

Appendix E
Earthworks Volume breakdown

<u>Cut</u>	
Zone A	8033
Zone B	20221
Infrastructure	839
Plot 2	10025
Plot 1	32443
Pond	6057
Made Ground From site strip	13213
	90831
<u>Fill</u>	
Cart and place excavated material as fill to formation - Plateau & Plot 1	90831

Appendix F

BWB 'Earthworks Specification'

APPENDIX 0/3: LIST OF CONTRACT SPECIFIC NUMBERED APPENDICES REFERRED TO IN THE SPECIFICATION AND INCLUDED IN THE CONTRACT

List A: Contract Specific Numbered Appendices Referred to in the Specification for Highway Works Included in the Contract

Appendix No	Title
	INTRODUCTION
0/3	List of numbered appendices referred to in the specification and included in the contract
0/4	List of drawings included in the contract
	PRELIMINARIES
1/5	Testing to be carried out by Contractor
1/23	Risks to Health and Safety
1/24	Quality Management System
	EARTHWORKS
6/1	Requirements for Acceptability & Testing etc. of Earthworks Materials
6/2	Requirements for dealing with Class U1B and class U2 unsuitable materials
6/3	Requirements for Excavation, Deposition, Compaction (Other Than Dynamic Compaction)
6/5	Geotextiles Used to Separate Earthworks Materials
6/6	Fill to structures and fill above structural foundations
6/7	Sub-formation and Capping Preparation & Surface Treatment Formation
6/8	Topsoiling
6/9	Earthwork environmental bunds, landscape areas 7 strengthening embankments
6/13	Ground Improvement
6/14	Limiting Values for Pollution of Controlled Waters
6/15	Limiting Values for Harm to Human Health and the Environment

APPENDIX 1/5: TESTING TO BE CARRIED OUT BY THE CONTRACTOR.

Clause	Work, Goods or Materials		Test	Frequency	Test Certificate	Comments
Series 600	Earthworks					
	Acceptable Limits				Required	Sulfate suite in accordance with SHW Clause 601:16 & 601:17. It shall comprise Water-soluble sulfate (WS), Total Sulfur (TS), Oxidisable Sulphide (S), Total Potential Sulfate (TPS) and pH. Test frequency relates to the class of material from each source. All Made Ground shall be tested in accordance with the requirements of Appendix 6/14 and 6/15 for chemical testing requirements & SHW Clause 710 for constituent parts
	Class	General Description				
	1	General granular fill	MC, Grading and UC (U)	1 per 500m ³		
			Sulfate Suite (U)	1 per 500m ² & min 5 per source		
			OMC/MDD (Vib Hammer)	1 per 2,500m ³ min 3 per source		
	2	General cohesive fill	MC, PI, Grading (U)	1 per 500m ³		
			OMC/MDD (U) (2.5kg for 2A, 2C or 4.5kg for 2B)	1 per 2,500m ³ , min 3 per source		
			Sulphate Suite (U)	1 per 500m ³ & min 5 per source		
			Undrained Triaxial [Su] at OMC (U)	1 per 2,500m ³ , min 3 per source		
	4	Fill to Landscape	MC (U) & HSV	1 per 500m ³		
			Grading (U)	1 per 2,500m ³ min 3 per source		
	6	Selected granular fill	Grading/uniformity coefficient/mc (U)	1 per 500m ³ , min 5 per source		
			OMC/MDD (Vib Hammer)	1 per 2,500m ³ & min 3 per source		
			CBR at OMC (U)	1 per 2,500m ³ & min 3 per source		
			PL/LL (U)	1 per 500m ³ & min 5 per source		
			Los Angeles Coefficient LA (U)	1 per source, for source approval before use		
			Organic matter / water soluble sulphate (WS) content (U)	1 per 500m ³ & min 5 per source		
			Oxidisable sulphides (OS), total sulphur and total potential sulphate (TPS) content (U)	1 per 500m ³ & min 5 per source		
			Bitumen content (U)	1 per 2,500m ³ (relevant classes only)		
			Drained shear parameters, CI 636 & 639	1 per source for source approval before use		
	7	Selected cohesive fill	MC, PI, Grading (U)	1 per 500 m ³ , min 5 per source		

Clause	Work, Goods or Materials		Test	Frequency	Test Certificate	Comments
Series 600	Earthworks					
			OMC/MDD (U) with HSV (4.5kg Rammer)	1 per 2,500m³ & min 3 per source		
			Particle Density	1 per 2,500m³ & min 3 per source		
			Undrained Triaxial [Su] at OMC (U) (tested at 50 kPa, 100 kPa and 200 kPa)	1 set of 3, per 2,500m³ & min 3 per source		
			Organic matter / water soluble sulphate (WS) content (U)	1 per 500m³ & min 5 per source		
			Oxidisable sulphides (OS), total sulphur and total potential sulphate (TPS) content (U)	1 per 500m³ & min 5 per source		
			pH/Chloride Ion Content (U)	1 per 500m³ & min 5 per source		
			Drained shear parameters (U)	1 per source for source approval before use		
			Permeability (U)	1 per source (relevant classes only)		
	9	Modified & Stabilised Fill	Only with prior written approval of the Client/ Client's Representative, the Engineer and BWB In accordance with the Contractor's agreed Mix Design and approved RAMS		Required	
			Mix Design Trials	1 per source per binder combination, refer to App 6/1, Table 6/1 & App 6/3		
			Pulverisation	1 per 50m x 50m, min 5 per day		
			Bearing Ratio (U)	1 per day, tested at 7 days following soaking, with every 4 th sample extended to 28 days soaking		
			MC (U)	1 per 500m³, min 5 per day		
			OMC/MDD (U) refer to Table 6/1 for method, by Class of fill.	1 per 2,500m³, min 3 per source		
602	Earthworks materials beneath the surface of a road or within an external paved area, if within 450mm of finished surface		Frost Heave	Source approval and mix design trials where stabilised materials are employed	Required	For <u>ALL</u> material within 450mm of an external finished formation
612	Compaction of Fills				Required	Compaction trial to be
		Method Placement	Compaction trial	1 per source per method		

Clause	Work, Goods or Materials		Test	Frequency	Test Certificate	Comments
Series 600	Earthworks					
			Field dry density	1 per 625 m³		witnessed by BWB Confirmatory testing required for method placement to ensure method is correct. For method placement, BS EN 16907-5: CI 7.2 must be complied with. For end product testing, there is a minimum of 3 tests per layer. The definition of a layer shall be any material of the same class, from the same source, placed at the same level, within 1 working day.
			Granular Fill: equivalent CBR (method to be agreed with BWB)	1 per 625 m³		
			Cohesive fill: undrained shear strength or equivalent CBR (method to be agreed with BWB)	1 per 625 m³		
			Dual cycle static plate load test using 0.60m plate	1 per 2,500m² per 1.5m of fill and at FFL (includes all cut & fill areas)		
			Compaction records	BS EN 16907-5:2018 Clause 7.2		
		End Product	Compaction trial	1 per source per method		
			Field dry density	1 per 25m x 25m per layer & min 3 per layer		
			Granular Fill: equivalent CBR (method to be agreed with Hydrock)	1 per 25m x 25m per layer & min 3 per layer		
			Cohesive fill: undrained shear strength or equivalent CBR (method to be agreed with Hydrock)	1 per 25m x 25m per layer & min 3 per layer		
			Dual cycle static plate load test using 0.60m plate	1 per 2,500m² per 1.5m of fill and at FFL (includes all cut and fill areas)		
	Drainage layers		Grading	1 per 400 tonnes or 200 m³	Required	
			Los Angeles	1 per source		

Notes

The minimum number of tests will be 3 per source, before the source can be approved by BWB for use.

Any material used without the prior written consent of BWB shall be deemed to have been undertaken at the Contractor's risk and the Contractor shall be liable and responsible for any and all remedial works required to rectify the situation. All costs associated with these remedial works are to be borne by the Contractor.

For sources in excess of 10,000m³, once 10,000m³ have been tested and confirmed as acceptable, the Contractor may request a relaxation in the frequency of source approval testing.

No reduction in the frequency of source approval testing may be adopted, until a revised frequency has been provided by BWB in writing.

(U) indicates that a UKAS or MCerts test report or certificate is required.

Unless otherwise shown in this Appendix, tests and test certificates for works, goods or materials as scheduled under any one clause are required for all such work, goods or materials in the works.

Frequency of testing applies to each separate earthwork material within each of the defined earthwork material classes.

Unless specifically stated to the contrary, all samples used in the testing shall be taken from materials after delivery to the site for incorporation into the works.

The Contractors attention is drawn to the requirements of the relevant Specification Appendices for the form of all deliverables, storage of test records and storage of records of materials imported to and exported from site.

Where source approval is specified, source testing shall be carried out at each quarry or stockpile used for supply to site and at each location of borrow/site winnings used for on-site material.

Definitions of abbreviations, where used in this appendix:

- mc: natural moisture content.
- Organic Matter: Organic Matter Content.
- OMC: Optimum Moisture Content.
- MDD: Maximum Dry Density.
- CBR: California Bearing Ratio, may be determined by direct or indirect methods, but all methods are subject to prior written approval of Hydrock.
- HSV: Hand Shear Vane for assessment of undrained shear strength, to be calibrated and correlated to laboratory measurements of undrained shear strength using triaxial compression.
- IDD: Intact Dry Density.
- ACM: Asbestos and Asbestos Containing Materials.
- MEXE: In situ assessment of equivalent CBR by MEXE Probe
- TRL DCP: Transport Research Laboratory Dynamic Cone Penetrometer for in situ assessment of equivalent CBR.

All Made Ground shall be tested in accordance with the chemical testing requirements as defined in the relevant Appendix for class of material and the requirements of Appendix 6/14 and 6/15.

All secondary materials shall be tested for constituent parts as defined by SHW Clause 710.

All secondary materials shall be given an appropriate Material Source and Source Code, as defined by SHW Table 6/7.

All earthworks shall be undertaken in accordance with the requirements defined in BS EN 16907-1 to BS EN 16907-6: 2018 inclusive, BS 6031 and the general requirements of the SHW, unless amended by the Contract Specific documents.

Should the Contractor identify a potential conflict in requirements between the various standards, they shall comply with the following procedure:

- 1. Immediately inform BWB of the potential conflict.**
- 2. Adopt the most onerous requirement until and unless otherwise advised by BWB.**

APPENDIX 1/23: RISKS TO HEALTH & SAFETY

1. GENERAL

- 1.1 In connection with substances hazardous to health the Contractor shall be responsible for taking all reasonable steps to secure the safety of his employees, members of the Employers team and members of the public through the carrying out of all reasonable steps in connection with:-
- i) Restrictions in relation to traffic management measures
 - ii) Restrictions in relation to working practices
 - iii) Measures to be taken to protect members of the public
 - iv) Monitoring to be undertaken by the Contractor
 - v) Traffic management proposals
- 1.2 The Contractor's attention is also drawn to the Construction, Design and Management Regulations which shall apply to the Works.

2. DUST MITIGATION, HAUL ROADS AND MUD/DUST ON HIGHWAY

- 2.1 The Contractor shall provide to the Council for prior written approval a scheme for the provision of wheel cleansing facilities for heavy commercial vehicles and any mobile plant which has an operating weight exceeding three tonnes, or such other tonnage that may be agreed in writing with the Council.
- 2.2 Such approved wheel cleansing facilities shall be installed in accordance with a timescale approved in writing by the Council and shall be maintained throughout the period of Construction works by the Contractor unless any variation has been approved in writing by the Council.
- 2.3 All heavy commercial vehicles or other mobile plant which has an operating weight exceeding three tonnes, or other such tonnage that may be agreed in writing with the Council, associated with the construction of the Development leaving the Site, shall on each occasion, prior to leaving, pass through the wheel cleansing facilities.
- 2.4 Appropriate measures shall be implemented at all times to minimise any dust emissions.
- 2.5 Temporary haul roads shall be maintained for the duration of their use to minimise any build-up of loose spoil etc. Any damage to the existing site haul roads shall be repaired at the contractor's expense.
- 2.6 Traffic both entering and working on site shall obey a maximum speed limit of 10 mph.
- 2.7 Mobile water bowsters and sprayers shall be available on site at all times to water unpaved haul roads and working areas. The water spray may include chemical dust suppressants or wetting agents to improve dust control.
- 2.8 All open bodied Heavy Commercial Vehicles carrying dry or loose aggregate, cement or soil into and out of the site, shall be sheeted or sealed so as to prevent the release of such material into the local environment.
- 2.9 An adequate supply of water shall be maintained on site at all times to allow for dust suppression activities to be carried out at short notice.

- 2.10 Where mobile water bowsers are no effective in suppressing dust then vapour masts shall be used. Such vapour masts shall be deployed at 20m centres on the downwind side of haul roads or excavations giving rise to significant dust or emissions of odour.
- 2.11 Regular inspections of the public highway adjacent to the site shall be carried out. If deemed necessary by the Contractor or the Supervisor, the highway shall be swept regularly to remove any mud, slurry or dust deposited by vehicles entering or departing the site. If the Supervisor considers that significant amounts of any detritus have been deposited on the public highway then operations shall be temporarily suspended until appropriate cleaning operations have been undertaken.
- 2.12 The Contractor shall, as soon as reasonably practicable, but no later than the end of each working day, sweep or otherwise clear away any mud or similar material which may be carried onto the public highway by vehicles leaving the Site during the period of the Development.

3. ODOUR

- 3.1 In general terms the excavation works are not considered likely to give rise to any significant odour problems.
- 3.2 If highly odorous materials are encountered, which may give rise to nuisance to neighbouring properties, vapour masts shall be deployed to provide odour control.
- 3.3 Any odorous materials shall be covered at the end of each working day and any stockpiles will be located away from any sensitive areas.
- 3.4 Plant and machinery shall be serviced regularly to ensure that exhaust fumes are not excessive.
- 3.5 Compliance with Legislation and Regulatory Approvals

APPENDIX 1/24: QUALITY MANAGEMENT SYSTEM

1. GENERAL

- 1.1 A Quality Plan shall be prepared by the Contractor, in accordance with the requirements of this Specification and associated appendices and in full compliance with the requirements set out in BS EN 16907-5: 2018 Earthworks: Quality Control.
- 1.2 The Quality Plan shall be submitted to the Client, the Client's Representative and BWB for its acceptance and agreement not later than 21 days after award of the Contract.
- 1.3 The Contractor shall submit Risk Assessment & Method Statements (RAMS) etc. prior to the commencement of any related work or activity and to a timetable included in the Quality Plan.
- 1.4 RAMS shall be reviewed and approved, in accordance with the Contractors Quality Plan, before any activity covered by the RAMS is commenced.

2. QUALITY PLAN

- 2.1 The Quality Plan shall include details on the following as a minimum, and expanded as required by the Contractors own QA procedures:
 - 2.1.1 Contractor's Organisation and Management

This shall include the organisation of the contract, line command and communication links between parties involved in the Contract on and off site.

Names, roles, responsibilities and authority of principal and key personnel.
 - 2.1.2 Identification of the parts of the Contractor's Quality Management System relevant to the Works.
 - 2.1.3 Supply Chain Management

Including details of control and communications processes, assessment of the supplier's and subcontractor's quality management systems and quality control capabilities, monitoring arrangements, review and acceptance of work items being undertaken by the subcontractor or supplier.

Details and scheduling of Quality Plans required by relevant quality management schemes.

Details of registration to relevant quality management schemes.
 - 2.1.4 Document Control

Controls relevant to the Works, including the control and processing of testing results, materials and workmanship certification and quality records.

The management of quality records as required in SHW Clause 104.7 (2022) and BS EN 16907-5:2018.

The control and scheduling of all documentation to be submitted to the Client, the Client's Representative, the Principal Engineer and BWB Engineer as required by the Specification throughout the Works.

2.1.5 Resource Management

Including details of the relevant skills and experience of personnel involved in the Works.

The relevant training and/or competency assessment certificates and/or registration/skills cards as required by SHW Sub-clause 104.10 (2022), or scheduling of when they will be provided.

2.1.6 Risk Assessment & Method Statements (RAMS)

RAMS shall be prepared by the Contractor for all activities identified in the Quality Plan. This shall include, but not be limited to, all items on the Geotechnical Risk Register, and any other associated risk register prepared by the Contractor or any other third party relevant to the works.

RAMS shall include all required Hold Points, defined by the designated Designer, Author and Owner of the document and the requisite review and approval process. This shall include the organisation and the role that they are performing on the project.

Where hold points are relevant to geotechnical aspects of the works, they shall be agreed in writing with the Contractor's appointed Designer's Geotechnical Advisor (DGA) before submission of the RAMS for approval by the relevant party.

RAMS shall include a risk register relevant to the activity to be undertaken and identify how the risk is to be managed and what information is to be provided to demonstrate compliance with the RAMS. Reference shall be made to BS EN 1997-1: 2024 and BS EN 1997-3 in the development of the risk assessment, and this shall include the appropriate Consequence Class.

A detailed schedule shall be provided for the submission of RAMS, including for initial items of work and the scheduling for all other RAMS that will be required throughout the works. This scheduling shall include times for submission of RAMS such that they are provided a minimum of 14 days prior to the proposed commencement of the relevant work, including all earthwork activities.

Works shall not commence until the relevant RAMS have been approved, in accordance with the Contractor's Quality Plan.

2.1.7 Hold Points

As described in SHW Clause 104.6. (2022) and App 1/24, the Quality Plans and the Contractor's RAMS shall indicate all Hold Points to be observed, and as described below:

- Contractors Hold Points:
 - » Points where no further work shall proceed without the written approval of the Appointed Person of the Contractor's Management, who shall be named in the Contractor's Quality Plan.
 - » Where hold points are relevant to geotechnical aspects of the works, they shall be agreed in writing with the Contractor's appointed DGA before submission of the RAMS for approval by the relevant party.

- Overseeing Organisation's Hold Points:
 - » Points where no further work shall proceed without the written approval of the designation representative of the Overseeing Organization.
- 2.1.8 The Contractor shall ensure the Quality Plans and associated quality documentation are made available to all parties involved with the works.
- 2.2 Quality Assurance Programme
 - 2.2.1 A comprehensive construction Quality Assurance (QA) programme shall be prepared by the Contractor and provided to the Client, the Client's Representative, the Engineer and BWB and it shall comply with the requirements of this Specification.
- 2.3 Quality Control Plan
 - 2.3.1 A Quality Control Plan for the earthworks is required to be submitted to the Client, the Client's Representative, the Engineer and BSB and shall be agreed prior to the commencement of any earthworks on site and shall include the following.

Sampling and test procedures, including

 1. Test Locations, developed in accordance with the requirements defined in Appendix 1/5 and the drawings
 2. Frequency of Testing, in compliance with the requirements defined in Appendix 1/5 and the drawings, to include.
 - a. The volume of material to be placed.
 - b. The purpose of the construction.
 - c. The material type and class to be used.
 - d. The rate of placement of the fill.
 - e. The assessed risk of non-compliance.
 - f. The type of tests to be undertaken, including method.
 3. Extent of data to be collected.
 4. Methods and criteria for checking acceptance against the requirements of the Specification.
 - 2.3.2 Organization chart identifying all relevant personnel and key tasks, in particular the individual who is responsible for overall quality control, and which individual(s) are tasked with the implementation and management of the Quality Control Plan.
 - 2.3.3 Procedures for reviewing samples, certificates, tests results and acceptability of materials.
 - 2.3.4 Plan for visual observations and inspections.
 - 2.3.5 Document control procedures.
 - 2.3.6 Procedures for recording non-conformance and what corrective actions are to be undertaken.
 - 2.3.7 Risk Assessment & Method Statements (RAMS), approved by the relevant parties, as defined in the approved Contractor's Quality Plan and as defined by the Specification.

3. TESTING

- 3.1 All aspects of quality control and quality assurance associated with the earthworks shall be undertaken accordance with the requirements defined in BS EN 16907-5: 2018 and as clarified by this Appendix.
- 3.2 The Principal Contractor shall be responsible for all testing, and ensuring that all testing, monitoring surveying, audits and inspections are undertaken. This shall include overall responsibility for ensuring the records are in accordance and compliance with the Design and Specification. The responsibility for ensuring testing is undertaken shall not be transferred to any other party.
- 3.3 The Contractor shall undertake all compliance testing required during the course of the filling operation to check the material classification, acceptance limits and, the method of compaction control as defined by Appendix 6/1. The minimum frequency of testing is defined in Appendix 1/5 of the specification with the material acceptance and compliance limits set out in Appendix 6/1 and specifically in Table 6/1.
- 3.4 The compliance testing of the earthwork materials shall be carried out by a laboratory which holds UKAS (for geotechnical tests) or MCERTS (for chemical and contaminations tests) accreditation for the specific test. Where it is not possible to obtain the testing of a material for a specific property to a UKAS or MCERTS accredited method, the Contractor shall obtain permission from the Employers Representative for the test that is to be completed by the proposed laboratory, before the test is undertaken.
- 3.5 The Contractor shall provide to BWB, by mid-day on the first working day of each week, an updated electronic summary (e.g. Microsoft Excel 2010 or similar as approved) of all testing which has been completed up to the end of works for the previous week.
- 3.6 The testing summary shall be in a form agreed with the Supervisor (refer to Section 4) the Client's Representative, the Engineer and BWB, and shall include the results of all *in situ* test results (if the final validated report has not been issued by the appointed laboratory, these results shall be denoted with a draft to show that they are not final results). The summary shall also include a list of all samples submitted for laboratory testing and provide the results of those laboratory tests where report certificates have been issued.
- 3.7 The information to be included for the summary of testing shall include, but not be limited to, the following:
- Unique test number.
 - Date of test.
 - Weather and site conditions at time of test.
 - Coordinated position to include easting & northing, correct to National Grid Reference.
 - Reduced level, correct to m OD.
 - Test grid reference.
 - Layer number (during placement of fill).
 - Material description and fill designation (Class) according to end-use.
 - Compaction control, either by Method Compaction or End Product

- Records to be provided where Method Compaction is adopted shall comply with the requirements of this Specification and BS EN 16907-5:2018 Clause 7.2.
 - Records to be provided where End Product is adopted shall comply with the requirements of this Specification and BS EN 16907-5:2018 Clause 7.3.
 - Test Type.
 - The result of the testing, its compliance with the Specification and any comments relating to the test.
 - Whether the results are Draft (before the issue of certificate) or Final (certificate issued and received by Contractor).
 - Name of organisation who performed test.
- 3.8 The Contractor is to make available on site at all times a file containing all test certificates in addition to the testing summary, for inspection by the Supervisor (refer to Section 4) the Client's Representative, the Engineer and BWB.
- 3.9 The results of all testing shall be submitted to the Supervisor as soon as they are reported, and no more than 1 day after issue of the test certificate to the Contractor. It is recognised that different tests may take different time to complete; however, the Contractor shall advise the Supervisor of any delay that they are aware of regarding the completion of any tests (e.g. a sample is being re-tested and the report will be delayed).
- 3.10 The Supervisor (refer to Section 4), the Client's Representative, the Engineer and BWB shall be given sufficient time to review the content of the testing and the associated test results.
- 3.11 If in the opinion of the Supervisor (refer to Section 4), or the Client's Representative, or the Engineer or BWB, the material alters in classification or becomes unacceptable for whatever reason during the course of the filling operations, the Contractor will be required to repeat the compliance testing as required by the relevant party who raised the concern. Equally, if the Contractor considers the classification of a material to have changed from that given in Appendix 6/1 they shall inform the Supervisor (refer to Section 4) the Client's Representative, the Engineer and BWB immediately.
4. The Contractor shall be responsible for removing from site any unacceptable material to suitably licensed facilities before the completion of their works.

5. SUPERVISOR

- 5.1 Where a Supervisor is required to be appointed to a Project by the Client, this shall be defined as the named individual or organisation who are to undertake the role of the Supervisor, as defined by the NEC 3 Engineering and Construction Contract (ISBN 978 07277 3382 5), shall be defined in the Contractor's Quality Plan.
- 5.2 The role of Supervisor is separate to the role of earthworks auditor and shall be appointed separately.
- 5.3 The role of Supervisor is different to site auditing and the two roles shall not be combined nor the terms intermixed.
- 5.4 The Supervisor performs a crucial role in ensuring compliance with project specifications, monitoring construction quality, and facilitating communication among project stakeholders, and shall include:
- Monitoring Compliance.
 - Defect Management.
 - Communication and Reporting.
 - Maintaining collaboration between all parties.
 - Authority and decision-making.

6. BWB EARTHWORK AUDITOR

- 6.1 BWB shall attend site with regular attendance and undertake the following earthwork auditing role:
- Liaison with the Contractor, the Supervisor, the Project Manager and the Client's Representative.
 - Reviewing of testing activities, this does not replace or absolve the Contractor from the responsibilities set out in the Specification requirements.
 - Observing and commenting on the quality of the earthwork activities. This does not replace or absolve the Contractor from the responsibilities set out in the Specification requirements.
 - Reviewing of soil/fill sampling as required under the specification and advising the Contractor of the results in order to allow the satisfactory progress of the works.
 - Auditing the Contractor's records against the requirements of the Specification and the Contractor's Quality Control Plan.
- 6.2 BWB can only provide comment on the works observed and it should be noted that:
- BWB is not present in a supervision role when undertaking auditing.
 - Site audits / inspections by BWB do not replace or absolve the Contractors from their responsibilities as set out in the Designs, Specifications and Remediation Strategy.
 - Reviewing of testing activities, does not replace or absolve the Contractors from the responsibilities set out in the designs.
 - Observing and commenting on the quality of the works does not replace or absolve the Contractors from the responsibilities set out in the designs.

7. CONTRACTOR'S VALIDATION AND VERIFICATION REPORT

7.1 Daily Records

7.2 The Contractor will maintain records of the works to include, but not be limited to, the following.

- Daily record sheets to include a summary of the day's activities.
- Progress photographs (not less than weekly).
- Weather conditions, including daily rainfall, maximum and minimum daily temperatures, wind speed and direction.
- Plant, personnel and visitors present.
- Aspects relating to Health & Safety and Environmental Control.
- Test results in accordance with the requirements of this Specification and the Contractor's Quality Control Plan.

7.3 The Contractor will ensure that the requirements of this Specification are complied with. Upon receipt of satisfactory demonstration that all of the works have been undertaken in accordance with the Specification, the Contractor shall provide a validation report. This report will include relevant site records and illustrate that the remedial and ground preparation works have been carried out in accordance with the Specification.

7.4 During the works and in areas of excavation, compaction or fill placement the Contractor will be required to undertake weekly topographical survey of the earthworks profile to provide a continuous record of the earthwork operations.

7.5 Contractor's Verification Report – Geotechnical Construction Record

7.6 A Geotechnical Construction record (GCR) and defined be BS EN 1993:2025 shall be prepared by the Contractor in accordance with the GDR, DQRA, RMS and MMP

7.7 The GCR shall form the verification report for the works and is required to be prepared by the Contractor on those aspects of the works they have completed and are responsible for.

- The Contractor's GCR report shall comply with the requirements of BS EN 1997-3: 2025 and shall include the following.
- Daily record sheets to include a summary of the day's activities
- Progress photographs.
- General description of the works completed, including any earthworks, excavations (including excavations of hard obstructions or foundations), placement and compaction methodology and plant used.
- Records of excavations including depth and volume of material excavated.
- Records of actual finished ground levels.
- Records of sampling locations.
- Results of all compliance testing and any non-conformance reports, which may be presented in summary format, so long as all certificates are available as required by □.
- The source and location of all waste material disposed offsite.

- The source and location of each source of imported material and details of the source approval procedure.
- The locations within the works of each fill source and the dates over which it was placed.
- Records of compaction plant used, including tachographs and/or Continuous Compaction Control (CCC) records where appropriate. These should be capable of demonstrating that sufficient compaction plant has been utilized on each fill area, at all times, to accommodate the quantity of material deposited, given the time period. The Contractors Quality Control records shall demonstrate that the capacity of the compaction plant was not exceeded by the capacity of works undertaken.
- Compaction records, in accordance with BS EN 16907-5:2018: Clause 7.2.
- Inspection records.
- Detailed weather conditions.
- Formation and foundation treatment, including drainage and treatment of soft areas, surveys of base of all excavations correct to NGR and reduced level to Ordnance Datum.
- Plant, personnel and visitors present.
- Aspects relating to Health and Safety, Environmental control.
- Waste transfer notes.
- Application of acceptability criteria and summary of control test results for each specific earthwork material placed during the earthworks operations, in accordance with this Specification and the Contractor's Quality Control Plan.
- Chemical and geotechnical test certificates and monitoring data including location and level with associated drawings.
- As built surveys, including base of excavations to include drawings.
- Coordinates, levels, invert levels and diameters of services remaining on site.
- Drawings showing the location and level of each specific earthwork's material placed during the Works, any feature or operation relevant to the earthworks including any instrumentation and the location of trial areas and control tests.
- All correspondence with Statutory Authorities.

APPENDIX 6/1: REQUIREMENTS FOR ACCEPTABILITY AND TESTING ETC. OF EARTHWORKS MATERIALS

1. ACCEPTABLE LIMITS FOR FILLS

- 1.1 All construction activities associated with the placement and compaction of fill, to form the permanent design, shall be treated as temporary works.
- 1.2 The geotechnical design of the earthworks, unless stated in the Geotechnical Design Report (GDR), shall be considered as a 'wished-in-place' design and the Contractor shall be responsible for all works, including all Temporary Works Design, required to form the permanent situation.
- 1.3 The responsibility for undertaking the temporary works shall include, but not limited to, the following:
 - The preparation of RAMS, for prior agreement before the commencement of any associated works.
 - The selection of plant and equipment.
 - The methodology for the placement and compaction of fill.
 - The undertaking of demonstration trials, including compaction trials to ensure the proposed methodology is acceptable.
 - The safe undertaking of the works to ensure no damage is done to works, the surrounding area, adjacent structures or other similar zones.
- 1.4 Earthworks materials are to comply with all parts of BS EN 16907-1:2018, the 600 series of the Highways Agency 'The Manual of Contract Documents for Highway Works', BS 6031:2009 and with the specific requirements of this appendix. Permitted classes of construction materials are defined in the following tables.
 - App 6/1: Table 6/1 Acceptable Earthworks Materials: Classification and Compaction Requirements, as amended by this Specification
 - SHW Table 6/2 Grading Requirements for Acceptable Earthworks Materials.
 - SHW Table 6/7 Material Sources and Source Codes for Imported Materials.
- 1.5 Where reference is made to testing in accordance with BS 1377, this shall mean the most recent version of that standard, at the time the test is to be undertaken. It is recognised that BS 1377 is currently undergoing a comprehensive revision, which may result in clauses or parts of the standard previously referred to changing. This may include the change in some terminology, such as moisture content to water content. Therefore, where a test is specified to be undertaken in accordance with BS 1377, it shall mean the most recent version of that standard, including any change in naming protocols or terminology.
- 1.6 All earthwork materials are to meet the acceptability limits as set out in Table 6/1 and SHW Table 6/2.
- 1.7 Engineered fill to external areas outside of the influence of buildings and structures may be constructed from Class 1 or Class 2 general fill unless otherwise stated on the drawings.

- 1.8 Engineered fill to raise site levels for building plateaus are to be constructed of Class 6 or Class 7 Selected Fill otherwise indicated on the Drawings. Where relevant any restrictions on the use of Class 2 materials are detailed in Specification Appendix 6/3, 6/14 and 6/15.
- 1.9 Engineered fill for landscape bunds shall comply with the specified materials defined on the drawings and as detailed in the GDR.
- 1.10 Classification of earthworks material shall be in accordance with BS EN 16907-1: 2018, SHW Clause 601 and SHW NG 6/1 for the derivation of Class U1A, U1B and U2 materials.
- 1.11 Processed Class U1A or U1B material may be used as earthworks materials subject to meeting the target acceptability limits as set out in Table 6/1, SHW Table 6/2, Appendix 6/14, 6/15 and site-specific requirements of the Remediation Strategy & Verification Plan (RS&VP).
- 1.12 The Drawings are intended to show the general approach to where each Class of fill is to be used, including the requirements for zoning of general fill, selected fill and processed fill.
- 1.13 Earthworks materials derived from processed Class U1B material and used in the works are to be identified separately on the Contractor's drawings.
- 1.14 Where undrained shear strength is specified as the method of acceptability testing, the Contractor may use a hand vane only when it has been calibrated and correlated against the unconsolidated undrained shear strength laboratory triaxial test to BS 1377 on 100mm nominal diameter samples, and the MCV test in accordance with BS 1377. Otherwise, shear strength testing requirements is to be as set out in 633 of the SHW.
- 1.15 Where 'recycled aggregate' is used in this Specification, the material shall be aggregate resulting from the processing of material used in a construction process. The aggregate shall have been tested in accordance with SHW Clause 710, and the content of other materials (Class X) including wood, plastic and metal shall not exceed 1% by mass.
- 1.16 Where 'recycled aggregate except recycled asphalt' is used in this Series, the aggregate shall have been tested in accordance with SHW Clause 710. Content of asphalt (mineral aggregate with a bituminous binder) shall not exceed 2% by mass, and the content of other materials (Class X) including wood, plastic and metal shall not exceed 1% by mass.
- 1.17 Where topsoil is encountered in any locations, a localised strip will be required for removal. The topsoil may be stockpiled for future use but may not be used as an engineered fill material. Topsoil shall only be accepted for reuse as a Topsoil if it has been proven to meet the requirements of this Specification and/or the Landscape Architects Specification, whichever is the more onerous.
- 1.18 If an authorised formation or material deposited as fill subsequently deteriorates due to inclement weather (or for any other reason) such that it would be reclassified as unacceptable and cannot be compacted in accordance with the Contract, the Contractor shall, at their own expense, either:
 1. Cease work on the material until its condition is such that it can again be classified as acceptable; or
 2. Make good by removing and disposing of the unacceptable material and replacing it with acceptable material.

The accuracy and permissible deviation from required formation levels, (to the underside of topsoil and subsoil), after completing the engineered fill shall be as follows:

- Development plateaus: +25mm / - 25mm
- Landscape Areas: +50mm / - 25mm
- As instructed by the Engineer or Client where these differ from those described above

2. SPECIAL REQUIREMENTS FOR DETERMINING ACCEPTABILITY, WHO CLASSIFIES WHERE, AND WHETHER TRIAL PITTING IS REQUIRED

- 2.1 Acceptability testing is to be the responsibility of the Principal Contractor, as defined in Appendix 1/24, and shall be carried out in accordance with Appendix 6/1 and at the frequencies given in Appendix 1/5 in a UKAS accredited testing laboratory.
- 2.2 Source approval of imported material is required, and the testing is to be the responsibility of the Contractor and be carried out in accordance with Appendix 6/1. Source approval shall comprise (as a minimum) 3 sets of the relevant test on each sub-unit of material to be used in the Contract or as defined in Appendix 1/5.
- 2.3 The Contractor is to maintain full records on each sub-unit of imported materials including but not limited to, the location of the sources, the supplier's details, the acceptability testing and the location it has been incorporated within the works.
- 2.4 On completion of each site specific earthworks operations a Geotechnical Construction Record (GCR), as defined by BS EN 1997-3:2025 is to be prepared by the Contractor and submitted to the Project Manager and is to comply with the requirements of both CD 622 Rev 1 Appendix I and BS EN 1997-3:2025: Appendix shall include as a minimum the following information.
 - 2.4.1 General description of the earthworks, excavations, placement and compaction methodology and plant used.
 - 2.4.2 Detailed weather conditions.
 - 2.4.3 Formation and foundation treatment including ground improvement, drainage measures and treatment of soft areas.
 - 2.4.4 Application of acceptability criteria and summary of the control test results for each specific earthworks material placed during the earthworks operations.
 - 2.4.5 A copy of all relevant test results including grid location and level.
 - 2.4.6 Drawings showing the location of each specific earthwork material placed during the earthworks operations, any feature or operation relevant to the earthworks including instrumentation and the location of the trial areas and control tests.
 - 2.4.7 An electronic copy of all the test results and monitoring associated with the earthworks operations.

- 2.5 Should any material be placed which has not been given prior written approval from Hydrock, the Contractor shall have done this at their own risk and they will be responsible for any and all remedial works required to rectify the situation. All costs associated with this remedial work are to be borne by the Contractor.

