Stage	CCSS
Date Created			
Stage Contract		Site Contract	

* Mandatoy Fields

Summary of initial risk classes A 4 / B 37 / C 25 / D 0 — Total: 66

Summary of residual risk classes A 0 / B 0 / C 66 / D 0 — Total: 66

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Hazard No	Haz Code	Run No																
CR16/CCSS/110/005/-	110	005	NA	Incompatible interfacing with adjacent contracts: Launching shaft and bored tunnelling works	**Inappropriate or non-workable connection design at interface :** 1.Lack of coordination of neighbouring contractors	1. Excessive ground movement 2. Movement to adjacent structures 3. Water drawdown 4. Waterproofing problem and associated repairs	1. Robust connection design	5	2	B	1. Coordination meetings between interfacing contractors 2. Construction Interface report by Contractor 3. Coordination between all parties (Clients, Contractors, Designers)	D&B Contractor	5	1	C	Open		
(111) INTERFACE WITH ADJACENT DEVELOPMENTS																		
CR16/CCSS/111/001/-	111	001	NA	Damage / Movement to Adjacent developments (e.g. Maju, SIM)	**Incomplete as-built information leading to inappropriate assumptions**	1. Damage to developments or excessive building movements 2. Injuries of construction workers 3. Enviromental damage 4. Delay of project	1. Desk study to locate the any exisiting structures (as-built drawings) 2. Propose trial pit and review trial pit result (including existing building conditions)	4	3	B	Contractor to: 1. Carry out his as-built assessment 2. Propose trial pit and review trial pit result (including existing building conditions) 3. Further investigation if required 4. Probing ahead of construction 5. High quality site records taken and checked on site 6. Review site records post-installtaion and pre-excavation	D&B Contractor	4	2	C	Open		
(112) FUTURE DEVELOPMENT OR ADDITION & ALTERATION WORKS																		
CR16/CCSS/112/001/-	112	001	NA	URA's Furture Development Interfacing with: 1. Station	1. Proposals for future infrastructure and developments interfacing with station 2. Unaware of future infrastructure and developments proposals	1. Construction delay / hinderance 2. Incompatible construction techniques	1. Minimum ERSS design requirement in the working drawings 2. Consultation of all relevant agencies 3. Development Interface Report to highlight therelated risks and design intent to the future developer 4. Provisonal pile casing provided in between bored tunnels	4	3	B	1. Coordination meetings between interfacing designers 2. Coordination between all parties (Client, Contractor, Designers)	D&B Contractor	4	2	C	Open		
(117) CONSTRUCTION METHODOLOGY																		
CR16/CCSS/117/001/-	117	001	NA	Instability of station box during construction	Inappropriate ERSS design system: 1. Poor soil-structure interaction modelling or lack of understanding of design software 2. Incorrect loading assumption 3. Incorrect work sequence 4. Incorrect information on adjacent structures 5. Not identifying the behaviour and response of the ground and adjacent structures 6. Misinterpretation / inappropriate use of the relevant design codes 7. Incompatible of design with adjacent structures	1. Collapse of ERSS 2. Collapse of / damage to adjacent structures 3. Injury/fatality of public / construction personnel 4. Construction equipment topples into excavation site 5. Damage to permanent works	1. Conduct adequate site investigation (reported in Factual geotechnical Reports provided in tender documents) 2. Interpret geological profile of excavation site and derive moderately conservative geotechnical design parameters (GIBR) 4. Robust ERSS Design with minimum design requirement in the working drawings provided 5. Detailed Instrumentation & monitoring plan proposal	5	2	B	1. Contractor to produce robust design 2. Sensitivity analysis of design input parameters 3. Independent checking by AC 4. Disaster planning including emergency services 5. Contingency planning, e.g. stop all excavation, ensure safe escape route for workers, additional temporary struts 6. Develop detailed IM monitoring with review levels 7. Stand-by recharge wells for settlement control 8. Perform further structural or geotechnical investigation e.g. trial trenching	D&B Contractor	5	1	C	Open		

Project Name	CR16	Stage	CCSS
Date Created			
Stage Contract		Site Contract	

* Mandatoy Fields

Summary of initial risk classes A 4 / B 37 / C 25 / D 0 — Total: 66

Summary of residual risk classes A 0 / B 0 / C 66 / D 0 — Total: 66

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Hazard No	Haz Code	Run No																
CR16/CCSS/117/002/-	117	002		Instability of station I box during construction	Wide excavation lead to difficulty in station construction: 1. Difficulty in strutting 2. Detailing problems 3. Unbalanced forces	1. Collapse of ERSS 2. Collapse of / damage to adjacent structures 3. Injury/fatality of public / construction personnel 4. Construction equipment topples into excavation site 5. Damage to permanent works	1. Robust design with minimum requirements to minimise movement 2. One strut failure analysis	5	3	A	1. Contractor to produce robust design with one strut failure analysis 2. High quality construction records 3. Sensitivity analysis of design input parameters 4. Independent checking by AC 5. Disaster planning including emergency services 6. Contingency planning 7. Briefing of site staff by contractor's designer 8. I&M monitoring strut loads with review levels developed 9. Regular site visits and checking by contractor's design engineers	D&B Contractor	5	1	C	Open		
CR16/CCSS/117/003/-	117	003		Instability of Station box during construction	Variable ground conditions: 1. Unbalanced forces 2. Unexpected high pore water pressure	1. Collapse of ERSS 2. Collapse of / damage to adjacent structures 3. Injury/fatality of public / construction personnel 4. Construction equipment topples into excavation site 5. Damage to permanent works	1. Conduct adequate site investigation (reported in Factual geotechnical Reports provided in tender documents) 2. Interpret geological profile of excavation site and derive moderately conservative geotechnical design parameters (GIBR) 3. Robust ERSS Design with minimum design requirement in the working drawings provided 4. Sensitivity study of design input parameters 5. Detailed Instrumentation & monitoring plan proposed by AE	5	3	A	1. Contractor to produce robust design and internally cross checked 2. Use adequate equipement for ERSS construction 3. Minimum penetration specified in contract 4. Probing (Minimum aleternate panels / 12m) 5. Site investigation by Contractor 6. Proper record of penetration into hard stratum on installation site records 7. Review site records post-installtaion and pre-excavation 8. Pre-qualify contractors	D&B Contractor	5	1	C	Open		
CR16/CCSS/117/004/-	117	004		Instability of Station box during construction	**Instability of wall toe:** 1. Local valleys 2. Insufficient penetration into hard stratum	1. Collapse of ERSS 2. Collapse of / damage to adjacent structures 3. Injury/fatality of public / construction personnel 4. Construction equipment topples into excavation site	1. Conduct adequate site investigation (reported in Factual geotechnical Reports provided in tender documents) 2. Geotechnical Interpretative Baseline Report 3. Sensitivity analysis of design input parameters / robust design to minimise movement 4. Minimum design requirement in the working drawings for ERSS design 5. Minimum penetration of panels is specified	5	2	B	1. Contractor to produce robust design and internally cross checked 2. Minimum probing requirements ahead of ERSS wall installation given in Particular Specification 3. Probing(minimum alternate panels / 12m) 4. Site investigation by contractor 5. Proper record of penetration into hard stratum on installation site records 6. Review site records post-installtaion and pre-excavation 7. Pre-qualify contractors	D&B Contractor	5	1	C	Open		