3. RENDERING UNACCEPTABLE MATERIAL ACCEPTABLE

- 3.1 The Engineer must be informed if Class U1B material is to be processed to meet the target acceptability limits as set out in Table 6/1 so that appropriate acceptability criteria for the control of contamination can be set and agreed upon by all parties before the commencement of such remedial works.
- 3.2 Earthworks materials generated by demolition works or from excavation of concrete hardstanding/foundations/piles, not classified as Class U1B or Class U2, are to be classified as Class U1A and be processed to meet the 'recycled aggregate' requirements of Clause 601.12 of SHW and the target acceptability limits as set out in Table 6/1, Table 6/2 and site-specific requirements. As far as it is practical, the Contractor should process Class U1A Made Ground material or excavated material into Selected Fill in preference to General Fill.
- 3.3 Rendering Class U1A material acceptable by any hydraulic binder, e.g. lime (quicklime), cement or any other similar product, by modification or stabilisation is permitted subject to prior written approval from the Client or the Client's Representative and BWB and subject to the requisite testing being completed and permissible values for sulfate (including Total Potential Sulfate, TPS) being demonstrated to all parties including the Client and their Advisors.
- 3.4 For the purposes of this Specification, soils with a TPS content more than 1.0% shall always be deemed to be unsuitable for treatment with hydraulic binders, including cement, lime & quicklime, irrespective of what any subsequent testing may appear to have demonstrated.
- 3.5 Retrospective approval on the use of hydraulic binders will not be provided by BWB.
- 3.6 Should the Contractor propose to use hydraulic binders, then the following criteria shall be fully considered and addressed by the Contractor, in their design and RAMS submission:
- There are no elevated sulfates in the material being treated.
 - » This requirement is from BS 1924, BS EN 13242, BS EN 16907-4:2018 (it was previously also defined in HA 74/07 although this is now withdrawn and will not be replaced) as well as the general requirements set out in the latest reversion SHW.
 - There are no elevated sulfates in the 0.50m below / within the surrounding material of that being treated.
 - » This requirement is taken from SHW Clause 601.16 & 601.17
- 3.7 To assist the Contractor in the development of the mix design for the use of hydraulic binders, and subject to the results of the mix design, the following limits on sulfates and sulphides are advised to be complied with:
- Maximum permitted Water-Soluble Sulfate Content of 1.5 g/l (SO_4), tested in accordance with TRL 447 Test No 1.

- Maximum permitted Total Sulphur Content of 0.25 % (SO_4), tested in accordance with BS EN 1744-1: Clause 10.
- Maximum permitted Oxidisable Sulphide Content of 0.40% (SO_4), tested in accordance with BS EN 1744-1: Clause 13.
- Maximum permitted Total Potential Sulfate (TPS) of 0.60 % (SO_4), tested in accordance with TRL 447 Test No 4.
- Maximum Organic Matter Content of 3.0 %, tested in accordance with BS 1377-3.

3.8 In order to seek approval on the use of hydraulic binders, the Contractor shall prepare a specific GDR and accompanying RAMS to the satisfaction of BWB, the Engineer and the Client/Client's Representative to cover the use of hydraulic binders, and this shall comply with the following Standards:

- Geotechnical Design, including mix design, in FULL accordance with:
 - » BS 1924-1&2:2018 (Stabilised soils);
 - » BS EN 1997-1:2004+A1:2013 (EC 7);
 - » BS 6031:2009 (Code of practice for earthworks);
 - » BS EN 13242:2013 (hydraulically bound and unbound materials for use in civil engineering); and
 - » BS EN 16907-4:2018 (Earthworks: Soil treatment with lime and/or hydraulic binders).
 - » DMRB CD 622: Annex G (Geotechnical Design Report)
- Specification for materials treatment:
 - » In accordance with all of the above standards, and in the form defined by BS EN 16907-1:2018-1 to 5 inclusive, in particular BS EN 16907-1:2018 Annex H.
- Updated Geotechnical Risk Register
 - » In the form defined by DMRB CD 622: Appendix G: Clause G9

4. REQUIREMENTS FOR GROUNDWATER LOWERING OR OTHER TREATMENT

- 4.1 The Contractor is responsible for all groundwater lowering where this is required for the purposes of the construction works. Based upon the available geotechnical records, it is not perceived that there will be a requirement for de-watering, however the underlying geology is known to contain relatively high permeability soils, therefore during periods of inclement weather temporary measures may be required for the control of groundwater.
- 4.2 The Contractor is responsible for obtaining all permits and/or licences required to undertake groundwater lowering and for treatment and/or disposal of said groundwater.
- 4.3 The Contractor shall allow for such seasonal and other variations to the groundwater levels, as might reasonably be anticipated. Consideration shall be given to the implications of Climate Change, in particular on the intensity and quantum of rainfall, that could occur during their works.
- 4.4 Where earthworks operations or ground improvement measures result in the expelling of groundwater into drainage layers or onto earthworks surfaces the discharged water shall be collected, treated if necessary and disposed of by the Contractor.

5. REQUIREMENTS FOR REMOVAL OFF SITE OF EXCAVATED ACCEPTABLE MATERIAL OR UNACCEPTABLE MATERIAL REQUIRING PROCESSING OR RETENTION OF SURPLUS MATERIAL ON SITE

- 5.1 No material is to be removed off site without the agreement of the Client or the Client's Representative.
- 5.2 Surplus material is to be temporarily stockpiled in areas designated for spoil storage. The earthworks design of the temporary stockpile is the responsibility of the Contractor's Temporary Works Designer.

6. PERMITTED USE OF ACCEPTABLE MATERIAL OR UNACCEPTABLE MATERIAL REQUIRED TO BE PROCESSED FOR PURPOSES OTHER THAN GENERAL FILL

- 6.1 Earthwork materials derived from processed Class U1B material is to be used in the works only where shown on the Drawings and where agreed with the Client /Client's Representative the Engineer and BWB.

7. REQUIREMENTS FOR IN SITU RESISTIVITY TESTS

- 7.1 Where required, the determination of resistivity is to be measured by in situ testing.

8. REQUIREMENTS FOR IN SITU REDOX POTENTIAL TESTS

- 8.1 Where required, the determination of redox potential is to be measured by in situ testing.

9. REQUIREMENTS FOR THE ASSESSMENT OF THE EFFECTS OF WATER SOLUBLE (WS) SULPHATE, OXIDISABLE SULPHIDES AND TOTAL POTENTIAL SULPHATE IN ACCORDANCE WITH TRL 447, TEST NOS. 1 TO 5

- 9.1 Where required as part of any lime modification or improvement works, the water soluble (WS) sulphate, oxidisable sulphides (OS) and total potential sulphate (TPS) are to be determined in accordance with Clause 644 of SHW, TRL 447 and BS EN 1744-1.

10. RESPONSIBILITY FOR THE WORKS

- 10.1 The Contractor is to be responsible for the works covered by the specification and is permitted to self-certify the works, in accordance with the requirements of the specification. The right of self-certification is not to be delegated or extended to any of the following parties:

- 10.1.1 Subcontractors, employed by the Contractor, including consultants.
- 10.1.2 Service owners or contractors (including but not limited to those either directly or indirectly employed by the Contractor) undertaking backfilling of diverted service trenches.
- 10.1.3 Other third party contractors undertaking works on the site.

11. MINIMUM AND MAXIMUM MOISTURE CONTENT FOR METHOD SPECIFICATION

- 11.1 App 6/1 Table 6/1 defines a set of criteria to be met for the moisture content of material, when it is controlled by Method Compaction to a specified method from SHW (2016) Table 6/4. The permitted maximum and minimum moisture contents are to be determined as part of the source approval testing.
- 11.2 Granular fill.
- 11.2.1 The permitted upper and lower moisture content shall be a function of the Optimum Moisture Content, when determined as part of the source approval testing, using the method defined in App 6/1: Table 6/1.
- 11.3 Cohesive Fill
- 11.3.1 The lower permitted moisture content for cohesive fill shall be the moisture content where a horizontal line plotted equivalent to 105% of the Maximum Dry Density intercepts the 5% air void line.
- 11.3.2 The upper permitted moisture content for cohesive fill shall be the dryer moisture content of either:
- 11.3.2.1 The moisture content at 95% of the Maximum Dry Density on the wet side of the compaction curve, (e.g. for moisture contents in excess of the Optimum Moisture Content).
 - 11.3.2.2 The moisture content equivalent the lowest permissible undrained shear strength as defined in Appendix 6/1: Table 6/1 and the GDR, for the specific fill class.

11.3.2.3 Where the shear strength of the material is less than the minimum permitted in Appendix 6/1: Table 6/1, the material will be deemed to be too wet.

12. Benching of fill

- 12.1 Benching of fill is required.
- 12.2 Reference shall be made to App 6/3 and the accompanying drawings for specific requirements relevant to the benching in of fill materials

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
GENERAL GRANULAR FILL	1	A	-	Well graded granular material	General fill	Any material, or combination of material designated as Class 3 in the Contract. Recycled aggregate. Additional restrictions as defined in SHW Table 6/1	(i) grading	BS 1377	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 2 modified as required following compaction trial to ensure minimum 95% of MDD OMC/MDD determined using Vibrating Hammer	1	A	-
							(ii) uniformity coefficient	See note 5	10	-				
							(iii) mc	BS 1377	OMC -2%	OMC +2%				
							(iv) OMC / MDD	BS 1377	-	-				
							(v) CBR at OMC	BS 1377	8%	-				
	1	B	-	Uniformly graded granular material	General fill	Any material, or combination of material designated as Class 3 in the Contract. Recycled aggregate. Additional restrictions as defined in SHW Table 6/1	(i) grading	BS 1377	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 3 modified as required following compaction trial to ensure minimum 95% MDD OMC/MDD determined using Vibrating Hammer	1	B	-
							(ii) uniformity coefficient	See note 5	-	10				
							(iii) mc	BS 1377	OMC -2%	OMC +2%				
							(iv) OMC / MDD	BS 1377	-	-				
							(v) CBR at OMC	BS 1377	8%	-				
	1	C	-	Coarse granular material	General fill	Any material, or combination of material designated as Class 3 in the Contract. Recycled aggregate	(i) grading	BS 1377	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 5 minimum 95% MDD OMC/MDD determined using Vibrating Hammer	1	C	-
							(ii) uniformity coefficient	See note 5	-	10				
							(iii) Los Angeles Coefficient	SHW Clause 635	-	50				

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
GENERAL COHESIVE FILL	2	A	-	Wet cohesive material	General fill	Any material, or combination of materials other than material designated as Class 3 in the contract	(i) grading	BS 1377	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 1 OMC/MDD determined using 2.5kg Rammer Except for materials with liquid limit greater than 50, only deadweight tamping or vibratory tamping rollers or grid rollers shall be used. ¹ The lower permitted moisture content is based on the moisture content where a horizontal line plotted at 105% of the MDD intersects the 5% Air void line. ² The upper permitted moisture content is based on the lower of: - the moisture content at 95% of the MDD; or - the moisture content where the undrained shear strength is 60 kPa. If the shear strength is less than 60 kPa the material will be deemed to be too wet.	2	A	-
						(ii) plasticity index (PI)	BS 1377	-	-					
						(iii) mc	BS 1377	¹ See compaction requirements	² See compaction requirements					
						(iv) undrained shear strength (c)	SHW Clause 633	60 kPa	-					
						(v) OMC/MDD	BS 1377	-	-					
						(vi) Particle Density	BS 1377	-	-					

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
GENERAL COHESIVE FILL	2	B	-	Dry cohesive material	General fill	Any material, or combination of materials other than material designated as Class 3 in the contract	(i) grading	BS 1377	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 2 OMC/MDD determined using 4.5kg Rammer Except for materials with liquid limit greater than 50, only deadweight tamping or vibratory tamping rollers or grid rollers shall be used. ¹ The lower permitted moisture content is based on the moisture content where a horizontal line plotted at 105% of the MDD intersects the 5% Air void line. ² The upper permitted moisture content is based on the lower of: • the moisture content at 95% of the MDD; or • the moisture content where the undrained shear strength is 80 kPa. If the shear strength is less than 80 kPa the material will be deemed to be Class 2A.	2	B	-
							(ii) plasticity index (PI)	BS 1377	-	-				
							(iii) mc	BS 1377	¹ See compaction requirements	² See compaction requirements				
							(iv) undrained shear strength (c)	SHW Clause 633	80 kPa	-				
							(v) OMC/MDD	BS 1377	-	-				
							(vi) Particle Density	BS 1377	-	-				

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
GENERAL COHESIVE FILL	2	C	-	Stony cohesive material	General fill	Any material, or combination of materials other than material designated as Class 3 in the contract	(i) grading	BS 1377	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 2 OMC/MDD determined using 2.5kg Rammer ¹ The lower permitted moisture content is based on the moisture content where a horizontal line plotted at 105% of the MDD intersects the 5% Air void line. ² The upper permitted moisture content is based on the lower of: • the moisture content at 95% of the MDD; or • the moisture content where the undrained shear strength is 60 kPa. If the shear strength is less than 60 kPa the material will be deemed to be too wet.	2	C	-
							(ii) plasticity index (PI)	BS 1377	-	-				
							(iii) mc	BS 1377	¹ See compaction requirements	² See compaction requirements				
							(iv) undrained shear strength (c)	SHW Clause 633	60 kPa	-				
							(v) OMC/MDD	BS 1377	-	-				
							(vi) Particle Density	BS 1377	-	-				

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
GENERAL COHESIVE FILL	2	D	-	Silty cohesive material	General fill	Any material, or combination of materials other than material designated as Class 3 in the contract	(i) grading	BS 1377	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 3 OMC/MDD determined using 2.5kg Rammer ¹ The lower permitted moisture content is based on the moisture content where a horizontal line plotted at 105% of the MDD intersects the 5% Air void line. ² The upper permitted moisture content is based on the lower of: - the moisture content at 95% of the MDD; or - the moisture content where the undrained shear strength is 60 kPa. If the shear strength is less than 60 kPa the material will be deemed to be too wet.	2	D	-
						(ii) plasticity index (PI)	BS 1377	-	-					
						(iii) mc	BS 1377	¹ See compaction requirements	² See compaction requirements					
						(iv) undrained shear strength (c)	SHW Clause 633	60 kPa	-					
						(v) OMC/MDD	BS 1377	-	-					
						(vi) Particle Density	BS 1377	-	-					
	2	E	-	Reclaimed Pulverised Fuel Ash cohesive material	General fill	Re-claimed material from lagoon or stockpile containing not more than 20% furnace bottom ash	(i) grading	BS 1377	To enable compaction to SHW Clause 612		End product 95% MDD MDD determined using 2.5kg rammer, to include particle density.	2	E	-
						(ii) bulk density	BS 1377	Declared						
						(iii) OMC & MDD	BS 1377	Declared	Declared					
						(iv) Particle Density	BS 1377	Declared	Declared					

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in additional to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
LANDSCAPE FILL	4	-	-	Various	Fill to landscape areas	Any material, or combination of materials	(i) grading	BS 1377	-	-	SHW Clause 620	4	-	-
							(ii) MC	BS 1377	-	Equivalent of C of 50kN/m²	Material to be placed to an appropriate method so as to ensure a minimum undrained shear of 50 kPa is achieved in the placed and compacted material			
							(iii) undrained shear strength by HSV	Manufacturers Instruction	50 kPa	150 kPa	An undrained shear strength in excess of 150 kPa is indicative of a material which is excessively dry, and has the potential for unacceptably high air voids and long-term instability should the material become saturated.			

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in additional to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
GENERAL COHESIVE FILL	5	A	-	Topsoil, or turf, or existing on site	Topsoiling	Topsoil designated as Class 5A in the Contract	(i) grading	SHW Clause 618	-	SHW Clause 618	-	5	A	-
	5	B	-	Imported topsoil	Topsoiling	General purpose grade complying with BS 3882	-	-	-	-	-	5	B	-

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED GRANULAR FILL	6	A	-	Selected well graded granular material	Below water	Natural gravel, natural sand, crushed gravel, crushed rock (other than argillaceous rock, chalk or colliery spoil), blast furnace slag, crushed concrete, or any combination thereof. Recycled aggregate, additional restrictions as defined in SHW Table 6/1.	(i) grading	BS 1377 (site)	SHW Table 6/2	SHW Table 6/2	No compaction	6	A	-
								BS EN 933-2	SHW Table 6/5	SHW Table 6/5				
							(ii) uniformity coefficient	See note 5	10	-				
							(iii) plasticity index	BS 1377	Non-plastic					
	6	B	-	Selected coarse granular material	Starter layer	Natural gravel, natural sand, crushed gravel, crushed rock (other than argillaceous rock, chalk or colliery spoil), blast furnace slag, crushed concrete, or any combination thereof. Recycled aggregate, additional restrictions as defined in SHW Table 6/1.	(i) grading	BS 1377 (site)	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 5	6	B	-
								BS EN 933-2	SHW Table 6/5	SHW Table 6/5				
							(ii) plasticity index	BS 1377	10	-				
							(iii) Los Angeles coefficient	SHW CI 635	-	50				
	6	C	-	Selected uniformly graded granular material	Starter layer	Natural gravel, natural sand, crushed gravel, crushed rock (other than argillaceous rock, chalk or colliery spoil), blast furnace slag, crushed concrete, or any combination thereof. Recycled aggregate, additional restrictions as defined in SHW Table 6/1	(i) grading	BS 1377 (site)	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 3 OMC to be determined using Vibrating Hammer unless otherwise agreed with BWB	6	C	-
								BS EN 933-2	SHW Table 6/5	SHW Table 6/5				
							(ii) uniformity coefficient	See note 5	-	10				
							(iii) Plasticity Index	BS 1377	Non-plastic					
							(iv) Los Angeles	SHW Clause 635	-	50				
							(v) mc	BS 1377	OMC -2%	OMC +2%				

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED GRANULAR FILL	6	D	-	Selected uniformly graded granular material	Starter layer below pulverised fuel ash	Natural gravel, natural sand, crushed gravel, crushed rock (other than argillaceous rock, chalk or colliery spoil), blast furnace slag, crushed concrete, or any combination thereof. Recycled aggregate, additional restrictions as defined in SHW Table 6/1.	(i) grading	BS 1377 (site)	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 4 OMC to be determined using Vibrating Hammer unless otherwise agreed with BWB	6	D	-
								BS EN 933-2	SHW Table 6/5	SHW Table 6/5				
							(ii) uniformity coefficient	See note 5	-	10				
							(iii) plasticity index	BS 1377	Non-plastic					
							(iv) mc	BS 1377	OMC -2%	OMC +2%				
	6	E	-	Selected granular material (fine grading)	Capping	Any material, or combination of materials, including recycled aggregates, with not more than 50% by mass of recycled bituminous planings and granulated asphalt, but excluding materials contaminated with tar and tar-bitumen binders, unburnt colliery spoil, argillaceous rock and chalk Property (vi) in the next column shall not apply if the Class Ra (asphalt) content of any recycled aggregate is 20% or less. Where material in this Class is imported onto site, it shall be classified as Class 6F4 with the requirements for that material	(i) grading	BS 1377 (site)	SHW Table 6/2	SHW Table 6/2				
								BS EN 933-2	SHW Table 6/5	SHW Table 6/5				
							(ii) MC	BS 1377	-	Declared				
							(iii) Liquid limit	BS 1377	-	45				
							(iv) plasticity index	BS 1377	-	20				
							(v) organic matter	BS 1377-3	-	3%				
							(vi) water soluble (WS) sulfate	BS 1744-1: Clause 10	-	1.5 g/l as SO ₄				
							(vii) Oxidisable sulphides (OS)	BS 1744-1: Clause 13	-	0.4% as SO ₄				
							(viii) SMC of chalk	SHW Clause 634	-	20%				

APPENDIX 6/1: TABLE 6/1(Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED GRANULAR FILL	6	F	1	Selected granular material (fine grading)	Capping	Any material or combination of materials (other than colliery spoil, argillaceous rock or chalk). Recycled aggregate, additional restrictions as defined in SHW Table 6/1.	(i) grading	BS 1377	Table 6/2	Table 6/2	SHW Table 6/4 Method 6 OMC to be determined using Vibrating Hammer	6	F	1
							(ii) OMC	BS 1377 Vibrating hammer (VH)	-	-				
							(iii) mc	BS 1377	OMC -2%	OMC+2%				
							(iv) Los Angeles coefficient	SHW Clause 635	-	50				
							(v) Class Ra (asphalt)	Clause 710	-	50%				
							(vi) bitumen content	BS EN 12697	-	2.0%				
	6	F	2	Selected granular material (coarse grading)	Capping	Any material or combination of materials (other than colliery spoil, argillaceous rock or chalk). Recycled aggregate, additional restrictions as defined in SHW Table 6/1.	(i) grading	BS 1377	Table 6/2	Table 6/2	SHW Table 6/4 Method 6 OMC to be determined using Vibrating Hammer	6	F	2
							(ii) OMC	BS 1377 (VH)	-	-				
							(iii) mc	BS 1377	OMC -2%	OMC+2%				
							(iv) Los Angeles coefficient	SHW Clause 635	-	50				
							(v) Class Ra (asphalt)	Clause 710	-	50%				
							(vi) bitumen content	BS EN 12697	-	2.0%				

APPENDIX 6/1: TABLE 6/1(Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in additional to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED GRANULAR FILL	6	F	3	Selected granular material	Capping (Not to be used below structures)	Recycled bituminous road planings and granulated asphalt, but excluding materials containing tar or tar-bitumen binders. Recycled aggregates, additional restrictions as defined in SHW Table 6/1.	(i) Grading & constituent parts	BS 1377 (Site)	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 6 Maximum compacted layer thickness shall be 200 mm.	6	F	3
								BS EN 933-2	SHW Table 6/5	SHW Table 6/5				
							(ii) OMC	BS 1377 (VH)	-	-				
							(iii) mc	BS 1377	OMC -2%	OMC+2%				
							(iv) Class Ra (asphalt)	SHW Clause 710	50%	-				
							(v) Bitumen content	BS EN 12697	-	10%				
	6	F	4	Selected granular material (fine grading) imported on to the site	Capping	Unbound mixture complying with BS EN 13285 containing aggregate conforming to BS EN 13242 from one or more of the source codes defined in SHW Table 6/4, including P; A2; A3; A4; B1; D2; D3; D4; G. Aggregates from source code A4 shall contain no more than 50% constituents in Class Ra. Property (x) in the next column shall not apply if the Class Ra content of any recycled aggregate is 20% of less	(i) size, grading	BS EN 13285 0/31.5 & G _E	SHW Table 6/5	SHW Table 6/5	SHW Table 6/4 Method 6 For OMC refer to the Optimum water content.	6	F	4
							(ii) max fines & oversize	BS EN 13285 UF ₁₅ & OC ₇₅	SHW Table 6/5	SHW Table 6/5				
							(iii) Los Angeles	BS EN 13242 LA ₆₀	-	60				
							(iv) volume stability, slag	BS EN 13242	Free from dicalcium silicate and iron disintegration					
							(v) volume stability, steel	BS EN 13242 – V ₅	-	-				
							(vi) other aggregate requirements	BS EN 13242	Category Nr, no requirement					
							(vii) lab dry density & OMC	BS EN 13242	Declared values					
							(viii) water content	NBS EN 1097-5	OMC -2%	OMC+2%				
							(ix) Class Ra content	SHW Clause 710	-	50%				
							(x) bitumen content	BS EN 12697	-	2.0%				

APPENDIX 6/1: TABLE 6/1(Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in additional to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED GRANULAR FILL	6	F	5	Selected granular material (coarse grading) imported on to the site	Capping	Unbound mixture complying with BS EN 13285 containing aggregate conforming to BS EN 13242 from one or more of the source codes defined in SHW Table 6/4, including P; A2; A3; A4; B1; D2; D3; D4; G. Aggregates from source code A4 shall contain no more than 50% constituents in Class Ra. Property (x) in the next column shall not apply if the Class Ra content of any recycled aggregate is 20% of less	(i) size, grading	BS EN 13285 0/31.5 & G _E	SHW Table 6/5	SHW Table 6/5	SHW Table 6/4 Method 6 For OMC refer to the Optimum water content.	6	F	5
	(ii) max fines & oversize	BS EN 13285 UF ₁₅ & OC ₇₅	SHW Table 6/5				SHW Table 6/5							
	(iii) Los Angeles	BS EN 13242 LA ₅₀	-				50							
	(iv) volume stability, slag	BS EN 13242	Free from dicalcium silicate and iron disintegration											
	(v) volume stability, steel	BS EN 13242 – V ₅	-				-							
	(vi) other aggregate requirements	BS EN 13242	Category Nr, no requirement											
	(vii) lab dry density & OMC	BS EN 13242	Declared values											
	(viii) water content	NBS EN 1097-5	OMC -2%				OMC+2%							
	(ix) Class Ra content	SHW Clause 710	-				50%							
	(x) bitumen content	BS EN 12697	-				2.0%							

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
GENERAL COHESIVE FILL	6	G	-	Selected granular material	Gabion filling	Natural gravel, crushed rock, crushed concrete or any combination thereof. None of these constituents shall include argillaceous rock. Where material is imported onto site which is not 'as dug' it shall be aggregate conforming to BS EN 13242 from one or more of the following source codes: P; A2	(i) Grading	BS 1377 (Site)	SHW Table 6/2	SHW Table 6/2	None	6	G	-
								BS EN 933-2	SHW Table 6/5	SHW Table 6/5				
							(ii) Los Angeles Coefficient	SHW Clause 635	-	50				

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED GRANULAR FILL	6	H	-	Selected granular material	Drainage layer to reinforced soil and anchored earth structures	Natural gravel, natural sand, crushed gravel, crushed rock, crushed concrete, chalk, well burnt colliery spoil or any combination thereof. Noe of these constituents shall include any argillaceous rock. Additional restrictions on constituents from SHW Table 6/4 Where imported onto site which is not 'as dug' shall be aggregate conforming to BS EN 13242 from one or more of the following source codes. P; A2; A3 & G1	(i) Grading	BS 1377 (Site)	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 3	6	H	-
								BS EN 933-2	SHW Table 6/5	SHW Table 6/5				
							(ii) Plasticity Index	Bs 1377	Non-plastic	Non-plastic				
							(iii) Los Angeles	SHW Clause 635	-	50				
							(iv) MC	BS 1377	OMC -2%	OMC +2%				
							(v) OMC & MDD	BS 1377 (VH)	Declared	Declared				
							(vi) pH	BS 1377-3	SHW Table 6/3	SHW Table 6/3				
							(vii) Chloride ion content	BS EN 1744-1	-	SHW Table 6/3				
							(vii) water soluble (WS) sulfate	BS EN 1744-1 Clause 10	-	SHW Table 6/3				
							(ix) oxidizable sulphides (OS)	BS EN 1744-1 Clause 13	-	SHW Table 6/3				
							(x) resistivity	SHW Clause 637	SHW Table 6/3	-				
							(xi) redox potential	SHW Clause 638	SHW Table 6/3	-				
							(xii) organic matter	BS 1377-3	-	SHW Table 6/3				
							(xiii) microbial activity index	SHW Table 6/3	-	SHW Table 6/3				

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED GRANULAR FILL	6	I	-	Selected well granular material	Fill to reinforced soil and anchored earth structures	Natural gravel, natural sand, crushed gravel, crushed rock, crushed concrete, chalk, well burnt colliery spoil or any combination thereof. Noe of these constituents shall include any argillaceous rock. Additional restrictions on constituents from SHW Table 6/4 Where imported onto site which is not 'as dug' shall be aggregate conforming to BS EN 13242 from one or more of the following source codes. P; A2; A3; D2 & G1	(i) Grading	BS 1377 (Site)	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 2	6	I	-
		BS EN 933-2	SHW Table 6/5	SHW Table 6/5										
	(ii) Uniformity coefficient	See note 5	10	-										
	(iii) SMC of chalk	SHW Clause 634	-	20%										
	(iv)	BS 1377	OMC -2%	OMC +2%										
	(v) OMC & MDD	BS 1377 (VH)	Declared	Declared										
	(vi) effective angle of friction	SHW Clause 636	$\phi' = 38^{\circ}$	-										
	(vii) Coefficient of friction soil/geogrid	SHW Clause 639	$\delta = 12^{\circ}$	-										
	(viii) pH value	BS 1377	SHW Table 6/3	SHW Table 6/3										
	(ix) Chloride ion content	BS EN 1744-1	-	SHW Table 6/3										
	(x) water soluble (WS) sulfate	BS EN 1744-1 Clause 10	-	SHW Table 6/3										
	(xi) oxidizable sulphides (OS)	BS EN 1744-1 Clause 13	-	SHW Table 6/3										
	(xii) resistivity	SHW Clause 637	SHW Table 6/3	-										
	(xiii) redox potential	SHW Clause 638	SHW Table 6/3	-										
	(xiv) organic matter	BS 1377	-	SHW Table 6/3										
	(xvi) microbial activity index	SHW Table 6/3	-	SHW Table 6/3										

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED GRANULAR FILL	6	J	-	Selected uniformly graded granular material	Fill to reinforced soil and anchored earth structures	Natural gravel, natural sand, crushed gravel, crushed rock, crushed concrete, chalk, well burnt colliery spoil or any combination thereof. Noe of these constituents shall include any argillaceous rock. Additional restrictions on constituents from SHW Table 6/4 Where imported onto site which is not 'as dug' shall be aggregate conforming to BS EN 13242 from one or more of the following source codes. P; A2; A3; D2 & G1	(i) Grading	BS 1377 (Site)	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 3	6	J	-
								BS EN 933-2	SHW Table 6/5	SHW Table 6/5				
							(ii) Uniformity coefficient	See note 5	5	10				
							(iii) SMC of chalk	SHW Clause 634	-	20%				
							(iv) MC	BS 1377	OMC -2%	OMC +2%				
							(v) OMC & MDD	BS 1377-4: 3.7	Declared	Declared				
							(vi) effective angle of friction	SHW Clause 636	$\phi' = 38^{\circ}$	-				
							(vii) Coefficient of friction soil/geogrid	SHW Clause 639	$\delta = 12^{\circ}$	-				
							(viii) pH value	BS 1377	SHW Table 6/3	SHW Table 6/3				
							(ix) Chloride ion content	BS EN 1744-1	-	SHW Table 6/3				
							(x) water soluble (WS) sulfate	BS EN 1744-1 Clause 10	-	SHW Table 6/3				
							(xi) oxidizable sulphides (OS)	BS EN 1744-1 Clause 13	-	SHW Table 6/3				
							(xii) resistivity	SHW Clause 637	SHW Table 6/3	-				
							(xiii) redox potential	SHW Clause 638	SHW Table 6/3	-				
							(xiv) organic matter	BS 1377	-	SHW Table 6/3				
							(xvi) microbial activity index	SHW Table 6/3	-	SHW Table 6/3				

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED GRANULAR FILL	6	K	-	Selected granular material	Lower bedding to corrugated steel buried structures	Natural gravel, natural sand, crushed gravel, crushed rock, crushed concrete, chalk, well burnt colliery spoil or any combination thereof. Noe of these constituents shall include any argillaceous rock. Additional restrictions on constituents from SHW Table 6/4 Where imported onto site which is not 'as dug' shall be aggregate conforming to BS EN 13242 from one or more of the following source codes. P; A2; A3; D2 & G1	(i) Grading	BS 1377 (Site)	SHW Table 6/2	SHW Table 6/2	End product 90% of maximum dry density of BS 1377 (Vibrating hammer)	6	K	-
							BS EN 933-2	SHW Table 6/5	SHW Table 6/5					
						(ii) Uniformity coefficient	See note 5	5	-					
						(iii) plasticity index	BS 1377	-	6					
						(iv) MC	BS 1377	OMC -2%	OMC +2%					
						(v) OMC & MDD	BS 1377 (VH)	Declared	Declared					
						(vi) Los Angeles Coefficient	SHW Clause 632	-	40					
						(vii) resistivity	SHW Clause 637	2000 ohm cm	-					
						(viii) pH value	BS 1377-3	6	9					
						(ix) Chloride ion content	BS EN 1744-1	-	0.025%					
						(x) water soluble (WS) sulfate	BS EN 1744-1 Clause 10	-	300 mg/l as SO ₄					
						(xi) oxidizable sulphides (OS)	BS EN 1744-1 Clause 13	-	0.06% as SO ₄					
						(xii) sulphide and hydrogen sulfide	Standard textbook of qualitative inorganic analysis	-	Rapid blackening of lead acetate paper					

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED GRANULAR FILL	6	L	-	Selected uniformly graded granular material	Upper bedding to corrugated steel buried structures	Natural gravel, natural sand, crushed gravel, crushed rock, crushed concrete, chalk, well burnt colliery spoil or any combination thereof. Noe of these constituents shall include any argillaceous rock. Recycled aggregate apart from recycled asphalt, additional restrictions on constituents from SHW Table 6/4 Where imported onto site which is not 'as dug' shall be aggregate conforming to BS EN 13242 from one or more of the following source codes. P; A2; A3; & G1	(i) Grading	BS 1377 (Site)	SHW Table 6/2	SHW Table 6/2	None	6	L	-
		BS EN 933-2	SHW Table 6/5				SHW Table 6/5							
		(ii) Uniformity coefficient	See note 5				5	-						
		(vii) resistivity	SHW Clause 637				2000 ohm cm	-						
		(viii) pH value	BS 1377				6	9						
		(ix) Chloride ion content	BS EN 1744-1				-	0.025%						
		(x) water soluble (WS) sulfate	BS EN 1744-1 Clause 10				-	300 mg/l as SO ₄						
		(xi) oxidizable sulphides (OS)	BS EN 1744-1 Clause 13				-	0.06% as SO ₄						
		(xii) sulphide and hydrogen sulfide	Standard textbook of qualitative inorganic analysis				-	Rapid blackening of lead acetate paper						

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED GRANULAR FILL	6	M	-	Selected granular material	Surround to corrugated steel buried structures	Natural gravel, natural sand, crushed gravel, crushed rock, crushed concrete, chalk, well burnt colliery spoil or any combination thereof. Noe of these constituents shall include any argillaceous rock. Additional restrictions on constituents from SHW Table 6/4 Where imported onto site which is not 'as dug' shall be aggregate conforming to BS EN 13242 from one or more of the following source codes. P; A2; A3 & G1	(i) Grading	BS 1377 (Site)	SHW Table 6/2	SHW Table 6/2	End product 90% of maximum dry density of BS 1377 Vibrating hammer	6	M	-
		BS EN 933-2	SHW Table 6/5				SHW Table 6/5							
		(ii) Uniformity coefficient	See note 5				5	-						
		(iii) plasticity index	BS 1377-2				-	6						
		(iv) MC	BS 1377-2				OMC -2%	OMC +2%						
		(v) OMC & MDD	BS 1377-4: 3.7				Declared	Declared						
		(vi) Los Angeles Coefficient	SHW Clause 632				-	40						
		(vii) resistivity	SHW Clause 637				2000 ohm cm	-						
		(viii) pH value	BS 1377-3				6	9						
		(ix) Chloride ion content	BS EN 1744-1				-	0.025%						
		(x) water soluble (WS) sulfate	BS EN 1744-1 Clause 10				-	300 mg/l as SO ₄						
		(xi) oxidizable sulphides (OS)	BS EN 1744-1 Clause 13				-	0.06% as SO ₄						
		(xii) sulphide and hydrogen sulfide	Standard textbook of qualitative inorganic analysis				-	Rapid blackening of lead acetate paper						

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in additional to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED GRANULAR FILL	6	N	-	Selected well graded granular material	Fill to structures	Natural gravel, natural sand, crushed gravel, crushed rock, crushed concrete, well burnt colliery spoil or any combination thereof. None of these constituents shall include any argillaceous rock. Recycled aggregate except recycled asphalt	(i) Grading	BS 1377 (Site)	SHW Table 6/2	SHW Table 6/2	End product 95% of maximum dry density of BS 1377 Vibrating hammer	6	N	-
							BS EN 933-2	SHW Table 6/5	SHW Table 6/5					
						(ii) Uniformity coefficient	See note 5	10	-					
						(iii) MC	BS 1377	OMC -2%	OMC +2%					
						(iv) OMC & MDD	BS 1377 (VH)	Declared	Declared					
						(v) Los Angeles Coefficient	SHW Clause 635	-	40					
						(vi) effective angle of friction & cohesion	SHW Clause 636	$\phi' \geq 38^\circ$ $C' \geq 0 \text{ kPa}$	-					
						(vii) Permeability	SHW Clause 640	$1 \times 10^{-4} \text{ m/s}$	-					
						(viii) Slope stability test (where required in Appendix 6/6)	SHW Clause 610	Appendix 6/6						

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED GRANULAR FILL	6	P	-	Selected granular material	Fill to structures	Natural gravel, natural sand, crushed gravel, crushed rock, crushed concrete, well burnt colliery spoil or any combination thereof. None of these constituents shall include any argillaceous rock. Recycled aggregate except recycled asphalt Additional restrictions on constituents from SHW Table 6/4 Where imported onto site which is not 'as dug' shall be aggregate conforming to BS EN 13242 from one or more of the following source codes. P; A2; A3; D2 & G1	(i) Grading	BS 1377 (Site)	SHW Table 6/2	SHW Table 6/2	End product 95% of maximum dry density of BS 1377 Vibrating hammer	6	P	-
								BS EN 933-2	SHW Table 6/5	SHW Table 6/5				
							(ii) Uniformity coefficient	See note 5	5	-				
							(iii) MC	BS 1377-2	OMC -2%	OMC +2%				
							(iv) OMC & MDD	BS 1377 (VH)	Declared	Declared				
							(v) Los Angeles Coefficient	SHW Clause 635	-	50				
							(vi) effective angle of friction & cohesion	SHW Clause 636	$\phi' \geq 38^\circ$ $C' \geq 0 \text{ kPa}$	-				
							(vii) Permeability	SHW Clause 640	1 X 10 ⁻⁴ m/s	-				
							(viii) Slope stability test (where required in Appendix 6/6)	SHW Clause 610	Appendix 6/6					