Project Name	CR16	Stage	CCSS
Date Created			
Stage Contract		Site Contract	

* Mandatoy Fields

Summary of initial risk classes A 4 B 37 C 25 D 0 Total: 66

Summary of residual risk classes A 0 B 0 C 66 D 0 Total: 66

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Hazard No	Haz Code	Run No																
CR16/CCSS/117/005/-	117	005	NA	Instability of Station box during construction	**Contractor does not follow the prescribed construction sequence:** 1. Substandard materials 2. Changes made on site do not comply with the design 3. Lack of understanding by the site staff	1. Collapse of ERSS 2. Collapse of / damage to adjacent structures 3. Injury/fatality of public / construction personnel 4. Construction equipment topples into excavation site	1. Sensitivity analysis of design input parameters / robust design to minimise movement 2. Clear and unambiguousconstruction sequence drawings 3. Design for unplanned excavation	5	2	B	1. Contractor to produce robust design and internally cross checked 2. Method statements 3. High quality construction records 4. Disaster planning including emergency services 5. Contingency planning 6. Briefing of site staff by contractor's designer 7. Proper site supervision 8. Regular site visits and checking by contractor's design engineers 9. Pre-qualify contractors	D&B Contractor	5	1	C	Open		
CR16/CCSS/117/006/-	117	006	NA	Instability of Station box during construction	**Insufficient monitoring during construction:** 1. Insufficient coverage of instruments 2. Wrong instruments specified 3. Instruments are faulty or not correctly calibrated 4. Frequency of readings is insufficient 5. Inadequate review of monitoring	1. Collapse of ERSS 2. Collapse of / damage to adjacent structures 3. Injury/fatality of public / construction personnel 4. Construction equipment topples into excavation site	1. Conduct adequate site investigation (reported in Factual geotechnical Reports provided in tender documents) 2. Interpret geological profile of excavation site and derive moderately conservative geotechnical design parameters (GIBR) 3. Robust ERSS Design with minimum design requirement in the working drawings provided 4. Sensitivity study of design input parameters 5. Detailed Instrumentation & monitoring plan proposal	5	3	A	1. Contractor to produce robust design and internally cross checked 2. Clear responsibility / action chains 3. Regular monitoring review meetings 4. Disaster planning including emergency services 5. Contingency planning 6. D&B Contractor to witness installation of instruments by the Instrumentation Contractor 7. Instrumentation Contractor is responsible for the accuracy of the instrumentation readings 8. Pre-qualify contractors	D&B Contractor	5	1	C	Open		
CR16/CCSS/117/007/-	117	007	NA	Working in confined space or constrained site	**Handling of temporary steelwork within confined site:** Craning steel members through restricted worksite openings	1. Injury to construction personnel 2. Delay to construction	1. Proposed efficient temporary works layout and construction sequence	4	2	C	Contractor to manage by: 1. Follow Confined spaces specification 2. Explicit method statement on removal of blinding layers prior to excavating below slabs 3. Tool box talks 4. Dedicated site safety officer 5. Site safety inductions 6. Implementation of permit to work system	D&B Contractor	4	1	C	Open		
CR16/CCSS/117/008/-	117	008	CR16/CCSS/999/001/-	Crane collapse or failure	**Overloading of lifting equipment:** Failure to observe safe work procedures	1. Crane collapse 2. Injury to construction personnel 3. Delay to construction 4. Damage to property	1. Efficient crane foundation design 2. Efficient design of structurs for crane loads 3. Limiting lifting loads 4. Robust ERSS design with suitable surcharge	4	2	C	Contractor to manage by: 1. Tool box talks 2. Dedicated site safety officer 3. Site safety inductions 4. Implementation of permit to work system	D&B Contractor	4	1	C	Open		
CR16/CCSS/117/009/-	117	009	NA	Constructibility problems of precast members	**Insufficient crane capacity for hoisting of precast memberst**	1. Crane collapse 2. Injury to construction personnel 3. Delay to construction 4. Damage to property	1. design and specify precast elements suitable for lifting 2. limiting weight of precast members	4	2	C	Contractor to manage by: 1. Method statement for safe lifting methods 2. Lifting plans	D&B Contractor	4	1	C	Open		

Project Name	CR16	Stage	CCSS
Date Created			
Stage Contract		Site Contract	

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Summary of initial risk classes A 4 B 37 C 25 D 0 Total: 66

Summary of residual risk classes A 0 B 0 C 66 D 0 Total: 66

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Hazard No	Haz Code	Run No																
(118) GROUND IMPROVEMENTS																		
CR16/CCSS/118/001/-	118	001		Ground improvement failure at: 1. TBM break out / intial drive after launching shaft	**Insufficient ground improvement:** 1. Inapporiate stiffness of ground improvement 2. Poor workmanship 3. Grouting over large width 4. Insufficient control of the work	1. Excessive ground movement / sink hole 2. Injury or fatality of construction workers 3. Damage to ERSS 4. Movements of adjacent structures 5. Delay of works	1. Minimum GI requirement in the working drawings	4	3	B	1. Contractor to produce robust GI design and internally cross checked 2. Contingency planning, inspection and monitoring 3. Method Statements to ensure safe working methods 4. Instrumentation / Monitoring	D&B Contractor	4	2	C	Open		
(120) HAZARDOUS MATERIALS																		
CR16/CCSS/120/001/-	120	001		Poor air quality during construction	Toxic fumes encountered during excavation 1. Methane from peat layers 2. Contaminant gas in reclaimed areas 3. Concentration of gases during top down construction	1. Sickness / fatality of construction workers 2. Suffocation to workers	1. Conduct adequate site investigation (reported in Factual geotechnical Reports provided in tender documents) 2. Historical Land Use Study	5	2	B	1. Gas monitoring by Contractor 2. QP(S) to be responsible for supervision / public safety 3. Contractor's Method Statements 4. Safety Management System	D&B Contractor	5	1	C	Open		
CR16/CCSS/120/002/-	120	002		Contaminated soils around at station construction site	**Construction near contaminated site and spoil disposal**	1. Intoxication of public or construction personnel	1. Soil toxicity tests 2. Site investigation (reported in Factual geotechnical Reports provided in tender documents) 3. Historical Land Use Study	4	3	B	1. Separation of contaminated soils 2. Removal of contaminated soil to licensed waste disposal site 3. Sampling for hazardous material characterisation 4. Contractor's Method Statements	D&B Contractor	4	2	C	Open		
(121) FIRE & EXPLOSIONS																		
CR16/CCSS/121/001/-	121	001		Fire or explosion during construction	Encounter unforeseen flammable materials 1. Breakage of buried services 2. Ignition of methane from peat layers 3. Contaminant gas 4. War relics/unexploded ordnances 5. Heavy vehicles carrying flammable materials may be driven into the construction site	1. Injury or fatality of public or construction workers 2. Damage to existing structures and services	1. Conduct adequate site investigation (reported in Factual geotechnical Reports provided in tender documents) 2. Historical Land Use Study	5	2	B	1. Contingency planning e.g. quick evacuation route 2. Provision of appropriate plant 3. Site investigation and geophysics by contractor 4. Interview people with relevant knowledge 5. Disaster planning including emergency services	D&B Contractor	5	1	C	Open		

Project Name	CR16	Stage	CCSS
Date Created			
Stage Contract		Site Contract	

* Mandatoy Fields

Summary of initial risk classes A 4 / B 37 / C 25 / D 0 — Total: 66

Summary of residual risk classes A 0 / B 0 / C 66 / D 0 — Total: 66

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Hazard No	Haz Code	Run No																
(122) FLOODING																		
CR16/CCSS/122/001/-	122	001		Flooding of excavation	1. Water inflows from ground 2. Heavy rain 3. Unexpected ground condition with high permeability of soil material 4. Insufficient pumping design 5. Pump failure	1. Flooding / disruption of RTS system 2. Damage to E&M equipments 3. Injury to construction personnel 4. Delay to construction	1. Highlight hazard in tender documents 2. Review contractors flood protection measures	5	2	B	1. Method Statements to ensure bund walls are built above flood protection level 2. Monitor water inflows and ground water levels 3. Mainetance of pumping system 4. Provision of large capacity standby pumps in PS 5. Provision of standby grouting if leakage is found 6. Emergency preparedness plan 7. Ensure Construction openning are not to far away for top down construction 8. Flood barriers	D&B Contractor	5	1	C	Open		
(123) CONFINED SPACE																		
CR16/CCSS/123/001/-	123	001		Work within confined spaces 1. Station box	1. Confined / Limited working space and access 2. Workers hit by machinery 3. Workers hit by debris falling from overhead slab 4. Suffocation due to lack of oxygen andaccumulation of exhaust gases	1. Injury or fatality of construction workers	1. Consider safety in design for confined spaces 2. Design adequate space for machinery 3. Adequate construction works and ventilation	5	2	B	1. Confined spaces specification 2. Explicit method statement on removal of blinding layers prior to excavating below slabs and to ensure safe working methods 3. Tool box talks 4. Adherence to confined spaces specification 5. Dedicated site safety officer 6. Site safety inductions 7. Provision of adequate pumps and blowers 8. Provision of gas detectors	D&B Contractor	5	1	C	Open		
(125) MAINTENANCE																		
CR16/CCSS/125/001/-	125	001		Inadequate access / provisions for maintenance	1. Workers falling from heights 2. Equipment / tools / parts ropping and hitting workers / public	1. Injury or fatalities of maintenance workers and or public	1. Consideration of access in design	5	2	B	1. Operation and Maintenance Manuals to be prepared by Operators 2. SWC to coordinate provisions for their equipment and systems during construction / installation	D&B Contractor	5	1	C	Open		
CR16/CCSS/125/002/-	125	002		Inadequate access / provisions for civil structures / architectural finishes maintenance	1. Workers falling from heights 2. Equipment / tools / parts ropping and hitting workers / public	1. Injury or fatalities of maintenance workers and or public	1. Consideration of access in design	5	2	B	1. Operation and Maintenance Manuals to be prepared by Operators 2. As-built drawings shall be kept by the maintenance department personnel for reference 3. Fall arrest system 4. Maintenance staff to be suitably trained 5. Maintenance works to be carried out during Engineering hours	D&B Contractor	5	1	C	Open		