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED GRANULAR FILL	6	Q	-	Selected granular material	Fill to structures	Natural gravel, natural sand, crushed gravel, crushed rock, crushed concrete, chalk, well burnt colliery spoil or any combination thereof. Noe of these constituents shall include any argillaceous rock. Recycled aggregate except recycled asphalt. Additional restrictions on constituents from SHW Table 6/4 Where imported onto site which is not 'as dug' shall be aggregate conforming to BS EN 13242 from one or more of the following source codes. P; A2; A3; D2 & G1	As for Class 1A, 1B or 1C with the addition of the following:				End product 95% of maximum dry density of BS 1377 Vibrating hammer	6	M	-
		(i) water soluble (WS) sulfate	BS EN 1744-1		300 mg/l as SO ₄									
		(ii) pH value	BS 1377-3	6	9									
		(ix) Chloride ion content	BS EN 1744-1	-	0.025%									
		(xi) oxidizable sulphides (OS)	BS EN 1744-1 Clause 13	-	0.06% as SO ₄									
		(xii) sulphide and hydrogen sulfide	Standard textbook of qualitative inorganic analysis	-	Rapid blackening of lead acetate paper									

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED GRANULAR FILL	6	R	-	Selected granular material	For stabilisation with lime and cement to form capping (Class 9F)	Any material or combination of materials, other than burnt colliery spoil and argillaceous rock.	(i) Grading	BS 1377 (Site)	SHW Table 6/2	SHW Table 6/2	Refer to Class 9F	6	R	-
								BS EN 933-2	SHW Table 6/5	SHW Table 6/5				
							(ii) MC	BS 1377	Contractors mix design					
							(iii) liquid limit	BS 1377	-	45				
							(iv) Plasticity index	BS 1377	-	20				
							(v) Organic matter	BS 1377	-	3%				
							(vi) water soluble (WS) sulfate	BS EN 1744-1 Clause 10		1.50 g/l as SO ₄				
							(vii) oxidizable sulphides (OS)	BS EN 1744-1 Clause 13	-	0.40% as SO ₄				
							(viii) IDD of chalk	SHW Clause 634	1.55 Mg/m³	-				
	6	S	-	Selected well graded granular material	Filter layer below subbase	Crushed rock or sand Where imported onto site which is not 'as dug' shall be aggregate conforming to BS EN 13242 from one or more of the following source codes: P.	(i) Grading	BS 1377 (Site)	SHW Table 6/2	SHW Table 6/2	-	6	S	-
							BS EN 933-2	SHW Table 6/5	SHW Table 6/5					
							(ii) Plasticity index	BS 1377	-	Non-plastic				

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED COHESIVE FILL	7	A	-	Selected cohesive material	Fill to structures	Any material, or combination of materials, other than argillaceous rock, chalk or colliery spoil Additional guidance and restrictions are presented in SHW Table 6/1.	(i) grading	BS 1377	SHW Table 6/2	SHW Table 6/2	End product of 95% of MDD and/or minimum undrained shear strength of 100 kN/m² (whichever is the more onerous) with less than 5% air voids MDD to be determined using 4.5kg Rammer and to include measurement of particle density. ¹ The lower permitted moisture content is based on the moisture content where a horizontal line plotted at 105% of the MDD intersects the 5% Air void line. ² The upper permitted moisture content is based on the lower of: - the moisture content at 95% of the MDD; or - the moisture content where the undrained shear strength is 100 kPa. If the shear strength is less than 100 kPa the material will be deemed to be Class 2A. ³ Where the Liquid Limit or plasticity index exceeds these values, BWB shall be immediately informed.	7	A	-
	(ii) mc	BS 1377	¹ See compaction requirements				² See compaction requirements							
	(iii) Sulphate (SO₄) total sulphur (S) and Total Potential Sulphate (TPS)	TRL 447					SHW Clause 601							
	(iv) undrained shear parameters (c and ϕ), 3 X 100mm diameter specimens tested @ 50, 100 & 200 kPa respectively	SHW Clause 633	C _u = 100 kPa				C _u = 300 kPa							
	(v) effective angle of friction (ϕ') and effective cohesion (c')	SHW Clause 636	ϕ' ≥ 27° C' ≥ 2 kPa				- -							
	(vi) liquid limit	BS 1377	-				³ 45							
	(vii) plasticity index	BS 1377	-				³ 25							

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED COHESIVE FILL	7	C	-	Selected cohesive material	Fill to reinforced soil	Any material, or combination of materials, other than argillaceous rock, chalk or unburnt colliery spoil. Additional guidance and restrictions are presented in SHW Table 6/1. Properties (xi), (xii), (xiii), (xiv),(xv) & (xvi) in next column only apply when metallic elements, facing units or fastenings are used,	(i) Grading	BS 1377	SHW Table 6/2	SHW Table 6/2	End product of 95% of MDD MDD to be determined using 4.5kg Rammer and to include measurement of particle density. ¹ The lower permitted moisture content is based on the moisture content where a horizontal line plotted at 105% of the MDD intersects the 5% Air void line. ² The upper permitted moisture content is based on the lower of: - the moisture content at 95% of the MDD; or - the moisture content where the undrained shear strength is 100 kPa. If the shear strength is less than 100 kPa the material will be deemed to be too wet. The upper and lower MCV shall be the equivalent the derived MC limits. ³ Where the Liquid Limit or plasticity index exceeds these values, BWB shall be immediately informed.	7	C	-
							(ii) MC	BS 1377	¹ See compaction requirements	² See compaction requirements				
							(iii) MCV	SHW Clause 632						
							(iv) undrained shear parameters (c and ϕ), 3 x 100mm diameter specimens tested @ 50, 100 & 200 kPa respectively	SHW Clause 633	$C_u = 100$ kPa	$C_u = 300$ kPa				
							(v) effective angle friction & cohesion	SHW Clause 636, 300mm shearbox	$\phi' \geq 27$ $C' \geq 2$	- -				
							(vi) Coefficient of friction soil/geogrid	SHW Clause 639	$\delta = 12$	-				
							(vii) OMC & MDD	BS 1377 (4.5kg)	Declared	Declared				
							(viii) Particle density	BS 1377	Declared	Declared				
							(ix) Liquid Limit	BS 1377	-	³ 45				
							(x) Plasticity index	BS 1377	-	³ 25				
							(xi) pH Value	BS 1377	SHW Table 6/3	SNW Table 6/3				
							(xii) Chloride ion content	BS EN 1744-1	-	SHW Table 6/3				
							(xiii) water soluble sulfate (WS)	BS EN 1744-1 Clause 10	-	SHW Table 6/3				
							(xiv) oxidizable sulphides (OS)	BS EN 1744-1 Clause 13	-	SHW Table 6/3				
							(xv) Resistivity	SHW Clause 637	SHW Table 6/3	-				
							(xvi) Redox potential	SHW Clause 638	SHW Table 6/3	-				

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631							
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED COHESIVE FILL	7	D	-	Selected stony cohesive material	Fill to reinforced soil	Any material, or combination of materials, other than argillaceous rock, chalk or unburnt colliery spoil. Additional guidance and restrictions are presented in SHW Table 6/1. Properties (xi), (xii), (xiii), (xiv),(xv) & (xvi) in next column only apply when metallic elements, facing units or fastenings are used,	(i) Grading	BS 1377	SHW Table 6/2	SHW Table 6/2	End product of 95% of MDD MDD to be determined using 4.5kg Rammer and to include measurement of particle density. ¹ The lower permitted moisture content is based on the moisture content where a horizontal line plotted at 105% of the MDD intersects the 5% Air void line. ² The upper permitted moisture content is based on the lower of: - the moisture content at 95% of the MDD; or - the moisture content where the undrained shear strength is 100 kPa. If the shear strength is less than 100 kPa the material will be deemed to be too wet. The upper and lower MCV shall be the equivalent the derived MC limits. ³ Where the Liquid Limit or plasticity index exceeds these values, BWB shall be immediately informed.	7	D	-
						(ii) MC	BS 1377	¹ See compaction requirements	² See compaction requirements					
						(iii) MCV	SHW Clause 632							
						(iv) undrained shear parameters undrained shear parameters (c and ϕ), 3 x 100mm diameter specimens tested @ 50, 100 & 200 kPa respectively	SHW Clause 633	$C_u = 100$ kPa	$C_u = 300$ kPa					
						(v) effective angle friction & cohesion	SHW Clause 636 300mm shearbox	$\phi' = 27$ $C' = 2$	-					
						(vi) Coefficient of friction soil/geogrid	SHW Clause 639	$\delta = 12$	-					
						(vii) OMC & MDD	BS 1377 (4.5kg)	Declared	Declared					
						(viii) Particle density	BS 1377	Declared	Declared					
						(ix) Liquid Limit	BS 1377	-	³ 45					
						(x) Plasticity index	BS 1377	-	³ 25					
						(xi) pH Value	BS 1377	SHW Table 6/3	SNW Table 6/3					
						(xii) Chloride ion content	BS EN 1744-1	-	SHW Table 6/3					
						(xiii) water soluble sulfate (WS)	BS EN 1744-1 Clause 10	-	SHW Table 6/3					
						(xiv) oxidizable sulphides (OS)	BS EN 1744-1 Clause 13	-	SHW Table 6/3					
						(xv) Resistivity	SHW Clause 637	SHW Table 6/3	-					
						(xvi) Redox potential	SHW Clause 638	SHW Table 6/3	-					

APPENDIX 6/1: TABLE 6/1(Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in additional to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631							
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED COHESIVE FILL	7	E	-	Selected cohesive material	For stabilisation with lime to form capping (Class 9D)	Any material, or combination of materials, other than unburnt colliery spoil.	(i) Grading	BS 1377	SHW Table 6/2	SHW Table 6/2	Refer to Class 9D	7	E	-
							(ii) MC	BS 1377	-	Declared				
							(iii) MCV	SHW Clause 632	Declared	-				
							(iv) plasticity index	BS 1377	10	-				
							(v) organic matter	BS 1377-3	-	3%				
							(vi) water soluble (WS) sulfate	BS EN 1744-1 Clause 10	-	1.50 g/l as SO ₄				
							(vii) oxidisable sulphides (OS)	BS EN 1744-1: Clause 13	-	0.40% as SO ₄				
							(viii) Total Potential Sulfate (TPS)	BS EN 1744-1: Clause 11	-	0.60% as SO ₄				

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in additional to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631							
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED COHESIVE FILL	7	F	-	Selected silty cohesive material	For stabilisation with cement to form capping (Class 9B)	Any material, or combination of materials, other than chalk, unburnt colliery spoil and argillaceous rock.	(i) Grading	BS 1377	SHW Table 6/2	SHW Table 6/2	Refer to Class 9B	7	F	-
	(ii) uniformity coefficient	See note 5	5				-							
	(iii) MC	BS 1377	-				Declared							
	(iv) MCV	SHW Clause 632	Declared				-							
	(v) liquid limit	BS 1377	-				45							
	(vi) plasticity index	BS 1377	-				20							
	(vii) organic matter	BS 1377-3	-				3%							
	(viii) water soluble (WS) sulfate	BS EN 1744-1 Clause 10	-				1.50 g/l as SO ₄							
	(ix) oxidisable sulphides (OS)	BS EN 1744-1: Clause 13	-				0.40% as SO ₄							
	(x) Total Potential Sulfate (TPS)	BS EN 1744-1: Clause 11	-				0.60% as SO ₄							

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in additional to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631							
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED COHESIVE FILL	7	G	-	Selected conditioned pulverised fuel ash (PFA) cohesive material	For stabilisation with cement to form capping (Class 9C)	Conditioned material direct from power station dust collection system and to which a controlled quantity of water has been added.	(i) MC	BS 1377	-	Declared	Refer to Class 9C	7	G	-
	(viii) water soluble (WS) sulfate	BS EN 1744-1 Clause 10	-	3.00 g/l as SO ₄										
	(ix) oxidisable sulphides (OS)	BS EN 1744-1: Clause 13	-	0.60% as SO ₄										
	(x) Total Potential Sulfate (TPS)	BS EN 1744-1: Clause 11	-	1.00% as SO ₄										

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in additional to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED COHESIVE FILL	7	H	-	Wet, dry, stony or silty cohesive material and chalk	Overlying fill for corrugated steel buried structures	As Class 2A, 2B, 2C, 2D general cohesive fill material or Class 3 chalk fill material, except that argillaceous rock, slag, PFA, or any combination thereof shall not be used	As for Class 2A, 2B, 2C, 2D or 3 with the addition of the following.				As per parent Class material.	7	H	-
							(i) Water soluble sulfate (WS)	BS EN 1744-1 Clause 10	-	300 mg/l				
							(ii) Oxidisable sulfate (OS)	BS EN 1744-1 Clause 13	-	0.06% as SO ₄				
							(iii) Chloride ion content	BS EN 1744-1	-	0.025 %				
							(iv) pH value	BS 1377-3	6	9				

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
SELECTED COHESIVE FILL	7	I	-	Selected cohesive material	Fill for stabilisation with lime and cement to form capping (Class 9E)	Any material, or combination of materials, other than unburnt colliery spoil.	(i) Grading	BS 1377	SHW Table 6/2	SHW Table 6/2	Refer to Class 9E	7	I	-
	(ii) MC	BS 1377	Declared				Declared							
	(iii) MCV	SHW Clause 632	Declared				Declared							
	(iv) plasticity index	BS 1377	10				-							
	(v) organic matter	BS 1377-3	-				3%							
	(vi) water soluble sulfate (WS)	BS EB 1744-1 Clause 10	-				1.50 g/l SO ₄							
	(vii) oxidizable sulphides (OS)	BS EN 1744-1 Clause 13	-				0.40% as SO ₄							
	(viii) Total Potential Sulfate (TPS)	BS EN 1744	SHW Table 6/3				0.60% as SO ₄							

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
STABILISED MATERIAL	9	A	-	Cement stabilised granular material	Capping	Class 6E with addition of cement according to SHW Clause 614	(i) Pulverisation	BS EN 13286-48	60%	-	SHW Table 6/4 Method 6, amended by compaction trial as required to achieve minimum 95% of MDD	9	A	-
							(ii) bearing ratio	BS EN 13286-47	15 %	-				
							(iii) MC	BS EN 13286-2	Contractors mix design	Contractors mix design				
							(iv) lab dry density & OMC	BS EN 13242 Vibrating Hammer	Declared values					
	9	B	-	Cement stabilised silty cohesive material	Capping	Class 7F with addition of cement according to SHW Clause 614	(i) Pulverisation	BS EN 13286-48	60%	-	SHW Table 6/4 Method 7, amended by compaction trial as required to achieve minimum 95% of MDD	9	B	-
							(ii) MCV immediately before compaction	SHW Clause 632	Contractors mix design	12				
							(iii) bearing ratio	BS EN 13286-47	15 %	-				
							(iv) MC	BS EN 13286-2	Contractors mix design	Contractors mix design				
							(v) lab dry density & OMC	BS EN 13242 4.5kg Rammer	Declared values					
	9	C	-	Cement stabilised conditioned Pulverised Fuel Ash (PFA) cohesive material	Capping	Class 7G with addition of cement according to SHW Clause 614	(i) Pulverisation	BS EN 13286-48	60%	-	SHW Table 6/1 Method 6, amended by compaction trial as required to achieve a minimum 95% MDD	9	C	-
							(ii) bearing ratio	BS EN 13286-47	15 %	-				
							(iii) MC	BS EN 13286-2	Contractors mix design	Contractors mix design				
							(iv) lab dry density & OMC	BS EN 13242 2.5kg Rammer	Declared values					

APPENDIX 6/1: TABLE 6/1 (Continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents	Material properties required for acceptability in addition to the requirements on use of fill materials in SHW Clause 601 and testing in SHW Clause 631				Compaction requirements in Clause 612 & additional notes	Class		
							Property (see exceptions in previous column)	Defined and testing in accordance with	Acceptable limits within					
									Lower	Upper				
STABILISED MATERIAL	9	D	-	Lime stabilised cohesive material	Capping	Class 7E with addition of lime according to SHW Clause 615	(i) Pulverisation	BS EN 13286-48	30%	-	SHW Table 6/4 Method 7, amended by compaction trial as required to achieve minimum 95% of MDD	9	D	-
							(ii) MCV immediately before compaction	SHW Clause 632	Contractors mix design	Contractors mix design				
							(iii) bearing ratio	BS EN 13286-47	15 %	-				
							(iv) MC	BS EN 13286-2	Contractors mix design	Contractors mix design				
							(iv) lab dry density & OMC	BS EN 13242 4.5kg Rammer	Declared values					
	9	E	-	Lime and cement stabilised cohesive material	Capping	Class 7I with addition of cement according to SHW Clause 643	(i) Pulverisation	BS EN 13286-48	30%	-	SHW Table 6/4 Method 7, amended by compaction trial as required to achieve minimum 95% of MDD	9	B	-
							(ii) MCV immediately before compaction	SHW Clause 632	Contractors mix design	Contractors mix design				
							(iii) bearing ratio	BS EN 13286-47	15 %	-				
							(iv) MC	BS EN 13286-2	Contractors mix design	Contractors mix design				
							(v) lab dry density & OMC	BS EN 13242 4.5kg Rammer	Declared values					
	9	F	-	Lime and cement stabilised well graded granular material	Capping	Class 6R with addition of lime and cement according to SHW Clause 643	(i) Pulverisation	BS EN 13286-48	60%	-	SHW Table 6/1 Method 6, amended by compaction trial as required to achieve a minimum 95% MDD	9	C	-
							(ii) bearing ratio	BS EN 13286-47	15 %	-				
							(iii) MC	BS EN 13286-2	Contractors mix design	Contractors mix design				
							(iv) lab dry density & OMC	BS EN 13242 Vibrating Hammer	Declared values					

APPENDIX 6/1: FOOTNOTES TO TABLE 6/1

Note	Commentary
1	App = contract specific Appendix
2	Tab = Table
3	Where in the Acceptable Limits column reference is made to App 6/1, only those properties having limits ascribed to them in contract specific Appendix 6/1 shall apply. Where contract specific Appendix 6/1 gives limits for other properties not listed in this Table, such limits shall also apply
4	Where BS 1377-2 is specified for MC, this shall mean BS 1377-2 where the material is a soil of BS EN 1097-5 where the material is required to conform to a harmonized European standard.
5	Uniformity coefficient is defined as the ratio of the particle diameters D_{60} and D_{10} on the particle size distribution curve, where: D_{60} = particle diameter at which 60% of the soil by mass is finer and D_{10} = particle diameter at which 10% of the soil by mass is finer.
6	The limiting values for Class U1B material are given in contract specific Appendix 6/14 and 6/15.
7	For works in Wales, additional reference shall be made to SHW Clause 602.1W
8	Where material source codes are referenced, these are listed in SHW Table 6/7.
9	Where materials are required to be aggregates conforming to BS EN 12620 materials certified as being compliant with BS EN 12620 are acceptable for use provided that they meet all the specification requirements and the Declaration of Performance for constituent parts to BS EN 12620 are provided to the Engineer and BWB.
10	Materials shall comply with the current European Regulations at the time of use. Reference shall be made to Annex ZA (informative) of BS EN 12620
11	Where undrained shear strength is specified as the method of acceptability testing, the Contractor may use a hand vane provided that it is correlated against the unconsolidated undrained shear strength laboratory triaxial test to BS 1377 on 100mm nominal diameter samples, and the MCV test in accordance with BS 1377. Otherwise, shear strength testing requirements is to be as set out in 633 of the Specification. The provision of a calibration certificate in the absence of a material specific correlation will not be accepted as demonstration of acceptability.
12	Where reference is made to testing in accordance with BS 1377, this shall mean the most recent version of that standard, at the time the test is to be undertaken. It is recognised that BS 1377 is currently undergoing a comprehensive revision, which may result in clauses or parts of the standard previously referred to changing. This may include the change in some terminology, such as moisture content to water content. Therefore, where a test is specified to be undertaken in accordance with BS 1377, it shall mean the most recent version of that standard, including any change in naming protocols or terminology

APPENDIX 6/2: REQUIREMENTS FOR DEALING WITH CLASS U1B AND CLASS U2 MATERIALS

1. General

- 1.1 Unacceptable material, Class U2 shall be defined as in SHW Clause 601.3. The Contractor is referred to the GDR, Earthwork Specification, Materials Management Plan (MMP) and any associated Remediation Strategy & Verification Plans (RS&VP) for the general requirements regarding Class U1B and Class U2 Unacceptable Material.
- 1.2 If unacceptable material is encountered within the works, a risk assessment will be carried out and the contractor shall make all necessary arrangements for their safe handling and disposal after consultation with the appropriate environmental authority in accordance with SHW Clause 602. As such the Contractor shall put in place contingency measures to deal with U2 materials if encountered during the earthworks.
- 1.3 The Contractor shall make all necessary enquiries and arrangements for the transfer of U1B and U2 materials for their disposal off-site and shall liaise with the relevant regulatory bodies prior to initiating removal of any material from site.
- 1.4 Where Class U1B material is identified and are unsuitable for treatment on site, the Contractor shall undertake appropriate testing including Waste Acceptance Criteria (WAC) Tests to determine the waste type and whether the waste will comprise U2 material, i.e. Hazardous Waste.
- 1.5 The Contractor shall inform the Engineer immediately of the discovery of U1B or U2 materials, asbestos or other gross contamination. The Contractor shall define in their Method Statement the procedures for handling asbestos, U1B or U2 materials or other waste.
- 1.6 No groundwater or surface water encountered during excavation shall be discharged to foul or storm sewer, nor to watercourses without the prior written approval of the Sewer provider or the Environment Agency respectively.
- 1.7 The Contractor shall ensure at all times that:
 - The exposure of site personnel and the general public to hazards is avoided.
 - Contamination or pollution migrating within the site or beyond the site boundaries is prevented.

1.8 Throughout the Works

- 1.9 The Contractor shall pay particular attention to the following.
 - 1.9.1 Handling and disposal of contaminated soils and water
 - 1.9.2 Keep the waste safe. Holders should protect the waste both whilst in their possession and for its future handling requirements. Security precautions where waste is to be held prior to removal from site should prevent theft, vandalism, waste scavenging and fly tipping. Waste shall be removed from site in appropriate containers.
 - 1.9.3 Transfer to the correct person. Waste may only be handed on to authorised persons or to persons authorised for transport purposes. The Contractor shall pay due regard to Duty of Care and associated regulations.

- 1.9.4 The Contractor shall ensure that waste is collected regularly. The maximum volume of material in a single stockpile on site at any time shall not exceed 500m³.
- 1.9.5 The Contractor shall ensure that all waste is stockpiled in accordance with a method statement approved by the Engineer and shall as a minimum included for bunding, basal membrane and top cover membrane to prevent rainfall infiltration and run-off.
- 1.9.6 The Contractor shall comply with Duty of Care Regulations and shall keep records of waste dispatched from site, including waste transfer notes. All records are to be made available to the Engineer and/or Regulator upon request. The Contractor shall ensure that all landfill gate receipts are copied to the Engineer within two working days of dispatch from site.
- 1.9.7 The Contractor shall ensure that all waste is taken to a disposal facility which is licensed to receive that specific waste type (as determined by chemical analyses and WAC tests).
- 1.9.8 All waste leaving the site shall be sheeted, without holes or tears in the sheeting fabric. Where possible, the Contractor shall use self-sheeting lorries to haul waste from the site. Where these are not available, the Contractor shall take appropriate measures to construct a safe and suitable sheeting gantry. Where sheets are to be laid over the container, they shall be secured in place. In the event of any loss of waste during transit, the Contractor shall ensure that the lost waste is collected and transported correctly to the receiving facility.
- 1.9.9 The Contractor shall supply the Engineer with a schedule containing vehicle registration number, owner, weight (unladen and gross maximum permitted) and driver details of each vehicle used for transport of materials off-site.

1.10 Sub-contracting

- 1.11 In order to ensure compliance with the Duty of Care Regulations, the Contractor must nominate all Sub-Contractors before a contract is entered into for undertaking this work.

1.12 Site Monitoring

- 1.13 The Contractor shall be responsible for all documentation of waste leaving the site and for validation of the chemical composition of waste.
- 1.14 A designated person must be made responsible for co-ordinating and ensuring that all appropriate precautions are taken against the escape of hazardous substances. This designated person shall maintain an up-to-date site record. The Contractor shall demonstrate the competence of this person to the satisfaction of the Engineer.
- 1.15 Only authorised persons shall be allowed access to the site. All site personnel shall be required to attend a site safety induction prior to commencement of works on the site.
- 1.16 All persons entering the site must be made fully aware of the hazards and risks on site prior to entering the site. Instructions shall be issued by the Contractor regarding Health and Safety precautions required. All persons will be required to sign a declaration of understanding and acceptance of site instructions. This is to protect both the individual and other personnel on the site. Non-compliance with this regime must in all cases result in refused entry to site.
- 1.17 If any person fails to comply with the health and safety precautions that person is to be removed from site immediately. Return to site would be at the discretion of the Engineer. The Contractor shall ensure that any individual who deliberately flaunts the health and safety precautions is dismissed from site and not permitted to return to the site.
- 1.18 In the instance of a possible danger occurring, safety on site shall be of utmost priority. Immediate action must be taken for the health and safety of all personnel on site. The location of the danger and any exclusion zone shall be evacuated immediately. The Contractor shall produce a method statement to set out the measures and steps to be followed in the event of such an occurrence and shall include, where applicable, for notification of emergency services, HSE, Planning Co-ordinator and the like.
- 1.19 All persons entering the site shall wear appropriate Personal Protective Equipment (PPE), which is to include but not be limited to: safety Wellingtons or boots (steel mid-sole and toe caps); overalls and/or impermeable outer garments; nitrile or other suitable gloves; safety goggles; and ear defenders.
- 1.20 First Aid facilities and suitably competent personnel shall be available at clearly identifiable locations on site.
- 1.21 A Site Safety Officer shall be appointed by the Contractor and shall be responsible for health surveillance on the site.
- 1.22 The Contractor shall take appropriate measures to avoid and prevent cross contamination of plant and personnel and also to ensure that all plant and personnel are free from contaminants and mud upon exiting the site.

APPENDIX 6/3: REQUIREMENTS FOR EXCAVATION, DEPOSITION, COMPACTION (OTHER THAN DYNMAIC COMPACTION)

1. EARTHWORKS GENERAL

- 1.1 All construction activities associated with the placement and compaction of fill, to form the permanent design, shall be treated as temporary works.
- 1.2 The geotechnical design of the earthworks, unless stated in the Geotechnical Design Report, shall be considered as a 'wished-in-place' design and the Contractor shall be responsible for all works, including all Temporary Works Design, required to form the permanent situation
- 1.3 The responsibility for undertaking the temporary works shall include, but not limited to, the following:
 - The preparation of RAMS, for prior agreement before the commencement of any associated works.
 - The selection of plant and equipment.
 - The methodology for the placement and compaction of fill.
 - The undertaking of demonstration trials, including compaction trials to ensure the proposed methodology is acceptable.
 - The safe undertaking of the works to ensure no damage is done to works, the surrounding area, adjacent structures or other similar zones.
- 1.4 All construction activities are to comply with this Specification and the requirements from BS EN 16907-3: Earthworks: Construction Practices.
- 1.5 Earthworks requirements including constraints on earthworks in relation to structures and water courses are to be defined in the Contractor's RAMS and shown on their Drawings.
- 1.6 No ground disturbing activities, including any earthmoving activities, are to commence prior to the Contractor obtaining any necessary permits or licences relating to protected species or habitats and the RAMS have been agreed by the relevant parties (see App 1/24).
- 1.7 If a licence or permit for such works is granted, those works shall only be undertaken during the periods as stated on the licence or permit under the direction of the licence or permit holder. A copy of the licence and/or permit shall be provided to the Client, and/or the Client's Representative, prior to commencement of the relevant activities.
- 1.8 Material excavated and designated for processing shall be transported to the appropriate process area for stockpiling and treatment. Clearly defined segregated stockpiles are required for different sub-classes of processed material.
- 1.9 The maximum permitted height of stockpiles, excluding topsoil Class 5, shall be 5.0 m unless otherwise agreed, with side slopes in accordance with the Contractors agreed RAMS. The maximum volume of any single stockpile shall not exceed 500m³ unless otherwise agreed in writing with BWB.

- 1.10 For temporary storage of earthworks materials, except topsoil Class 5, maximum permitted height of stockpiles shall be 5.0 metres unless otherwise agreed in writing with BWB, subject to other restrictions noted elsewhere in this specification and in accordance with the Contractors agreed RAMS.
- 1.11 Earthworks materials requiring to be stockpiled shall be stored in individual stockpiles for each earthworks class and end-use.
- 1.12 On completion of a stockpile the slopes shall be trimmed to falls to shed rainwater and the surface sealed to limit infiltration. Temporary drainage shall be provided at the base of the stockpile to collect runoff from the stockpile and to carry any surface water away from the base of the stockpile.
- 1.13 The Contractor shall provide and maintain such measures as necessary to eliminate the production of dust from the stockpile during the life of the stockpile.

2. BULK EXCAVATION

- 2.1 The bulk excavation shall be carried out in accordance with the Earthwork Drawings and in accordance with the approved Contractor's RAMS and Temporary Earthworks Design, and as necessary to remove all unsuitable soils, obstructions and extraneous items not previously identified.
- 2.2 The exposed sub-formation shall be inspected by a suitably qualified geotechnical engineer prior to any upfilling, to ensure a suitable stater layer has been achieved. The records of this inspection shall be collected by the Contractor for inclusion in the GCR, as required by App 1/24
 - 2.2.1 The Contractor shall develop a specific set of RAMS to cover the protocols for the inspection, testing and approval of the sub-formation, in accordance with App 1/24.
 - 2.2.2 All areas of the sub-formation shall be identified by an approved grid system, with an agreed referencing numbering protocol. The spacing of the grid system may be modified to suit each area but should be no smaller than 25m x 25m and no greater than 50m x 50m.
 - 2.2.3 Testing of the sub-formation shall be undertaken in accordance with this specification and as detailed in App 1/5, before any upfilling.
 - 2.2.4 A site audit inspection report shall be prepared for each area of the sub-formation, which shall be included in the Contractors GCR (refer to the requirements of App 1/24).
 - 2.2.5 A topographical survey shall be undertaken by the Contractor at the base and sides of all excavations, including the sub-formation, once the condition of the sub-formation has been approved.
 - 2.2.6 Upfilling shall not commence until the grid cell has been tested, inspected by all relevant parties, surveyed and approved by the Engineer and BWB.

- 2.3 Should the Contractor intend to use any special methods to assist in excavation work, then details shall be submitted to the Engineer and BWB for comment at least three weeks in advance of the work, and no work shall commence on the portion of the excavation concerned until consent has been given in writing.
- 2.4 Any large obstructions or unexpected findings discovered during excavation shall be reported immediately to the Client, the Client's Representative, the Engineer and BWB.
- 2.5 Following completion of any excavation, particular care must be taken to avoid any deterioration of the excavated surface. The Contractor shall be responsible for protecting the excavations against damage from weather and/or construction traffic.
- 2.6 Where ground is considered unsuitable by the Client, or the Client's Representative, or the Engineer or BWB is identified at the bottom of excavations or at the sub-formation level, the Contractor shall, under the direction of the Engineer and/or BWB, excavate to such further depth as may be required. Such extra depth shall be filled with acceptable fill, the class and designation of which shall be commensurate with the area and with the prior written agreement of the Engineer and BWB.
- 2.7 Excavations and all earthworks activities shall be carried out by the Contractor in such a way as to avoid disturbance and/or damage to the surrounding ground (including adjacent temporary works and works under construction), existing roads, pavements, buildings, infrastructure, ground, slopes, excavations, utilities, services etc, on and adjoining the area of work and/or site.
- 2.8 The Contractor shall be solely responsible for the safety and stability of all temporary works, including all excavations, slopes (e.g. temporary cut faces, temporary earthwork slopes, slopes during construction before they are completed etc), deposition & compaction of fill and for the sufficiency of all temporary supports and designs thereto. This shall include the provision and maintenance of temporary drainage and management of water, from any source.
- 2.9 Should any material be encountered that gives rise to the opinion that it may be contaminated, either by visual and/or olfactory evidence, this shall be reported immediately to the Engineer and BWB, who shall advise on the appropriate course of action. Reference is made to the general requirements for Class U1B and Class U2 materials described in App 6/2.
- 2.10 Excavations shall be planned to ensure that the cutting (either for a temporary condition or to form the permanent profile), are not left in a condition that may cause water, from any source, to be pond or be retained for any period of time on the exposed face.

3. CUTTING FACES

- 3.1 No specific limitations or restrictions on undercutting are included, but the Contractor shall comply with their agreed RAMS (see App 1/24) and their Temporary Works Designer requirements when excavating, including but not limited to trenches at the toe of any slopes.
- 3.2 Clearing loose material from cutting slopes by airline hose is not permitted.

- 3.3 The Contractor shall provide additional drainage measures to intercept and discharge seepages from cutting slopes in general accordance with the details provided in the Drawings.
- 3.4 The Contractor is responsible for all drainage required to carry out the works and to protect them upon completion, which will include, where necessary, temporary drainage measures.
- 3.5 Cutting faces which are to have topsoil shall be made good prior to topsoil placement. If the drawings do not show design details for specific areas of the site, then any of the methods set out in Clause 603.7 of SHW (2016) shall be used as required except that the use of concrete, grout, masonry infill and sprayed concrete is not permitted.

4. WATER COURSES

- 4.1 Details of regrading existing water courses, construction of new water courses and earthworks drainage ditches are shown to be shown on the Drawings. During the Contractors preparation of their RAMS, they shall ensure that they have been provided with these drawings, and any associated information and records.
 - 4.2 Redundant watercourses shall be drained and cleaned as described on the Drawings and in the Contractor's approved RAMS. Excavated arisings are to be treated as described in Appendix 6/2. Watercourses shall be filled with earthworks materials as shown on the Drawings.
 - 4.3 The Contractor shall provide for such measures as may be necessary to ensure that water, whether ground water, from precipitation or any other source does not accumulate in excavations or on sub-grades.
 - 4.4 The Contractor shall arrange for the rapid dispersal of water shed on to the surface of earthworks or completed formation during construction or which enters the earthworks from any other source.
 - 4.5 The Contractor shall provide where necessary temporary watercourses, ditches, drains, pumping or other means of maintaining the earthworks free from water. Such provision shall include carrying out the work of forming the earthworks in such a manner that their surfaces have at all times a sufficient minimum cross-fall and, where practicable, a sufficient longitudinal gradient to enable them to shed water and prevent ponding.
 - 4.6 The management of surface water shall include the provision of temporary measures to remove water expelled from the ground due to the change in imposed load from the construction or construction activities (including ground improvement, where this is undertaken).
 - 4.7 All works and associated costs relating the control and management of water on site, from existing, proposed or redundant watercourses or from any other sources including groundwater, rainfall and surface water is the responsibility of the Contractor. All costs are to be borne by the Contractor and the Contractor is deemed to have read, understood and fully accounted for these costs within their Tender submission.
 - 4.8 Any uncertainty over the issues associated with water or groundwater control should be submitted to the Engineer and to BWB for clarification, as soon as any such issue is noted or identified by any party.
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5. CONSTRUCTION GENERAL REQUIREMENTS

- 5.1 Location of fill types are shown on the Drawings.
- 5.2 Landscape fill shall only be placed with areas of the site identified as landscaping, which may include environmental bunds and landscape bunds. Reference shall be made to the requirements set out in App 6/9 for specific requirements for their construction.
- 5.3 General fill, Class 1, Class 2 and Class 3 shall only to be used in external areas outside of the influence of the proposed structures, including retaining walls.
- 5.4 Any fill placed within the influencing zone of structures, including retaining walls, shall comply with the requirements of Class 6 or Class 7 selected fill.
- 5.5 Unless otherwise advised, the influencing zone shall be taken as a region within 5m of the building envelope and a zone transcribed at 45° downwards and away from foundations.
- 5.6 The Contractor is responsible for agreeing with the Engineer and BWB the extents of the General Fill and Selected Fill.
- 5.7 Locations of starter layers are to be shown on Drawings and where shallow ground water is either encountered or expected, at the base of excavation where fill is to be placed. The extent of all starter layers shall be agreed with the Engineer and BWB, before the commencement of any fill placement.
- 5.8 Over-steepening of embankment side slopes shall only be permitted with the approval of the Engineer and BWB.

6. CONSTRUCTION OF FILL

- 6.1 Embankment slopes shall not be constructed steeper than that shown on the Drawings. Temporary over-widening or steepening to achieve adequate compaction of the shoulders of the embankment is only permitted with the prior approval of the Engineer and BWB.
- 6.2 Any areas requiring staged construction of fills, the details for the staged construction and hold periods are to be detailed in the Contractor's RAMS. Guidance is provided in the GDR. Upon approval of the RAMS, requirements for hold points shall be shown on the Drawings and are to be under the direction of BWB. The need for hold points to be observed will be a function of the Contractors proposed program and their intended method of working.
- 6.3 Any areas requiring surcharging, the relevant details including levels, time periods for surcharging, type of surcharge material are to be shown on the Drawings.
- 6.4 Areas requiring protection of the formation or sub-formation against weather, shall be carried out in accordance with Clause 608.9(ii) of SHW, are to be shown on the Drawings and coordinated with the Contractor's program and agreed RAMS.
- 6.5 Any areas requiring starter layer, together with class type and thicknesses are shown on the Drawings and where shallow ground water is either encountered or expected, at the base of excavation where fill is to be placed. The extent of all starter layers shall be agreed with the Engineer and BWB, before the commencement of any fill placement.

- 6.6 Where required by the Geotechnical Design, the proposed staged process of earthworks shall be detailed within the GDR.
- 6.7 Where required by the proposed method of working and program by the Contractor, there may be additional requirements necessary to be observed relevant to staged construction. This shall be detailed in the Contractors RAMS with coordination and approval of their geotechnical advisor.
- 6.8 Formation for earthworks construction and cutting formations shall be proof-rolled using a minimum compactive effort as detailed in Specification Clause 613.11 and 613.12. This minimum compactive effort shall be increased for cutting formations where different compactive efforts, dependent on the type of follow-on earthworks operations, are required by the Specification. The identification of a 'soft spot' is both a quantitative and qualitative assessment and can depend on the response of the ground to the compactive effort during the proof-rolling.
- 6.9 The GIR and subsequent geotechnical assessment had identified the presence of unacceptable ground and associated areas requiring mitigation. The mitigation requirements and are set out in the GDR and associated drawings and will include the excavation and replacement of unacceptable material. This process shall follow the general principles of dealing with soft spots.
- 6.10 For the purposes of this contract, the definition of a soft area will correspond to a CBR of less than 2.5% ($C_u < 50$ kPa). As a guide, matting, bow-waving or ground heave shall be deemed to be indicative of a 'soft spot' which would then require testing by the contractor to determine the competency of the subgrade. The Contractor is to agree with the Client's Representative, the Engineer and BWB and the full the extent of 'soft spot' treatment.

6.11 Soft Spots

- 6.12 It is expected that localised 'soft spots' will occur during the during the proof rolling exercise and as such detailed discussion and agreement will be required with the Client's Representative, the Engineer and BWB at the outset in order to adopt a standardised procedure for dealing with this occurrence.
- 6.13 Where a soft-spot is identified, the sequence of activities shall include, as a minimum, the following:
- Delineation at the current formation the extent of soft spot.
 - Excavation of soft spot.
 - Inspection of the area of the soft spot post removal of affected material by the BWB and may include the Client's Representative and the Engineer, who should be informed of the activities before they commence.
 - In situ assessment on strength (hand vane shear strength in the case of cohesive soils) at the base and sides of the excavation, typically at 5m centres and as agreed with BWB.
 - Survey of the extent of the soft spot excavation by the Contractor, following removal of all unacceptable fill material.
 - Replacement of affected material with suitable engineered fill, compliant with the requirements of Appendix 1/5 and Table 6/1.

- Where the depth of the soft spot exceeds 0.50m, the sides of the excavation shall be benched in accordance with this Appendix.
- Records of extent of soft spots to be presented in accordance with the requirements set out in Appendix 1/24 and provided in the Contractor's GCR.

7. COMPACTION

7.1 General

7.2 Fill to be used on this site will be derived from site won materials, which will either be classed as general fill to external areas, landscape fill to landscape areas, and selected fill for use below and within the influencing zone of all structures.

7.3 Requirements for compaction of earthworks materials shall comply with the GDR, BS EN 16907, SHW Clause 612 and DMRB HA 70.

7.4 Method Compaction Specification

7.5 App 6/1 Table 6/1 specifies which classes of fill are to be controlled by Method Placement. Method compaction is described in DMRB HA 70/94 and BS EN 16907: Earthworks.

7.6 A compaction trial **shall** be undertaken for **each source**, **each class** and **each compaction method**, under the observation of BWB.

7.7 The scope of the compaction trial, as a minimum, shall comply with BS EN 16907-3:2018: Annex A. Should the Contractor not have access to this document, they shall immediately inform BWB, and BWB will provide details of the requisite information.

7.8 The purpose of the compaction trial is to demonstrate that the predicted performance of the fill, as set out in the GDR, can be achieved by the material and the method of compaction.

7.9 The method of compaction may be amended, following the completion of the trial, so as to ensure the method will achieve the required level of performance of the fill.

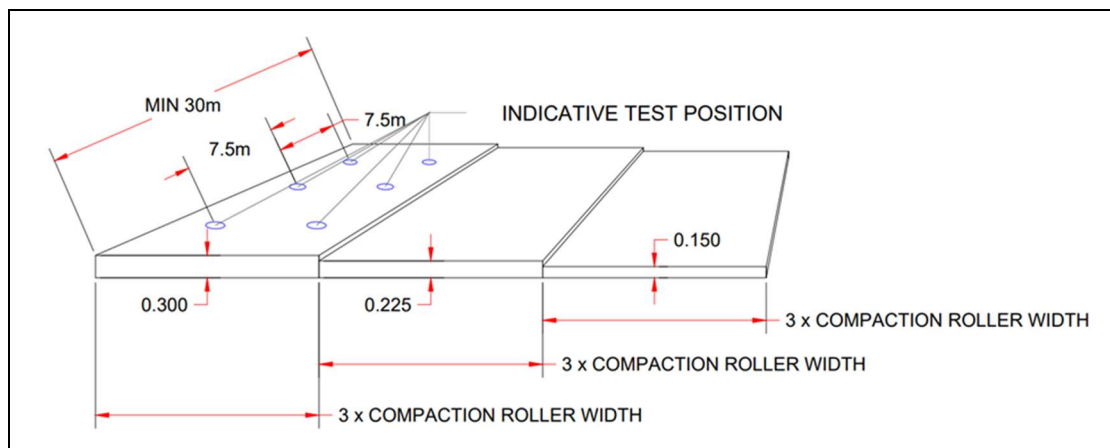


Figure 7-1: General arrangement for compaction trial, BS EN 16907-3: Annex A

- 7.10 In order to comply with the requirements of the GDR and the contact specification, testing of fill during placement is required to confirm the adopted method is achieving the minimum design performance, and shall be undertaken in accordance with App 1/5 and BS EN 16907-5:2018: Clause 7.2
- 7.11 BS EN 16907-5:2018: Clause 7.2 requires a combination of the sub-clauses 7.13, □ & 7.15 to be complied with. This shall be in addition to the testing defined in App 1/5, and shall be presented as part of the Contractor's GCR.
- 7.12 The following clauses are based on the requirements from BS EN 16907-5:2018: Clause 7.2, and shall be complied with, unless otherwise agreed with BWB.
- 7.13 Records to be provided on the visual checks and manual recording of the conformity of the execution with the Method Specification, including, but limited to, the following:
- Number of passes of compaction plant.
 - Compacted layer thickness.
 - Source approval acceptability and acceptability of the material in terms of moisture content compliance at time of compaction
 - Type and mass of compactor, including manufacturers name and unique equipment reference.
 - Speed of compactor.
 - Frequency of vibration, where vibration was used as part of compaction.

- 7.14 Checking recording and provision of daily records on the volume of compacted material (Q), and the total compacted surface covered by the compactor to compact the volume (S, controlled by tachograph), see Q/S method from BS EN 16907-5: 2018 Annex B for additional information.
- 7.15 Checking, recording and provision on the number of compacted passes, layer thickness and speed of compactor using a compactor equipped with full Global Navigation Satellite System recording and documentation systems, in accordance with CEN/TS 17006.

7.16 End Product Specification

- 7.17 App 6/1 Table 6/1 specifies those materials which are to be controlled by end product testing.
- 7.18 A compaction trial shall be undertaken for each source, each class and each compaction method, under the observation of BWB.
- 7.19 The scope of the compaction trial, as a minimum, shall comply with BS EN 16907-3:2018: Annex A. Should the Contractor not have access to this document, they shall immediately inform BWB, and BWB will provide details of the requisite information.
- 7.20 The purpose of the compaction trial is to demonstrate that the predicted performance of the fill, as set out in the GDR, can be achieved by the material and the method of compaction.
- 7.21 The demonstration of compliance for materials controlled by end product specification shall be through full compliance of the testing requirements defined in App 1/5, including all *in situ* testing.
- 7.22 Compliance testing is the responsibility of the Contractor and shall be in compliance with BS EN 16907-5: 2018 Clause 8.

7.23 Compliance Testing

- 7.24 The requirements for compliance testing is defined in the GDR and App 1/5.
- 7.25 In accordance with BS EN 16907-5: 2018: Clause 8.2, where the *in situ* density is measured by a density gauge (e.g. Nuclear Density Gauge), or other indirect methods, such as a Soil Density Gauge, the moisture content used for the determination of dry density shall only be calculated from a laboratory measured value.
- 7.26 Gauge readings may be used on site as a guide during the placement of fill; however, the compliance density must be determined by direct measurement of the moisture content.
- 7.27 The following compliance limits shall be applied, unless otherwise agreed in writing with BWB.
 - 7.27.1 *Method Placement*
 - 7.27.2 No more than 10% of results shall be less than 95% of the MDD, with no reading less than 92%
 - 7.27.3 No more than 10% of results shall have a calculated air void content (for cohesive fill classes only) in excess of 5% and no result above 8%.

- 7.27.4 No more than 10% of the undrained shear strengths (for cohesive fill only) shall be less than the lower value defined in Table 6/1, and no result less than 90% of this value (e.g. if Table 6/1 defines the minimum strength to be 65kPa, no more than 10% of results shall be less than 65 kPa and no result less than 58 kPa).
- 7.27.5 No more than 10% of the equivalent bearing ratio shall be less than the lower value defined in Table 6/1, and no result less than 90% of this value (e.g. if Table 6/1 defines the minimum bearing ratio to be 8%, no more than 10% less than 8% and no result less than 7.2%). The same process and application of compliance limits shall be applied where the subgrade surface modulus is measured, instead of the bearing ration, when using LWD equipment.
- 7.27.6 Dual Cycle Static Plate Load Tests at finished earthworks Final Formation Level (FFL) shall have 100% compliance with the minimum stiffness defined in the GDR.
- 7.27.7 *End Product*
- 7.27.8 No more than 10% of results of any layer shall be less than 95% of the MDD, with no reading less than 92%
- 7.27.9 No more than 10% of results of any layer shall have a calculated air void content (for cohesive fill classes only) in excess of 5% and no result above 8%.
- 7.27.10 No more than 10% of the undrained shear strengths (for cohesive fill only) of any layer shall be less than the lower value defined in Table 6/1, and no result less than 90% of this value (e.g. if Table 6/1 defines the minimum strength to be 100kPa, no more than 10% less than 100 kPa and no result less than 90 kPa).
- 7.27.11 No more than 10% of the equivalent bearing ratio shall be less than the lower value defined in Table 6/1, and no result less than 90% of this value (e.g. if Table 6/1 defines the minimum bearing ratio to be 15%, no more than 10% less than 15% and no result less than 13.5%). The same process and application of compliance limits shall be applied where the subgrade surface modulus is measured, instead of the bearing ration, when using LWD equipment
- 7.27.12 Dual Cycle Static Plate Load Tests at finished earthworks Final Formation Level (FFL) shall have 100% compliance with the minimum stiffness defined in the GDR.

- 7.28 For the avoidance of doubt, a layer shall be any layer of fill, from the same source and same class, placed and compacted at the same location and level, on the same working day. Subsequent filling on subsequent days, at same location and level, shall constitute a new layer of fill
- 7.29 Where compaction control is by Method Placement, should routine testing identify the predicted end performance has not been met, the method and/or limiting acceptability limits from App 6/1 Table 6/1 shall be revised.
- 7.30 Where compaction control is by End Product testing, should the non-compliance rate exceed the permitted range, the material shall be removed and replaced with alternate acceptable fill in compliance with the specification.

7.31 Dual Cycle Plate Load Testing

- 7.32 In accordance with the requirements of the Geotechnical Design and BS EN 16907-5:2018, dual cycle plate load tests are required during the placement of the fill, and at the completion of the filling process.

7.33 Dual Cycle, Static Plate Load test for Modulus of Subgrade Reaction for floor slab design.

- 7.34 This test should be undertaken with a minimum 0.60m diameter plate, unless otherwise agreed in writing with BWB.
- 7.35 The Contractor's appointed testing house will need to provide their methodology and Method Statement, to BWB for prior agreement, for the undertaking of this test, following the withdrawal of DMRB IAN 73/06 Rev in 2019.
- 7.36 The test procedure shall be fully cognisant of the following sub-clauses.
- 7.37 The modulus of subgrade reaction is an elastic modulus and can only be proven if the test is done cyclically to ensure repeatable results. Therefore, it is recommended that the testing protocols comply with the following.
 - 7.37.1 The initial seating stress is to be based upon the stress required to induce at least 1.5mm.
 - 7.37.2 The first load cycle shall be applied incrementally, to achieve cumulate settlement intervals of 0.25, 0.50, 0.75, 1.00, 1.25 and 1.5mm respectively. Each incremental stress shall maintained until there is less than 0.05mm per minute per increment before the next load is applied.
 - 7.37.3 Upon achieving the 1.50mm settlement and less than 0.05mm per minute requirement, the plate shall be unloaded back to zero and the non-recoverable settlement at a stress of 0 kPa is recorded.
 - 7.37.4 The dial gauges shall be re-set to zero, and the test is repeated to achieve the same number of increments with the corresponding same level of induced deformation (e.g. stress applied to achieve 0.25mm increments, up to a maximum nominal deformation of 1.50mm).
 - 7.37.5 The general loading sequence for this method is presented as Table 7-1.
 - 7.37.6 The assessment and reporting of the results shall include the following stages:
 - 7.37.6.1 Check that the non-recoverable settlement after the first cycle is less than 50% of the total (e.g. if the total settlement was 1.50mm, then after unloading back to zero the

gauges should return to less than 0.75mm). If this is not achieved, additional stress cycles may be undertaken as this can be indicative of poor compaction, until repeatable values are recorded.

7.37.6.2 Compare the stiffness (E , E_{pit}), calculated in accordance with BS EN 1997-2: 2007: App K, of the final cycle divided by the stiffness of the previous cycle. The target ratio for floor slabs should be less than 2.2, and never above 2.5.

7.37.6.3 The modulus of subgrade reaction (k_s , k_{762}) calculated in accordance with BS EN 1997-2: 2007: App K, for the final cycle, as the design value of the subgrade and checked against the slab design requirements. The laboratory will need to confirm the method of conversion of k to k_{762} within their method statement.

Table 7-1: Dual Cycle Plate Load Test for measurement of the Modulus of Subgrade Reaction, 600mm plate

Load & Pressure Increment Details - for Selected end performance		Maximum permissible rate of movement before next load increment applied	Settlement requirements and maximum permissible settlement where relevant
Plate Diameter	600 mm		
Load Reference	Applied Stress (AS)		
Seating Load	Sufficient to induce min 1.50mm settlement	< 0.05 mm/min	Declared
Reset before 1st Load Cycle	0.0 kPa	< 0.05 mm/min	Declared then reset to 0mm
Increment 1-1	1 x load increment	< 0.05 mm/min	< 1.25 mm
Increment 1-2	2 x load increment	< 0.05 mm/min	< 2.50 mm
Increment 1-3	3 x load increment	< 0.05 mm/min	< 3.75 mm
Increment 1-4	4 x load increment	< 0.05 mm/min	< 5.00 mm
Increment 1-5	5 x load increment	< 0.05 mm/min	< 6.25 mm
Increment 1-6	6 x load increment	< 0.05 mm/min	< 7.50 mm
Reset before 2nd Load Cycle	0.0 kPa	< 0.02 mm/min	< 0.50 x max settlement at increment 1-6
Reset settlement Gauge	0.0 kPa	0.00 mm	Dial reset to 0.00 mm
Increment 2-1	1 x load increment	< 0.05 mm/min	< 0.63 mm
Increment 2-2	2 x load increment	< 0.05 mm/min	< 1.25 mm
Increment 2-3	3 x load increment	< 0.05 mm/min	< 1.88 mm
Increment 2-4	4 x load increment	< 0.05 mm/min	< 2.50 mm
Increment 2-5	5 x load increment	< 0.05 mm/min	< 3.13 mm
Increment 2-6	6 x load increment	< 0.05 mm/min	< 3.75 mm

7.38 The load increments to be applied are a function of the target modulus of subgrade reaction. To assist, a series of values have been derived, when using the 600mm plate for a range of modulus values, as k_{762} , between 20,000 kN/m³ to 100,000 kN/m³.

Table 7-2: Load Increment for 600mm plate, for use with Table 7-1

Modulus of Subgrade Reaction, k BS EN 1997-2:2007; App K.3	Modulus of Subgrade Reaction, k_{762} DMRB IAN 73/06 Rev 1	Load Increment for use with Table 7-1
24,863 kN/m ³	20,000 kN/m ³	15.5 kPa

Modulus of Subgrade Reaction, k BS EN 1997-2:2007; App K.3	Modulus of Subgrade Reaction, k_{762} DMRB IAN 73/06 Rev 1	Load Increment for use with Table 7-1
37,295 kN/m ³	30,000 kN/m ³	23.3 kPa
49,727 kN/m ³	40,000 kN/m ³	31.3 kPa
62,158 kN/m ³	50,000 kN/m ³	38.8 kPa
74,590 kN/m ³	60,000 kN/m ³	46.6 kPa
87,021 kN/m ³	70,000 kN/m ³	54.4 kPa
99,453 kN/m ³	80,000 kN/m ³	62.2 kPa
111,885 kN/m ³	90,000 kN/m ³	69.9 kPa
124,316 kN/m ³	100,000 kN/m ³	77.7 kPa

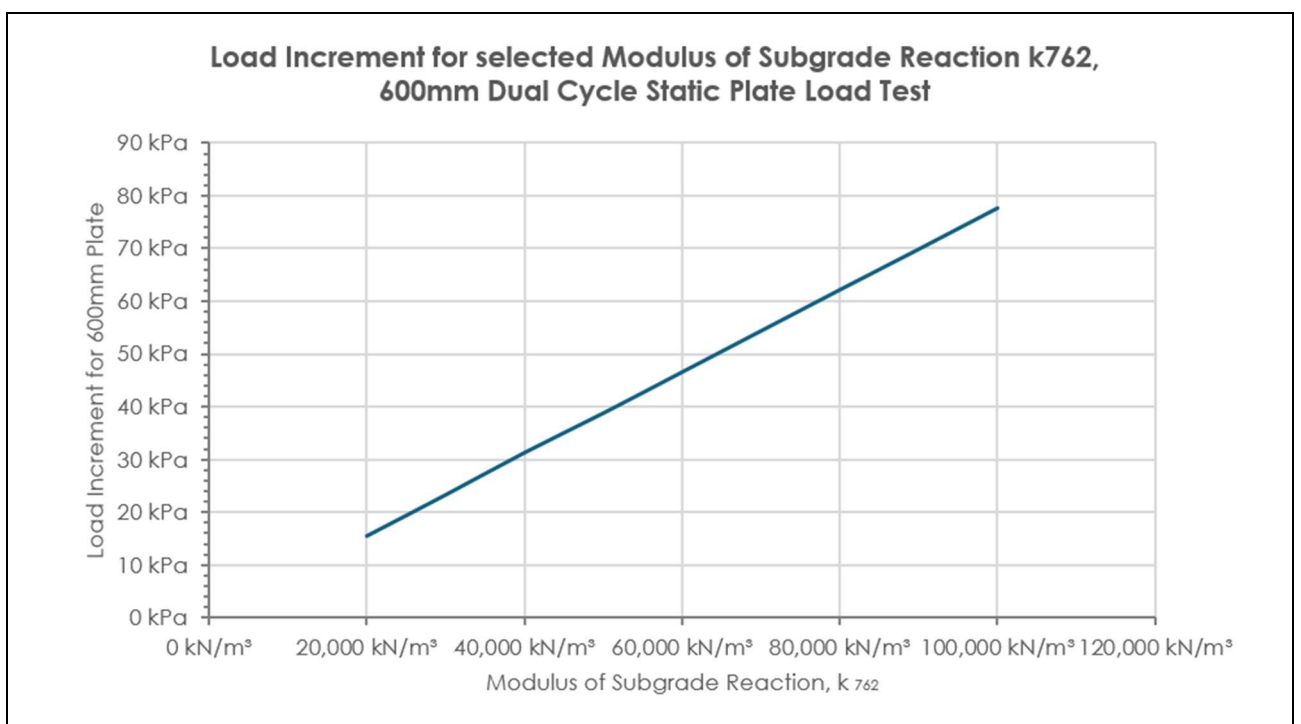


Figure 7-2: Load Increment for 600mm plate, for use with Table 7-1

7.39 Dual Cycle, Static Plate Load Test for Confirmation of Permissible Bearing Pressure of Foundations

- 7.40 This test should be undertaken with a minimum 0.60m diameter plate unless otherwise agreed in writing with BWB. The method of analysis should follow BS 1377-9: 1990, BS EN 16907-5: 2018 and the ICE Specification for Ground Treatment 1987: Clause 6.17.1
- 7.41 The loads shall be applied and held for a period of time until an acceptable level of on-going rate of settlement is met. The permissible Bearing Pressure, defined in the GDR, is required to calculate the pressure and associated load for each increment.

Table 0-1: Dual Cycle Plate Load Test for Conformation of the Permissible Bearing Pressure of Foundations

Load & Pressure Increment Details		Maximum permissible rate of movement before next load increment applied	Settlement requirements and maximum permissible settlement where relevant
Load Reference	Proportion of Permissible Bearing Pressure (PBP)		
Seating Load	0.10 x PBP	≤ 0.02 mm/min	Declared
Reset before 1 st Load Cycle	0.00 X PBP	< 0.02 mm/min	Declared then reset to 0mm
Increment 1-1	0.50 x PBP	< 0.02 mm/min	Declared
Increment 1-2	1.00 X PBP	< 0.02 mm/min	Declared
Increment 1-3	1.50 X PBP	< 0.02 mm/min	Declared
Increment 1-4	2.00 X PBP	< 0.02 mm/min	Declared
Increment 1-5	2.50 X PBP	< 0.02 mm/min	Declared
Increment 1-6	3.00 X PBP	< 0.02 mm/min	Declared
Reset before 2 nd Load Cycle	0.00 X PBP	< 0.02 mm/min	≤ 0.50 x max settlement at 1-6
Reset settlement Gauge	0.00 x PBP	0.00 mm	Dial reset to 0.00 mm
Increment 2-1	0.50 x PBP	< 0.02 mm/min	$\leq$ ¹ 2.00 mm
Increment 2-2	1.00 X PBP	< 0.02 mm/min	$\leq$ ¹ 4.00 mm
Increment 2-3	1.50 X PBP	< 0.02 mm/min	$\leq$ ¹ 6.00 mm
Increment 2-4	2.00 X PBP	< 0.02 mm/min	$\leq$ ¹ 8.00 mm
Increment 2-5	2.50 X PBP	< 0.02 mm/min	$\leq$ ¹ 10.00 mm
Increment 2-6	3.00 X PBP	< 0.02 mm/min	$\leq$ ¹ 12.00 mm
Notes: ¹ This data is not usually suitable for the derivation of a modulus of subgrade reaction, k, due to the different and more onerous rate of settlement criteria			

8. ADDITIONAL LIMITATION OF DEPOSITION OF MATERIALS REFERRED TO IN SHW Clause 601.13, 601.14 & 601.17

- 8.1 Cobbles having an equivalent diameter of more than 150mm shall not be deposited within 1.3 m of the finished surface at any location.

9. RESTRICTIONS ON BATTERING OF EXCAVATIONS FOR FOUNDATIONS AND TRENCHES AND REQUIREMENTS FOR BENCHING

- 9.1 No specific limitations or restrictions are included for the battering of excavations for foundations, but the Contractor shall comply with their Temporary Works Designer's requirements and the agreed RAMS.
- 9.2 Battered excavations are to be benched prior to backfilling. Benching requirements are shown on the Drawings and as described in Clause 11.

10. EXCAVATION SUPPORTS TO BE LEFT IN PLACE

- 10.1 No excavation supports are to be left in place.

11. BENCHING OR SHAPING OF EARTHWORKS SLOPE FACES TO RECEIVE FILL

- 11.1 Fill shall only be placed on a horizontal plane, and never on a sloping profile.
- 11.2 A sloping profile is considered by this Specification to be any face that is steeper than 1 vertical (v) to 15 horizontal (h) equivalent to an angle of 3.8°, with the slope being measured at right angles across the width of the fill area, embankment, bund etc (e.g. the most onerous profile).
- 11.3 Benching of fill is required when filling voids and where the fill is to be placed against faces which are steeper than 1 v:15h, e.g. against a sloping profile.
- 11.4 Bench heights are to be based on a multiple of the relevant compacted layer thickness.
- 11.5 For slopes slacker than or equal to 1v: 10h, the height of each bench may be limited to a single layer of compacted fill, cut and trimmed at the time a level formation is prepared.
- 11.6 For slopes between 1v: 10h to 1v: 3h, equivalent to a slope range of between 5.7° and 18.4°, the height of each bench shall be a maximum of two compacted layers of fill. The length of each bench shall be a function of the bench height and the slope of the face to be benched in to. Each bench shall be surveyed and the records provided in accordance with App 1/24.
- 11.7 For slopes of between 1v: 3h and 1v: 2v, equivalent to a slope range of between 18.4° and 26.6°, the height of each bench shall be a minimum of two compacted layers of fill to a maximum of either 4 layers of fill or 1m, whichever is the lesser. The length of each bench shall be a function of the bench height and the slope of the face to be benched in to. Each bench shall be surveyed and the records provided in accordance with App 1/24.

- 11.8 For slopes steeper than 1v: 2h, equivalent to an angle in excess of 26.6°, the height of each bench shall be a minimum of three compacted layers of fill, with a maximum height of either 4 layers or 1m, whichever is the lesser. The length of each bench shall be a function of the bench height and the slope of the face to be benched in to. Each bench shall be surveyed and the records provided in accordance with App 1/24.
- 11.9 The details of all benching details shall be agreed before works commence and shall be based on the following requirements.
- 11.10 Each bench shall be surveyed, recorded, and presented as part of the Contractors GCR, as required by App 1/24
- 11.11 Benches are to be formed commensurate with the time of fill placement and compaction, to limit the time where an over-steep face may be left exposed.
- 11.12 Additional surveying of benches may be requested by the Client's Representative, or the Engineer of BWB and if requested, the records shall be presented in the Contractors GCR in accordance with App 1/24.
- 11.13 Where, due to the progress of the work, the difference in level between adjacent areas of filling exceed 600mm, the Contractor shall cut the edge of higher filling to form benches, having a minimum width at least 2 times the height of the vertical face. This benching detail shall be surveyed and included in the Contractor's GCR in accordance with App 1/24.
- 11.14 Fill material in areas of benching shall be carefully placed and compacted to ensure that no voids occur at the upright steps of the benching.
- 11.15 Placing and compaction of the fill material shall continue to a level above an adjacent bench before material is placed upon that bench.
- 11.16 Four additional passes of the roller shall be made on the area within two metres each side of the upright face immediately following the compaction of the first layer of fill material on each bench.

12. MIXING OF EXCAVATED MATERIALS

- 12.1 Mixing of acceptable and unacceptable excavated material is not permitted. All excavated materials are to be stored in individual stockpiles, not exceeding 500m³ unless otherwise agreed with BWB.
- 12.2 Mixing of soils derived from different geological groups is not permitted. Upon excavation each geological group shall be segregated and stored in separate stockpiles or re-used immediately at the agreed final point of deposition.

13. FILL TO EXCAVATED VOIDS OR NATURAL VOIDS IN FOUNDATION EXCAVATIONS

- 13.1 Areas of inadequate strength shall be removed and backfilled.
- 13.2 The plan extent and depth of each area shall be agreed with the Engineer and BWB.
- 13.3 The plan area and depth following excavation shall be Inspected (notification shall be given to the Client's Representative, the Engineer and BWB, so that they may also have the opportunity to attend and inspect), tested and surveyed before backfilling, and the records presented as part of the Contractor's GCR in accordance with App 1/24.

Appendix 6/3: REQUIREMENTS FOR EXCAVATION, DEPOSITION, COMPACTION (OTHER THAN DYNMAIC COMPACTION)

- 13.4 For small areas and depths, blinding concrete may be used, with prior agreement with the Engineer and BWB on the grade and AC classification before use.
- 13.5 For more extensive areas and depths, backfill shall be acceptable fill, as defined by the GDR and Specification compacted to Table 6/1 of the Specification unless otherwise shown on the drawings.
- 13.6 The records of backfilling, including surveys, bench details, testing, fill material and class used and any other relevant information, as required by App 1/24, shall be presented in the Contractor's GCR.

14. FILL TO LANDSCAPE AREAS

- 14.1 Where landscape fill material (Class 3D or Class 4) is to be used within approved locations on site, the material shall be placed in accordance with the specific requirements defined in App 6/9, the Geotechnical Design, BS EN 16907 and Clause 620 of the SHW.

APPENDIX 6/5: GEOTEXTILES USED TO SEPARATE EARTHWORK MATERIAL

1. Use of Geotextiles and Geocomposites – General Requirements

- 1.1 Geotextiles used to separate earthworks materials may include geocomposites and geogrids.
- 1.2 Geotextiles, geocomposites and geogrids shall be used where shown on the Drawings and shall comply with Clause 609 of SHW (2016) and be CE marked.
- 1.3 Where geotextiles, geocomposites and geogrids materials are to be used to replace or repair *in situ* geotextiles, geocomposites and geogrids the replacement or repair materials are to be like-for-like.

2. Materials

- 2.1 Geotextile separators shall be thermally bonded and non-woven or needle punched polyethylene or polypropylene.
- 2.2 Geocomposites shall comprise a single-cusped HDPE sheet thermally bonded on both sides to a permeable geotextile fabric as described above.
- 2.3 Geogrids shall comprise polyethylene or polypropylene.
- 2.4 Geotextiles shall be manufactured from synthetic fibres. The geotextile shall be inert to all chemical naturally found in soils and shall have no solvents at ambient temperature. It shall not be susceptible to hydrolysis, shall be resistant to aqueous solutions of salts, acids and alkalis and shall be non-biodegradable.
- 2.5 Full test certificates for the proposed geotextile covering the requirements of clause 609 of the SHW (2016) shall be submitted to the designer at least two weeks prior to installation. If on-going control testing is required, this shall be detailed in App 1/5.
- 2.6 The properties described in SHW Clause 609.4 (2016) shall be proved by the manufacturer's Quality Assured Certification which itself shall have been approved by an independent organisation.
- 2.7 Details of laying and lapping shall be as described in SHW Clause 609.5 (2016) and in accordance with the manufacturers requirements. For separation of earthworks materials, an overlap of 1.0m should be provided.
- 2.8 Geotextiles shall be supplied to site in an undamaged condition and shall not be damaged by site handling, whether supplied in the form of rolls or packages. The methods of supply and handling adopted shall ensure that; the geotextile is supplied dry, and remains dry; the geotextile is protected from abrasion and damage; the geotextile is protected from contamination; and the geotextile is protected from exposure to sunlight (ultra-violet radiation in particular).
- 2.9 Items within consignments of geotextiles shall be supplied to site clearly marked with the name of the product and its grade or code number, in order that it shall easily be identified both before and after removal of any wrapping.

- 2.10 The geotextiles shall at all times prior to placement be stored under cover and suitably protected from direct sunlight and water. Geotextiles shall not, by virtue of their storage environment, be removed from site. Wrapping provided shall not be removed before the geotextile is used.

3. Design Life

- 3.1 All geotextiles, geocomposites and geogrids which are to be incorporated in the permanent works shall have a minimum life expectancy of 120 years unless otherwise shown on the Drawings.

4. Frequency of Testing

- 4.1 The frequency of testing of geotextiles, geocomposites and geogrids shall be as shown in Appendix 1/5.
- 4.2 Where App 1/5 does not define a requirement for testing, reliance shall be placed on the manufacturer's CQA and certification, and copies of all delivery tickets are to be included in the Contractor's GCR in accordance with App 1/24.

5. Testing Criteria

- 5.1 Geotextiles shall meet the following criteria.

Table 5-1: Geotextile Acceptability Criteria

Property	Acceptable limit	Defined and tested in accordance with
Mean wide width strip tensile strength	As stated in the GDR, SGMF and drawings	BS EN ISO 10319:1996
Mean CBR puncture resistance		BS EN ISO 12236:1996
Mean trapezoidal tear resistance		ASTM D4533
Mean AOS O90 pore size		BS EN ISO 12956:1999
Permeability, 5 cm head		BS EN ISO 11058:1999

- 5.2 Geocomposites shall meet the following criteria:

Table 5-2: Geocomposite Acceptability Criteria

Property	Acceptable limit	Defined and tested in accordance with
In-plane water flow at 20 kPa (HG1)	As stated in the GDR, SGMF and drawings	BS 6906(7)(MOD)
In-plane water flow at 500 kPa (HG1)		BS 6906(7)(MOD)
Composite thickness at 2 kPa		BS EN 964-1:1995
Tensile strength long/cross		BS EN ISO 10319:1996

Property	Acceptable limit	Defined and tested in accordance with
CBR puncture resistance		BS EN ISO 12236:1996
Permeability, 5 cm head		BS EN ISO 11058:1999

5.3 Additional testing requirements for Geocomposites are as follows.

5.3.1 The Contractor shall submit to the Client's Representative, the Engineer and BWB, all relevant test results to confirm that sufficient bond is provided between the filter fabric and cusped core as agreed with the Contractor and the Project Manager.

5.3.2 The Contractor shall submit to the Engineer and BWB large shear box test results to confirm the soil/geocomposite interaction parameters. The minimum requirements for the tests are that all materials and normal loads shall be as per the intended use in the Contract, with separate tests carried out where variations are expected. The frequency of testing shall be as set out in Appendix 1/5.

5.4 Geogrids shall meet the following criteria:

Property	Acceptable limit	Defined and tested in accordance with
Characteristic Strength (Pc)	As stated in the GDR, SGMF and drawings	BS EN ISO 10319:1996
Characteristic Peak Strain		BS EN ISO 10319:1996

6. Details of Laying and Lapping (in addition to the particular manufacturers recommendations).

- 6.1 All geotextiles shall be laid and lapped in accordance with Clause 609.5 of SHW (2016) or with the manufacturers requirements whichever is the greater.
- 6.2 Geocomposite sheets shall be rolled out in the locations shown on the Drawings and be orientated so that they drain towards the toe of the slope. Adjacent sheets shall be fixed with the core butt joined. The geotextile flap on the edge of the drainage sheet shall be extended across the joint shiplap style. All fixing and cutting details shall be in accordance with the manufacturer's requirements. The backfill shall not comprise sharp objects and shall be placed in an advancing face, with plant working on top of previously placed backfill. Mechanical plant shall not operate directly on the geocomposite unless protected by 300mm of earthworks fill.
- 6.3 Care shall be taken to ensure that the geotextile is not damaged during placement or during the deposition, spreading and levelling of the fill material. No traffic or site plant shall be permitted to traffic the reinforcement prior to placing the fill.
- 6.4 The fabrication and installation shall be planned and implemented taking into account existing or diverted services and drainage works.

7. Requirement for Placing and Compaction of Fill

- 7.1 The layer or surface against which the geotextile is to be placed shall not have protrusions or sharp projects that are likely to damage the geotextile during installation or in service. It shall be free from stumps, stones or other large protrusions that could cause damage to the geotextile.
- 7.2 Fill shall be spread such that the first layer advances across roll width rather than along the roll lengths. Care shall be taken to avoid damage to the geotextile. No traffic or site plant shall be permitted to travel on the geotextile prior to placing of fill.
- 7.3 Fill shall not be tipped directly onto the geotextile. Fill shall be carefully spread onto previously placed geotextile and shall be taken forward and placed by hand-raking or suitable plant with a bucket type that causes the covering material to cascade onto the fabric. The fill shall not be dropped directly onto the geotextile. The fill shall be deposited and spread to prevent segregation. Covering with fill material shall be carried out immediately after laying.
- 7.4 During placing and compaction of fill, care shall be taken to avoid displacing the geotextile. At overlaps, the top piece of geotextile shall be the first to be covered by fill and no fill shall be permitted to come between overlapping layers.