Project Name	CR16	Stage	CCSS
Date Created			
Stage Contract		Site Contract	

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Hazard No	Haz Code	Run No																
CR16/CCSS/125/003/-	125	003		Difficulties in replacing of E&M equipment	1. Inadequate access / provisions for equipment replacement	1. Injury or fatalities of maintenance workers and or public	1. Consideration of access in design	5	2	B	1. Operation and Maintenance Manuals to be prepared by Operators 2. SWC to coordinate provisions for their equipment and systems during construction / installation 3. As-built drawings shall be kept by the maintenance department personnel for reference 4. Maintenance staff to be suitably trained	D&B Contractor	5	1	C	Open		
(999) OTHER HAZARDS																		
CR16/CCSS/999/001/-	999	001	NA	Noise, dust and vibration	**Construction works in close proximity to the public Excessive noise due to construction**	1. Injury to public or construction personnel 2. Disruption of essential services 3. Negative PR 4. Delays 5. Claims	1. Environmental Impact Assessment Study 2. Noise level studies	3	4	B	1. Contingency planning, e.g. additional noise barriers, inspection and monitoring 2. Method Statements to ensure safe working methods 3. Installation of sound barriers 4. Installation of dust barriers 5. Dust and vibration level monitoring	D&B Contractor	3	1	C	Open		
CR16/CCSS/999/002/-	999	002	NA	Road vehicles entering construction site 1. TBM launch shaft 2. excavations	**Traffic congestion due to minimum diversions, drivers seeking alternative routes**	1. Injury of construction workers and public 2. Damage to temporary or permanent works	1. Traffic Impact Assessment	4	3	B	1. Speed restrictions in place 2. Minimise traffic around construction sites	D&B Contractor	4	1	C	Open		
CR16/CCSS/999/003/-	999	003	NA	Dangerous traffic conditions	1. Inappropriate / complicated traffic diversion schemes 2. interface of site operations and existing road network	1. Injuries 2. Traffic accidents 3. Impact on local residences	1. Robust traffic diversion design	3	3	B	1. Speed restrictions in place 2. Minimise traffic around construction sites	D&B Contractor	3	2	C	Open		
CR16/CCSS/999/004/-	999	004	NA	Vehicular movement on site	1. Movement of site specific machinery e.g. trucks moving excavated soil	1. Injury to site staff	1. Efficient construction staging and worksite design	3	3	B	1. Speed restrictions in place 2. Minimise traffic around construction sites	CR16 Design Team	3	2	C	Open		
CR16/CCSS/999/005/-	999	005	NA	Damage to construction works due to a natural disaster	**Occurrence of a natural disaster duringconstruction:** 1. Flooding 2. Heavy rainfall causing significant ground water table rise	1. Flooding of excavation 2. Collapse of temporary works and adjacent structures 3. Injury or fatality of public or construction personnel 4. Disruption of essential services 5. Delays 6. Claims	1. Flood levels defined in GIBR	5	2	B	1. Robust ERSS design including flood barriers 2. Temporary groundwater controls and pumps within excavation 3. Disaster planning including emergency services 4. Contingency planning e.g. quick evacuation route 5. Bund wall for flooding mitigation	D&B Contractor	5	1	C	Open		
CR16/CCSS/999/006/-	999	006		Instability of crane at construction sites	**Inadequate ground conditions to suitably support crane**	1. Crane collapse 2. Injury to construction personnel 3. Delay to construction 4. Damage to property	1. Efficient crane foundation design 2. Efficient design of structurs for crane loads 3. Limiting lifting loads 4. Robust ERSS design with suitable surcharge 5. GIBR	4	3	B	1. Pre-qualify contractors 2. Specify cranage requirements including the following: a) Suitable pads and RC slabs if necessary to adequately spread outrigger forks b) Crane routes to be pre-determined by and under the control of the contractor's appointed lifting engineer	D&B Contractor	4	2	C	Open		

Project Name	CR16	Stage	CCSS
Date Created			
Stage Contract		Site Contract	

Summary of initial risk classes A 4
B 37
C 25
D 0
Total: 66

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C 66
D 0
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Hazard No	Haz Code	Run No																
CR16/CCSS/999/007/-	999	007		Falling from height into deep excavation	**Illegal entry, trespassing during construction**	1. Fatalities 2. Injuries	1. Specifications to be included in tender documents 2. Robust security plan design 3. Design low height wall with security fence aroundoverrun portion daylights	5	2	B	1. Implementation of adequate and suitable security measures during Construction	D&B Contractor	5	1	C	Open		

ARUP

The Risk Register is a "live document" and it will be the responsibility of all parties involved in the design, construction and commissioning of the CR206 Project and to ensure that all reasonable means and measures are put in place for the effective management of all the safety risks.to continue to identify new risks that arises

Summary of Initial Risk Classes

A	2
B	21
C	11
D	0
	34

Summary of Residual Risk Classes

A	0
B	5
C	20
D	9
	34

Risk Register

Project Title: CR206
CONTRACT CR206 Design and Construction of Maju Station and Tunnels for Cross Island Line

Stage
Architectural and Engineering

Revision
Preliminary

Date
09-Jan-23

1			3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Hazard ID			Hazard	Hazard Cause	Incident / Accident	Current Measures	Accident Severity	Accident Frequency	Risk Class	Proposed Control Measures	Hazard Owner	Residual Accident Severity	Residual Accident Frequency	Residual Risk Class	Status	HA Form No.	Remarks
Hazard No.	Hazard Code	Running number															
CR206 - Design and Construction of Maju Station and Tunnels for Cross Island Line																	
Adjacent Structures or Buildings																	
Obstructions																	
CR2001/CCSS	109	1	Unknown obstruction	Undetected underground obstructions (Underground Cables, Pipes etc.)	- Construction activities interrupted / delayed. - Risk of damage to unknown asset.	- Desk top study of known sea bed obstructions and Liaison with Authorities. - Historical Land Use Records	3	2	C	- Continue with Desk Top Study, Liaison with Authorities and Historical records - Study will concentrate on area immediately around construction site - Contractor to explore the potential obstructions if broader use of the Straits navigation is necessary.	D&B Contractor	3	1	D	Open		
CR2001/CCSS	109	2	TBM clash with underground obstructions	- Unforeseen underground obstructions. - Failure to locate buried structures (e.g. steel casings from backfilled ground investigation holes) - Failure to locate buried items in the ground - Existing pilling not removed properly from exisitng properties	- Clash of the TBM with unforeseen underground obstructions. - Programme delay and cost implications due to additional works.	- Careful review of available as built information along the tunnels alignment. - At locations where such a possibility is probable historical deep piles has been proposed to be extracted prior to tunneling activities.	3	2	C	Additional probe drilling shall be implemented by the contractor at locations where any uncertainties exist.	D&B Contractor	3	1	D	Open		