8. Number of Tests on Samples

- 8.1 The number of tests shall be as set out in Appendix 1/5.
- 8.2 Where App 1/5 does not define a requirement for testing, reliance shall be placed on the manufacturer's CQA and certification, and copies of all delivery tickets are to be included in the Contractor's GCR in accordance with App 1/24

9. Length of Time Samples are to be Kept.

- 9.1 The Contractor shall store samples for a minimum of 24 months.

APPENDIX 6/6: FILL TO STRUCTURES AND FILL ABOVE STRUCTURAL FOUNDATIONS

1. FILL TO STRUCTURES

- 1.1 Requirements and material classes for fill to structures and fill above structural foundations are shown on the drawings.
- 1.2 Any fill placed within the influencing zone of structures, including retaining walls, shall comply with the requirements of Class 6 or Class 7 selected fill.
- 1.3 Unless otherwise advised, the influencing zone shall be taken as a region within 5m of the building envelope and a zone transcribed at 45° downwards and away from foundations. This is shown figurative in Figure 1-1.

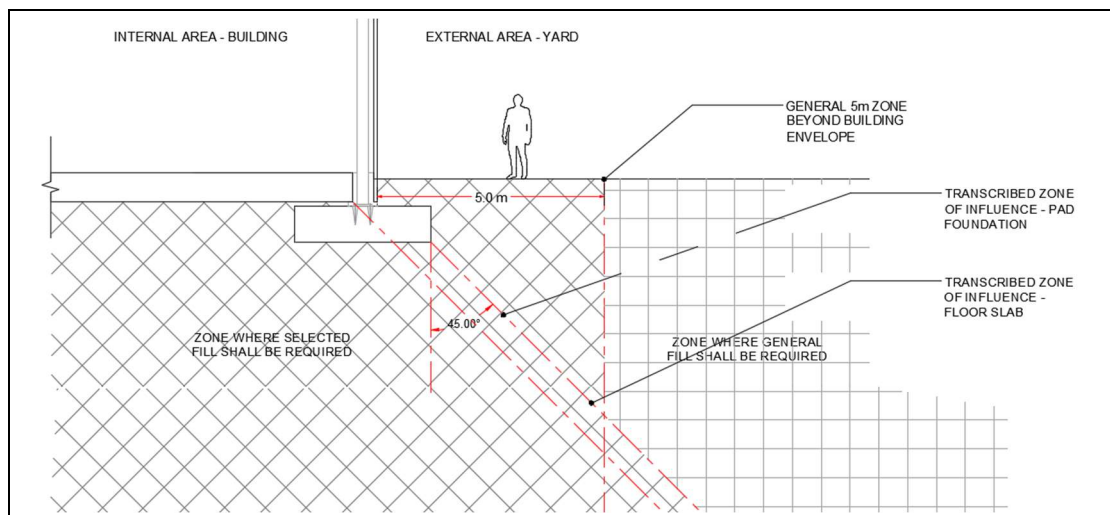


Figure 1-1: Zone of influence from structures where selected fill is required.

- 1.4 The Contractor is responsible for agreeing with the Engineer and BWB the extents of the General Fill and Selected Fill.
- 1.5 The Contractor is directed to the requirements set out in App 6/1 for the acceptability limits for selected fill and App 6/3 for the compaction and demonstration of end product.
- 1.6 Prior to placing blinding concrete at the design foundation level, or immediately prior to filling the excavation where no blinding layer is required, the formation shall be inspected (and tested if deemed necessary during the inspection) by the Contractor in the presence of the Engineer and BWB to confirm that the design assumptions with regard to formation strength have been met as follows:
 - 1.6.1 Visual inspection: to ensure the exposed subgrade is consistent with the design assumptions, and ensure that there is no detritus or standing water present. This shall be accompanied by photographic records, to be included in the Contractors GCR.
 - 1.6.2 Cohesive Soils: by use of a calibrated and correlated shear vane test to prove that the undrained shear strength value at a depth of 0.2m below excavation formation level is greater than the minimum stated on the substructure drawings.

- 1.6.3 Granular Soils: with prior written approval of Hydrock, by use of a Dynamic Probe to prove that the equivalent SPT 'N' value is greater than the minimum stated on the substructure drawings.
- 1.6.4 Dual cycle Static Plate Load Testing using 600mm diameter plate, to the loads defined in Appendix 6/3 and on the drawings and to achieve the associated settlement requirements.
- 1.6.5 The use of dual cycle Static Plate Load testing may be supplemented with the prior agreement of the Engineer and BWB, by the use of the Light Weight Deflectometer (LWD) subject to the LWD being externally calibrated and has been correlated to static plate load testing, on the same fill class and source.
- 1.6.6 Retrospective approval of the LWD will not be possible, and this shall be agreed in writing before the LWD is used as a measure of material compliance.
- 1.7 The tests referred to above shall be taken at representative locations across the formation in accordance with Appendix 1/5 or as directed by the Engineer and BWB. The tests shall undertake using suitably calibrated equipment. Additional tests shall be undertaken at any apparent areas of inadequate strength identified visually by the Client's Representative, the Engineer and/or BWB.
- 1.8 The locations, results and correlation of the equipment used shall be recorded. The Contractor shall keep records of the inspections, testing and any subsequent remedial measures, including the test locations, test values and calibrations of the equipment used. All records shall be presented in the Contractor's GCR, in accordance with App 1/24.

2. FULL SCALE DETERMINATION OF SLOPE STABILITY

- 2.1 Material for use as 'Fill to Structures' does not require full scale determination of slope stability in accordance with Clause 610.6 of SHW (2016) unless this is a specific requirement of the Contractors alternative design or as requested by the Engineer and/or BWB.

APPENDIX 6/7: SUB-FORMATION AND CAPPING AND PREPARATION AND SURFACE TREATMENT OF FORMATION

1. TREATMENT OF FORMATION

1.1 GENERAL REQUIREMENTS

- 1.2 The locations and required thickness of capping and/or sub-base thickness are shown on the Engineer's Drawings.
- 1.3 Cut to fill transitions zones shall be constructed as shown on the Engineer's Drawings, amended as required by the requirement for over-excavation of unsuitable material, and where ground mitigation works are required. This is described in the GDR and as shown on the Drawings.
- 1.4 The general terms used in this Specification, relevant to the sub-formation and capping, are represented in Figure 1-1.

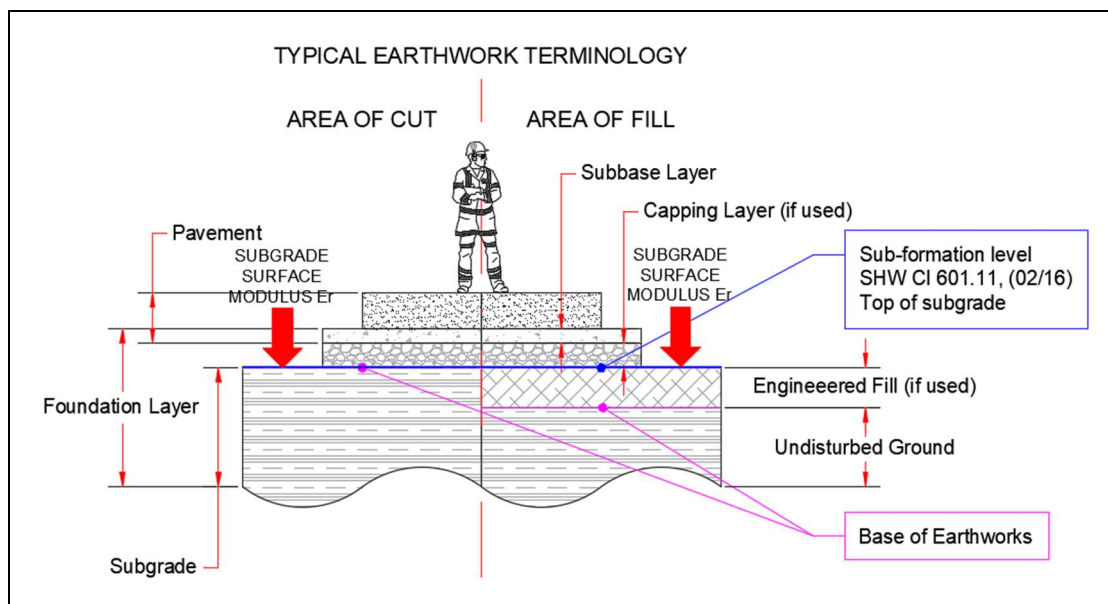


Figure 1-1: Typical earthwork terminology

- 1.5 The Contractor shall agree all areas where over-excavation and replacement are required with the Engineer and BWB.
- 1.6 The Contractor shall provide all survey data and drawing records, as described in App 1/24,
- 1.7 Final preparation of the sub-formation and formation shall only be carried out after installation of the scheduled drainage at that location.
- 1.8 The minimum subgrade surface modulus (E_r), the equivalent Bearing Ratio (CBR) and corresponding undrained shear strength of the subgrade for each location is summarised in the GDR, presented on the Engineer's Drawings and as described in Table 6/1 and App 6/3. Areas of subgrade that are below the minimum shall be improved by the methods shown on the Engineer's Drawings and in accordance with the GDR.
- 1.9 The subgrade surface modulus shall be determined at the frequency defined in App 1/5, as shown on the Drawings and as required by the Engineer and BWB. The Contractor shall test the subgrade to determine the subgrade surface modulus, as defined by DMRB CD 225 Rev 1, using one of the following test methods appropriate to the subgrade material being tested in accordance by:
 - 1.9.1 Dual Cycles Static Plate Load Test (PLT) following the requirements of App 6/3.
 - 1.9.2 Dynamic Plate Load Test using the LWD, correlated to static dual cycle tests, to confirm relationship between dynamic and static plate load test results, in accordance with the requirements of App 6/3.

2. ALLOWED SURFACE LEVEL TOLERANCES

- 2.1 Surface level tolerances shall comply with SHW Clause 616.1 (2016).

3. CAPPING MATERIALS

- 3.1 The permitted capping materials are shown as described in Clause 613.3 of SHW (2016).
- 3.2 Material used within 450mm of the designated final road or external surface level shall not be frost susceptible.

4. PROCEDURE FOR CONSTRUCTION OF CAPPING FOR CUTTINGS AND EMBANKMENTS

- 4.1 The procedures for construction of capping for cuttings and embankments are as stated in Clauses 613.11 and 613.12 respectively of SHW (2016) unless otherwise shown on the Drawings.

5. DEMONSTRATION AREA AND TESTING

- 5.1 The Contractor shall provide a demonstration area to trial the proposed capping materials. If the trial area is outside the location of the permanent works the trial area formation shall be of similar strength and characteristics as to the permanent works formation. The laying and compaction methods used within the trial area shall be the same as those proposed for the permanent works.
- 5.2 The demonstration area may form part of the permanent works but shall only be accepted if the results of testing comply with the Specification.

6. SUB-FORMATION SHAPING

- 6.1 The sub-formation shall be shaped as Clause 613.8 (2016) of SHW unless shown otherwise on the Drawings.

7. MODIFICATION & STABILISATION

- 7.1 Modification and stabilisation is may be permitted and will require the prior written approval of the Client/Client's Representative, the Engineer and BWB and supported by appropriate testing undertaken to demonstrate that the maximum permissible TPS is not exceeded.
- 7.2 Reference shall be made to the requirements set out in Appendix 6/1 where the use of hydraulic binders is being considered, irrespective of the purpose of the treatment.

8. TREATMENT OF FORMATION

- 8.1 Treatment of soft spots shall be completed prior to final preparation of sub-formation.
- 8.2 Replacement of soft materials, to formation level, shall be with either additional approved Class 6F Selected Capping Material or Type 1 subbase or as agreed with the Engineer and BWB, using selected granular material and an appropriate geosynthetic reinforcement.

8.3 Areas of formation that do not have a surface tolerance within the limits stated in Clause 616.1 of SHW (2016) are to be excavated to depths given on the Drawings and infilled with either additional approved capping or as agreed with the Engineer and BWB using selected granular material with geosynthetic reinforcement.

8.4 Details and locations of formation treatment and removal of soft material are to be kept by the Contractor and presented in their GCR in accordance with APP 1/24.

9. RATE OF SPREAD OF HYDRAULIC BINDERS

9.1 Notwithstanding the general requirement on the use of binders is not permitted without prior written approval, if treatment is accepted then the testing for the rate of lime spreading shall be in accordance with Clause 615.6 of SHW (2016).

10. CHEMICAL ANALYSIS REPORTS

10.1 Notwithstanding the general requirement that the use of binders is not permitted without prior written approval, if treatment is accepted then chemical analysis reports for 'available lime' are to be provided weekly in accordance with Clause 615.4 of SHW (2016).

11. PREPARATION OF FORMATION ON EXISTING SUB-BASE MATERIAL

11.1 Preparation of formation on existing sub-base material shall be in accordance with Clause 616 of SHW (2016).

12. REQUIREMENTS FOR CEMENT TYPE IN LIME AND CEMENT STABILISATION

12.1 Notwithstanding the general requirement that the use of binders are not permitted without prior written approval, if treatment is accepted then the level of sulphates is to be confirmed before the use of hydraulic binders can be approved.

12.2 Modification and stabilisation shall not be undertaken without the prior written approval of the Client's Representative, the Engineer and BWB.

13. REQUIREMENTS FOR ALTERNATIVE THICKNESS OF LAYERS TO BE STABILISED

13.1 Notwithstanding the general requirement that the use of binders is not permitted without prior written approval, if treatment is accepted then the layer thickness shall comply with the requirements of Clause 643.9 of SHW (2016).

14. ALTERNATIVE TREATMENT REQUIREMENTS FOR LAYERS TO BE STABILISED

14.1 Notwithstanding the general requirement that the use of binders is not permitted without prior written approval, if treatment is accepted then the treatment of layers to be stabilised shall comply with the requirements of Clauses 643.10 and 643.16 of the SHW (2016).

APPENDIX 6/8: TOPSOILING

1. GENERAL

- 1.1 Topsoiling shall be carried out using Class 5 material complying with App 6/1, Table 6/1 and in accordance with the requirements of the Landscape Architects Landscape Scheme, presented under a separate cover.
- 1.2 The topsoil depth shall be as specified in the Landscape Scheme and in accordance with the Landscape Architects plans and specifications.
- 1.3 Unless otherwise instructed by the Landscape Architect, imported topsoil shall comply with BS 3882:1994, General Purpose Grade.
- 1.4 No topsoil shall be supplied from any source until a sample of the topsoil from each source has been inspected and approved by the Landscape Architect or the Client's Representative, Engineer or BWB. All topsoil supplied must be of the same quality as the approved sample(s).
- 1.5 Topsoil shall be spread, graded and consolidated by hand or mechanical means.
- 1.6 Reference shall be made to App 6/3 for the benching in of fill materials and the preparation of the subgrade ready to receive topsoil.
- 1.7 The methodology for preparing the subgrade to receive topsoil shall be demonstrated by on-site trials, with the Engineer, BWB and the Landscape Architect in attendance, before any permanent works are undertaken.
- 1.8 The findings from the demonstration trial shall be encapsulated in the Contractor's RAMS and shall be subject to agreement, in accordance with App 1/24, before any permanent placement of topsoil is undertaken.
- 1.9 Deposition of the topsoil shall be undertaken strictly in accordance with the Landscape Architects design and specification.
- 1.10 Any materials deemed unsuitable by the Client's Representative, the Engineer, BWB or the Landscape Architect, that are brought to the surface by the spreading, grading and consolidation of topsoil shall be collected up disposed of offsite, in accordance with the requirements of Appendix 6/2.
- 1.11 Top soiled areas shall not be traversed by machinery or used for storage purposes.

APPENDIX 6/9: EARTHWORK ENVIRONMENTAL BUNDS, LANDSCAPE AREAS & STRENGTHENING EMBANKMENTS

1. EARTHWORK ENVIRONMENTAL BUNDS

1.1 Location and types of construction

- 1.2 Requirements for Earthwork Environmental Bunds are shown on the Drawings.
- 1.3 Earthwork Environmental Bunds are to be constructed of materials as detailed in the GDR and as shown on the Drawings.
- 1.4 Environmental Bunds that are to be topsoiled are shown on the Drawings and in agreement with the requirements of the Ecological Consultant and the Landscape Plan, presented under a spate cover.
- 1.5 imported topsoil shall comply with the requirements for General Purpose in accordance with BS 3882.

2. LANDSCAPE AREAS

2.1 Locations

- 2.2 Locations of Landscape Areas are shown on the Drawings.

2.3 Requirements for Compaction

- 2.4 Class 4 material shall be compacted in accordance with Clause 620 of SHW and as defined in the Landscape Plan.

2.5 Construction requirements

- 2.6 Construction requirements and contouring of Landscape Areas are as detailed in the GDR, designs prepared by Specialist Designers, Contractors approved RAMSA and as detailed on the Drawings.

2.7 Construction Constraints

- 2.8 The following constraints, requirements and restrictions shall be included in RAMS for the construction of environmental bunds, landscape bunds and strengthened earthworks and shall be complied with and detailed in the Contractor's Quality Plan and Method Statements, defining how each item shall be complied with, including the provision of records to be included in the Contractors Validation report.
- 2.9 The guidance provided for the construction of landscape bunds shall be considered in the development of other RAMS for associated earthwork activities, in particular if the Consequence Class and consequence of failure of the earthworks is considered to be above CC1.

- 2.10 Direction of travel

- All plant shall operate in a direction parallel to the face of the slope and/or crest and shall not traverse the face of the slope from toe to crest.
- 2.11 Speed of operation of plant
- The maximum permitted speed of dumpers within the landscape bund shall be 5 mph or 8 kph.
 - The maximum permitted speed of dozers operating within the landscape bund shall be 3 mph or 5 kph.
 - The maximum operating speed of compaction plant within the landscape bund shall be 3mph or 5kph.
- 2.12 Before any fill material can be placed:
- The underlying layer of material shall be demonstrated to have an equivalent undrained shear strength more than the minimum defined in the GDR and accompanying Earthwork Specification, using the approved methodology and/or an equivalent subgrade stiffness modulus before the placement of the next layer of fill.
- 2.13 Maximum number of layers permitted to be placed during a single working day
- The maximum number of layers which may be placed during a single working day, at any given location within the earthworks shall be 2.
- 2.14 Maximum increase in level before mandatory Hold Point
- A maximum increase in ground level of 1.5m is permitted (commensurate with the frequency of plate load testing), before a mandatory hold point of 14 days is observed, unless otherwise agreed in writing with BWB.
 - The hold point may need to be increased, subject to inspection by BWB, before the re-commencement of fill placement
- 2.15 Constraint on type of plant.
- All plant to be used shall be detailed in the Contractor's RAMS, and only approved plant shall be used.
- 2.16 Leachate and surface water management.
- A daily inspection shall be undertaken to identify any areas of standing water and/or leachate on the top of the earthworks.
 - Where observed, the liquid shall be collected that day and dealt with, as part of the site wide water management strategy
- 2.17 Monitoring
- All geotechnical monitoring shall be undertaken in strict accordance with App 6/12
 - All geotechnical monitoring data shall undergo a formal review before the commencement of fill placement.
- 2.18 Compaction records to be provided in accordance with BS EN 16907-5: 2018: Clause 7.2.
- 2.19 Requirements for topsoiling
- The requirements for topsoil of the Landscape Areas are shown on the Drawings and in the Landscape Plan

3. Strengthened embankments

- 3.1 Location
 - 3.1.1 The location of strengthened embankments are detailed in the GDR and as shown on the drawings.
 - 3.1.2 Where strengthened earthworks are required, reference shall be made to the Special Geotechnical Measures Form (SGMF) as defined by DMRB CD 622 and BS EN 1997-3:2025 document shall be prepared, and this shall set out the design requirements.

APPENDIX 6/13: GROUND IMPROVEMENT VIBRO-REPLACEMENT STONE COLUMNS (VSC)

1. INTRODUCTION

1.1 Objective of Treatment

1.2 The treatment shall be designed to provide a minimum bearing resistance of 125 kN/m² to support the construction of landscape bunds, and stabilise the landform, to control differential settlements to better than 1:500, over a minimum 60 year design life.

1.3 Where the treatment is to be undertaken below landscape bunds, the limit on total settlement post construction shall be 50mm, for other areas, including the car-park, this shall be reduced to 25mm.

1.4 Method of Treatment

1.5 It has been assumed that the Specialist Contractor would employ dry, bottom feed techniques, and that full depth treatment of the identified compressible ground is required.

1.6 The Specialist Contractor shall confirm the method of installation and depth of treatment as part of their technical design and submission.

1.7 Design Requirements

1.8 Detailed design of the Vibro-replacement Stone Columns (VSC) shall be undertaken by the Specialist Contractor and shall be provided in writing for prior approval before the commencement of site works and this shall include all Risk Assessment & Method Statements (RAMS) and Drawings required to complete the Works in accordance with the Design.

1.9 The Contractor shall supply all necessary equipment and materials and perform all operations for the installation of VSC in accordance with the details shown on the Drawings and detailed in the VSC Design.

1.10 The Contractor shall provide the Design of the VSC ground treatment to the Engineer and BWB, for agreement before works commence.

2. VIBRO-REPLACEMENT STONE COLUMN DESIGN

2.1 The Contractor is required to provide the VSC Design, and this shall include their Specification for the works and all necessary Drawings and Method Statements, prepared in accordance with BRE BR391.

2.2 The VSC Design prepared by the Specialist Contractor shall include, but not be limited to, the following information:

2.2.1 A statement on the technical objective of the treatment.

2.2.2 the target performance which the treatment is to achieve, including:

- The minimum permissible bearing capacity, as defined by BS EN 1997 and BS 8004.

- The maximum acceptable total settlement.
 - The acceptable magnitudes of differential settlement.
- 2.2.3 Detailed Method statements (RAMS) on how the works will be completed.
- 2.2.4 The installation method (dry, bottom feed, full depth) to be adopted and written confirmation that due regard has been given to the ground and groundwater conditions.
- 2.2.5 What actions are to be taken if ground heave occurs during installation.
- 2.2.6 Written confirmation that any subsequent changes in ground level have been evaluated and included in the design.
- 2.2.7 Written confirmation that any adverse effects on existing foundation systems, building, earthworks or buried structures have been considered, evaluated and addressed by the design;
- 2.2.8 The design shall demonstrate by calculation, using an agreed methodology, that the spacing and layout of the stone columns fulfils the requirements for minimum bearing capacity, total and differential settlement criteria appropriate to the foundation solution and shall include.
- The technical criteria on which treatment depth is to be decided;
 - For full-depth treatment, the competent stratum shall be identified for each column or group of columns.
 - The minimum diameter of the VSC to be achieved.
 - The minimum stiffness for the VSC to be achieved;
 - The critical depth at which maximum bulging could occur; and
 - The maximum permissible column load.
- 2.2.9 The source of materials to be used in the construction of the VSC, and written confirmation through the provision of appropriate testing and supporting Method Statements that the materials are suitable, including:
- That they are suitable for be used to form the columns, including grading and angularity.
 - That they are 'hard' with an appropriate LA coefficient defined by the VSC Design.
 - That they are chemically inert, and on what basis this statement has been made.
 - That they will be stored so as to remain fit for purpose before they are used.
 - That they will remain stable during the column construction.
 - That they will remain stable during the working life, in he anticipated ground water conditions.
- 2.2.10 Written procedures on how the works will be undertaken, and that this is in full accordance with the requirements of the Specification.
- 2.2.11 Written confirmation of who will be responsible for the installation of the Working Platform and provision of the Federation of Piling Specialists (FPS) Rig Loading Certificate for the tracked plant to be used, in accordance with the requirements of BRE BR470.

- 2.2.12 All necessary drawings which will be required to undertake the work, including:
- The VSC layout for each zone, including the setting out details.
 - The site working levels.
 - The maximum gradient which can be tolerated by the site plant, including tracked machines.
- 2.2.13 Method Statement detailing actions to be employed should hard obstructions be encountered.
- 2.2.14 Method Statement detailing actions to be taken and methodology to be used should pre-boring be required.
- 2.2.15 Written confirmation on the location tolerance for each VSC, and unless otherwise agreed this shall be 150mm, and that where a VSC is more than 150mm it shall be re-installed at the correct location.
- 2.2.16 Method Statement detailing what actions are to be taken should the poker deviate by more than 1:20 during column formation.
- 2.2.17 The method of recording the volume of stone used in forming the column, the acceptable variation in stone used for columns of the same length and what actions will be taken where the variation is too great.
- 2.2.18 Whether or not re-grading and rolling will be required based upon the foundation level being a minimum 600mm below the level from which treatment was undertaken.
- 2.2.19 A template of how the daily records will be presented, to be approved, and to include, but not limited to, the following details:
- The unique stone column reference, consistent with the Design Drawings.
 - The date and time of column construction.
 - The method of treatment and plant type.
 - The depth of penetration at each column location.
 - The quantity of stone used in each column, and whether or not this was within the acceptable variation range.
 - The presence or otherwise of ground heave (plus estimate if detected).
 - The vibrator power consumption during penetration.
 - The vibrator power consumption during compaction.
 - The presence of any recorded obstructions and delays;
 - Any unforeseen conditions encountered.
 - The results of any testing undertaken, including plate load tests, skip tests and dummy foundation tests.
- 2.2.20 The Specification shall state the type and frequency of testing to be undertaken, which shall be agreed with the Engineer and BWB, and include, but not be limited to, as a minimum:
- 600mm diameter plate test per day of treatment per VSC rig.
 - 600mm diameter plate load test on each and every column where the stone up-take was outside of the stated tolerable limits stated in the Specification.
 - As requested by the Client/Client's Representative, the Engineer or BWB.

- 2.3 The VSC Design, including all Method Statements and Drawings, shall be submitted for prior approval before the commencement of any site works. The Contractor must account for approval by the Engineer and BWB to be sought before commencement on site, within their program of works.
- 2.4 The minimum target performance for the treatment is stated in Section 1.1. The VSC Design shall describe the manner in which the treatment will improve the particular ground conditions across the site
- 2.5 The maximum permissible deviation at the point of installation between centres of stone columns shall not exceed the required spacing by 150 mm in any direction.
- 2.6 The post treatment performance requirements for settlement and/or strength/density are to be shown on the Drawings by the VSC Designer.

3. BASIS OF DESIGN - PERFORMANCE EVALUATION

- 3.1 The VSC Design is to include the calculated load bearing capacities and settlement of the treated ground. These shall comply with the specified requirements and based upon the nature, extent and magnitude of the load application and stated tolerances for post construction movements, provided by the designer of the supported structure.
- 3.2 The information on line loads and assumed permissible bearing pressure shall be sourced by the Specialist Contractor from the Engineer and BWB

3.3 Changes in Ground Level

- 3.4 The VSC Design shall include any additional change in imposed load from any change in ground level, including any earthworks cut to fill required to prepare the site.

3.5 Adverse Effects

- 3.6 Vibro Designer of the Vibro Works is to consider any adverse effects the vibro treatment may have on existing adjacent foundation systems, buildings, earthworks and buried structures. Where potential adverse effects of subsequent construction activities on the vibro ground treatment have been considered and identified, then a detailed Method Statement from the Vibro Designer, included as part of the VSC Design, shall be provided.

3.7 Treatment Layout

- 3.8 The VSC Design shall demonstrate by calculation that the spacing and layout of stone columns fulfils the requirements for minimum bearing capacity and total and differential settlement criteria for each structure to be supported and its foundation system.
- 3.9 The layout and spacing of the columns shall be clearly shown on the VSD Design Specification Drawings and each VSC to be clearly numbered for reference, and neither the location nor spacing shall be varied without the prior agreement of the Vibro Designer.

3.10 Treatment Depth

- 3.11 The technical criteria on which the treatment depth has been selected is to be stated within the VSC Design

3.12 Full Depth Treatment

- 3.13 The geotechnical assessment has identified that full depth treatment is required and that the Vibro Designer shall, as part of the formation of the VSC Design, confirm that this method is appropriate and identify for each column or group of columns the depth to the competent strata. Site records are to detail both the depth to the competent strata derived from the geotechnical review and design calculations and the actual depth of treatment achieved during VSC installation.

4. MATERIALS

4.1 Material Suitability

- 4.2 As part of the formation of the VSC Design, the Vibro Designer is to provide details on the materials to be used for the construction of the stone columns and demonstrate through appropriate test results that the material is suitable for the intended use. The material shall be hard, chemically inert and to remain stable during column construction and working life in the anticipated ground water conditions.

4.3 Material Grading

- 4.4 The VSC Design shall include the requisite grading envelope for the material to be used in the column construction. As the VSC will be bottom fed, the appropriate grading of the material will be governed by the equipment to be used, and shall be able to flow freely through the bottom feed delivery system without arching. Upon compaction, the material is to form a dense column fully interlocked with the surrounding ground.

4.5 Supply and Storage

- 4.6 Appropriate Method Statements are to be provided by the Vibro Designer within the VSC Design which will demonstrate that the material to be used shall be specified and be suitable for the equipment to be used. In addition to this, should the source of the material change then the Vibro Designer is to informed immediately this is known and written confirmation provided by them that the alternative source is acceptable.
- 4.7 The Vibro Designer or Contractor are also to provide an appropriate Method Statement detailing how the material is to be stored on site, prior to use, in such a manner as to ensure that the material remains fit for purpose.

5. EXECUTION OF TREATMENT

5.1 Compliance

- 5.2 Works are to be undertaken by the Contractor in accordance with the written procedures, Method Statement and VSC Design to ensure compliance with the stated requirements. Documentary evidence, including site records, are to be provided by the Contractor in order to demonstrate compliance with the specification and shall include, as a minimum, the information detailed in Section 2.2.

5.3 Working Platform

- 5.4 The Contractor or Vibro Designer are required to state whether or not a Working Platform is required to be provided for them. Should a Working Platform be required, the design of this shall be undertaken in accordance with the guidance from BRE BR470, and the Contractor is to provide the rig loadings in accordance with this document as part of the VSC Design.

5.5 Where the Working Platform is to be pre-installed before mobilisation of the Contractor's equipment, the design, construction and maintenance will be undertaken strictly following the guidance from BRE BR470.

5.6 Where the Contractor is to provide their own Working Platform, they are deemed to have followed strictly the guidance from BRE BR470 unless otherwise stated within the VSC Design and with prior written the agreement of the Engineer.

5.7 Working Levels

5.8 The VSC Design shall detail the site working levels required by the Working Platform and clearly state the maximum gradient which can be tolerated by the site plant, including tracked machines.

5.9 Site working levels and the Working Platform shall be maintained throughout the duration of the Works, in accordance with the guidance and recommendations from BRE BR470. Unless otherwise stated and agreed, the party which installed the Working Platform shall maintain the Working Platform although it is the responsibility of the Contractor to clearly state who they believe will be responsible for this work. In the absence of this clear statement and agreement, the Contractor shall be responsible for the Working Platform.

5.10 Near Surface Obstructions

5.11 Where near surface obstructions have been identified, they shall be broken out prior to the commencement of the vibro works, and the resulting void filled with granular material which can be penetrated and compacted by the vibrating poker. Unless otherwise stated in the VSC Design, the Contractor is responsible for the removal of near surface obstructions.

5.12 Setting Out

5.13 Setting out shall be carried out by the Contractor from established grid lines and maintained for the duration of the vibro works.

5.14 The Contractor is responsible for setting out their Works in accordance with the Drawings and the VSC Design. Immediately before treatment, each stone column position shall be clearly marked with a suitable identifiable pin or marker. All stone columns shall be carefully set out to the plan position shown on the contract layout drawings for the vibro works.

5.15 Pre-boring

5.16 The Vibro Designer shall provide an appropriate Method Statement identifying the ground conditions where pre-boring may be required and the method and sequence of works to be undertaken should it be required.

6. TREATMENT

6.1 Location Tolerance

6.2 Stone columns are to be installed within 150mm of the position shown on the contract drawings for the vibro works.

6.3 Verticality

- 6.4 Stone columns shall be constructed as near to vertical as possible. The poker shall not deviate by more than 1 in 20 during column formation. The Vibro Designer is to provide a Method Statement detailing what remedial actions are to be taken should the poker deviate by more than 1 in 20, and this shall be included within the VSC Design.

6.5 Depth Variation

- 6.6 Any variation in depth of stone columns due to site conditions not anticipated in the design shall be reported immediately to the Vibro Designer. The Vibro Designer shall include calculations identifying the depth for each column or group of columns as part of the VSC Design and this information is to be recorded on the Drawings and the daily site records.

6.7 Removal of Obstructions

- 6.8 Unforeseen obstructions encountered below ground level shall be reported immediately to the Client's Representative, the Engineer, BWB and the Vibro Designer. The Vibro Designer shall agree whether or not the obstruction is to be removed. Where it is decided to remove the obstruction, the void shall be backfilled with granular material which can be penetrated and compacted by the vibrating poker.

6.9 Stone Quantities

- 6.10 The Vibro Designer shall, as part of their calculations, identify both the anticipated quantity of stone to be used for each column length and quantify the tolerable variation in stone volume. Significant variation in the quantity of stone used for columns of similar length shall be reported immediately to the Engineer and BWB and the Vibro Designer.
- 6.11 The Vibro Designer shall provide a Method Statement as part of the VSC Design as to what actions may be taken should significant variation in the quantity of stone occur. This shall include, as a minimum, the requirement to undertake a plate load test using a 600mm plate on each column which is outside the tolerance for stone used.

6.12 Contamination of Stone Column

- 6.13 The Method Statements produced as part of the VSC Design shall include details on what care is to be taken to ensure lumps of spoil are not allowed to fall into the hole and contaminate the stone column.

6.14 Compaction close to ground

- 6.15 The formation of structural foundation or new earthworks shall be a minimum of 600mm below the level from which treatment was carried out or, where this is not possible, provide a detailed Method Statement within the VSC Design describing what additional works will be required.

6.16 SITE RECORDS

- 6.17 As detailed and described in Section 2.2, the VSC Design shall include an approved template for the recording of daily activities, and shall as a minimum, but not limited to, contain the following details:
- Unique stone column reference, consistent with the Design Drawings.
 - The date and time of column construction.
 - Method of treatment and plant type.

- Depth of penetration at each column location.
- Quantity of stone used in each column, and whether or not this was within the acceptable variation range.
- Presence of ground heave (plus estimate if detected).
- Vibrator power consumption during penetration.
- Vibrator power consumption during compaction.
- Obstructions and delays.
- Any unforeseen conditions encountered.
- Results of any testing undertaken, including plate load tests, skip tests and dummy foundation tests.

7. TESTING

7.1 General

7.2 The Vibro Designer, shall state within the VSC Design, the type and frequency of testing which is to be undertaken for this project.

7.3 Quality Control

7.4 The Vibro Designer is responsible for identify and detailing a range of suitable tests to be completed as part of the vibro works, in order to ensure consistency in workmanship. The test method, frequency of testing and criteria for acceptance are to be agreed between the Vibro Designer, the Engineer and the NHBC prior to the commencement of the site works.

7.5 This shall include as a minimum, but not be limited to, the following:

- Column plate tests using a 600mm diameter plate test per day of treatment.
- Column plate tests using a 600mm diameter plate load test on each and every column where the stone up-take was outside of the stated tolerable limits stated in the VSC Design.
- As requested by the Client/Client's Representative, the Engineer or BWB.

- 7.6 The loading criteria and duration of loads to be used for the column plate load tests are to be defined by the Vibro Designer and agreed, in writing, by the Engineer before the commencement of site works.
- 7.7 The column plate load tests shall be carried out using a nominal 600mm diameter plate, placed concentrically on individual columns loaded in agreed increments with the settlement of the plate measured against a stable reference beam.
- 7.8 It is recommended that the Vibro Designer considers the use of dual plate load tests, as described in App 6/3. In the conceptual assessment, a minimum column stiffness of 50 MPa had been adopted.
- 7.9 The use of dual cycle testing will ensure that any movement due to lower compaction within the upper portion of the column will be removed, and the measurement of stiffness can be based on the long-term condition.
- 7.10 Table 7-1 presents the typical loads and associated rate of settlement, necessary to assess the column stiffness, based on an assumed minimum target of 50 MPa.
- 7.11 The calculation of the column stiffness is recommended to follow the Plate settlement modulus equation, from BS EN 1997-2:2007: Annex K.2, for records from the second load cycle, between the stress range of 0 kPa and 150 kPa, where a settlement of less than 1.25mm should return a plate settlement modulus of at least 50 MPa.