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Interface with Adjacent Contracts																	
CR2001/CCSS	110	1	- Leakage at the interface between tunnelling and cut & cover box - Differential settlement between tunnels and cut and cover box	Improper connection at interface or flawed waterproofing at interface - Poor workmanship - Bad detailing - Poor design coordination - Inappropriate structural detailing at interface - Lack of coordination of neighbouring contractors	- Water ingress - Localised ground settlements - Excessive ground settlements - Potential hazards with level change - Remedial works would cause delay to construction	- Specify ground treatment at interfaces - Specify waterproofing requirements -Robust interface detailing -Detailed interfacing clauses in Particular Specification - Specify TBM with grouting facility in Particular Specification	4	2	C	- Implementation of good workmanship and proper site supervision by contractor - Proper site supervision - Good practice of QA/QC procedures - High quality construction records - Contractor's Method Statement to ensure safe working methods - Regular inspection and maintenance - LTA M&W Specifications & PS - Specified TBM with grouting facility - Contingency planning e.g. stop all excavation, ensure safe escape route for workers, additional temporary struts. - Instrumentation / Monitoring - Review levels to be developed - Sensitivity of design input parameters - Engineers to review contractor's design to ensure it comply to LTA M&W Specifications & PS requirements	D&B Contractor	4	1	C	Open		
CR2001/CCSS	110	3	Differential settlement between bored tunnel and cut and cover box	Use of different construction method i.e. cut and cover and bored tunnels (no foundations) - Poor detailing - Poor workmanship - Poor design coordination	- Cracking / leakage - Misalignment of tracks in running tunnels - Operational issues / negative PR	- Tunnel settlement analyses - Sensitivity of design input parameters - Develop interface details - Suitable joint details	4	2	C	- Implementation of good workmanship and proper site supervision by contractor - Proper site supervision - Good practice of QA/QC procedures - High quality construction records - Contractor's Method Statement to ensure safe working methods	D&B Contractor	4	1	C	Open		

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Future Developments or Addition & Alteration Works																	
CR2001/CCSS	112	1	Clashes between railway structures and future infrastructure works and/or developments	- Proposals for future infrastructure and developments in direct conflict with alignment and proposed RTS structures - Unaware of future infrastructure and developments proposals	- Incompatible construction techniques - Delay of works	- Minimum design requirement are spelt out in the drawings for ERSS design. - Consultation with relevant agencies - Development Interface Report to highlight the related risks and design intent to the future developer - Future developer to carry out detailed impact assessment to the proposed CRL2 - Loading provisions and requirements to stipulate in the D&B PS	4	3	B	- Coordination meetings between interfacing designers - Coordination between all parties (Client, Contractor, Design Consultants) - Future developer to carry out detailed impact assessment to newly constructed CRL structures	D&B Contractor	4	1	C	Open		
CR2001/CCSS	112	2	Underdesign of Future Development Interface	Inadequate loading assumption, Misalign stump column position	- DFEs (Deep Foundation Element) supporting future development are overstressed - Failure of roof slab (for future development directly on top of station roof slab) - Injury or fatalities of public	- To confirm with URA on the future loading provision (number of storeys, usage of the building, etc.) - To coordinate and document stump column position - To clearly indicate the stump column loading in DIR	5	2	B	- Permanent structure to be designed with additional safety factor - Permanent structure to be design for worse case load and design condition - Coordinate with relevent agencies on Future Development	D&B Contractor	4	1	C	Open		
Tunnelling																	
CR2001/CCSS	113	1	Excessive vibration due to bored tunnelling	-	- Damage to vibration sensitive equipment - Exceed vibration for human comfort	- Check with stakeholders on any vibration sensitive equipment along bored tunnel alignment - environmental impact assessment report to calculate vibration	4	3	B	- Contractor's method statement - EIA	D&B Contractor	4	2	B	Open		
CR2001/CCSS	113	5	Excessive settlement of adjacent buildings due to tunnel boring	Unforeseen ground conditions Volume loss associated with bored tunnels is greater than anticipated Inappropriate face pressures Loss of face pressure/blowout Water drawdown Long term settlements Poor ground improvement work	- Damage to buildings - Delays - Claims - Closure of roads - Injuries / fatalities of construction workers and public - Damage to adjacent structures - Damage to road - Injury to construction workers - Flooding	- Initial site investigation - Visual inspection surveys and Building Impact assessments - Specification of instrumentation and monitoring requirements by D&B Contractor - Optimised alignment to maximise tunnel clearances - LTA TBM Specifications to suit ground conditions	5	2	B	- Method Statements to ensure safe/appropriate working methods - Extensive site investigation including trial trench during detailed design stage - Use of appropriate equipment / boring technique - Continuity of TBM operational staff - Deep settlement markers if necessary - Pre-qualify Contractors - Real time monitoring if necessary - LTA TBM Specifications to suit ground conditions - Independent instrumentation / monitoring of ground movement and building settlement - Close Monitoring to Tunnelling KPI	D&B Contractor	4	1	C	Open		