Table 7-1: Dual Cycle Plate Load Test for Conformation of the Column Stiffness and Permissible Bearing Pressure

Load & Pressure Increment Details		Maximum permissible rate of movement before next load increment applied	Settlement requirements and maximum permissible settlement where relevant
Load Reference	Applied Stress [kPa]		
Seating Load	25 kPa	≤ 0.02 mm/min	Declared
Reset before 1 st Load Cycle	0 kPa	< 0.02 mm/min	Declared then reset to 0mm
Increment 1-1	75 kPa	< 0.02 mm/min	Declared
Increment 1-2	150 kPa	< 0.02 mm/min	Declared
Increment 1-3	225 kPa	< 0.02 mm/min	Declared
Increment 1-4	300 kPa	< 0.02 mm/min	Declared
Increment 1-5	375 kPa	< 0.02 mm/min	Declared
Increment 1-6	450 kPa	< 0.02 mm/min	Declared
Reset before 2 nd Load Cycle	0..0 kPa	< 0.02 mm/min	$\leq 0.50 \times$ max settlement at 1-6
Reset settlement Gauge	0 kPa	0.00 mm	Dial reset to 0.00 mm
Increment 2-1	75 kPa	< 0.02 mm/min	Declared
Increment 2-2	150 kPa	< 0.02 mm/min	≤ 1.25 mm
Increment 2-3	225 kPa	< 0.02 mm/min	Declared
Increment 2-4	300 kPa	< 0.02 mm/min	Declared
Increment 2-5	375 kPa	< 0.02 mm/min	Declared
Increment 2-6	450 kPa	< 0.02 mm/min	Declared

7.12 Performance Testing

- 7.13 Suitable test methods shall be defined by the Vibro Designer, and agreed with the Engineer and BWB, and used to verify that the VSC treatment has achieved the pre-determined criteria set out in the contract documents and defined in the VSC Design.
- 7.14 The Vibro Designer shall ensure that the proposed testing is appropriate for the amount of treatment, variability in the ground conditions, type of foundation, depth of ground loaded and any other relevant factors.

7.15 Load Tests

- 7.16 It is not anticipated that largescale load zone tests would be required, unless site observations of the response of the ground, or significant variation in installed VSC length or volume of material identify areas of concern.
- 7.17 Where required and agreed between the Vibro Designer, the Engineer and BWB, large scale loads tests shall be carried out. The VSC Design is subject to prior approval of the Engineer and BWB, and the Contractor and the Vibro Designer must recognise that additional requirements may be placed upon once the design has been submitted for approval.

7.18 Large Plate Load Tests.

- 7.19 Large plate load tests, where required, shall be carried out by loading a rigid plate or cast in situ concrete pad, large enough to span one or more columns and the intervening ground.

7.20 Zone Load Tests

- 7.21 Zone tests, where required, shall be carried out by loading a much larger area of treated ground, usually by constructing and loading a full-sized foundation or placing earth fill to simulate widespread loads.

7.22 Penetration tests

- 7.23 Where required by the VSC Design, *in situ* penetration tests shall be used where changes in ground properties due to VSC treatment can be measured and directly related to criteria set out in the contract documents and the VSC Design, or to pre-treatment data obtained using the same technique.
- 7.24 One or more of the following tests may be carried out, subject to prior approval of the Engineer and BWB:
- Standard Penetration Tests (SPT) carried out at specific depths to determine the penetration resistance of treated ground between columns;
 - Dynamic Probing (DP), carried out to provide a record of the penetration resistance of treated ground between columns; and
 - Static Cone Penetrometer Test (CPT) carried out at to provide a continuous record of penetration resistance of treated ground between stone columns.

7.25 The site at Upton has been the subject to detailed assessment using CPT's as part of the previous ground investigation and this could be adopted by the Vibro Designer, subject to prior approval.

7.26 REPORTING

7.27 The number and types of test and their locations and depth shall be recorded. Signed copies of these records and the test results shall be submitted as required by the contract.

Benniman Construction Group Ltd
Dove Valley Park
Miry Lane, Dove Valley Park, Foston

Geotechnical Design Report

Dove Valley Park
Miry Lane, Dove Valley Park, Foston
Geotechnical Design Report

Birmingham
Livery Place, 35 Livery Street, Colmore Business District, Birmingham, B3 2PB
T: 0121 233 3322

Leeds
Whitehall Waterfront, 2 Riverside Way, Leeds
LS1 4EH
T: 0113 233 8000

London
11 Borough High Street
London, SE1 9SE
T: 0207 407 3879

Manchester
11, Portland Street, Manchester M1 3HU
T: 0161 233 4260

Nottingham
Waterfront House, Station Street, Nottingham NG2 3DQ
T: 0115 924 1100

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1. INTRODUCTION

BWB Consulting Ltd (BWB) had been appointed by Benniman Construction Group Ltd (BCG) to assist them in providing geotechnical advice with respect to the proposed development identified as Dove Valley Park. The specific development areas is also known as Miry Lane, Dove Valley Park, Foston.

The ultimate Client for the development is Clowes Developments UK Ltd (Clowes). Clowes had appointed Jackson Purdue Lever (JPL) as the Civil Engineer for the scheme, with an understanding that JPL would also be acting as the Structural Engineer.

A number of documents have been provided to BWB for review, including the following sources of information.

- Site Investigation Report, Dove Valley, Foston. Reported prepared by Lucion Ground Engineering Ltd, on behalf of Clowes Developments UK Ltd, document reference 118613-Rev 0 (Draft) dated April 2025, updated to Rev 1 and re-issued in July 2025.
- Base Build Specification, Unit 11C, Dove Valley Park, 450,000 sq ft. Document prepared by Clowes Developments UK Ltd, Revision 1, dated 17th April 2024.
- AutoCAD Topographical Survey. Document reference 43317A_T_REV3 3D. Document provided by electronic link from Jackson Purdue Lever.
- AutoCAD model of proposed earthworks, including earthwork isopach indicating proposed cut to fill requirements. Document reference 002949-JPL-ZZ-ZZ-D-C-1101-S2-P03 Earthworks Assessment. Document provided by electronic link from Jackson Purdue Lever

Following an initial review by BWB, a series of Technical Design Notes (TDN) have been prepared, including this document. In support of this TDN, the following documents should be reviewed:

- 255659-BWB-ZZ-XX-TDN-GE-4001-S1-P01: Geotechnical review
- 255659-BWB-ZZ-XX-TDN-GE-4002-S2-P01: Post CPTu investigation geotechnical review and proposed ground strategy.
- 255659-BWB-ZZ-XX-TDN-GE-4003-S2-P02: Enabling Earthworks & Ground Improvement.

Document 255659-BWB-ZZ-XX-TDN-GE-4001, presented a review of the geotechnical data, and helped inform a design investigation, utilising static Cone Penetrometer Tests (CPTu) using a piezocone.

Document 255659-BWB-ZZ-XX-TDN-GE-4002 presented a review of the design investigation using the CPTu records, updated the Ground Model (GM) and Geotechnical Design Model (GDM) and developed a scope of works appropriate to complete the Enabling Works.

Document 255659-BWB-ZZ-XX-TDN-GE-4003) presents the geotechnical design for the Enabling Works and is accompanied by an Earthwork Specification and a series of drawings.

The content of the above three listed TDN's are considered to form the Geotechnical Design Report (GDR) in conjunction with the Ground Investigation Report (GIR) document 118613-Rev 1, as defined by BS EN 1997-1:2004+A1:2013 to cover the earthworks and ground improvement to be completed as part of the Enabling Works

Copies of the the TDNs are provided under this cover.

BWB Technical Design Note: 22569-BWB-ZZ-XX-TDN-GE-4001

BWB Technical Design Note: 22569-BWB-ZZ-XX-TDN-GE-4002

BWB Technical Design Noe: 22569-BWB-ZZ-XX-TDN-GE-4003

GEOTECHNICAL REVIEW

3rd June 2025

Project Name:	Dove Valley Park
Project No:	255659
Revision:	P01
Reference:	255659-BWB-ZZ-XX-TDN-GE-4001-S1-P01.1
Author:	Ian Gardner
Reviewer	
Approver:	

1. INTRODUCTION

BWB Consulting Ltd (BWB) had been appointed by Benniman Construction Group Ltd (BCG) to assist them in providing geotechnical advice with respect to the proposed development identified as Dove Valley Park. The specific development areas is also known as Miry Lane, Dove Valley Park, Foston.

The ultimate Client for the development is Clowes Developments UK Ltd (Clowes). Clowes had appointed Jackson Purdue Lever (JPL) as the Civil Engineer for the scheme, with an understanding that JPL would also be acting as the Structural Engineer.

A number of documents have been provided to BWB for review, including the following sources of information.

- Site Investigation Report, Dove Valley, Foston. Reported prepared by Lucion Ground Engineering Ltd, on behalf of Clowes Developments UK Ltd, document reference 118613-Rev0 (Draft) dated April 2025.
- Base Build Specification, Unit 11C, Dove Valley Park, 450,000 sq ft. Document prepared by Clowes Developments UK Ltd, Revision 1, dated 17th April 2024.
- AutoCAD Topographical Survey. Document reference 43317A_T_REV3 3D. Document provided by electronic link from Jackson Purdue Lever.
- AutoCAD model of proposed earthworks, including earthwork isopach indicating proposed cut to fill requirements. Document reference 002949-JPL-ZZ-ZZ-D-C-1101-S2-P03 Earthworks Assessment. Document provided by electronic link from Jackson Purdue Lever.

The content of this Technical Design Note (TDN) has been prepared on behalf of BCG, to assist them in understanding the likely geotechnical solution required for the development. It is noted that within the Site Investigation report (GIR, document reference 118613-Rev0), that the authors of the report had identified specific geological sequences present on site, that they considered unsuitable for a founding stratum. In addition to the suitability or otherwise of specific strata to support new structures, consideration has to be given to the implications of the required earthworks cut to fill, and the potential for excessive settlement to occur where new fill is placed over potentially compressible deposits.

This TDN includes a resume of the review of the currently available geotechnical information, identifies a potential ground improvement strategy, and presents a scope of recommended supplementary design investigation intended to remove as far as possible, any uncertainties in the optimum solution for the site.

As required by the Base Build Specification, all geotechnical designs have to be completed in accordance with all current codes of practice and British Standards. For the purpose of this review, the following standards represent the current UK code for geotechnical design have been adopted:

- BS EN 1997-1:2004+A1:2013: Geotechnical Design, general rules.
 - Reference has also been made to the second generation of BS EN 1997-1: 2024, BS EN 1997-2:2024 & BS EN 1997-3:2025, which whilst not formerly adopted until March 2028, do provide an enhancement of the geotechnical design process and the required content for a Geotechnical Design Report.
 - This standard requires each geostructural element to be given a Geotechnical Category (GC), with earthworks and embankments defined as GC 2.
 - This standard requires the preparation of a Geotechnical Design Report (GDR), where the qualitative and quantitative findings of the geotechnical design process are to be presented, along with the necessary drawings, specifications and schedule of monitoring and inspection.
 - The GDR is to be prepared once the appointment of the contractor is made and shall be specific to the geotechnical elements to be constructed, including earthworks, ground improvement and any associated retaining walls.
 - The content of the GDR is now defined in BS EN 1997-3:2025, which whilst not to be formerly adopted until March 2028, is considered to be relevant where no other form of report structure has been given. The structure of the report should also be cognisant of the guidance provided in DMRB CD 622, as advised by BS 6031.
- BS EN 1997-2:2007: Geotechnical design, ground investigation and testing.
- BS 6031:2009: Code of practice for earthworks.
 - This standard is subservient to BS EN 1997
- BS EN 16907:1 2018 to BS EN 16907-5:2018, Earthworks
 - This series of standards covers the preparation of the earthwork specification, following the requirements of BS EN 1997 and BS 6031.
 - As defined by BS 6031 & BS EN 16907, the basis for the earthwork specification would be the Manual of Contract Documents for Highway Works, Volume 1, Specification for Highway Works (SHW), modified as required by the geotechnical design process.

In preparing this TDN, reference has been made to the above standards. It should be recognised that this TDN does not represent the geotechnical design solution, and as a requirement of BS EN 1997, a GDR will need to be prepared.

2. GEOLOGICAL GROUND MODEL

From a review of the available data presented in the GIR, a geological ground model has been developed. The following figures present key aspects of the geological model and have been used in the development of the preliminary geotechnical recommendations.

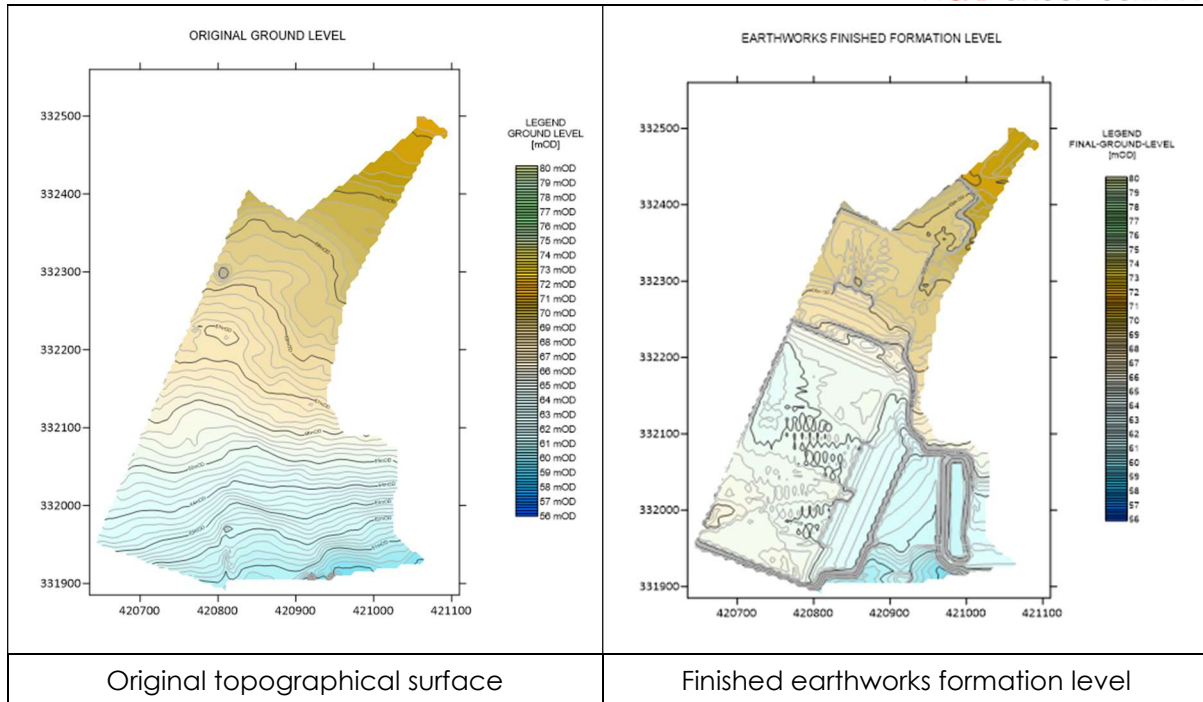


Figure 2-1: Original (left) and final ground level (right)

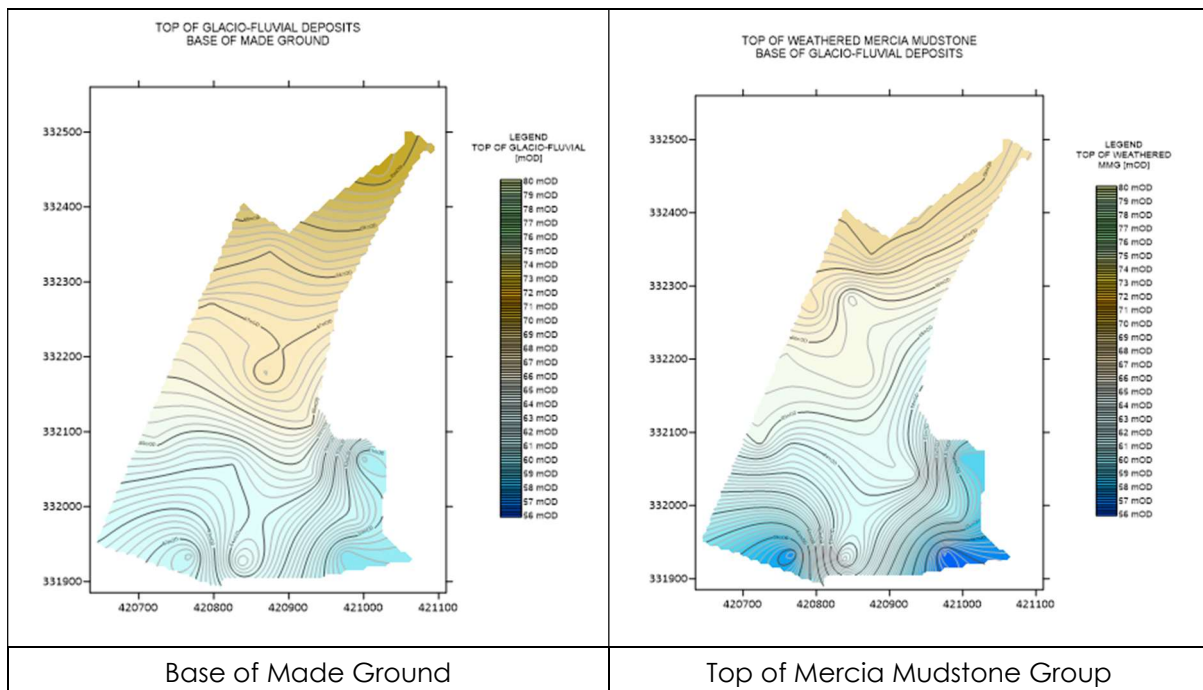


Figure 2-2: Key geological surfaces, base of Made Ground and Top of Mercia Mudstone

Figure 2-1 and Figure 2-2 present several of the geological surfaces that had been prepared based on the available geotechnical information. From a review of the GIR, an additional surface was developed, based on the inferred depth to a suitable founding strata. It is of note that the extent and complexity of the available GIR is limited, and that a quantum of interpretation has had to be made, to infer the competency of material between investigation locations, as well as the strength of stiffness of each deposit.

Based on the review of the likely depth to suitable founding stratum, a surface was prepared identifying the corresponding reduced level to this layer, as well as a model of the predicted

residual thickness of 'poor' ground remaining, following the proposed cut to fill. These figures are presented as Figure 2-3

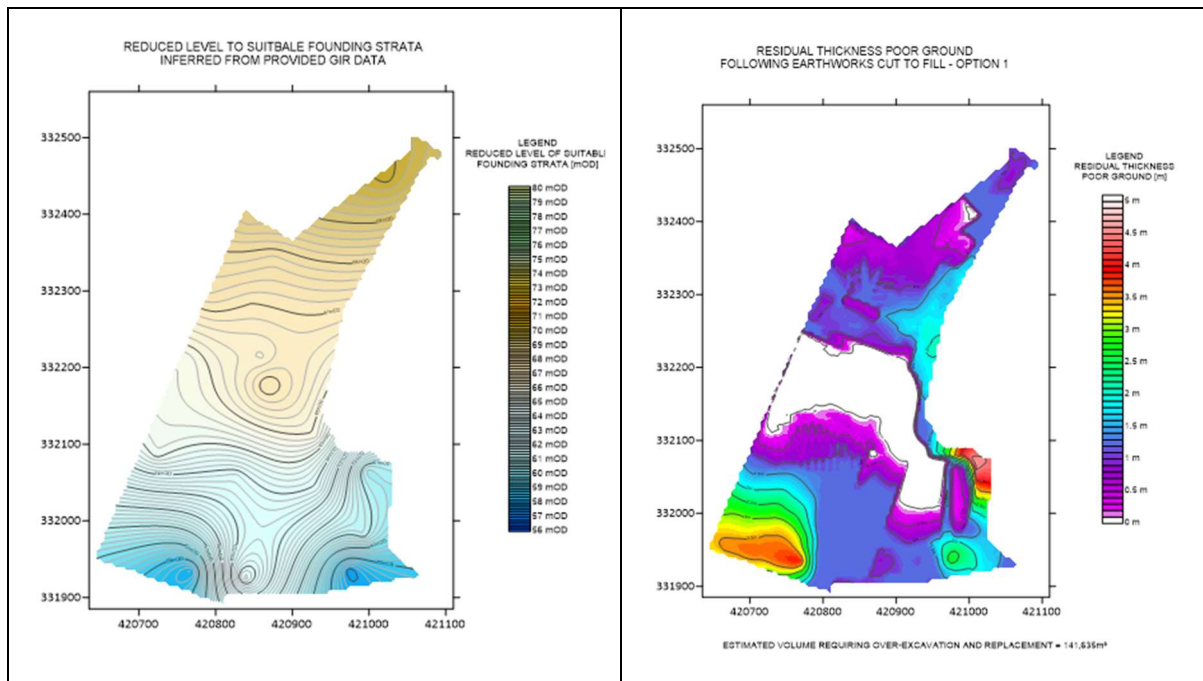


Figure 2-3: Reduced level to suitable founding stratum and residual thickness of poor ground following cut to fill.

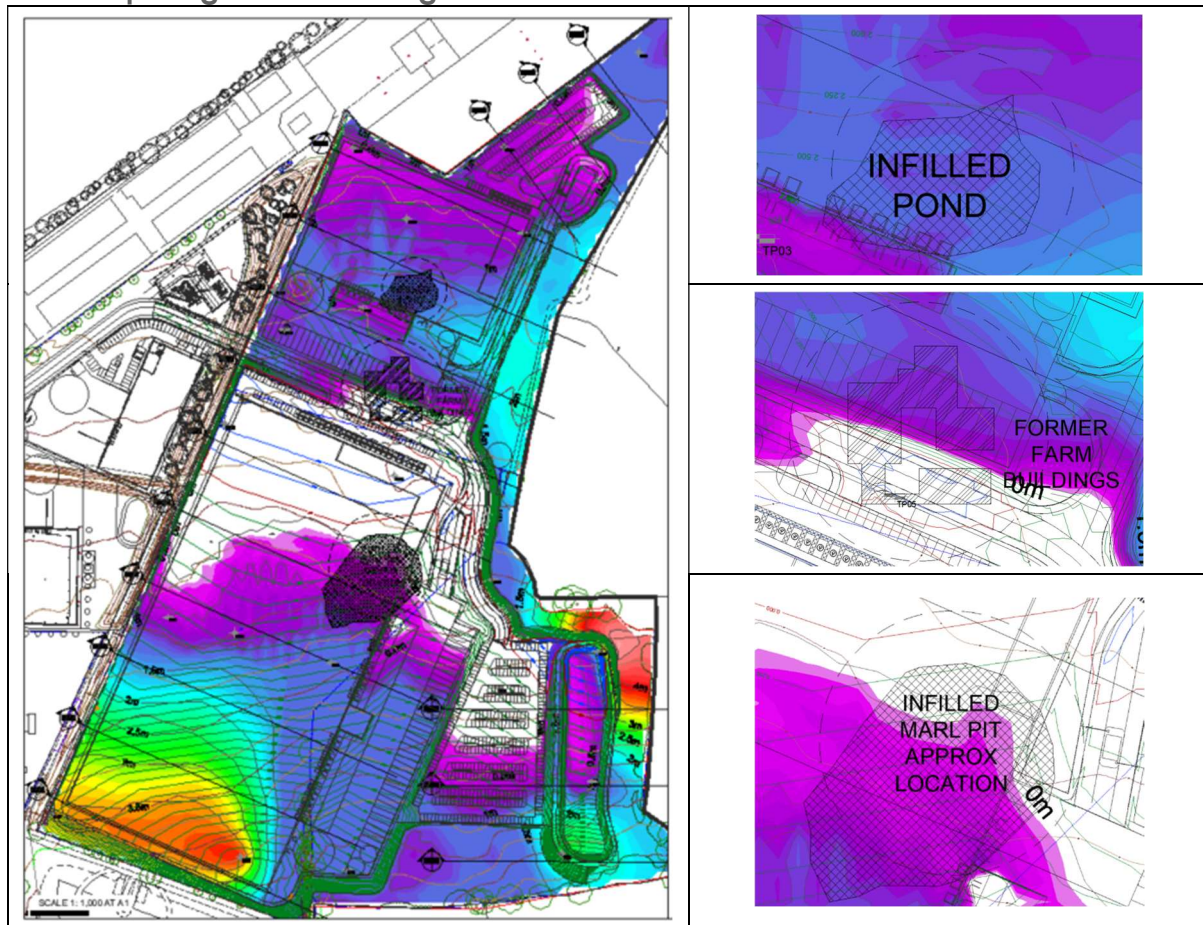


Figure 2-4: Residual thickness of poor ground following earthworks cut to fill

The model surface presented in Figure 2-3 has been overlaid with the proposed development plan, as shown on BWB drawing 255659-BWB-ZZ-XX-DR-GE-4001-Sheet1, a copy of which is presented at Appendix A, and an extract provided as Figure 2-4.

Figure 2-4 and Drawing 255659-BWB-ZZ-XX-DR-GE-4001 also present the approximate location of three historical features, that can impact the geotechnical solution and had not been investigated during the previous phase of works. Although they were noted to be present. The three features are:

- An infilled former pond in the northern sector of the site.
- The location of the former farm, and associated buildings, to the immediate South of the infilled pond.
- An infilled former Marl Pit, within the central section of the site, located below Unit 11C.

The geological model has then been developed into a geotechnical model, in order to inform the proposed ground solution and enabling works strategy.

3. GEOTECHNICAL GROUND MODEL

The findings from the GIR was that the superficial glacio-fluvial and alluvial deposits would be unsuitable for the support of foundations, as well as ground bearing floor slabs. The modelling of the deposition of this material indicated that the greatest thickness of this material would be in the South of the wider site area. This is also the region where the greatest depth of fill is required. The combination of both of these aspects would mean that in the South of the site, the combined thickness of poor bearing strata, and engineered fill, could exceed 8m.

In the centre of the site, following the cut to fill operation, all superficial soils would be removed and there is a section to the North of Unit 11C where the intact Mercia Mudstone could be exposed.

In the North of the site, the residual thickness of the poorer bearing strata is expected to be less than 1.5m. This would mean that foundations could be extended to bear into the competent Mercia Mudstone, with little impact on engineering requirements. However, for the floor slab, should the residual weaker soils be left *in situ*, this could impact the performance of the slab, should a ground bearing solution be adopted.

Further to the above consideration relevant to the building structures, along the Southwestern and Southern boundary of the site, as well as the placement of engineered fill and slopes to be formed, two retaining walls are also required. Given the reported competency of the of the subgrade, it is considered that some form of ground improvement would be required, before any engineered fill could be placed, where slopes and retaining walls are required. The same situation has been identified in the East of the site, where the proposed landscape bund is underlain by a notable thickness of potentially compressible material, that could lead to slope instability both during construction as well as in the long-term condition.

In consideration of the above points and geotechnical risks, the outline proposal would be to undertake ground improvement in the form of Vibro-replacement Stone Columns (VSC). Areas of the site would require their installation prior to the placement of engineered fill, whilst in the majority of instances, there are engineering and commercial advantages to this being undertaken post earthworks filling. This approach would then be coupled with targeted over-excavation and replacement of material, in order to optimise the geotechnical solution for the support of the new buildings and infrastructure.

The following points summarise the proposed treatment across the site.

- Zone A: VSC treatment prior to earthworks, along the Southwestern and Southern extent of the proposed embankment.
 - This would then be followed by the placement of the engineered fill, and the installation of the two retaining walls, identified as Retaining Wall B (Southwest embankment) and Retaining Wall A (Southern embankment).
- Zone B: Post earthworks VSC treatment to support the ground bearing floor slab and the foundations, across the Southern portion of Unit 11C.
 - This treatment is also proposed to be undertaken within the area of the infilled Marl Pit, located within Unit 11C.
- Zone C: Post earthworks VSC treatment to support the ground bearing floor slab, with pad foundations extended to competent strata, where the depth of the residual poor soils is less than 1.5m from base of slab.
- Zone D: Post earthworks VSC treatment to support the slab, as a transitional zone, where the residual thickness of poor ground is reduced or removed through the earthworks exercise
 - This transitional zone is likely to comprise VSC installed on a wider grid

The above zones of treatment, based on the current understanding of the geological ground model, is presented on BWB Drawing 255659-BWB-ZZ-XX-DR-GE-4002, a copy of which is presented at Appendix A, and an extract provided as Figure 3-1.

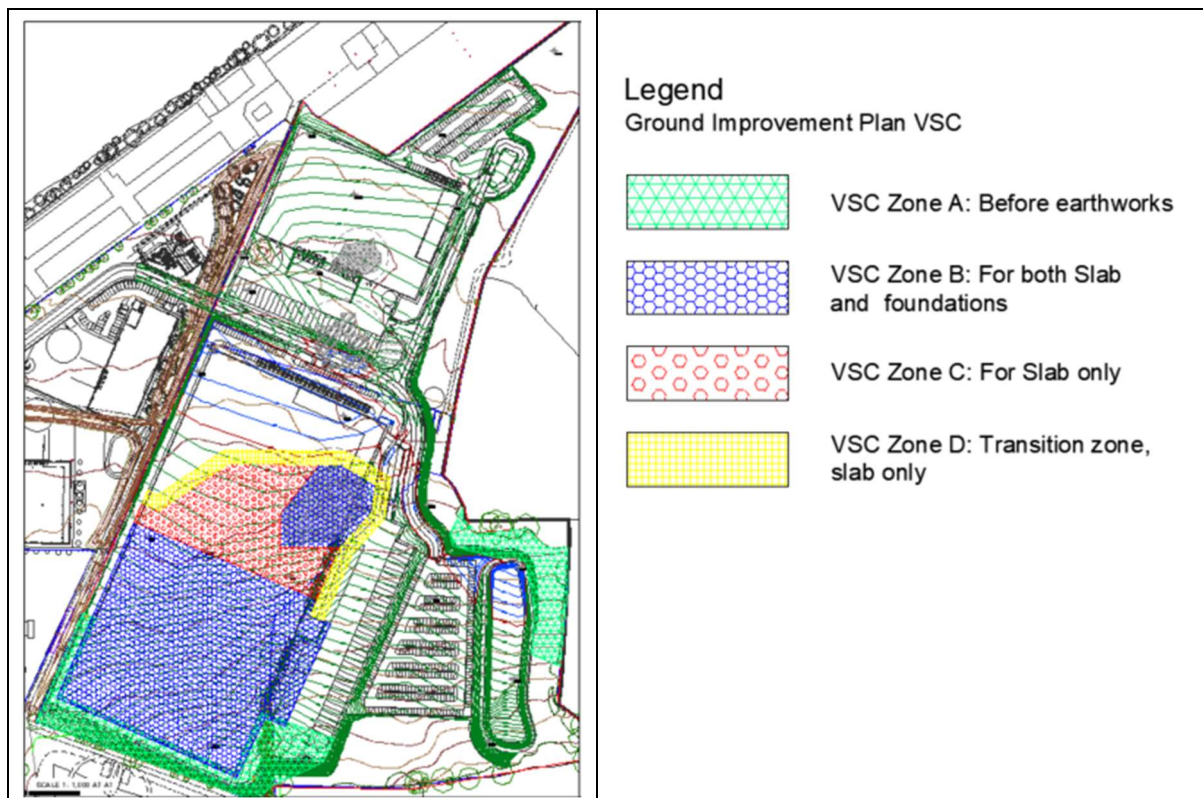


Figure 3-1: Proposed VSC treatment zones

For the North of the site, the current geological model has indicated that the residual thickness of 'poor' ground is likely to be less than 1m below the proposed structures. Given the limited thickness of this material, there are two potential strategies that have been considered, as summarised below:

- Option 1: Over-excavation of poor soils and their replacement with acceptable fill, meeting the requirements of the GDR and its Earthwork Specification.
- Option 2: In situ ground treatment, such as High Energy Impact Compaction (HEIC), using a BOMAG BW 226 (or similar).
 - This option has been considered, as the GIR has indicated that the soils which requirement improvement in this area are likely to be predominantly granular in nature, and that their thickness is unlikely to exceed 2m.

In support of the development of the proposed ground treatment, a series of cross-sections have been developed and are presented on drawings 255659-BWB-ZZ-XX-DR-GE-4001-SHEET 2 to SHEET 4 inclusive. Copies of these drawings are provided at Appendix A.

As noted previously, the current scope of investigation has identified problematic materials across the site for which mitigation will be required. However. The extent of the information upon which this has been based is limited, with gaps in the data set, including the three features that were identified but not investigated. In consideration of this, a scope of supplementary investigation has been proposed, and is described in more detail in Section 4.

4. DESIGN INVESTIGATION

A supplementary investigation is proposed to be undertaken in order to inform the geotechnical design and subsequent development of the GDR.

The proposed form of investigation is to utilise Static Cone Penetrometer (CPT) equipment, fitted with a piezocone, so that measurements of in situ pore pressure can be made, in order to assist with the interpretation of the data.

The location and spacing of the CPT positions has been based on the indicative site zonation for treatment, as described in Section 3 and as presented on BWB Drawing 255659-BWB-ZZ-XX-DR-GE-4002. In general, a spacing of 50m centre to centre has been adopted for Zones A, B, C and D, with a tightening up of the grid related to the infilled Marl Pit and Pond.

A total of 59 CPT's are proposed. A priority list has been considered, so that should some locations not be able to be completed within the given timescale for this investigation, the implications of missing data should not adversely impact the finalised geotechnical design. Of the 59 locations, 48 are considered to be priority 1, as these will be used to delineate the extent of treatment, including the infilled Marl Pit and Pond. The remaining 11 are intended to provide a greater level of detail related to composition and competency of the infilled material within both the Marl Pit and Pond.

The locations for the proposed CPTs are shown on BWB Drawing 22569-BWB-ZZ-XX-DR-GE-4002, and have been extracted and tabulated, as presented as Table 4-1.

Table 4-1: Scope of Design Investigation using CPT equipment.

Ref	Easting	Northing	Depth	Priority	Reason
CPT001	420651.645	331964.951	10.00 m	1	Correlation to BH 04, design of pre-earthworks VSC
CPT002	420694.946	331939.951	10.00 m	1	Design of pre-earthworks VSC
CPT003	420694.946	331989.951	10.00 m	1	Below building VSC
CPT004	420694.946	332039.951	10.00 m	1	Design of pre-earthworks VSC, and below building

Ref	Easting	Northing	Depth	Priority	Reason
CPT005	420738.248	331964.951	10.00 m	1	Below building VSC
CPT006	420738.248	332014.951	10.00 m	1	Below building VSC
CPT007	420738.248	332064.951	10.00 m	1	Below building VSC
CPT008	420738.248	332114.951	6.00 m	1	Transition zone for VSC
CPT009	420748.538	331918.786	10.00 m	1	Design or pre-earthworks VSC
CPT010	420781.549	331939.951	10.00 m	1	Below building VSC
CPT011	420781.549	331989.951	10.00 m	1	Below building VSC
CPT012	420781.549	332039.951	10.00 m	1	Below building VSC
CPT013	420781.549	332089.951	8.00 m	1	Slab VSC
CPT014	420781.549	332139.951	8.00 m	1	Slab VSC
CPT015	420792.502	331902.826	10.00 m	1	Design of pre-earthworks VSC
CPT016	420824.850	331914.951	10.00 m	1	Design of pre-earthworks VSC
CPT017	420824.850	331964.951	10.00 m	1	Below building VSC
CPT018	420824.850	332014.951	10.00 m	1	Below building VSC
CPT019	420824.850	332064.951	8.00 m	1	Slab VSC
CPT020	420824.850	332089.951	15.00 m	1	Infilled Marl Pit
CPT021	420824.850	332114.951	10.00 m	1	Highwall of infilled pit / Slab VSC
CPT022	420839.096	332114.793	15.00 m	2	Infilled Marl Pit
CPT023	420839.284	332089.951	15.00 m	2	Infilled Marl Pit
CPT024	420839.284	332139.951	8.00 m	1	Slab VSC
CPT025	420846.501	332077.451	10.00 m	1	Highwall of infilled pit / Slab VSC
CPT026	420846.501	332102.451	15.00 m	1	Infilled Marl Pit
CPT027	420846.501	332127.451	15.00 m	1	Infilled Marl Pit
CPT028	420853.718	332114.951	15.00 m	1	Infilled Marl Pit
CPT029	420857.212	332281.489	10.00 m	1	Pond delineation
CPT030	420857.212	332306.489	10.00 m	1	Pond delineation
CPT031	420860.934	332102.451	15.00 m	1	Infilled Marl Pit
CPT032	420864.902	332293.989	10.00 m	1	Pond delineation
CPT033	420868.151	332089.951	15.00 m	1	Infilled Marl Pit
CPT034	420868.151	332114.951	15.00 m	2	Infilled Marl Pit
CPT035	420868.151	332127.451	15.00 m	2	Infilled Marl Pit
CPT036	420868.151	332139.951	15.00 m	1	Infilled Marl Pit
CPT037	420871.646	332281.489	10.00 m	1	Pond delineation
CPT038	420871.646	332293.989	10.00 m	1	Pond delineation
CPT039	420871.646	332306.489	10.00 m	1	Pond delineation
CPT040	420875.254	332287.739	10.00 m	2	Pond delineation
CPT041	420875.254	332300.239	10.00 m	2	Pond delineation
CPT042	420878.863	332268.988	10.00 m	1	Pond delineation

Ref	Easting	Northing	Depth	Priority	Reason
CPT043	420878.863	332293.989	10.00 m	1	Pond delineation
CPT044	420878.863	332318.989	10.00 m	2	Pond delineation
CPT045	420882.471	332287.739	10.00 m	2	Pond delineation
CPT046	420882.471	332300.239	10.00 m	2	Pond delineation
CPT047	420882.585	332114.951	15.00 m	1	Infilled Marl Pit
CPT048	420885.706	332306.532	10.00 m	1	Pond delineation
CPT049	420886.080	332281.489	10.00 m	1	Pond delineation
CPT050	420886.080	332293.989	10.00 m	2	Pond delineation
CPT051	420889.802	332102.451	10.00 m	1	Highwall of infilled pit / Slab VSC
CPT052	420889.802	332127.451	10.00 m	1	Highwall of infilled pit / Slab VSC
CPT053	420893.296	332293.989	10.00 m	1	Pond delineation
CPT054	420900.513	332281.489	10.00 m	2	Pond delineation
CPT055	420900.513	332306.489	10.00 m	1	Pond delineation
CPT056	420956.921	332088.417	10.00 m	1	Design of pre-earthworks VSC
CPT057	421009.182	332076.516	10.00 m	1	Design of pre-earthworks VSC
CPT058	421015.278	332014.455	10.00 m	1	Design of pre-earthworks VSC
CPT059	421022.084	332049.227	10.00 m	1	Design of pre-earthworks VSC

Subject to the supplementary, design investigation being undertaken, the recommendations for ground treatment will be reviewed and revised accordingly.

The duration for the proposed design investigation using the CPT equipment is likely to take between four and five days on site, with the provision of data, in AGS 4.0 format, expected within one working week of the completion of the site works. Experience has shown that the data may be available for review with several days of site works being completed, but this would need prior agreement with the Specialist Contractor.

Upon receipt of the AGS data, the records would undergo a separate interpretation by BWB, before being used to develop an updated geotechnical ground model. Typically, this would comprise the derivation of the stiffness and settlement characteristics of the ground, supported by a series of plots of subgrade stiffness. At the completion of this exercise, a revised ground strategy would be provided. At present, it is expected that this could be provided within one top two weeks from receipt of the CPT records, as it is expected that during this two week analysis period, discussions would be held with Specialist Contractors regarding the scope of ground treatment, including the use of VSC as well as HEIC.

APPENDIX A: DRAWINGS

POST CPT GEOTECHNICAL REVIEW

18th July 2025

Project Name:	Dove Valley Park
Project No:	255659
Revision:	P01
Reference:	255659-BWB-ZZ-XX-TDN-GE-4002-S1-P01.1
Author:	Ian Gardner
Reviewer:	
Approver:	

1. INTRODUCTION

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The ultimate Client for the development is Clowes Developments UK Ltd (Clowes). Clowes had appointed Jackson Purdue Lever (JPL) as the Civil Engineer for the scheme, with an understanding that JPL would also be acting as the Structural Engineer.

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- Base Build Specification, Unit 11C, Dove Valley Park, 450,000 sq ft. Document prepared by Clowes Developments UK Ltd, Revision 1, dated 17th April 2024.
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- AutoCAD model of proposed earthworks, including earthwork isopach indicating proposed cut to fill requirements. Document reference 002949-JPL-ZZ-ZZ-D-C-1101-S2-P03 Earthworks Assessment. Document provided by electronic link from Jackson Purdue Lever.

Following an initial review by BWB, a Technical Design Note (TDN) was prepared, BWB Document Reference 25569-BWB-ZZ-XX-TDN-GE-4001, issued on the 3rd June 2025. It is recommended that the content of this previous TDN is read, in conjunction with this document. The previous TDN provided recommendations for the undertaking of additional ground

investigation, using the static cone penetrometer (CPTu) equipment to better delineate the areas of concern on site. Further to this, a supplementary phase of ground investigation was undertaken by Lucion Ground Engineering Ltd at the end of June 2025, which has also been provided to BWB for review.

The content of this TDN presents an updated review of the ground conditions on the site, with respect to the proposed development, and encapsulates the records from the CPT investigation, commissioned by BCG and undertaken between the 30th June 2025 and 4th July 2025.

2. GEOLOGICAL GROUND MODEL

From a review of the available data presented in the GIR, a geological ground model had been developed. The Ground Model (gm) has been updated following the completion of the supplementary phases of investigation, and developed into a Geotechnical Design Model (GDM). A series of figures have been developed to present the Ground Model, and this includes an updated finished earthworks formation model.

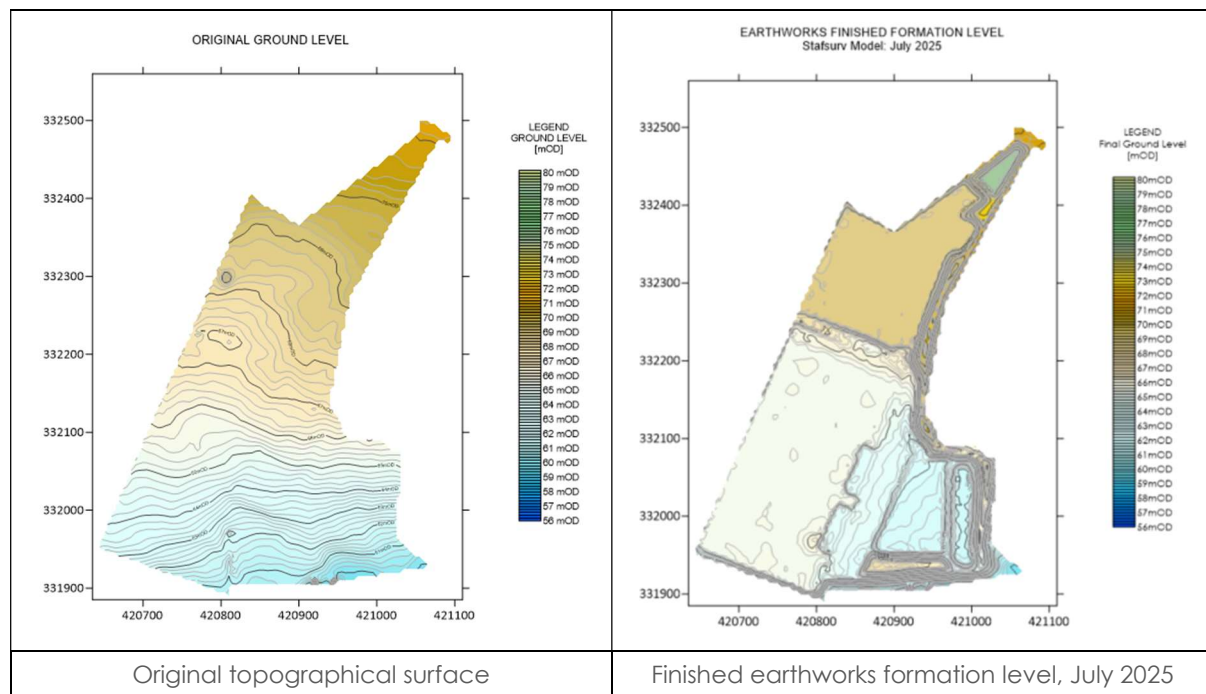


Figure 2-1: Original (left) and final ground level (right)

The records from the CPTu investigation have undergone a separate interpretation of the factual records, with copies of the interpreted data presented at Appendix B. The results from the CPTu data have been used to derive a large number of geotechnical parameters, including the derivation of a number of moduli values. Based on these records, a number of distribution plots have been developed, including the base of lower strength stratum, as presented in Figure 2-2. However, it was noted that the lower strength strata identified from the CPTu records was generally relatively thin and was often only encountered several meters below the current (existing) ground level.

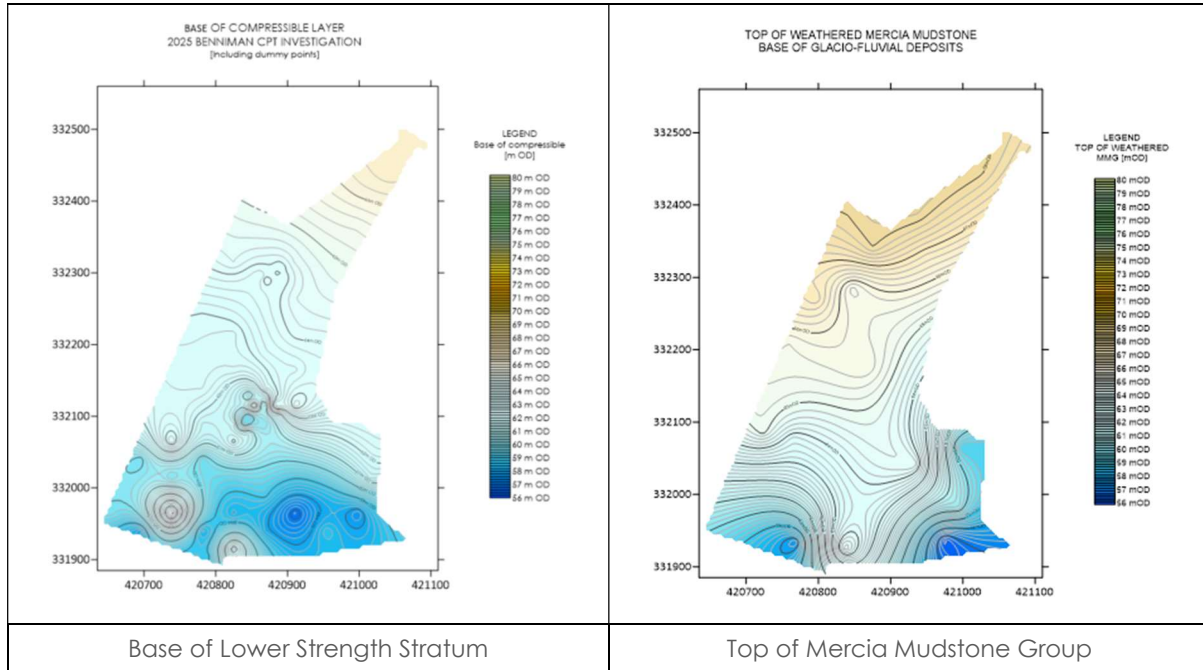


Figure 2-2: Base of Lower Strength Stratum and Top of Mercia Mudstone

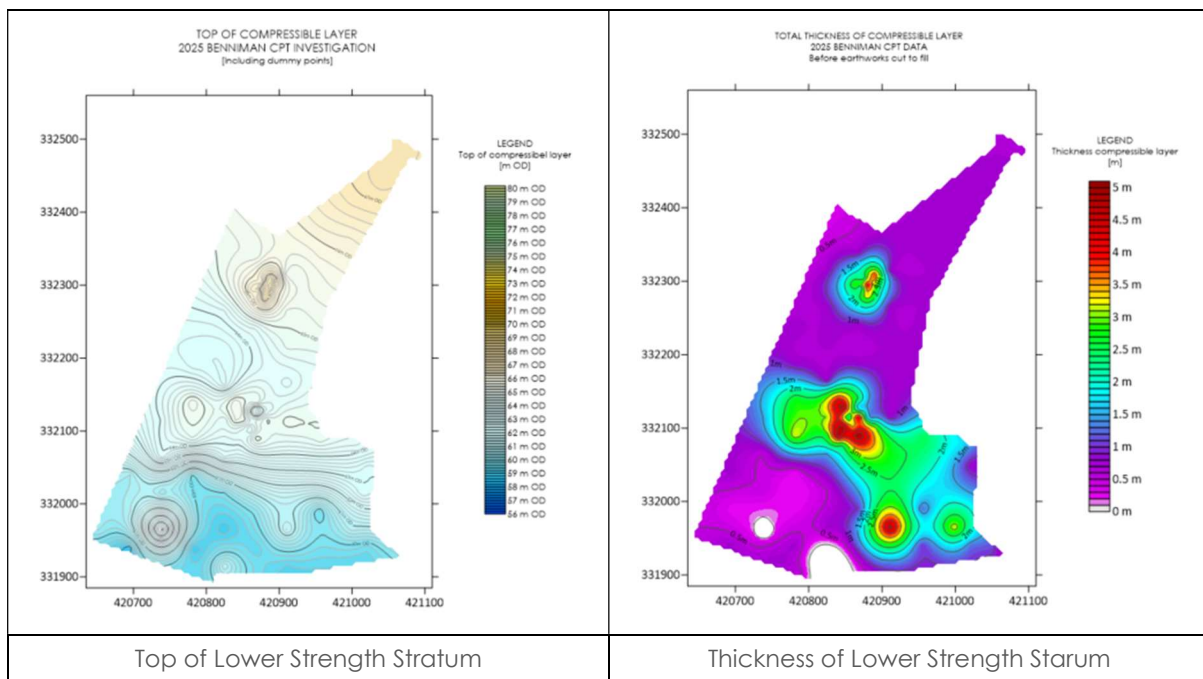


Figure 2-3: Top and thickness of Lower Strength Stratum

It is noted that the distribution of lower strength material, as well as its thickness, is somewhat in variance to the original assessment, as presented in 255659-BWB-ZZ-XX-TDN-GE-4001. This is due to several factors, including:

- The previous assessment has adopted the principal that the thickness of lower strength material was effective from the finished surface profile, to the base of the weak soil, as this was intended to inform the depth to which VSC may need to be installed.
- The two areas of infilled ground (pond and marl pit) were not included in the original GIR and as such there was no data available on their depth or composition.

- The number of data locations and associated data records is now significantly greater than the original GIR.

The revised Ground Model has been used to update the Geotechnical Design Model, presented in Section 3.

3. GEOTECHNICAL DESIGN MODEL

Reference is made to the initial considerations presented in 255659-BWB-ZZ-XX-TDN-GE-4001, where four zones had been identified, that may have required ground treatment using VSC, either pre or post earthworks. The zones are described below:

- Zone A: VSC treatment prior to earthworks, along the Southwestern and Southern extent of the proposed embankment.
 - This would then be followed by the placement of the engineered fill, and the installation of the two retaining walls, identified as Retaining Wall B (Southwest embankment) and Retaining Wall A (Southern embankment).
- Zone B: Post earthworks VSC treatment to support the ground bearing floor slab and the foundations, across the Southern portion of Unit 11C.
 - This treatment is also proposed to be undertaken within the area of the infilled Marl Pit, located within Unit 11C.
- Zone C: Post earthworks VSC treatment to support the ground bearing floor slab, with pad foundations extended to competent strata, where the depth of the residual poor soils is less than 1.5m from base of slab.
- Zone D: Post earthworks VSC treatment to support the slab, as a transitional zone, where the residual thickness of poor ground is reduced or removed through the earthworks exercise
- This transitional zone is likely to comprise VSC installed on a wider grid.

At the conclusion of the previous TDN, a phase of additional investigation had been recommended, so as to inform the proposed ground treatment and the associated extent that may be required. However, following the supplementary phases of investigation, the inferred ground model has changed noticeably from the previous assumptions. This is presented in Figure 3-1.

The possible reasons for the discrepancy between the two models are described in Section 2.

In consideration of the new ground model, the proposed remedial works has been reviewed in terms of scope, type and extent. In order to complete the re-assessment on the ground solution, two main risks have been considered, as summarised below:

- Serviceability Limit State (SLS), Settlement.
 - This would include settlement due to the change in stress from the earthwork cut to fill exercise and the design loads from new structures and the development.
- Ultimate Limit State (ULS), bearing resistance and slope stability.

- Should low strength soils still be present below foundations and retaining walls, there may be a risk of shear failure, loss of support and ground resistance.
- Should earthwork embankments and slopes be formed in close proximity to low strength subgrade, this may lead to slope failure as well and loss of bearing resistance below differentially loaded regions.

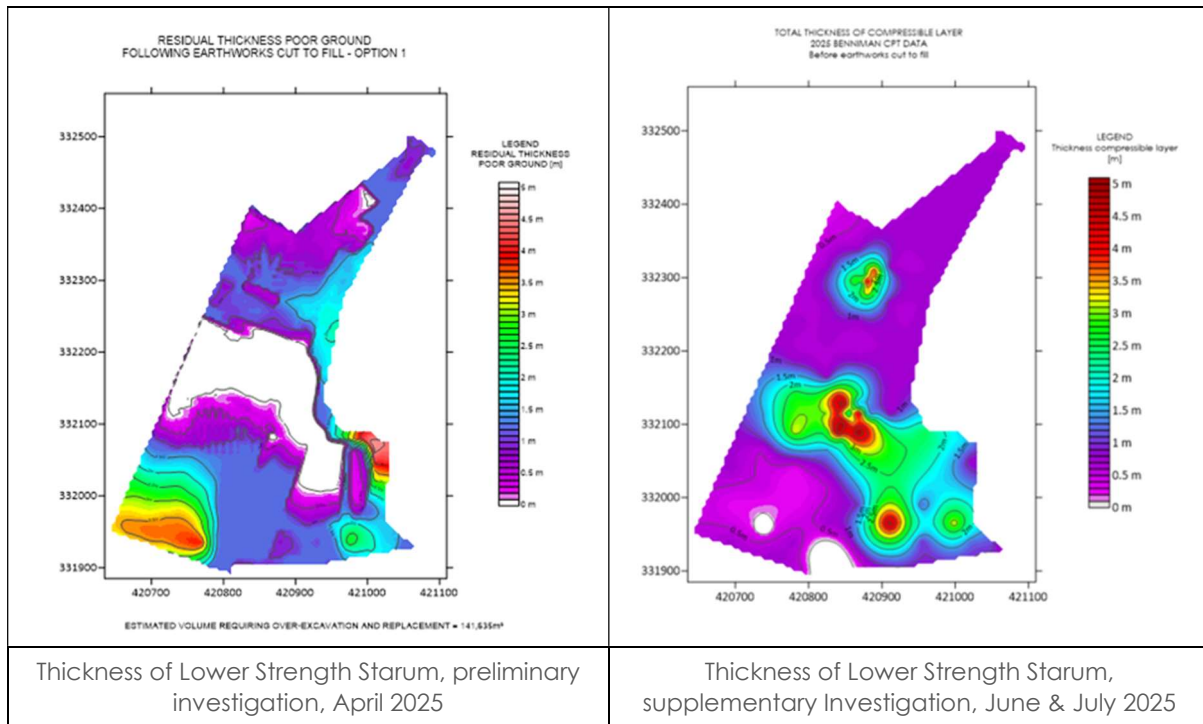


Figure 3-1: Comparison between preliminary and updated ground model

3.1.1 Serviceability Limit State, Settlement

The first phase of re-assessment has considered the likely settlement of the ground. In order to complete this, a series of SLS criteria were selected, as summarised below:

- Total post construction settlement below ground bearing floor slabs to be no more than 25mm with a differential of better than 1:750 within the subgrade, for an equivalent Uniformly Distributed Load (UDL) of 50 kPa.
 - Consideration may be given to the quantum of settlement that could occur during the enabling works, before the permanent structure is built.
 - Consideration may be given to time factoring of the floor slab UDL, to replicate the 'real-world' loading, that is in place for a sufficient period of time to induce primary settlement within the subgrade.
- Total settlement of external areas, including roads, pavements and areas of hard standing, to be no more than 50mm post construction, with a differential of better than 1:750 within the subgrade, for an adopted transient UDL equivalent to 10kPa.
 - Consideration may be given to the quantum of settlement that could occur during the enabling works, before the permanent structure is built

The records from the CPTu data have been analysed in order to derive a series of subgrade settlement modulus values, that can then be used to assess the settlement of the ground, due to changes in applied stress.

In accordance with Design Approach 1 from BS EN 1997-1:2004+A1:2013, all calculations have applied the reduction to the actions and soil parameters using Combination 1 and 2 (DA1/1 and DA1/2) for STR and GEO Limit States. This approach has been used for geotechnical analysis in accordance with definitions and methodology specified in BS EN 1997.

3.1.2 Settlement Contributions

Settlement has been considered from a number of different processes as well as different load combinations. Settlement can be divided into four main processes, as summarised below:

- Immediate Settlement, S_0
 - This is the near instantaneous response of the ground due to the application of the load.
 - The magnitude of ground movement associated with this is a function of the characteristics of the ground as well as the magnitude of the load.
- Self-weight Settlement, S_w
 - This is the settlement induced within new fill, due to its self-weight
 - The magnitude of self-weight settlement will be a function of the unit weight of fill, the thickness of the material and the associated stiffness.
- Primary, consolidation settlement, S_1 .
 - This is the response of the ground due to the closing up of voids, typically water filled.
 - The magnitude of ground movement associated with this is a function of the characteristics of the ground as well as the magnitude of the load.
 - The rate at which primary settlement occurs is related directly to the permeability of the ground.
 - Primary settlement typically provides the largest individual contribution to the magnitude of overall ground movement.
 - The profile of settlement against time can be described by a polynomial regression and is typically plotted on a log time vs settlement graph and forms a curve, which flattens as consolidation nears completion.
- Secondary, creep settlement, S_2 .
 - This is the long-term slow response of the ground to changes in stress.
 - The magnitude of movement due to creep is not governed by the magnitude of stress applied but is a function of the characteristics of the ground.

- The rate at which creep settlement occurs can be described by a logarithmic regression and forms a straight line when plotted on a log time vs settlement graph.
- A change in stress, including variation on water levels, can instigate a new phase of creep movement.

In addition to the various mechanisms of settlement described above, there are a number of different loading conditions which are considered. These are summarised below:

1. Settlement due to self-weight of the fill material, including duration of fill placement.
2. Settlement induced in the underlying soils due to the placement of the fill material.
3. Settlement induced in the underlying soils and engineered fill due to the permanent load from new structures.
4. Settlement induced in the underlying soils and engineered fill due to the transient (live) loading from the development and highways.
5. A reduction in the total post construction settlement due to the proportion of settlement that would be expected to occur during the construction program, with the corresponding post construction settlement.

3.1.3 Immediate settlement, S_0

This form of settlement will occur during the construction process, typically instantaneous with the application of the load; therefore, the contribution from immediate settlement due to the placement of the fill is not normally considered. Where immediate settlement is included, this will be detailed in the design report.

The general equation used to estimate immediate settlement is given below:

Equation 3-1: Prediction of immediate settlement

Immediate settlement, S_0 = $\sum \{\Delta\sigma_v \times h \times (1 / E_u)\}$; where

$\Delta\sigma_v$ is the change in vertical stress in the soil layer under consideration

h is the thickness of the soil layer under consideration

E_u is the undrained modulus for the soil layer under consideration

Based on the review of the ground conditions, it is expected that any contribution from immediate settlement due to the placement of the engineered fill, as part of the earthworks cut to fill exercise, will occur during the enabling works. As such, any contribution from immediate settlement due to earthworks has not been considered further.

As the new structure is constructed, there would be expected to be an additional ground movement upon immediate loading. Based on a wished in place UDL of 50 kPa for the floor slab, this could be in the order of 4 to 5mm. However, when considering the manner in which the floor would be loaded, partly during the building fit out and then during its operation, the movement due to immediate settlement is expected to be less than 2mm.

3.1.4 Self-weight Settlement, S_w .

The contribution from self-weight settlement has been calculated in accordance with BS 6031:2009 Clause 7.6.3.2, replicated below:

Equation 3-2: Prediction of Self-weight settlement to BS 6031:2009: Cl 7.6.3.2

Total self-weight settlement, S_w = $[0.5 \times (\gamma_b \times h^2)] / D$; where

γ_b is the unit weight of the fill, as taken from the Characteristic and Design Values presented in the GDR.

h is the thickness (height for an embankment) of the fill.

D is the constrained modulus of the fill (referenced by the symbol M in SHW Clause 642, equivalent to the Oedometric Modulus E_{oed}).

The maximum thickness of fill under any building is currently expected to be 4m, with an average generally less than 2.0m. Based on a minimum Oedometric Modulus for the selected engineered fill of 15 MPa (commensurate with a cohesive fill that has been placed to 95% of the 4.5 kg Rammer Maximum Dry Density (MDD), a bulk unit weight in the order of 20 kN/m³, with less than 5% air voids and a minimum undrained shear strength of 80 kPa), would return a maximum self-weight contribution of 11mm, with an average of 3mm.

Based on the likely grading of the fill material, which would be sourced from the near surface predominantly granular, deposits, the majority of the self-weight settlement (~85%) would be expected to occur during the construction process. This would leave a residual contribution at the end of the enabling works, of around 0mm to 2mm.

3.1.5 Primary (consolidation) settlement, S_1 .

For normal ground conditions, the largest contributor to settlement would be from primary, consolidation settlement. This has formed the main focus when considering the compliance of the ground solution against the adopted SLS criteria defined previously in this TDN.

The assessment of settlement due to the application of permanent and variable loads has been undertaken using a combination of proprietary software, including FINE GEO5 Settlement and OASys PDisp, supported by in-house excel spreadsheets used to derive the Characteristic and Design Values.

The general approach for the prediction of settlement due to primary consolidation follows the adjusted elasticity methodology as defined in BS EN 1997-1:2004+A1: Appendix F.2.

The general equation for adjusted elasticity, from BS EN 1997-1:2004+A1:2013 is presented below:

Equation 3-3: Prediction of Primary Settlement, Adjusted Elasticity method to BS EN 1997-1:2004+A1:2013: App F.2

Primary settlement, S_1 = $p \times B \times (f / E_m)$; where

E_m is the design value of the modulus of elasticity

B is the width of the loaded area

f is the settlement coefficient

p is the bearing pressure, linearly distributed at the base of the foundation

The value of the settlement coefficient, f , will depend on the shape and dimensions of the foundation area, the variation in stiffness with depth, the thickness of the compressible formation, the Poisson's ratio and the point for which settlement is calculated.

To solve 'f', a number of complimentary proprietary software programmes have been used, including OASys PDisp. Equation 3-3 has been re-written as follows:

Equation 3-4: Prediction of Primary Settlement, Adjusted Elasticity method for individual soil layer

Primary settlement, $S_1 = \sum \{ \sigma_z \times h \times ((1 - \nu^2)/E'd) \}$; where

$E'd$ is the drained modulus for the soil layer under assessment.

h is the thickness of the soil layer under assessment.

σ_z Is the change in stress, at the centre of the layer under assessment.

ν is the Poisson's ratio for the soil layer under assessment

Utilising the profiles of stiffness, for each of the CPTu's (please refer to the tabulated recorded provided at Appendix B), a further rationalisation on the assessment of primary settlement has been completed, adopting the use of the Subgrade Settlement Modulus, for each of the CPTu profiles.

In order to derive the Subgrade Settlement Modulus, the following general procedure has been followed.

- The interpretation of the CPTu data has been expanded to derive a Young's Modulus value for each data point (e.g. a reading is taken every 10mm) and then collated into soil layers of no more than 250mm in thickness, with an upper and lower value attributed to each layer.
- The derived Young's Modulus and Poisson's Ratio for each layer is inputted to OASys PDisp.
- The model extent in PDisp is set to 100m x 100m
- The displacement grid in PDisp is set to 100m x 100m
- A design uniformly distributed load of 100 kPa, applied over an area of 100m x 100m.
- The settlement at a point located at the centre of the loaded area is calculated (e.g. with model coordinates of $x = 50$ and $y = 50$).
- With the settlement calculated at the centre of the loaded area, and setting the dimensions to 100m x 100m, there is no depth reduction in stress or resultant strain / settlement from edge effects
- The total settlement calculated at the centre of the loaded area (in mm) is divided by the applied stress (100 kPa), to derive the ratio commensurate with units of mm/kPa.
- The reciprocal of the derived ratio (in mm/kPa) is calculated to return a value in units of MN/m³, and this value has been defined as the Subgrade Settlement Modulus.

This approach is commensurate with the modulus of subgrade reaction, but applied over the entire soil profile, and governed by the dimensions of the loaded area, the magnitude of load and the actual induced strain.

Equation 3-5: Prediction of Primary Settlement, using Subgrade Settlement Modulus derived from soil profile

Primary settlement, $S_1 = \sigma_z \times (1/E_{ssm})$; where:

E_{ssm} is the Subgrade Settlement Modulus, derived for each CPT profile

The use of the E_{ssm} and Equation 3-5 is only valid when considering primary settlement under large loaded areas, such as the imposed stress from new earthworks and floor slabs in excess of 50m x 50m. For smaller areas, Equation 3-3 and Equation 3-4 have been used.

In consideration of the assessment of primary settlement, three different stiffness models have been developed, as summarised below:

A. Stiffness Model A:

- a. The stiffness model derived for the existing condition, before any earthworks cut to fill operation.

B. Stiffness Model B:

- a. The stiffness model, taking into account the earthwork cut to fill based on the change in level presented in Figure 2-1, with all fill set with a stiffness of 15 MPa.
- b. This model includes the low stiffness material present within the infilled Marl Pit and Pond.

C. Stiffness Model C:

- a. The refined stiffness of the ground, following the earthworks cut to fill, and the replacement of poor ground, from the 5 identified zones where over-excavation and replacement is recommended.
- b. The process of identifying the 5 zones of over-excavation is described in subsequent sections and is intended to replace the need for VSC to be installed.
- c. Should installation of VSC be the preferred solution, the treated ground would be expected to behave in a similar manner should the option where over-excavation and replacement have been adopted.

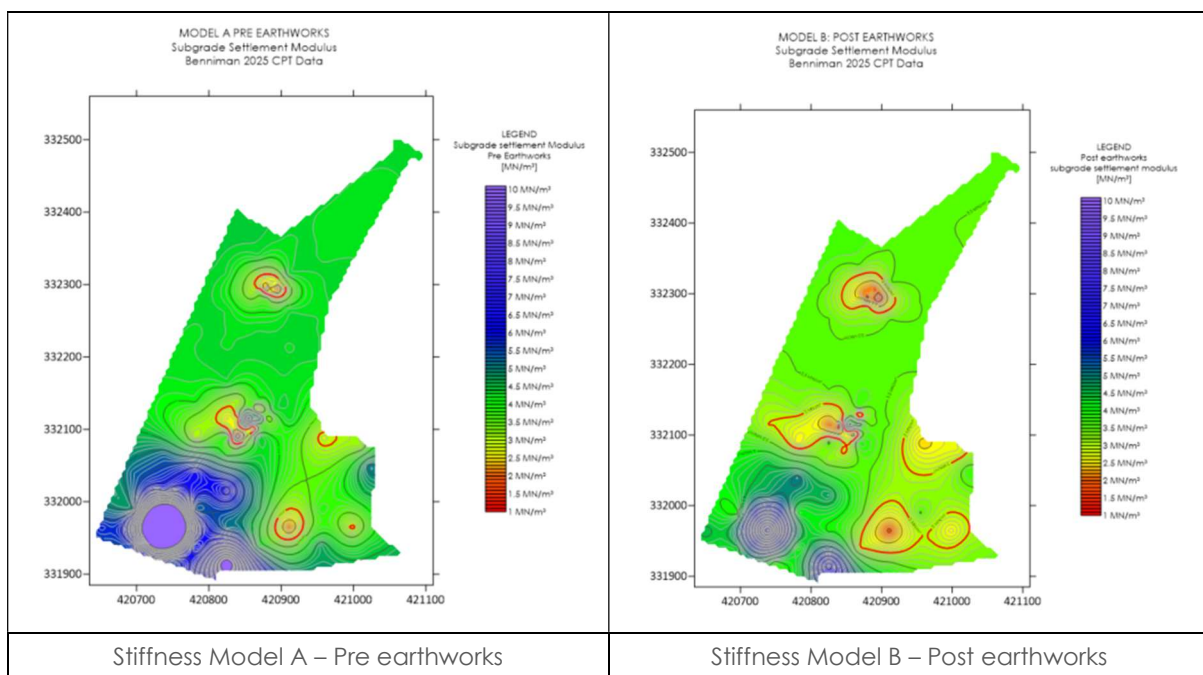


Figure 3-2: Stiffness Model A (pre-earthworks) and Stiffness Model B (post earthworks)

It is of note that the overall stiffness of the ground would reduce, following the earthwork cut to fill operation, as the earthworks will remove the near surface very stiff granular soils, and the anticipated stiffness of new engineered fill is less than the undistributed soils.

From reference to the ground stiffness models presented in Figure 3-2, the following points are also noted:

- The location of the infilled Marl Pit and the Pond are clearly shown to be of lower stiffness
- The Southwestern and Southern Boundary, whilst there is a relatively thin layer of more compressible soil at depth, this area is indicated to have the overall highest stiffness.
- Within the Southeast of the site, there is clearly an area of much lower stiffness, which is consistent with the revised model on the extent of weaker soils.

In terms of settlement assessment due to changes in load, the following models have been run:

1. The total settlement due to the total change in stress from earthworks, floor slabs and external areas, considering the development has been 'wished-in-place'
 - a. The mean bulk unit weight of the fill has been taken as 20 kN/m³.
 - b. The floor slab load has been applied as a UDL of 50 kPa.
 - c. All other areas of the site, outside of the floor slabs, has a UDL of 10 kPa applied.
2. The factored settlement due to the earthworks, with the full, 'wished-in-place' UDL from floor slabs and external areas.
 - a. The contribution of settlement due to the earthworks cut to fill has been reduced by 60%, which will have occurred construction commences, and this is considered to be a lower bound, conservative assessment.
 - b. The floor slab load has been applied as a UDL of 50 kPa.
 - c. All other areas of the site, outside of the floor slabs, has a UDL of 10 kPa applied.
3. The factored settlement due to the earthworks, time factored floor slab loading and a 'wished-in-place' external UDL.
 - a. The contribution of settlement due to the earthworks cut to fill has been reduced by 85%, which will have occurred before the floor slab is cast and this is considered to be a lower bound, conservative assessment.
 - b. The floor slab load has been applied as a time factored UDL of 37 kPa, commensurate with 2/3 of the full design UDL.
 - c. All other areas of the site, outside of the floor slabs, has a UDL of 10 kPa applied

Based on the finished formation level, as presented in Figure 2-1, a cut to fill model has been developed in the GDM, and the associated change in stress derived. In addition to the stress

from the earthworks, two areas of 50 kPa have been included (to replicate to the two indicative building footprints) and all other areas have had a general UDL of 10 kPa applied.

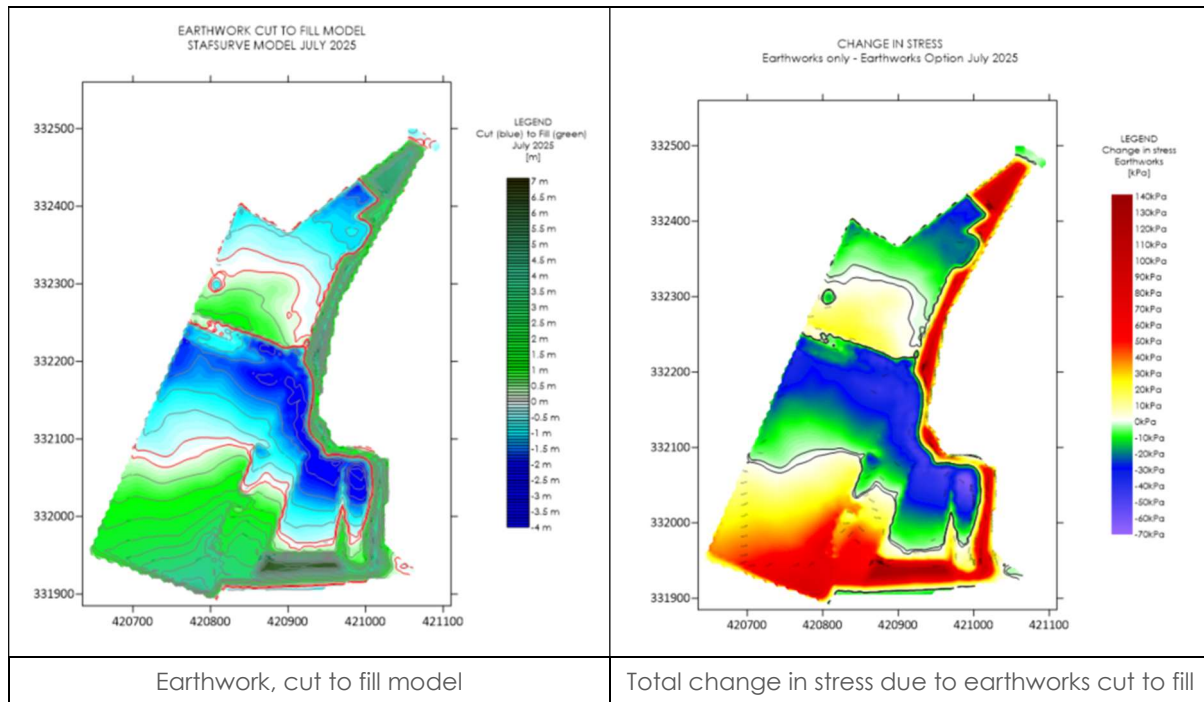


Figure 3-3: Earthworks cut to fill and change in stress due to earthworks.