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CR2001/CCSS	113	6	Excessive Settlement of utilities due to tunnel boring	Unforeseen ground conditions Volume loss associated with bored tunneling is greater than anticipated Inappropriate face pressures adopted Loss of face pressure/blowout Water drawdown Long term settlements	- Damage / breakage of utilities - Fire / explosion - Flooding - Disruption of essential service - Delays - Claims - Closure of roads - Injuries / fatalities of construction workers and public	- Initial site investigation - Study of latest utility records - Consultation with utility companies for additional information - Optimised alignment to maximise tunnel clearances	5	2	B	- Method Statements to ensure safe/appropriate working methods - Extensive Site investigation incl. trial trench during design stage - Independent instrumentation / monitoring - Use of appropriate equipment / boring technique - Continuity of TBM operational staff - Deep settlement markers where necessary - Real time monitoring where necessary - Specification of instrumentation and monitoring requirements by D&B Contractor - Utility damage assessments - Pre-qualify Contractors - LTA TBM specifications to suit ground conditions -Close monitoring to Tunnelling KPI	D&B Contractor	4	1	C	Open		
CR2001/CCSS	113	7	Excessive water ingress during bored tunnelling works	Inadequate face pressure applied Improper tail void grouting Damaged segment due to construction loading Inappropriate TBM for the ground conditions encountered Highly gorund permeability encountered	- Delays - Damage to adjacent structures - Damage to road - Injury to construction workers - Flooding	- Review of existing SI information - Pre-treatment requirement in Particular Specification - Sensitivity analysis of design input parameters / robustness of design approach - Specify most appropriate TBM in the Particular Specification	4	3	B	-Implementation of good workmanship and proper site supervision by contractor -Good practice of QA/QC procedures -High quality construction records -Method Statements to ensure safe/appropriate working methods -Facility for regrouting -Design to consider construction loadings	D&B Contractor	4	2	B	Open		
CR2001/CCSS	113	8	Leakage at the interface between TBM and retrieval shaft	Improper connection at interface - Poor workmanship - Poor design co-ordination	- Water ingress - Damage to existing utilities and adjacent structures - Flooding	- Pre-treatment requirement - Ground treatment at interface specified by D&B Contractor	4	3	B	- Adequate Ground Improvement (GI) during detailed design by D&B Contractor - Implementation of good workmanship and proper site supervision by contractor - Proper site supervision - Good practice of QA/QC procedures - High quality construction records - Method Statements to ensure safe/appropriate working methods - Regular inspection and maintenance - Facility for regrouting	D&B Contractor	4	2	B	Open		
CR2001/CCSS	113	9	Leakage at the interface TBM and retrieval shaft	Flawed waterproofing at the interface -Poor workmanship - Bad detailing - Inadequate grouting measures	- Water ingress - damage to existing utilities and adjacent structures -Flooding	- Specify waterproofing requirements	4	3	B	- Implementation of good workmanship and proper site supervision by contractor - Proper site supervision - Good practice of QA/QC procedures - High quality construction records - Method Statements to ensure safe/appropriate working methods - Facility for regrouting	D&B Contractor	4	2	B	Open		
CR2001/CCSS	113	10	Toxic fumes, smoke, open flames, excessive heat	TBM dismantling - Burning off of TBM parts	- Injuries to construction workers	- Spacious shaft, minimum temporary strutting	3	2	C	- Area in which TBM will be dismantled is open to the atmosphere (not confined space) - Method Statements to ensure safe/appropriate working methods - Ensure adequate ventilation within workspace areas	D&B Contractor	3	1	D	Open		

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CR2001/CCSS	113	11	Ground cave in	Soft-eyes opening during retrieval shaft to tunnels connection - Bad detailing - Inadequate grouting measures - Poor workmanship	- Water ingress - Injuries to construction workers - Localised ground settlements	- D&B Contractor to produce full detailed soft eye design - Ground treatment at interface specified by D&B Contractor	4	3	B	- Implementation of good workmanship and proper site supervision by contractor - Proper site supervision - Good practice of QA/QC procedures - High quality construction records - Method Statements to ensure safe/appropriate working methods	D&B Contractor	4	2	B	Open		
CR2001/CCSS	113	12	Differential settlement between bored tunnel and TBM launch shaft	Use of different construction method i.e. cut and cover shaft (ERSS walls) and bored tunnels (no foundations)	- Cracking / leakage - Misalignment of tracks in running tunnels - Operational issues / negative PR	- Tunnel settlement analyses	4	2	C	- Contractor to develop detailed shop drawings during construction. - Method Statement to demonstrate effective working methods.	D&B Contractor	4	1	C	Open		
CR2001/CCSS	113	13	Water ingress into Launch Shaft at TBM launching	Insufficient & ineffective ground improvement Insufficient Ground Investigation	- Delays - Damage to adjacent structures - Damage to road - Injury to construction workers - Flooding of construction site	More effective GI Proposal (DSM or equivalent) More ground investigation during design and by contractor	3	3	B	- Method Statements to ensure safe/appropriate working methods - Facility for new ground improvement	D&B Contractor	3	2	C	Open		
CR2001/CCSS	113	14	Excessive ground and building deformation due to unsafe CHI	Highly permeable ground conditions Existing geological features which provide water channel to the tunnel (faults etc.) Inappropriate compressed air pressure application	1. Risk to personnel working in cutter head chamber 2. Excessive ground water draw down. 3. Excessive water ingress 4. Ground subsidence at surface. 5. Damage to surface structures and utilities	-highlight site constraint on tender specifications - Ground investigation by contractor - Careful review of available as built information along the tunnels alignment.	4	3	B	-Establish predetermined cutter head intervention zones that are prepared with pre-grouting if necessary -Determine water ingress allowed during cutter head interventions under different conditions - Method Statements to ensure safe/appropriate working methods - Independent instrumentation / monitoring of adjacent structures - Use of appropriate equipment / boring technique - Continuity of TBM operational staff - Carry out grouting for CHI where necessary	D&B Contractor	4	1	C	Open		
CR2001/CCSS	113	15	Uncoordinated Interface Construction Detail at Contract Interface	Poor communication and coordination of interface requirements to adjacent station contractor for tunneling between stations	- Injury to workers. -Damage to environment/property	Regular interface meetings & sharing, proper/clear design interface record, & drawings.	3	2	C	- Method Statements to ensure safe/appropriate working methods - Regular inspection	D&B Contractor	3	1	D	Open		
CR2001/CCSS	113	16	Insufficient Work Space at Launch area	Insufficient TBM launch shaft size Insufficient ventilation and lighting	- Injury to workers, - Blockage of emergency ingress/egress, - Accidents due to logistic/lifting of materials & workers movement	Proper planning, maximise space/opening, consultation with tbm supplier, lesson learnt from previous projects	3	2	C	- Launch shaft area is open to the atmosphere (not confined space) - Method Statements to ensure safe/appropriate working methods - Ensure adequate ventilation within workspace areas - Contractor to specify Standard Operating Procedure - Regular inspection and maintenance	D&B Contractor	3	1	D	Open		