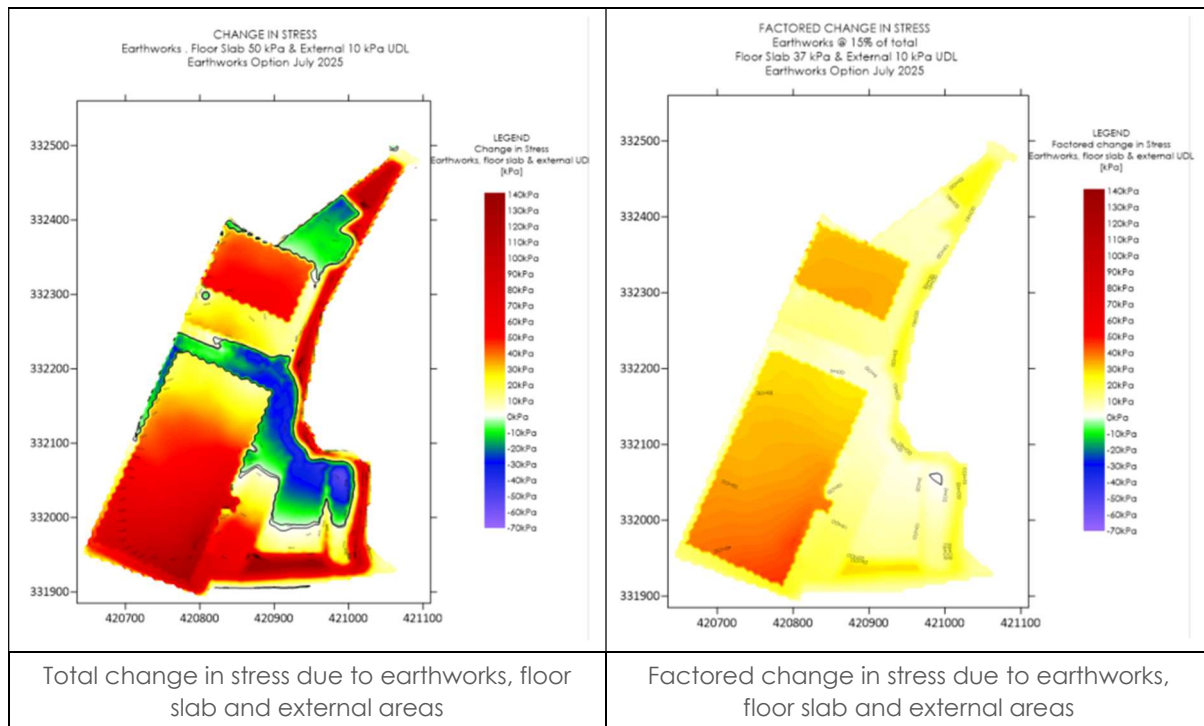


Figure 3-4: Total change in stress, and factored change in stress

For each of the defined stress models, a global settlement analysis has been undertaken and are presented in the following figures.

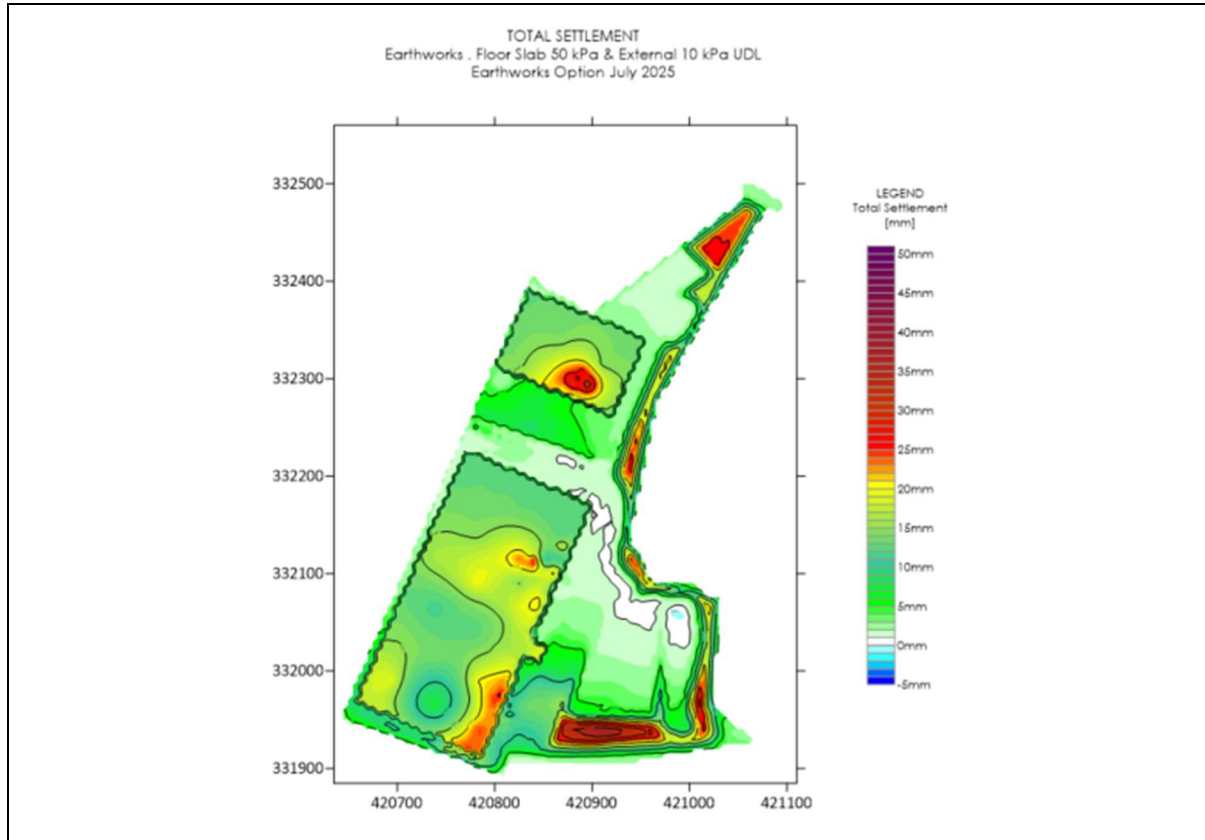


Figure 3-5: Total settlement for combined Stiffness Model A and B, all loads 'wished-in-place'

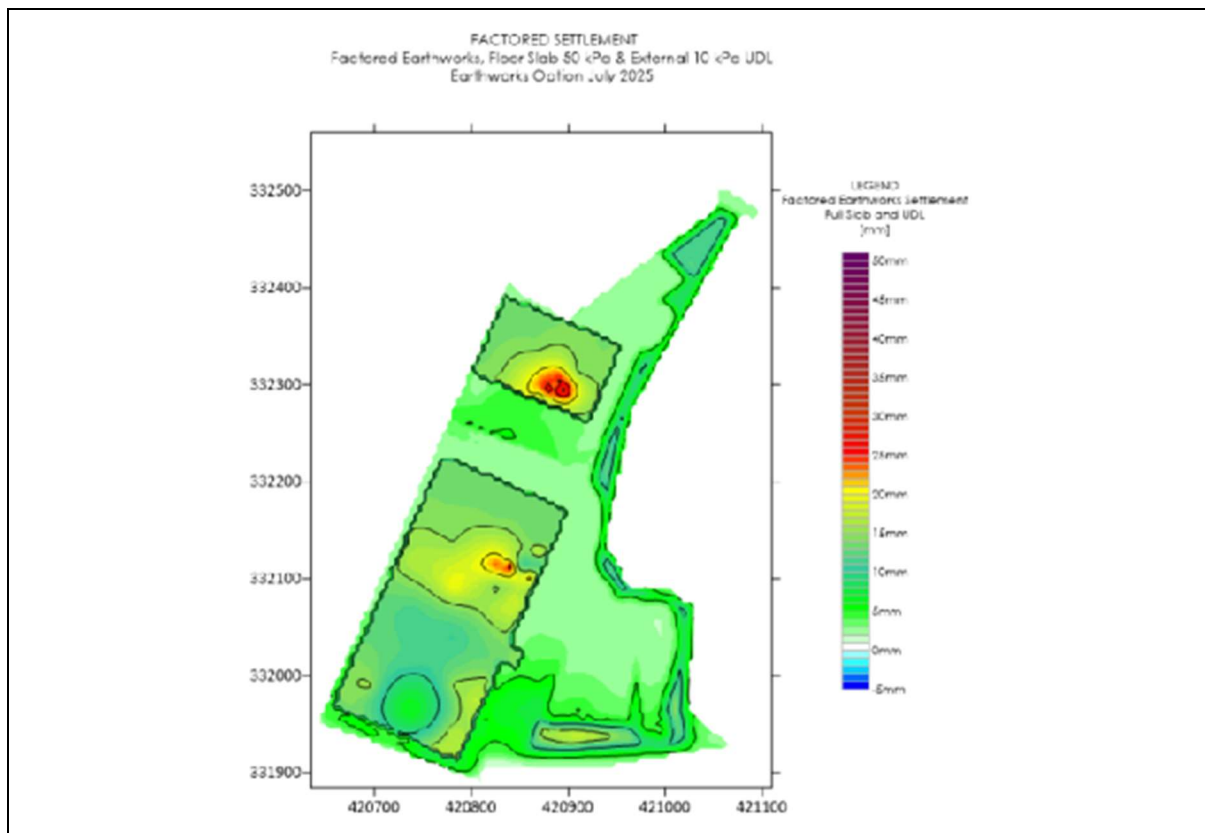


Figure 3-6: Combined Stiffness Model A & B Factored earthworks settlement (40% remaining) and 'wished-in-place' floor slab and full external UDL

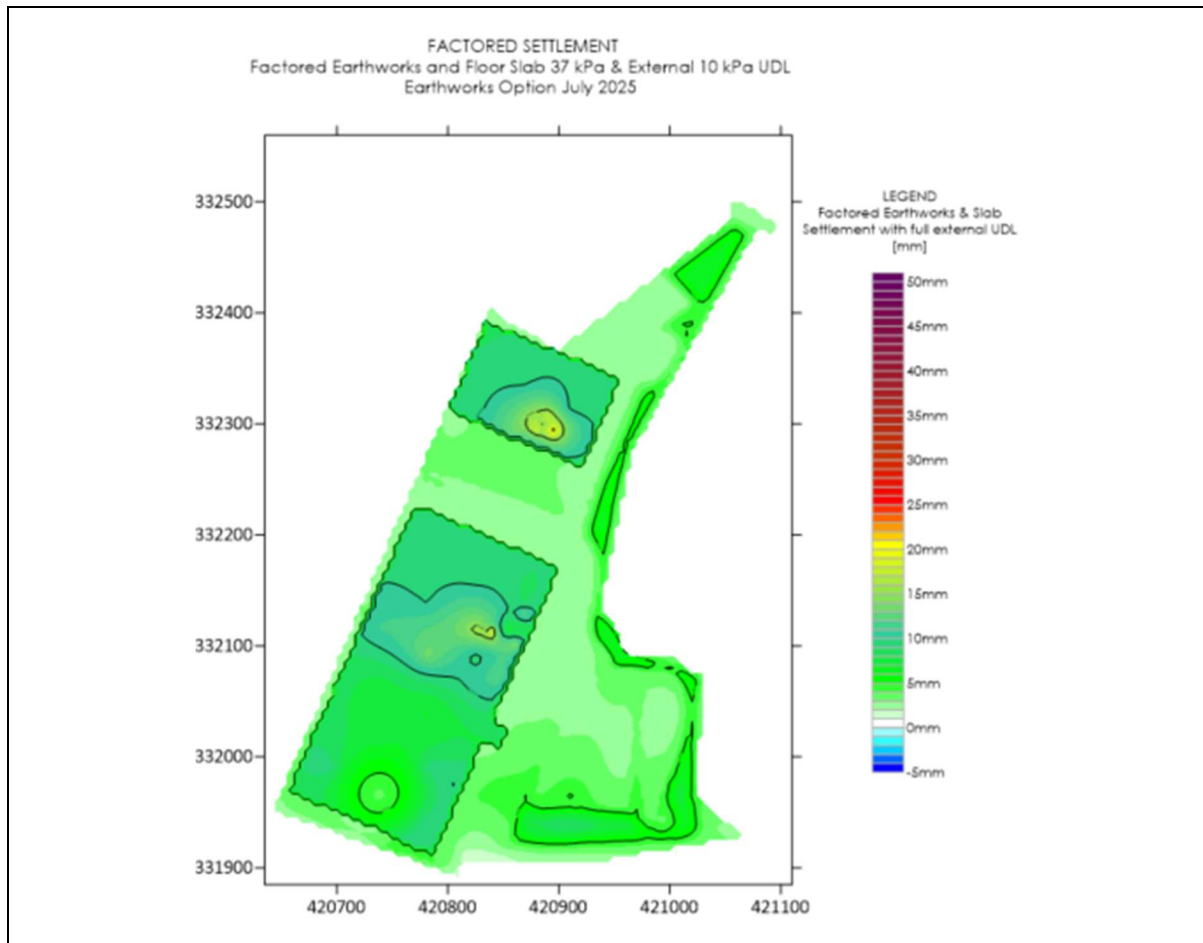


Figure 3-7: Combined Stiffness Model A & B, Factored earthworks settlement (15% remaining, factored floor slab (67% remaining) and full external UDL

Whilst the modelling may suggest that settlement could meet the adopted SLS requirements, if the use of load factoring was permitted, this is only part of the overall assessment. Consideration has also been given to the ULS situation, in particular related to the new embankments and slopes to be formed within the influencing zone of identified weaker soils.

Based on the analysis of the recent ground investigation data and the associated modelling, five zones have been identified that require additional mitigation.

These zones have provisionally been given the nomenclature of Zone A to Zone E, and are described below.

A. ZONE A: Infilled Pond

- a. It is recommended that the infilled material is excavated, sorted screened and replaced with acceptable engineered fill.
- b. It is considered likely that the upper material would be suitable for re-use with little to no processing, however, the lower material is reported to be of low strength, most likely related to the moisture content.
- c. In order to render the lower material suitable for re-use and subject to meeting the appropriate chemical and contamination criteria, consideration may be given to the use of hydraulic binders (e.g. quick lime).

- d. Should hydraulic binders be proposed by the Earthworks Contractor, a suitable suite of mix design trials will be required, guidance for which is provided under a separate cover.

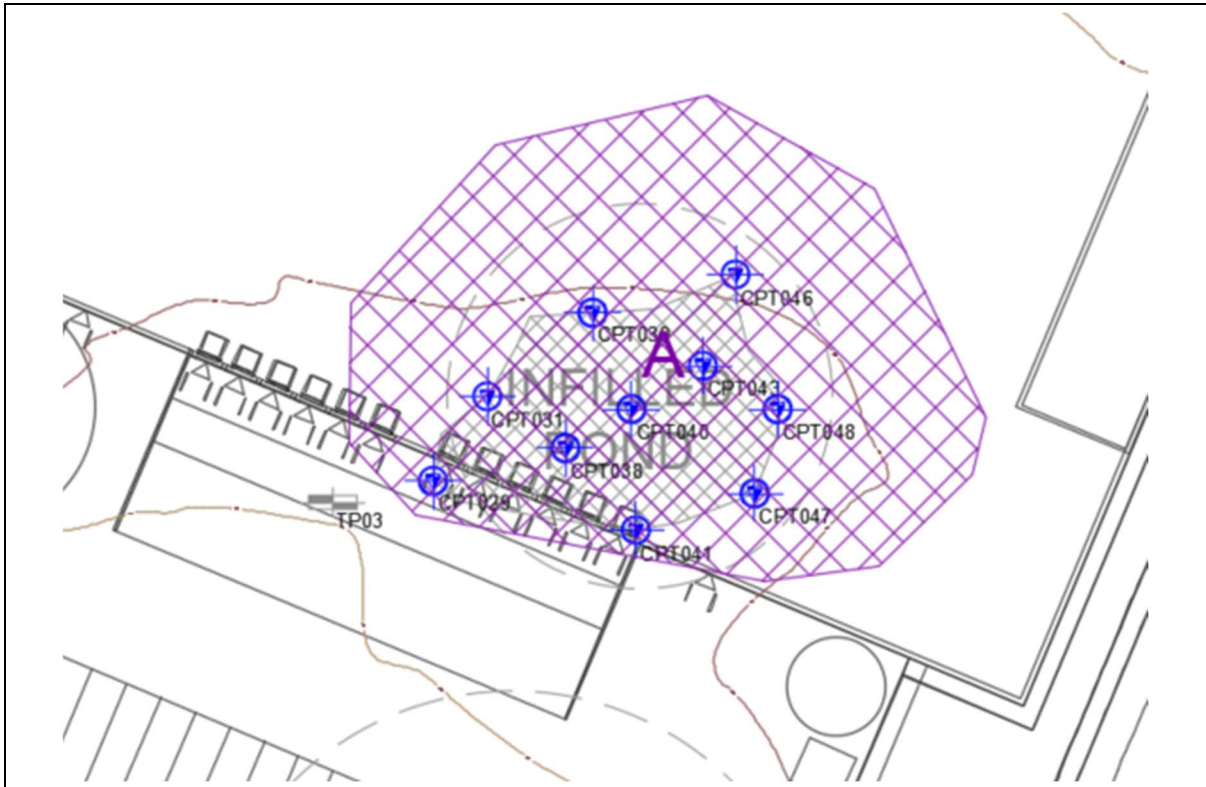


Figure 3-8: Indicative extent of Zone A, infilled pond

B. Zone B. Infilled Marl Pit

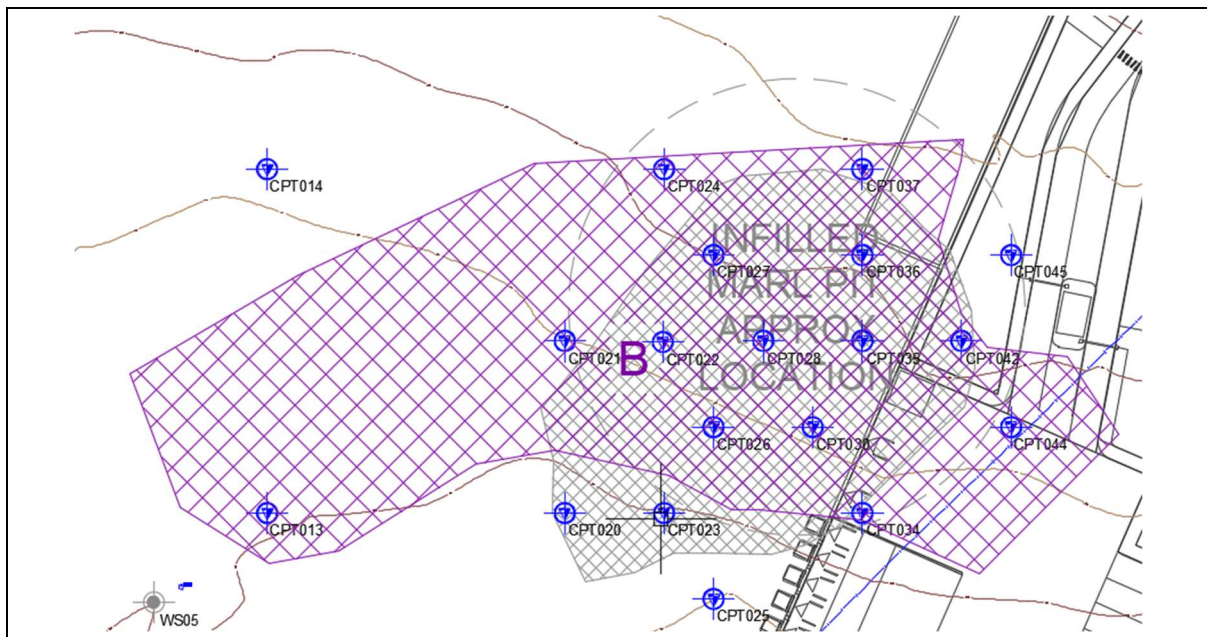


Figure 3-9: Indicative extent of Zone B, infilled Marl Pit

- a. Based on the findings from the supplementary Lucion investigation in June 2025 and the subsequent CPTu data provided by BCG, all materials within the infilled Marl Pit are recommended for excavation, sorting screening and processing.
- b. The composition of the infilled material is likely to include some material that is not suitable for retention on site, including waste materials that may have been deposited as part of the former operation of the site by the RAF.
- c. The extent of the excavation is shown to extend further to the East than the inferred extent of the pit, as a notable thickness of poorer soils were recorded in CPT013 (please refer to the records presented in Appendix B).
- d. As noted for the infilled pond, the upper materials that are excavated may be suitable for reuse, however deeper weaker soils are likely to require modification to permit them to be retained.
- e. In order to render the lower material suitable for re-use and subject to meeting the appropriate chemical and contamination criteria, consideration may be given to the use of hydraulic binders (e.g. quick lime).
- f. Should hydraulic binders be proposed by the Earthworks Contractor, a suitable suite of mix design trials will be required, guidance for which is provided under a separate cover.

C. Zone C: Eastern landscape bund

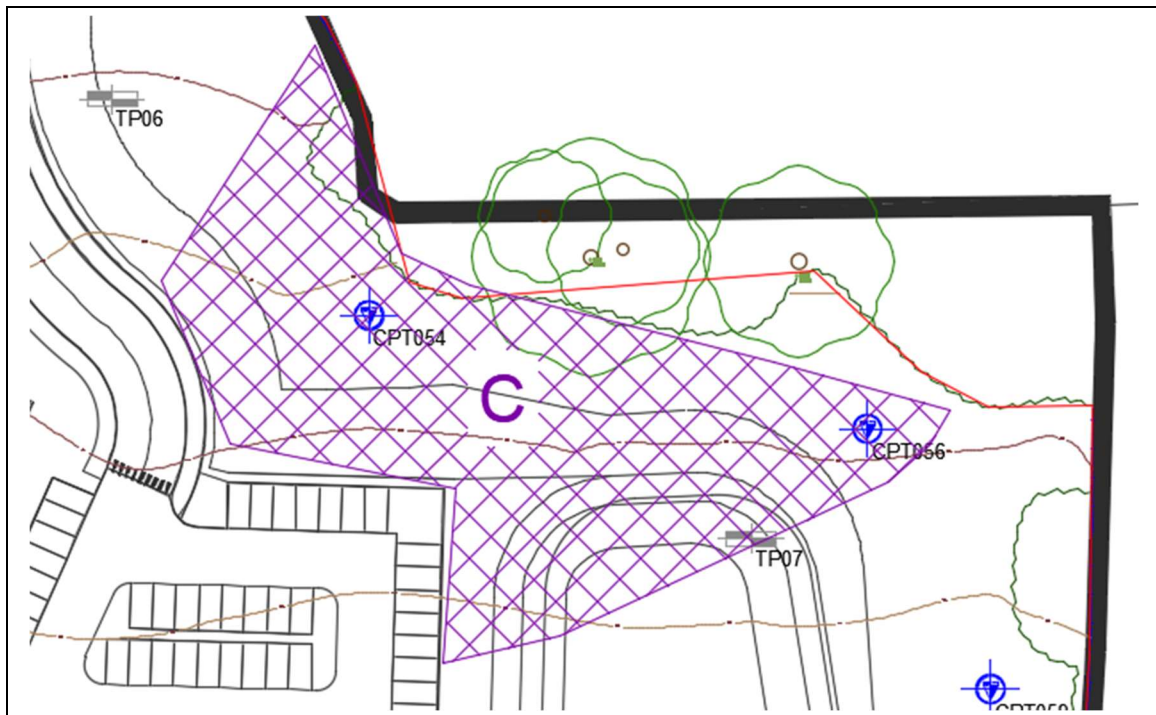


Figure 3-10: Indicative extent of Zone C, below East landscape bund.

- a. This is an area where a significant volume of landscape fill is to be placed, and the records from CPT054 and CPT056 have recorded a thickness of weak soil, which could lead to a ULS failure of the subgrade.
- b. This is an area where two strategies may be considered:

- i. Installation of VSC before the placement of the landscape fill
 - ii. Excavation and replacement of the affected soils with suitable fill
- c. It is considered likely that the upper material would be suitable for re-use with little to no processing, however, the lower material is reported to be of low strength, most likely related to the moisture content.
 - d. In order to render the lower material suitable for re-use and subject to meeting the appropriate chemical and contamination criteria, consideration may be given to the use of hydraulic binders (e.g. quick lime).
 - e. Should hydraulic binders be proposed by the Earthworks Contractor, a suitable suite of mix design trials will be required, guidance for which is provided under a separate cover.

D. Zone D: Balancing Pond and Southeastern Landscape Bund

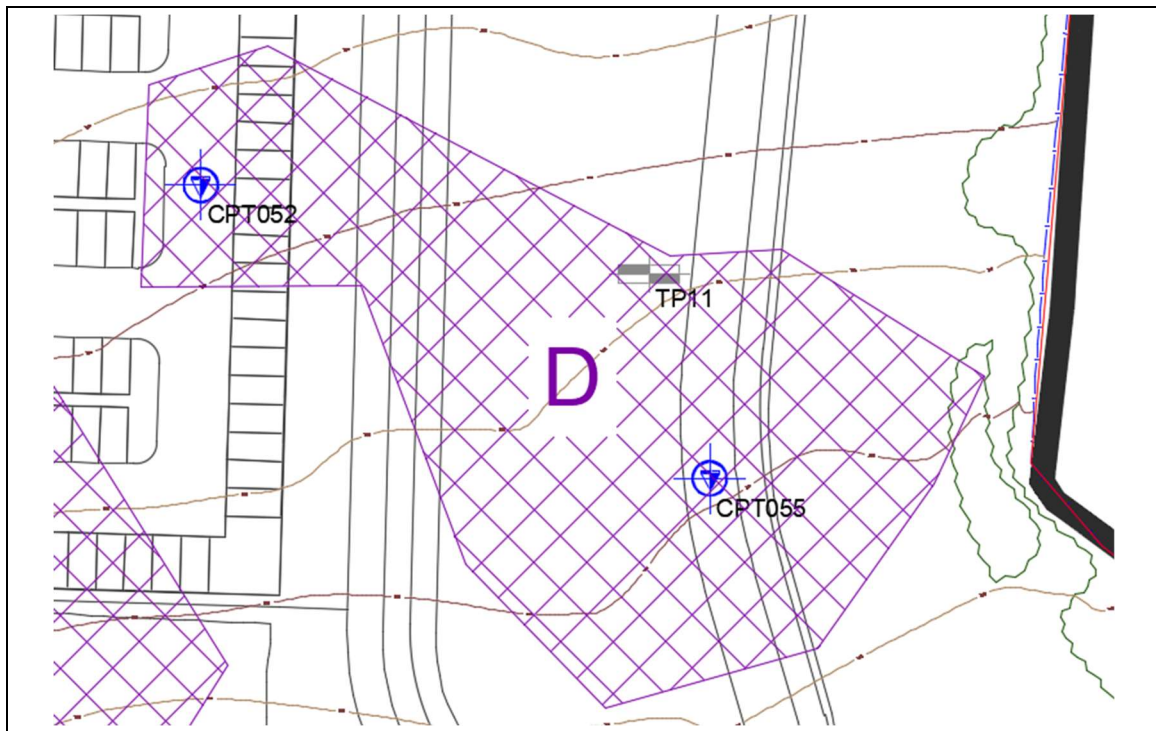


Figure 3-11: Indicative extent of Zone D, Balancing Pond and landscape Bund

- a. This is an area where a significant volume of landscape fill is to be placed, and the records from CPT052 and CPT055 have recorded a thickness of weak soil, which could lead to a ULS failure of the subgrade.
- b. This is an area where two strategies may be considered:
 - i. Installation of VSC before the placement of the landscape fill
 - ii. Excavation and replacement of the affected soils with suitable fill
- c. It is considered likely that the upper material would be suitable for re-use with little to no processing, however, the lower material is reported to be of low strength, most likely related to the moisture content.

- d. In order to render the lower material suitable for re-use and subject to meeting the appropriate chemical and contamination criteria, consideration may be given to the use of hydraulic binders (e.g. quick lime).
- e. Should hydraulic binders be proposed by the Earthworks Contractor, a suitable suite of mix design trials will be required, guidance for which is provided under a separate cover.

E. Zone E: Carpark and Southern Landscape Bund

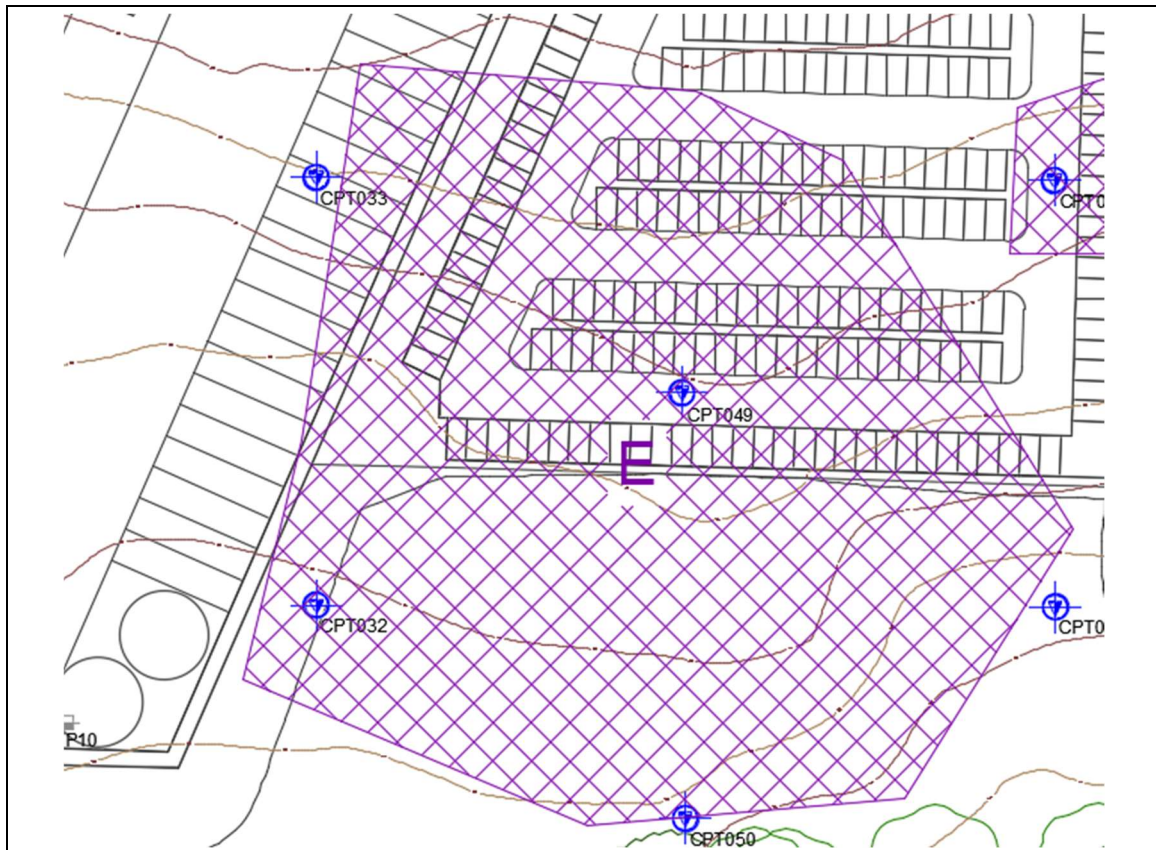


Figure 3-12: Indicative extent of Zone E, Carpark and Southern landscape bund

- a. This is an area where a significant volume of landscape fill is to be placed, and the records, in particular centred around CPT049, have recorded a thickness of weak soil, which could lead to a ULS failure of the subgrade.
- b. This is an area where two strategies may be considered:
 - i. Installation of VSC before the placement of the landscape fill
 - ii. Excavation and replacement of the affected soils with suitable fill
- c. It is considered likely that the upper material would be suitable for re-use with little to no processing, however, the lower material is reported to be of low strength, most likely related to the moisture content.
- d. In order to render the lower material suitable for re-use and subject to meeting the appropriate chemical and contamination criteria, consideration may be given to the use of hydraulic binders (e.g. quick lime).

- e. Should hydraulic binders be proposed by the Earthworks Contractor, a suitable suite of mix design trials will be required, guidance for which is provided under a separate cover.

The area and volume of each zone has been estimated from the GDM and is summarised in Table 3-1.

Table 3-1: Summary of Zones requiring mitigation, over-excavation & replacement

Region	General description	Approximate plan area	Approximate volume
Zone A	Infilled Pond	2,600 m ²	12,600 m ³
Zone B	Infilled Marl Pit	5,700 m ²	22,400 m ³
Zone C	Below landscape bund (East)	2,100 m ²	6,700 m ³
Zone D	Below landscape bund (West)	2,000 m ²	9,000 m ³
Zone E	Below car park and landscape bund (South)	6,300 m ²	39,500 m ³

Based on the need to address the risk from the five identified zones, a revised stiffness model (Model C) had been developed, where the impacted material has been excavated and replaced with acceptable engineered fill, as presented as Figure 3-13.

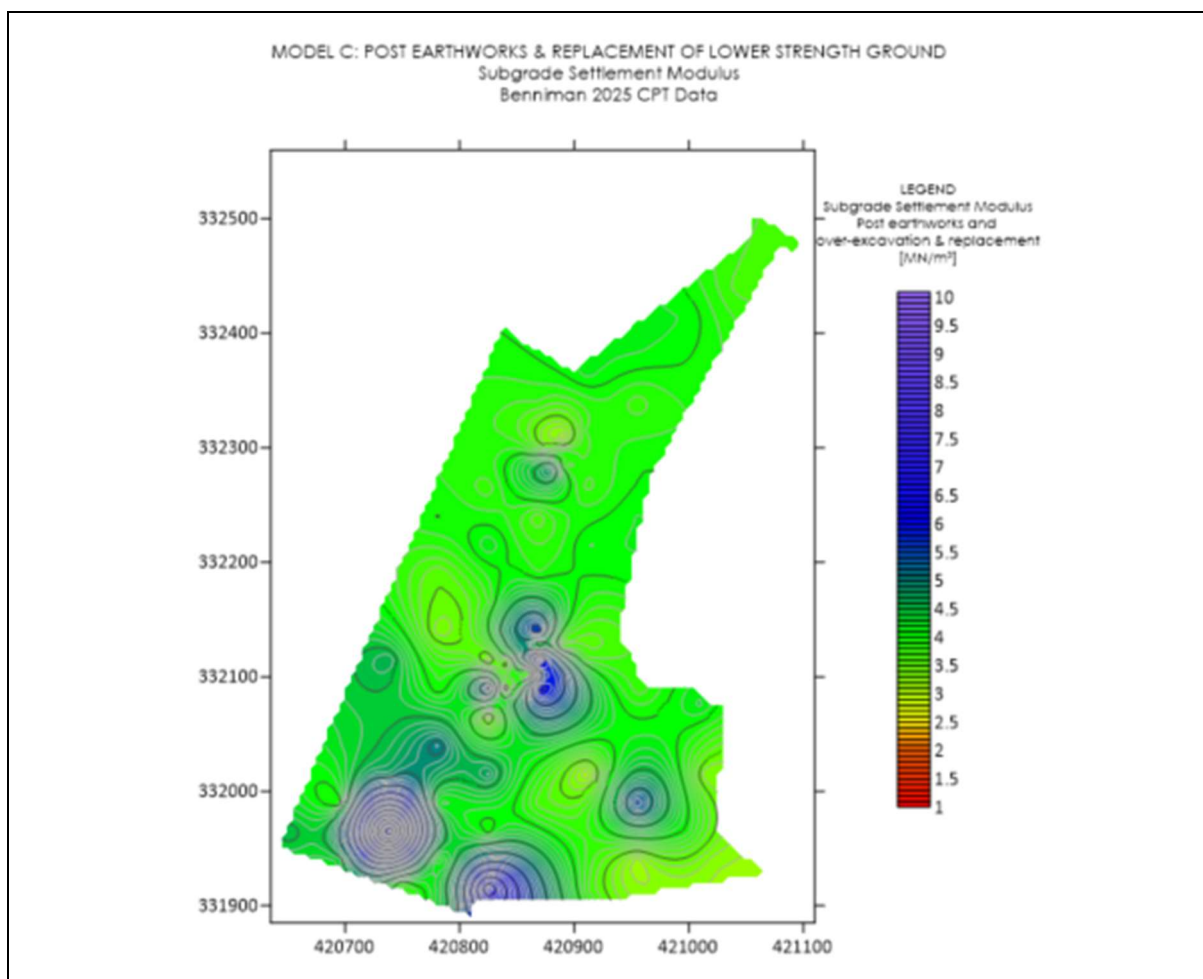


Figure 3-13: Stiffness Model C – Post earthworks and replacement of low strength material