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CR2001/CCSS	113	17	Lost of pressure at TBM Face and Decompression Chamber	Failure in power/power trip and back-up power supply to TBM, - Skills of operator	- Fatality, - Bends, - Delays, - Serious injury - Road settlement - Sink hole	- Specify that TBM to be equipped adequate back-up power	5	2	B	- Method Statements to ensure safe/appropriate working methods - Use of appropriate equipment - Continuity of TBM operational staff - Pre-qualify Contractors - LTA TBM specifications to suit conditions -Contractor's LEW to conduct regular checks, Drills, PS Specification, - Instrumentation and monitoring - Additional site supervision - Proper face pressure design by PE	D&B Contractor	4	1	C	Open		
CR2001/CCSS	113	18	Fire in TBM & back up areas	Overheating motor, machine failure, - Insufficient compartmentation, - Failure to enforce fire safety measure, hot works	- Fatality, - Bends, - Delays, - Serious injury	- D&B Contractor to design structure for adequate ventilation within workspace areas	5	2	B	- Method Statements to ensure safe/appropriate working methods - Ensure adequate ventilation within workspace areas - Contractor to allow Shelter Chamber in TBM in the event of emergency - Contractor to conduct regular checks, Drills, sufficient space to evacuate, enough working space	D&B Contractor	4	1	C	Open		
CR2001/CCSS	113	19	Sink hole formation, building settlement	Insufficient face pressure	-Injuries, - Damage to properties and roads, - Disruption to traffic	- Adequate Soil Investigation - Adequate ground improvement design - Control of volume loss and over-excavation.	3	2	C	- Method Statements to ensure safe/appropriate working methods - Independent instrumentation / monitoring on ground movement - Use of appropriate equipment / boring technique - Continuity of TBM operational staff - Deep settlement markers if necessary - Real time monitoring if necessary - Skilled operator, -Proper face pressure design by PE	D&B Contractor	3	1	D	Open		
CR2001/CCSS	113	20	Blow out of ground	Excessive face pressure	- Injuries, - Damage to properties and roads, - Disruption to traffic	- Adequate Soil Investigation - Adequate Ground Improvement design,	3	2	C	- Method Statements to ensure safe/appropriate working methods - Independent instrumentation / monitoring on ground movement - Use of appropriate equipment / boring technique - Continuity of TBM operational staff - Deep settlement markers if necessary - Real time monitoring if necessary - Skilled operator, -Proper face pressure design by PE -Close monitoring of tunnelling KPI	D&B Contractor	3	1	D	Open		

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CR2001/CCSS	113	21	Segment erection and lifting operation - Segment falls from height - Collapse of segment while erection - Air hose bursting - Uncontrolled movement due to pneumatic hose detachment - Bolts failing - Segment falls due to vacuum loss from damaged segment	- Platform/ staging not secure - Poor coordination among workers - Failure of vacuum erector - Vacuum loss through damaged segment while dismantling	- Damage to segment and TBM equipment - Injuries/ fatalities to construction workers	- Specify in the Particular Specification that the Contractor should produce detailed shop drawings for the segment handling system, including segment erector, method of gripping segments and the interface of TBMs with the segmental lining system elements	5	2	B	- Method statements to ensure safe/appropriate working methods - Staging, platform and vacuum should be certified by Tunnel Supervisor prior to use - Jacking rams should be used to induce compression in rings built - Supervisor should check that workers keep their hands away from the free edge of segment during erection - Supervisor to ensure that all rings are bolted correctly - Adequate planned maintenance of vacuum lifter and other lifting devices - Hoses and impact wrenches to have the whip lashes to avoid detachment - Designated personnel are to be briefed on the segment lifting, handling and placement procedures as stated in the method statement - Ensure no unauthorised personnel enter the segment erection area	D&B Contractor	4	1	C	Open		
CR2001/CCSS	113	22	Segment erection and lifting operation - Failure of erector and workers trapped under erector	- Poor control of erector - Miscommunication between ring builder and erector operator	- Damage to segment and TBM equipment - Injuries/ fatalities to construction workers	- Specify in the Particular Specification that the Contractor should produce detailed shop drawings for the segment handling system, including segment erector, method of gripping segments and the interface of TBMs with the segmental lining system elements	5	2	B	-Method statements to ensure safe/appropriate working methods - Review risk assessment for segment erection works - Regular communication between ring builder and erector operator - Workers to be educated on the action plan during failure of erector - No one to be in the activation line of the thrust rams during operation	D&B Contractor	4	1	C	Open		
CR2001/CCSS	113	23	Segment dismantling due to crack or damage - Crushed by segment falling from height - Segment falls due to vacuum loss due to crack or damage - Improper use of vacuum erector to dismantle segment	- Incompetent works and failure of lifting equipment - Lack of tail clearance between segment & tail skin plate - lack of proper lifting methods or materials while dismantling segment from the built rings	- Damage to segment and TBM equipment - Injuries/ fatalities to construction personnel	- Specify in the Particular Specification that the Contractor should produce detailed shop drawings for the segment handling system, including segment erector, method of gripping segments and the interface of TBMs with the segmental lining system elements	5	2	B	- Method statements to ensure safe/appropriate working methods - Suitable webbing slings to be wrapped between the segment and vacuum erector using chain/ lever block to hold the segment in place while removing the crack/ damaged segment from the built ring - Use of erector to remove segments as per approved method statement - Workers to be educated on the sequence of dismantling	D&B Contractor	4	1	C	Open		
CR2001/CCSS	113	25	Excessive ground movement when Tunnelling in areas without ground/building instrumentaion monitoring	Lack of access or suitable locations for instrument installation	- Late discovery of damages to existing structures - Late discovery of inappropriate TBM KPI applied	- tunnel face control from TBM to mitigate excessive movement	3	4	B	- Method Statements to ensure safe/appropriate working methods - prequalify contractors - qualified staff for tunnelling in such conditions - control of over excavation during tunnelling - seal the gaps and provide grout for the over excavation. - Proper face pressure design by PE - Close Supervision of tunnelling KPI - Alternative locations for instrumentation to be identified and installed.	D&B Contractor	3	2	C	Open		
CR2001/CCSS	113	27	Impact to utilities, buildings, structures due to ground movement	Excessive ground movement	Damage to structures, utilities, significant repair work	- ground improvement and monitoring works along the alignment	4	4	A	- Method Statements to ensure safe/appropriate working methods - precondition and post condition survey of all structures - baseline monitoring and regular monitoring to idenify any issues early - Proper face pressure design by PE - Close Supervision of tunnelling KPI	D&B Contractor	4	1	C	Open		

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CR2001/CCSS	113	34	TBM stuck underground	Unforeseen ground conditions Hard rock (maximum thrust is not sufficient to advance TBM) Poor performance of TBM Damage to TBM cutterhead due to unsuitable cutterhead design	Tunnelling stops	Adequate site investigation. LTA Specifications to indicate the most appropriate TBM	3	3	B	1. Use the GIBR to predict the ground conditions ahead of the TBM 2. Ensure the TBM is suitable and sufficiently robust for predicted conditions 3. Carry out relevant tests on available SI samples 4. Carry out regular TBM maintenance 5.TBM design to suit alignment and geological conditions 6. Provide adequate thrust force in the TBM	D&B Contractor	2	1	D	Open		
CR2002/CCSS	109	4	TBM clash with underground obstructions under PUB earth drain	- Unforeseen underground obstructions. - Failure to locate buried structures (e.g. steel casings from backfilled ground investigation holes) - Failure to locate buried items in the ground - Existing pilling not removed properly from exisitng properties	- Clash of the TBM with unforeseen underground obstructions. - Programme delay and cost implications due to additional works.	- Careful review of available as built information along the tunnels alignment.	3	2	C	Additional probe drilling shall be implemented by the contractor at locations where any uncertainties exist.	D&B Contractor	3	2	C	Open	0	0
CR2001/CCSS	113	42	Excessive settlement along railway corriodor	Unforeseen ground conditions Volume loss associated with bored tunnels is greater than anticipated Inappropriate face pressures Loss of face pressure/blowout Water drawdown	- Damage to buildings - Delays - Claims - Closure of roads - Injuries / fatalities of construction workers and public - Damage to adjacent structures	- Initial site investigation - Visual inspection surveys and Building Impact assessments - Specification of instrumentation and monitoring requirements by D&B Contractor - Optimised alignment to maximise tunnel clearances	5	2	B	- Method Statements to ensure safe/appropriate working methods - Extensive site investigation including trial trench during detailed design stage - Use of appropriate equipment / boring technique - Continuity of TBM operational staff - Deep settlement markers if necessary	D&B Contractor	4	1	C	Open	0	0

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Ground Improvements																	
CR2001/CCSS	118	1	Ground improvement failure	Inappropriate ground improvement methods	- Collapse of ground - Ground upheave - Injury or fatality of construction workers and public - Waterproofing problems and associated repair - Damage to buildings - Delay of works - Movements of adjacent structures	- Minimum design requirement are spelt out in the drawings - Discussion with ground improvement contractor to understand current technology	5	3	A	- Jet grouting trials - Contingency planning - Contingency planning e.g. stop all excavation, ensure safe escape route for workers, additional temporary struts. - Instrumentation / Monitoring - Additional site investigation and geophysics - Pre-qualify contractors -AC checkers to carry out their respective independent assessment during design stages and QP(D) and QP(S) supervision would be carried out during construction stages.	D&B Contractor	4	1	C	Open		
Confined Space																	
CR2001/CCSS	123	1	Work within confined spaces (underground structures, cross passages, sumps)	- Workers hit by machinery - Workers hit by debris falling from overhead slab - Suffocation due to lack of oxygen and accumulation of exhaust gases	Injury or fatality of construction workers	- Consider safety in design for confined spaces -Design adequate space for machinery -Adequate construction works and ventilation	5	2	B	- Confined spaces specification - Explicit method statement on removal of blinding layers prior to excavating below slabs and to ensure safe working methods - Tool box talks - Adherence to confined spaces specification - Dedicated site safety officer - Site safety inductions - Provision of adequate pumps and blowers - Provision of gas detectors	D&B Contractor	4	1	C	Open		
Other Hazards																	
CR2001/CCSS	999	1	Noise, dust and vibration	Construction works in close proximity to the public Excessive noise due to construction	- Injury to public or construction personnel - Disruption of essential services - Negative PR - Delays - Claims	- Environmental Impact Assessment - Noise level studies - Engagement with relevant authorities on the requirements and stipulate in D&B PS	3	4	B	- Contingency planning, e.g. additional noise barriers, inspection and monitoring - Method Statements to ensure safe working methods - Installation of sound barriers - Installation of dust barriers - Dust and vibration level monitoring	D&B Contractor	3	1	D	Open		